



United States Department of the Interior



FISH AND WILDLIFE SERVICE

Oregon Fish and Wildlife Office

2600 SE 98th Avenue, Suite 100

Portland, Oregon 97266

Phone: (503) 231-6179 FAX: (503) 231-6195

Reply To: 01EOFW00-2017-F-0370
File Name: Bull Trout SLOPES_BO.docx
TS Number: 17-459
TAILS: 01EOFW00-2017-F-0370
Doc Type: Final

JUN 29 2017

Mr. Shawn H. Zinszer
Chief, Regulatory Branch
Corps of Engineers, Portland District
P.O. Box 2946
Portland, Oregon 97208-2946

Subject: Formal Consultation for Standard Local Operating Procedures for Endangered Species to Administer Stream Restoration; Stormwater, Transportation, or Utilities Actions; and In-Water or Over-Water Structure Actions and Effects to Bull Trout and Bull Trout Critical Habitat [Project No. NWP-2017-83] (*FWS reference: 01EOFW00-2017-F-0370*)

Dear Mr. Zinszer:

This document transmits the Fish and Wildlife Service's (Service) Biological Opinion (Opinion) for the United States Army Corps of Engineers' (Corps) proposed Standard Local Operating Procedures for Endangered Species (SLOPES) to administer Stream Restoration; Stormwater, Transportation, or Utilities Actions; and In-Water or Over-Water Structure Actions and the effects on the federally threatened bull trout (*Salvelinus confluentus*) and bull trout critical habitat, as requested by the Corps, in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). The Service received your April 28, 2017, request and the accompanying Proposed Action on May 3, 2017.

The Corps determined, and the Service agrees, that the proposed action *may affect, and is likely to adversely affect* bull trout and/or bull trout critical habitat in the action area. This Opinion is based on information provided in the proposed action, telephone and electronic correspondence, and other sources of information. A complete administrative record for this consultation is on file at the Service's La Grande Field Office in La Grande, Oregon.

We appreciate the great collaboration between Peter Olmstead of your staff and Justin Martens in our La Grande Field Office. Our co-location in La Grande helped facilitate a quicker completion of this important programmatic consultation. If you, or any of your staff, have questions about

this Opinion, or require more information regarding this consultation, please contact Justin Martens or Gary Miller in our La Grande Office at (541) 962-8584.

Sincerely,

A handwritten signature in blue ink that reads "Paul Henson". The signature is fluid and cursive, with the first name "Paul" being larger and more prominent than the last name "Henson".

Paul Henson, Ph.D.
State Supervisor

Enclosure

cc:

Peter Olmstead, Corps of Engineers, La Grande, Oregon
Gary Miller, Fish and Wildlife Service, La Grande, Oregon
Bridget Moran, Fish and Wildlife Service, Bend, Oregon
Chris Allen, Fish and Wildlife Service, Portland, Oregon
Janine Castro, Fish and Wildlife Service, Portland, Oregon
Justin Martens, Fish and Wildlife Service, Portland, Oregon

Endangered Species Act – Section 7 Consultation

**Programmatic Biological Opinion
for**

**Standard Local Operating Procedures for Endangered Species
to Administer Stream Restoration; Stormwater, Transportation,
or Utilities Actions; and In-Water or Over-Water Structure Actions and
Effects to Bull Trout and Bull Trout Critical Habitat.
[FWS reference: 01EOFW00-2017-F-0370].**

**Prepared by the La Grande Field Office
U.S. Fish and Wildlife Service
La Grande, Oregon**



Paul Henson, Ph.D., State Supervisor



Date

Federal Action Agencies: US Army Corps of Engineers,
Portland District,
Operations and Regulatory Branches

Affected Species and Determinations:

ESA-listed Species	ESA Status	Is the action likely to adversely affect this species or its critical habitat?		Is the Action likely to jeopardize this species?	Is the action likely to destroy or adversely modify critical habitat for this species?
		Spp.	CH		
Bull Trout (<i>Salvelinus confluentus</i>)	T	Yes	Yes	No	No

Table of Contents

INTRODUCTION	6
Background	6
Consultation History	7
BIOLOGICAL OPINION	8
1.0 PROPOSED ACTION	8
1.1 Project Design Criteria - General Construction Measures	17
1.2 Project Design Criteria I - Types of RES Actions	30
1.3 Project Design Criteria II - Types of STU Actions	36
1.4 Project Design Criteria III - Types of IWOW Actions	46
1.5 Action Area	48
2.0 STATUS OF BULL TROUT	49
2.1 Analytical Framework for the Jeopardy and Adverse Modification Determinations	49
2.2 Status of the Species	51
2.2.1 Species Description	51
2.2.2 Legal Status	52
2.2.3 Life History	52
2.2.4 Population Dynamics	53
2.2.5 Status and Distribution	58
2.3 Status of Bull Trout Critical Habitat	80
2.3.1 Current legal status of critical habitat	80
2.3.2 The Physical and Biological Features (PBFs)	82
3.0 Environmental Baseline	86
4.0 Effects of the Action on the Species and Designated Critical Habitats	89
4.1 Effects of Near and Instream Construction	90
4.2 Activity Category Specific Effects	93
4.3 Effects of the Action to Bull Trout	126
4.4 Scope of Effects to Bull Trout	130
4.5 Effects of the Action on Bull Trout Critical Habitat	131
5.0 Cumulative Effects	139
5.1 Integration and Synthesis	140
5.2 Species at the Population Scale	141
6.0 Conclusion	142
6.1 Bull Trout	142
6.2 Bull trout Critical Habitat	142
7.0 INCIDENTAL TAKE STATEMENT	143
7.1 Amount or Extent of Take	143
7.2 Effect of the Take	150
7.3 Reasonable and Prudent Measures and Terms and Conditions	150
7.4 Conservation Recommendations	152
8.0 REINITIATION OF CONSULTATION	158
LITERATURE CITED	159
APPENDIX A: PROGRAMMATIC NOTIFICATION FORMS	195
APPENDIX B: Electrofishing Recommendations for Sampling Larval Pacific Lampreys	200

List of Tables

Table 1. Listing status ¹ , status of critical habitat designations and relevant Federal Register (FR) decision notices for ESA-listed species considered in this Opinion.....	7
Table 2. Herbicide adjuvants, trade names, and application areas.	27
Table 3. Herbicide buffer distances by herbicide formula, stream type, and application method.	29
Table 4. Stream/Shoreline Distance and Reservoir/Lake Area Designated as Bull Trout Critical Habitat.....	80
Table 5. Potential pathways of effects of invasive and non-native plan control.	107
Table 6. Estimate of the amount of average capture, per year for projects authorized or carried out under SLOPES BT.....	147
Table 7. Estimate of the average take, per five-year period, for projects authorized or carried out under SLOPES BT.....	147

List of Figures

Figure 1. Action area consisting of major drainage basins and Bull Trout Recovery Units in Oregon.....	49
--	----

LIST OF COMMON ACRONYMS

ARBO	Aquatic Restoration Biological Opinion
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BO	SLOPES BT Opinion
CFR	Code of Federal Regulations
CWA	Clean Water Act
DBH	diameter at breast height
DPS	distinct population segment
ELJ	engineered logjams
ESA	Endangered Species Act
EPA	U.S. Environmental Protection Agency
FMO	Bull trout foraging, migrating and overwintering habitat
FR	Federal Register
HUC	Hydraulic Unit Code
HWM	high water mark
ITS	Incidental Take Statement
IWOW	Either referring to the NMFS SLOPES In-water Over-water BO; or In-water Over-water actions
LW	large wood
MLLW	Mean Lower Low Water
NMFS	National Marine Fisheries Service
ODFW	Oregon Department of Fish and Wildlife
OLW	Ordinary Low Water
PA	U.S. Army Corps of Engineers Proposed Action
PBF	physical and biological features
PDC	project design criteria
POEA	polyethoxylated tallow amine
RHA	Rivers and Harbors Act
RHCA	riparian habitat conservation areas
RR	Riparian Reserve
RU	Recovery Unit
SLOPES BT	Standard Local Operating Procedures for Endangered Species Bull Trout Opinion
SR	Bull trout spawning and rearing habitat
STU	Either referring to the NMFS SLOPES Stormwater, Transportation, and Utilities BO; or Stormwater, Transportation, and Utilities actions
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WRDA	Water Resources Development Act

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.

Background

This document transmits the U.S. Fish and Wildlife Service's (Service or USFWS) biological opinion (Opinion or BO) based on our review of the proposed actions (PA) for Standard Local Operating Procedures for Endangered Species: Bull Trout (SLOPES BT). This document was prepared in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 USC 1531 *et seq.*), and implementing regulations at 50 CFR 402. The request for formal consultation, signed by the U.S. Army Corps of Engineers, Portland District (Corps), was received by USFWS on May 15, 2017.

The Corps proposes a SLOPES BT program as it applies to Corps activities involving aquatic habitat restoration (RES); stormwater, transportation, or utilities (STU); and in-water or over-water (IWOW) actions with respect to bull trout. "SLOPES" refers to the process and criteria that the Corps uses to guide the administration of activities regulated under Section 404 of the Clean Water Act (CWA), Section 10 of the Rivers and Harbors Act (RHA) of 1899; and Sections 206, 536, and 1135 of the Water Resources Development Act (WRDA), in areas occupied by Endangered Species Act (ESA)-listed fish or their designated critical habitats.

Section 404 of the CWA requires authorization from the Secretary of the Army, acting through the Corps, for the discharge of dredged or fill material into all waters of the U.S., including adjacent wetlands. Discharges of fill material generally include, without limitation, any placement of fill that is necessary for construction of any type of structure, development, property protection, reclamation, or other work involving the discharge of fill or dredged material. A Corps permit is required whether the work is permanent or temporary. Examples of temporary discharges included dewatering of dredged material before final disposal, and temporary fills for access roadways, cofferdams, storage, and work areas.

Section 10 of the RHA requires authorization from the Secretary of the Army for the creation of any structure, excavation, or fill, within the limits defined for navigable waters of the U.S., if the structure or work will affect the course, location, or condition of the waterbody. The law applies to any dredging or disposal of dredged material, excavation, filling, channelization, or any other modification of a navigable water of the U.S., and applies to all structures, from the smallest floating dock to the largest commercial undertaking. It further includes, without limitation, any wharf, dolphin, weir, boom, breakwater, jetty, groin, bank stabilization, mooring structures (such as pilings), aerial or subaqueous power transmission lines, intake or outfall pipes, permanently moored floating vessel, tunnel, artificial canal, boat ramp, aids to navigation, and any other permanent or semi-permanent obstacle or obstruction.

Section 1135 of WRDA authorizes the Corps to modify the structure or operation of a Corps project to restore or improve environmental quality and ecosystem functions impaired by that project, provided that the modification does not conflict with the authorized project purposes.

Section 206 of WRDA expands this authority to cover construction of projects for the restoration and protection of aquatic ecosystems unrelated to an existing Corps facility. Section 536 of WRDA authorizes studies and ecosystem restoration actions in the Lower Columbia River and Tillamook Bay. The Corps has environmental restoration programs in place, in Oregon, that are authorized by these authorities and are intended to restore habitat for ESA-listed salmon, steelhead and bull trout.

Many fish-bearing streams within the Corps' jurisdiction are occupied by ESA-listed salmon, steelhead, and/or bull trout. Individual ESA consultation for permits within these streams with bull trout results in a substantial workload for both the Corps and USFWS, often with little additional benefit to the species. Many of these activities are minor and repetitive in nature, and consultation on them has resulted in the imposition of similar conditions for regulatory approval.

Consultation History

Since March 21, 2001, the Corps Portland District has used SLOPES with NMFS for salmon and steelhead, as described in a series of programmatic biological opinions (NMFS, 2004; 2012; 2013; 2014) to guide its review of individual permit requests under section 10 of the RHA and section 404 of the CWA, including requests for authorization of activities which are similar to those that may be regulated under the following 2012 (or current version) Corps nationwide permits (NWP): NWP-3 Maintenance; NWP-6 Survey Activities; NWP-7 Outfall and Associated Intake Structures; NWP-9 Structures in Fleeting and Anchorage Areas; NWP 10-Mooring Buoys; NWP-12 Utility Line Activities; NWP 13-Bank Stabilization; NWP-14 Linear Transportation Projects; NWP 19-Minor Dredging; NWP-25 Structural Discharge; NWP-27 Aquatic Habitat Restoration, Establishment, and Enhancement; NWP 36-Boat Ramps; NWP 37-Emergency Watershed Protection and Rehabilitation; NWP 42-Recreational Facilities; and NWP 43-Stormwater Management Facilities. The Corps NWPs will be updated in 2017.

The Corps uses SLOPES to evaluate applications for stream and wetland restoration actions that are within the range of ESA-listed salmon and steelhead; requests for authorization of activities related to STU projects; and activities for IWOW projects. To date, the SLOPES process has only been used for salmon and steelhead projects regulated by NMFS; however this Opinion broadens the scope of SLOPES application to ESA-listed bull trout projects regulated by the USFWS (Table 1).

Table 1. Listing status¹, status of critical habitat designations and relevant Federal Register (FR) decision notices for ESA-listed species considered in this Opinion.

Species	Listing Status	Critical Habitat
Bull trout (<i>Salvelinus confluentus</i>)	T, 6/10/1998, 63 FR 31647	10/18/2010 , 75 FR 63898

1. Listing status: 'T' means listed as threatened; 'E' means listed as endangered.

Because no previous SLOPES process has existed for bull trout, all applications the Corps received for actions involving bull trout require site-specific ESA consultation. While informal discussions between the Corps and USFWS regarding SLOPES BT have been ongoing for some time, an initial PA was drafted on April 17, 2016. Further revisions to this document occurred throughout 2016, and the final PA was submitted on May 3, 2017. This Opinion will allow for

applications for actions that the Corps finds to be within the range of effects considered in this SLOPES BT Opinion to be issued a permit with corresponding conditions; applications that are not found to be within this range of effects are submitted to USFWS for additional, site-specific ESA consultation.

BIOLOGICAL OPINION

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 USFWS, 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 Services 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 specifying the impact of any incidental taking, and including reasonable and prudent measures to minimize such impacts.

1.0 PROPOSED ACTION

The Corps proposes this programmatic Section 7 consultation to provide streamlined ESA coverage as it applies for certain activities authorized under their Regulatory and Civil Works Programs in the State of Oregon, except for the Klamath River Basin, and that affect ESA-listed Bull Trout (*Salvelinus confluentus*) populations or their designated critical habitat. The Corps' authority over these actions is founded in Section 404 of the Clean Water Act, Section 10 of the Rivers and Harbors Act of 1899; and Sections 206, 536, and 1135 of the Water Resources Development Act. The Corps proposes to apply the following design criteria, in relevant part, to every action authorized under this Opinion. Measures described under "Administration" apply to the Corps as it manages the Standard Local Operating Procedures for Endangered Species (SLOPES) for bull trout (SLOPES BT) program. Measures described under "General Construction" apply, in relevant part, to each action that involves a construction component. Measures described under "Types of Action" apply, in relevant part, to each specific type of actions as described. The Types of Action are divided into three broad categories: (I) Restoration (RES), (II) Stormwater, Transportation, or Utilities (STU), and (III) In-Water Over-Water Structures (IWOW). This reflects the organization of the three previous SLOPES programmatic consultations between the Corps and the NMFS for consistency and ease of implementation. The Corps will ensure that all other measures apply to each party that is given authorization for, or carries out, an action under SLOPES BT. The following action types and project design criteria have been numbered to include one of four suffix letters that correspond to the applicable Action Type. Those letters are "R" for Restoration; "S" for Stormwater, Transportation, or Utilities; "I" for In-water or Over-water Structures; and "G" for General. The project design criteria with a suffix of "R", "S", or "I" are only applicable to those projects falling under the corresponding action type; while design criteria with a suffix of "G" are applicable to all actions carried out under SLOPES for BT.

Action Type I. Restoration (RES)

The Corps is proposing to use SLOPES BT to authorize ten categories of action related to aquatic habitat restoration, including wetland restoration. Those categories are:

- 1R. Boulder Placement** to increase habitat diversity and complexity, improve flow heterogeneity, provide substrate for aquatic vertebrates, moderate flow disturbances, and provide refuge for fish during high flows by placing large boulders in stream beds where similar natural rock has been removed.
- 2R. Fish Passage Restoration** to improve fish passage by installing or improving step structures, fish ladders, or lamprey ramps at an existing facility, or replacing or improving culverts or fish screens.
- 3R. Large Wood Restoration** to increase coarse sediment storage, habitat diversity and complexity, retain gravel for spawning habitat, improve flow heterogeneity, provide long-term nutrient storage and substrate for aquatic macroinvertebrates, moderate flow disturbances, increase retention of leaf litter, and provide refuge for fish during high flows by placing large wood in areas where natural wood accumulations have been removed.
- 4R. Off- and Side-Channel Habitat Restoration** to reconnect stream channels with floodplains, increase habitat diversity and complexity, improve flow heterogeneity, provide long-term nutrient storage and substrate for aquatic macroinvertebrates, moderate flow disturbances, increase retention of leaf litter, and provide refuge for fish during high flows by restoring or modifying hydrologic and other essential habitat features of historical river floodplain swales, abandoned side channels, and floodplain channels.
- 5R. Pile Removal** to improve water quality by eliminating chronic sources of toxic contamination.
- 6R. Set-Back Existing Berms, Dikes and Levees** to reconnect stream channels with floodplains, increase habitat diversity and complexity, moderate flow disturbances, and provide refuge for fish during high flows by increasing the distance that existing berms, dikes or levees are set back from active streams or wetlands.
- 7R. Spawning Gravel Restoration** to improve spawning substrate by compensating for an identified loss of a natural gravel supply.
- 8R. Streambank Restoration** to restore eroding streambanks by (a) bank shaping and installation of coir logs or other soil reinforcements as necessary to support riparian vegetation; (b) planting or installing large wood, trees, shrubs, and herbaceous cover and controlling invasive and non-native plant species as necessary to restore ecological function in riparian and floodplain habitats; or (c) a combination of the above methods.

- 9R. Water Control Structure Removal** to reconnect stream corridors, reestablish wetlands, improve fish passage, and restore more natural channel and flow conditions by removing earthen embankments, subsurface drainage features, low-head dams, spillway systems, tide gates, outfalls, pipes, instream flow redirection structures (*e.g.*, drop structure, gabion, groin), or similar devices used to control, discharge, or maintain water levels.
- 10R. Wetland Restoration** to restore degraded wetlands by excavation and removal of fill materials.

Action Type II. Stormwater, Transportation, or Utilities (STU)

The Corps is proposing to use SLOPES BT to authorize three categories of actions related to stormwater, transportation or utilities, specifically:

- 1S. Streambank and channel stabilization** to ensure that roads, culverts, bridges and utility lines do not become hazardous due to the long-term effects of toe erosion, scour, subsurface entrainment, or mass failure. This action includes installation and maintenance of scour protection, such as at a footing, facing, or headwall, to prevent scouring or down-cutting of an existing culvert, road foundation, or bridge support. It does not include scour protection for bridge approach fills. Proposed streambank stabilization methods include alluvium placement, vegetated riprap with large wood (LW), log or roughened rock toe, woody plantings, herbaceous cover, deformable soil reinforcement, coir logs, bank reshaping and slope grading, floodplain flow spreaders, floodplain roughness, and engineered log jams (ELJs), alone or in combination. Any action that requires additional excavation or structural changes to a road, culvert, or bridge foundation is covered under road, culvert and bridge maintenance, rehabilitation, and replacement.
- 2S. Road surface, culvert and bridge maintenance, rehabilitation and replacement.** Maintenance, rehabilitation, and replacement to ensure that roads, culverts and bridges remain safe and reliable for their intended use without impairing fish passage, to extend their service life, and to withdraw temporary access roads from service in a way that promotes watershed restoration when their usefulness has ended. This includes actions necessary to complete geotechnical surveys, such as access road construction, drill pad preparation, mobilization and set up, drilling and sampling operations, demobilization, boring abandonment, and access road and drill pad reclamation. It also includes, excavation, grading, and filling necessary to maintain, rehabilitate, or replace existing roads, culverts, and bridges. This type of action does not include significant channel realignment, installation of fish passage (*e.g.*, fish ladders, juvenile fish bypasses, culvert baffles, roughened chutes, step weirs), tidegate maintenance or replacements other than full removal, construction of new permanent roads within the riparian zone that are not a bridge approach, or construction of a new bridge where a culvert or other road stream crossing did not previously exist, or any project which will result in or contribute to other land use changes that trigger effects, including indirect effects not considered in this proposed action.

- 3S. Stormwater facilities and utility line stream crossings** to install, maintain, rehabilitate, or replace stormwater facilities, or pipes or pipelines used to transport gas or liquids, including new or upgraded stormwater outfalls, and cables, or lines or wires used to transmit electricity or communication. Construction, maintenance or improvement of stormwater facilities include surveys, access road construction, excavation, grading, and filling necessary to maintain, rehabilitate, or replace existing stormwater treatment or flow control best management practices (BMPs). Utility line actions involve excavation, temporary side casting of excavated material, backfilling of the trench, and restoration of the work site to preconstruction contours and vegetation. This type of action does not include construction or enlargement of gas, sewer, or water lines to support a new or expanded service area for which effects, including indirect effects from interrelated or interdependent activities, have not been analyzed in this Opinion. This Opinion also does not include construction of any line that transits the bed of an estuary or saltwater area at depths less than -10.0 feet (mean lower low water).

Action Type III. In-Water or Over-Water Structures (IWOW)

The Corps is proposing to use SLOPES BT to authorize four categories of actions related to In-Water or Over-Water Structures, specifically:

- 1I. Install a new or expanded aid to navigation, mooring buoy, mooring dolphin, recreational boat dock, or recreational boat ramp**, including all actions necessary to complete installation *e.g.*, geotechnical surveys, pile driving and minimal excavation (less than 25 cubic yards), grading, or filling. A recreational boat dock consists of a fixed pier, elevated walkway, ramp and float; and a recreational boat ramp is an inclined plane (usually of concrete) extending from the upland into the water that is used to move boats to or from the water.

This action does not include any project that would install a new mooring buoy, mooring dolphin, recreational boat dock or recreational boat ramp at a site with any of the following characteristics:

- a. An alcove, backwater slough, downstream of a bar or island, side channel, or any other shallow-water area (means a water column depth of less than 20 feet as measured at Ordinary Low Water (OLW) or Mean Lower Low Water (MLLW) where routine maintenance dredging will be required), flow is insufficient to dissipate fuels and other pollutants from vessels, or water depth is insufficient to prevent the structure from grounding out during normal low flow conditions.
- b. A Superfund Site designated by the U.S. Environmental Protection Agency, a state-designated clean-up area, or the likely impact zone of a significant contaminant source, as identified by historical information or the Corps' best professional judgment.
- c. Within a Corps or Service compensatory mitigation site or aquatic habitat enhancement, restoration, preservation, or creation site.

- 2I. Maintain, rehabilitate, replace, or remove an existing in-water or over-water structure** as necessary to extend the useful service life of the structure, or to withdraw the public or private structure from service when its usefulness has ended. Eligible structures include, but are not limited to, an aid to navigation, boat house, boat launch ramp, breakwater, buoy, commercial/industrial/recreational pier or wharf, port/industrial/marina facilities,¹ covered boat house, dock, dolphin, float plane hangar, floating storage unit, floating walkway, groin, jetty, marina, mooring structure, permanently moored floating vessel, private boat dock, recreational boat ramp, or wharf.

This does not include any action that would occur in a Superfund Site designated by the U.S. Environmental Protection Agency, a state-designated clean-up area, or the likely impact zone of a significant contaminant source, as identified by historical information or the Corps' best professional judgment.

- 3I. Dredging to maintain vessel access** to previously authorized docks, wharfs, mooring structures, and boat ramps by maintaining an existing dredge prism, provided that any dredged materials and subsequent leave surface are suitable and approved for in-water disposal. Where appropriate, this includes maintenance and advanced maintenance to ensure that vessel access is not interrupted by normal changes in river conditions during a reasonable interval between dredging events. This action does not include any modification that changes the character, scope, size, or location of the project area or previously authorized dredge prism.

This does not include any action that:

- a. Does not meet the terms and conditions of Nationwide Permits 3, 19, or 35, as amended.
- b. Is part of the Corps' navigation program to maintain Federal navigation channels, or that would occur in a Superfund Site designated by the U.S. Environmental Protection Agency, a state-designated clean-up area, or the likely impact zone of a significant contaminant source, as identified by historical information or the Corps' best professional judgment.

- 4I. Dredging to maintain functionality** of previously authorized channels, culverts, water intakes, or outfalls, provided that (a) the volume of material moved is limited to the minimum amount necessary to restore existing use, and all naturally-occurring sediment and debris, including large wood, are side cast or returned to the channel downstream from the structure where it will continue to provide aquatic habitat function, (b) fish passage at the structure will be maintained, and meet NMFS passage criteria.

This does not include any action that would:

- a. Not meet the terms and conditions of Nationwide Permit 3, 19, or 35, as amended; or

¹ This includes replacing existing pilings, fender piles, group pilings, walers, and fender pads. It also includes the installation of new mooring dolphins and structural pilings, height extension of existing pilings and the relocation of floats within an existing marina.

- b. Include any water intake or point of diversion that does not have a fish screen that is installed, operated and maintained according to National Marine Fisheries Service (NMFS) fish passage and screening criteria (2011 or current version), site-specific designs as approved by USFWS and NMFS (if a minor variance is requested), or meets the Service's bull trout specific screening and passage criteria when developed; or
- c. Occur in a Superfund Site designated by the U.S. Environmental Protection Agency, a state-designated clean-up area, or the likely impact zone of a significant contaminant source, as identified by historical information or the Corps' best professional judgment.

2.1.1 Program Administration

1. **Initial rollout.** The Corps will cooperate with the Service to provide an initial rollout of this Opinion for Corps staff to ensure that these conditions are considered at the onset of each project, incorporated into all phases of project design, and that any constraints, such as the need for fish passage or hydrologic engineering, are resolved early on and not under-designed as add-on features.
2. **Failure to report may trigger reinitiation.** The Service may recommend reinitiation of this consultation if the Corps fails to provide full reports or organize, facilitate, and attend the annual coordination meeting.
3. **Full implementation required.** Failure to comply with all applicable conditions for a specific project may invalidate protective coverage of ESA section 7(o)(2) regarding "take" of listed species, and may lead the Service to a different conclusion regarding the effects of that project.
4. **Review and approval.** The Corps will review each project to be covered under this Opinion to ensure that:
 - a. The project is:
 - i. Within the present or historic range of ESA-listed bull trout or designated critical habitat.
 - ii. May affect bull trout or their designated critical habitat.
 - iii. The effects are likely to be within the range of effects considered in this Opinion.
 - iv. Permits will include all PDC as an enforceable condition of every action authorized under this Opinion. The Corps will also include each applicable PDC as a final action specification of every WRDA civil works action carried out under this Opinion.
 - v. Any applicant receiving Corps authorization will comply with all of the following conditions, including obtaining Service review and approval, as appropriate.

- b. The Service will review and approve any project with any of the following elements, including any additional conservation measures necessary to ensure that the effects of those projects are within range of effects considered in this Opinion:
 - i. Modification or variance of any requirement.
 - ii. Fish passage restoration, including any culvert replacement or retrofit. The Corps proposes to review and fund fish passage projects for bull trout. The objective of fish passage restoration is to allow all life stages of bull trout access to historical habitat from which they have been excluded and focuses on restoring safe upstream and downstream fish passage to stream reaches that have become isolated by obstructions. Although passage actions are generally viewed as positive actions for native fish restoration, there may be occasions where restoring passage exposes native fish (isolated above or below a barrier) to negative influences (predation, competition, hybridization) from non-native species such as brook trout. Proposed passage projects that may increase bull trout exposure to non-native species must be approved by the appropriate Service Field Office Supervisor.
 - iii. Fishway intended to attract, collect, exclude, guide, transport, or release bull trout including, but not limited to, a culvert retrofit, a pool-riffle structure, or a roughened chute
 - iv. Blasting
 - v. Water Control Structure or dam removal
 - vi. Earthwork at an EPA-designated Superfund Site, a state-designated clean-up area, or in the likely impact zone of a significant contaminant source, as identified by historical information or the Corps' best professional judgment.
 - vii. Preservative and Pesticide Treated Wood. The Corps and Service will review all projects involving treated wood in or near aquatic habitats to ensure that the effects of those projects are within range of effects considered in this Opinion. Generally speaking, the agencies will refer to the NOAA Fisheries guidelines titled: *The Use of Treated Wood Products in Aquatic Environments: Guidelines to West Coast NOAA Fisheries Staff for Endangered Species Act and Essential Fish Habitat Consultations in Alaska, Northwest and Southwest Regions*; dated October 12, 2009, or the most recent state of the science, when making that determination. Projects involving treated wood cannot proceed without review and approval by the Service.
- c. **Default Approval** – Actions not requiring review and approval from the Service in accordance with section 4(b) above are automatically approved under SLOPES BT after 45 days has passed from receipt of the project notification form, unless the Service notifies the Corps within this period that the action does not qualify for SLOPES BT. Individual approval prior to the 45-day suspense may be granted by the Service at their discretion.
- d. **Individual Approval** – Projects requiring review and approval from the Service in accordance with section 4(b) above cannot proceed to construction until final approval is granted. The Service will notify the Corps within 45 days whether the action is

approved or disqualified. If the Service requires additional time for review, they will notify the Corps and a mutually agreeable timeline will be implemented.

- e. **Minor Variance Process** - Because of the wide range of proposed activities and the natural variability within and between stream systems, some projects may be appropriate for minor variations from criteria specified herein. Service Division or Field Office Supervisors may authorize variances under the following circumstances:
 - i. When there is a clear conservation benefit (i.e. a net gain of aquatic resource function), or
 - ii. The project is within the scope, intent, and range of effects considered within the SLOPES BT Opinion (i.e. no additional harm to listed species or critical habitat), or
 - iii. Urgent or emergency-like situations as approved by the Corps and Service.
 - iv. Minor variances may be requested as part of the above notification process and must:
 - (1) Cite SLOPES BT identifying number
 - (2) Cite the relevant criterion by page number
 - (3) Define the requested variance
 - (4) Explain why the variance is necessary
 - (5) Provide a rationale why the variance will either provide a conservation benefit or, at a minimum, not cause additional adverse effects
 - (6) Include as attachments any necessary approvals by state agencies
 - f. **Prohibitions** - The project will not:
 - i. Make the program exceed the amount or extent of take described in the incidental take statement issued with this Opinion
 - ii. Be of a scope and scale that it requires an environmental impact statement; thereby requiring an individual project analysis under the ESA
5. **Permit conditions.** The Corps will include all project design criteria as an enforceable condition of every action authorized under this Opinion. The Corps will also include each applicable design criterion as a final action specification of every WRDA civil works action carried out under this Opinion.
6. **Site access.** The Corps will retain the right of reasonable access to each project site to monitor the use and effectiveness of these conditions.
7. **Monitoring and reporting.** The Corps will ensure that the appropriate notifications and reports are submitted to the Service for each project to be completed under this Opinion. All notifications and reports are to be submitted electronically through a mutually agreeable file transfer protocol:
- a. Project notification within 45-days before start of construction (Part 1) unless waived by the Service on a case-by-case basis.
 - b. Project completion within 60-days of end of construction (Part 1 with Part 2 completed).

- c. Fish salvage within 60-days of work area isolation with fish capture (Part 1 with Part 3 completed).
8. **Annual program report.** The Corps' Regulatory and Civil Works Branches will each submit a monitoring report to the Service by February 15 each year that describes the Corps' efforts to carry out this Opinion. The report will include an assessment of overall program activity, a map showing the location and type of each action authorized and carried out under this Opinion, and any other data or analyses the Corps deems necessary or helpful to assess habitat trends as a result of actions authorized under this Opinion. The Corps will submit reports to the Service by email at this address: slopes@fws.gov.
9. **Annual coordination meeting.** The Corps' Regulatory and branches will organize, facilitate, and attend an annual coordination meeting with the Service by March 31 each year to discuss the annual report and any actions that can improve conservation under this Opinion, or make the program more efficient or accountable.
10. **SLOPES BT program additions/corrections.** The Corps proposes an amendment process for SLOPES BT to correct deficiencies and provide flexibility to include additional restoration actions or methods that are not identified in the present document, without reinitiating consultation on the entire program.² Existing political, social, technological, scientific, or capacity constraints that currently exclude certain types of actions may change to such a degree as to allow these activities to proceed under SLOPES BT at a future date. For example, a new restoration method or project type may have to proceed through several individual consultations before project design criteria are refined in a manner that ensures predictable effects and beneficial outcomes to bull trout. Once predictability is achieved, the Corps or Service may desire certain changes to SLOPES BT.

New restoration methods, project types, or other program changes can be proposed for inclusion into SLOPES BT at a local or provincial scale via local Service/Corps personnel coordination. Local personnel shall present a consistency document to a review team consisting of upper level supervisors and specialists who will then review the proposal and decide whether or not the project activity is consistent with the effects and beneficial outcomes described under this Opinion. Further, the review team can propose new actions, accompanied by a consistency document, for inclusion into SLOPES BT. The consistency document shall include the following as consultation with the Service:

- a. Project type, description
- b. Ecological process and disruption being addressed
- c. Benefits to bull trout
- d. How the project is consistent with effects specified in SLOPES BT
- e. List of conservation measures and PDC to be used that are not included in this Opinion.

² The standard for reinitiation of formal consultation is established in 50 CFR 402.16, and the Corps shall request reinitiation when it believes that any condition described in that section applies.

1.1 Project Design Criteria - General Construction Measures

1G. Project Design.

- a. Use the best available scientific information regarding the likely effects of climate change on resources in the project area, including projections of local stream flow and water temperature, to ensure that the project will be adaptable to those changes.
- b. Obtain all applicable regulatory permits and official project authorizations before beginning construction.
- c. Minimize the extent and duration of earthwork, *e.g.*, compacting, dredging, drilling, excavation, and filling.
 - i. Avoid use of heavy equipment, vehicles or power tools below bankfull elevation unless project specialists determine such work is necessary, or would result in less risk of sedimentation or other ecological damage than work above that elevation.
 - ii. Complete earthwork in wetlands, riparian areas, and stream channels as quickly as possible.
- d. Cease project operations when high flows may inundate the project area, except for efforts to avoid or minimize resource damage.

2G. Site contamination assessment.

- a. The level of detail and resources committed to such an assessment will be commensurate with the level and type of past or current development at the site. An applicant's assessment may include the following:
 - i. Review available records, such as former site use and records of any prior contamination events.
 - ii. If the project site was used for industrial processes (*i.e.*, mining or manufacturing with chemicals), inspect to determine the environmental condition of the property.
 - iii. Interview people who are knowledgeable about the site, *e.g.*, site owners, operators, and occupants, neighbors, or local government officials.
- b. Consult with the Service if ground disturbance to accomplish the proposed project would potentially release contaminants to aquatic habitat that supports listed fish species.

3G. Site layout and flagging.

- a. Before any significant ground disturbance or entry of mechanized equipment or vehicles into the construction area, clearly flag that area to identify:
 - i. Sensitive areas, *e.g.*, wetlands, water bodies, ordinary high water, spawning areas.
 - ii. Equipment entry and exit points.
 - iii. Road and stream crossing alignments.
 - iv. Staging, storage, and stockpile areas.
- b. Before use of herbicides, clearly flag all buffer areas, including any no-application zones.

4G. Staging, storage, and stockpile areas.

- a. Designate and use staging areas to store hazardous materials, or to store, fuel, or service heavy equipment, vehicles and other power equipment with tanks larger than 5 gallons, that are at least 150 feet from any natural water body or wetland, or on an established paved area, such that sediment and other contaminants from the staging area cannot be deposited in the floodplain or stream.
- b. Natural materials that are displaced by construction and reserved for restoration, *e.g.*, large wood, gravel, and boulders, may be stockpiled within the 100-year floodplain.
- c. Dispose of any material not used in the project and not native to the floodplain outside of the functional floodplain.
- d. After construction is complete, obliterate all staging, storage, or stockpile areas, stabilize the soil, and re-vegetate the area.³

5G. Erosion control.

- a. Use site planning and site erosion control measures commensurate with the scope of the project to prevent erosion and sediment discharge from the project site.
- b. Before significant earthwork begins, install appropriate, temporary erosion controls downslope to prevent sediment deposition in the riparian area, wetlands, or water body.
- c. During construction, if eroded sediment appears likely to be deposited in the stream during construction, install additional sediment barriers as necessary.
- d. Temporary erosion control measures may include fiber wattles, silt fences, jute matting, wood fiber mulch and soil binder, or geotextiles and geosynthetic fabric.
- e. Soil stabilization using wood fiber mulch and tackifier (hydro-applied) may be used to reduce erosion of bare soil, if the materials are free of noxious weeds and nontoxic to aquatic and terrestrial animals, soil microorganisms, and vegetation.
- f. Remove sediment from erosion controls if it reaches 1/3 of the exposed height of the control.
- g. Whenever surface water is present, maintain a supply of sediment control materials and an oil-absorbing floating boom at the project site.
- h. Remove temporary erosion controls after construction is complete and the site is fully stabilized.

6G. Hazardous material spill prevention and control.

- a. At the project site:
 - i. Post written procedures for notifying environmental response agencies, including an inventory and description of all hazardous materials present, and the storage and handling procedures for their use.
 - ii. Maintain a spill containment kit, with supplies and instructions for cleanup and disposal, adequate for the types and quantity of hazardous materials present.
 - iii. Train workers in spill containment procedures, including the location and use of the spill containment kits.

³ Road and path obliteration refers to the most comprehensive degree of decommissioning and involves decompacting the surface and ditch, pulling the fill material onto the running surface, and reshaping to match the original contour.

- b. Temporarily contain any waste liquids generated under an impervious cover, such as a tarpaulin, in the staging area until the wastes can be properly transported to, and disposed of, at an approved receiving facility.

7G. Equipment, vehicles, and power tools.

- a. Select, operate and maintain all heavy equipment, vehicles, and power tools to minimize adverse effects on the environment, *e.g.*, low pressure tires, minimal hard-turn paths for track vehicles, use of temporary mats or plates to protect wet soils.
- b. Before entering wetlands or within 150 feet of a waterbody, replace all petroleum-based hydraulic fluids with biodegradable products.⁴
- c. Invasive species prevention and control.
 - i. Before entering the project site, power wash all heavy equipment, vehicles and power tools, allow them to fully dry, and inspect them to make certain no plants, soil, or other organic material adhering to the surface.
 - ii. Before entering the water, inspect any watercraft, waders, boots, or other gear to be used in or near water and remove any plants, soil, or other organic material adhering to the surface.
- d. Inspect all equipment, vehicles, and power tools for fluid leaks before they leave the staging area.
- e. Before operation within 150-feet of any waterbody , and as often as necessary during operation, thoroughly clean all equipment, vehicles, and power tools to keep them free of external fluids and grease and to prevent leaks and spills from entering the water.
- f. Generators, cranes or other stationary heavy equipment operated within 150-feet of any waterbody must be maintained and protected as necessary to prevent leaks and spills from entering the water.

8G. Drilling and Boring

- a. If drilling or boring are used, isolate drilling operations in wetted stream channels using a steel casing or other appropriate isolation method to prevent drilling fluids from contacting water.
- b. If drilling through a bridge deck is necessary, use containment measures to prevent drilling debris from entering the channel.
- c. Sampling and directional drill recovery/recycling pits, and any associated waste or spoils will be completely isolated from surface waters, off-channel habitats and wetlands.
- d. All waste or spoils will be covered if precipitation is falling or imminent.
- e. All drilling fluids and waste will be recovered and recycled or disposed to prevent entry into flowing water.

⁴ For additional information and suppliers of biodegradable hydraulic fluids, motor oil, lubricant, or grease. See, Environmentally Acceptable Lubricants by the USEPA (2011); *e.g.*, mineral oil, polyglycol, vegetable oil, synthetic ester; Mobil® biodegradable hydraulic oils, Total® hydraulic fluid, Terresolve Technologies Ltd.® bio-based biodegradable lubricants, Cougar Lubrication® 2XT Bio engine oil, Series 4300 Synthetic Bio-degradable Hydraulic Oil, 8060-2 Synthetic Bio-Degradable Grease No. 2, etc. The use of trade, firm, or corporation names in this opinion is for the information and convenience of the action agency and applicants and does not constitute an official endorsement or approval by the U.S. Department of Interior or the Service of any product or service to the exclusion of others that may be suitable.

- f. If a drill boring case breaks and drilling fluid or waste is visible in water or a wetland, make all possible efforts to contain the waste and contact the Service within 48 hours.
- g. Waste containment
 - i. All drilling equipment, drill recovery and recycling pits, and any waste or spoil produced, will be contained and then completely recovered and recycled or disposed of as necessary to prevent entry into any waterway. Use a tank to recycle drilling fluids.
 - ii. When drilling is completed, remove as much of the remaining drilling fluid as possible from the casing (*e.g.*, by pumping) to reduce turbidity when the casing is removed.

9G. Temporary access roads and paths.

- a. Whenever reasonable, use existing access roads and paths preferentially.
- b. Minimize the number and length of temporary access roads and paths through riparian areas and floodplains.
- c. Minimize removal of riparian vegetation.
- d. When it is necessary to remove vegetation, cut at ground level (no grubbing).
- e. Do not build temporary access roads or paths where grade, soil, or other features suggest slope instability.
- f. After construction is complete, obliterate all temporary access roads and paths, stabilize the soil, and revegetate the area.
- g. Temporary roads and paths in wet areas or areas prone to flooding must be obliterated by the end of the in-water work window. Decompact road surfaces and drainage areas, pull fill material onto the running surface, and reshape to match the original contours.

10G. Dust abatement.

- a. Employ dust abatement measures commensurate with soil type, equipment use, wind conditions, and the effects of other erosion control measures.
- b. Sequence and schedule work to reduce the exposure of bare soil to wind erosion.
- c. Maintain spill containment supplies on-site whenever dust abatement chemicals are applied.
- d. Do not use petroleum-based products.
- e. Do not apply dust-abatement chemicals, *e.g.*, magnesium chloride, calcium chloride salts, ligninsulfonate, within 25 feet of water or a stream channel.
- f. Do not apply ligninsulfonate at rates exceeding 0.5 gallons per square yard of road surface, assuming a 50:50 solution of ligninsulfonate to water.
- g. Do not apply dust abatement chemicals at stream crossings, within 25 feet of a water body, or in other areas where they may runoff directly into a wetland or water body.

11G. Temporary stream crossings.

- a. No stream crossing may occur at active spawning sites, when holding adult listed fish are present, or when eggs or alevins are in the gravel.
- b. Do not place temporary crossings in areas that may increase the risk of channel re-routing or avulsion, or in potential spawning habitat, *e.g.*, pools and pool tailouts.
- c. Minimize the number of temporary stream crossings; use existing stream crossings

- whenever reasonable.
- d. Install temporary bridges and culverts to allow for equipment and vehicle crossing over perennial streams during construction.
 - e. Wherever possible, vehicles and machinery must cross streams at right angles to the main channel.
 - f. Equipment and vehicles may cross the stream in the wet only where the streambed is bedrock, or where mats or off-site logs are placed in the stream and used as a crossing.
 - g. Obliterate all temporary stream crossings as soon as they are no longer needed, and restore any damage to affected stream banks or channel.

12G. Barge Use.

Any barge used as a work platform to support construction will be:

- a. Large enough to remain stable under foreseeable loads and adverse conditions.
- b. Inspected before arrival to ensure vessel and ballast are free of invasive species.
- c. Secured, stabilized and maintained as necessary to ensure no loss of balance, stability, anchorage, or other condition that can result in the release of contaminants or construction debris.

13G. Surface water withdrawal and construction discharge water.

- a. Surface water may be diverted to meet construction needs, but only if developed sources are unavailable or inadequate.
- b. Diversions may not exceed 10% of the available flow and must have a juvenile fish exclusion device that is consistent with NMFS's criteria (2011 or current version), site-specific designs as approved by USFWS and NMFS (if a minor variance is requested), or meets the Service's bull trout specific screening and passage criteria when developed.
- c. Treat all construction discharge water using the best management practices applicable to site conditions to remove debris, sediment, petroleum products, and any other pollutants likely to be present, (e.g., green concrete, contaminated water, silt, welding slag, sandblasting abrasive, grout cured less than 24 hours, drilling fluids) to ensure that no pollutants are discharged from the construction site. Pump seepage water from the de-watered work area to a temporary storage and treatment site or into upland areas and allow water to filter through vegetation prior to reentering the stream channel. Treat water used to cure concrete until pH stabilizes to background levels.

14G. Fish passage.

- a. Provide fish passage for any adult or juvenile ESA-listed fish likely to be present in the action area during construction, unless passage did not exist before construction or the stream is naturally impassable at the time of construction.
- b. After construction, provide fish passage for any adult or juvenile ESA-listed fish that meets NMFS's fish passage criteria (2011 or current version), site-specific designs as approved by USFWS and NMFS (if a minor variance is requested), or meets the Service's bull trout specific screening and passage criteria when developed, for the life of the action.
- c. If the provision of temporary fish passage during construction will increase negative

effects on aquatic species of interest or their habitat, a variance can be requested from the Service's Field Office Supervisor. Pertinent information, such as the species affected, length of stream reach affected, proposed time for the passage barrier, and alternatives considered, will be included in the variance request.

15G. Fish Screens.

- a. Submit to the Service for review and approval fish screen designs for surface water diverted by gravity or by pumping at a rate that exceeds 3 cubic feet per second (cfs).
- b. All other diversions will have a fish screen that meets the following specifications:
 - i. An automated cleaning device with a minimum effective surface area of 2.5 square feet per cubic foot per second, and a nominal maximum approach velocity of 0.4 feet per second, or no automated cleaning device, a minimum effective surface area of 1 square foot per cubic foot per second, and a nominal maximum approach rate of 0.2 foot per second; and
 - ii. A round or square screen mesh that is no larger than 2.38 millimeters (mm) (0.094") in the narrow dimension, or any other shape that is no larger than 1.75 mm (0.069") in the narrow dimension.
- c. Each fish screen will be installed, operated, and maintained according to NMFS's fish screen criteria (2011 or current version), site-specific designs as approved by USFWS and NMFS (if a minor variance is requested), or meets the Service's bull trout specific screening and passage criteria when developed.

16G. In-water work timing.

- a. Unless the in-water work is part of a natural hazard response, complete all work within the wetted channel during dates listed in the most recent version of Oregon Guidelines for Timing of In-water Work to Protect Fish and Wildlife Resources (ODFW, 2008).
- b. Hydraulic and topographic measurements and placement of large wood or gravel may be completed anytime, provided the affected area is not occupied by adult fish congregating for spawning, or in an area where redds are occupied by eggs or pre-emergent alevins.

17G. Pile Installation.

- a. Pile may be concrete, or steel round pile, steel H-pile, or wood
- b. Unless a registered professional engineer provides a written statement describing how it is the only practicable method, impact pile driving is not allowed under this proposed action. In those cases that require an impact hammer a project specific variance must also be obtained from the appropriate Service Field Office Supervisor.
- c. When using an impact hammer to drive or proof a steel pile, one of the following sound attenuation methods will be used:
 - i. Completely isolate the pile from flowing water by dewatering the area around the pile.
 - ii. If water velocity is 1.6 feet per second or less, surround the pile being driven by a confined or unconfined bubble curtain that will distribute small air bubbles around 100% of the pile perimeter for the full depth of the water column. See, e.g., NMFS and USFWS (1998), Wursig et al. (2000), and

- Longmuir and Lively (2001).
- iii. If water velocity is greater than 1.6 feet per second, surround the pile being driven with a confined bubble curtain (e.g., surrounded by a fabric or non-metallic sleeve) that will distribute air bubbles around 100% of the pile perimeter for the full depth of the water column.
 - iv. Provide the Service with information regarding the timing of in-water work, the number of impact hammer strikes per pile and the estimated time required to drive piles, hours per day pile driving will occur, depth of water, and type of substrate, hydroacoustic assumptions, and the pile type, diameter, and spacing of the piles.
 - v. Jetting may be used to install pile in areas with coarse, uncontaminated sediments that meet criteria for unconfined in-water disposal (USACE Northwest Division, 2009).

18G. Work area isolation.

- a. Isolate any work area within the wetted channel from the active stream whenever ESA-listed fish are reasonably certain to be present, or if the work area is less than 300-feet upstream from known spawning habitats.
- b. Engineering design plans for work area isolation must include all isolation elements and fish release areas.
- c. Dewater the shortest linear extent of work area practicable, unless wetted in-stream work is deemed to be minimally harmful to fish, and is beneficial to other aquatic species.⁵
 - i. Use a coffer dam and a by-pass culvert or pipe, or a lined, non-erodible diversion ditch to divert flow around the dewatered area. Dissipate flow energy to prevent damage to riparian vegetation or stream channel and provide safe downstream reentry of fish, preferably into pool habitat with cover.
 - ii. Where gravity feed is not possible, pump water from the work site to avoid rewatering. Maintain a fish screen on the pump intake to avoid juvenile fish entrainment.
 - iii. Pump seepage water to a temporary storage and treatment site, or into upland areas, to allow water to percolate through soil or to filter through vegetation before reentering the stream channel with a treatment system comprised of either a hay bale basin or other sediment control device.
 - iv. Monitor below the construction site to prevent stranding of aquatic organisms.
 - v. When construction is complete, re-water the construction site slowly to prevent loss of surface flow downstream, and to prevent a sudden increase in stream turbidity.
- d. Whenever a pump is used to dewater the isolation area and ESA-listed fish may be present, a fish screen must be used that meets the most current version of NMFS's fish screen criteria (2011 or current version), or site-specific designs as approved by USFWS and NMFS (if a minor variance is requested). Service approval is required for pumping that exceeds 3 cfs.

⁵ For instructions on how to dewater areas occupied by lamprey, see USFWS (2010).

19G. Fish capture.

- a. If practicable, allow listed fish species to migrate out of the work area or remove fish before dewatering; otherwise remove fish from an exclusion area as it is slowly dewatered with methods such as hand or dip-nets, seining, and trapping with minnow traps (or gee-minnow traps).
- b. Fish capture must be supervised by a qualified fisheries biologist, with experience in work area isolation and competent to ensure the safe handling of all fish.
- c. Conduct fish capture activities during periods of the day with the coolest air and water temperatures possible, normally early in the morning to minimize stress and injury of species present.
- d. Monitor the nets needed to isolate a site frequently enough to ensure they stay secured to the banks and free of organic accumulation.
- e. Electrofishing may only be used after other means of fish capture are determined to be not feasible or ineffective during the coolest time of day.
 - i. To minimize impacts to bull trout, electrofishing activities shall be conducted according to the NMFS guidelines (2000) including use of only direct current (DC) or pulsed direct current within the following ranges:
 - (1) If conductivity is less than 100 μ s, use 900 to 1100 volts.
 - (2) If conductivity is between 100 to 300 μ s, use 500 to 800 volts.
 - (3) If conductivity greater than 300 μ s, use less than 400 volts.
 - ii. Do not intentionally contact fish with the anode.
 - iii. Begin electrofishing with a minimum pulse width and recommended voltage, then gradually increase to the point where fish are immobilized.
 - iv. Immediately discontinue electrofishing if fish are killed or injured, i.e., dark bands visible on the body, spinal deformations, significant de-scaling, torpid or inability to maintain upright attitude after sufficient recovery time. Recheck machine settings, water temperature and conductivity, and adjust or postpone procedures as necessary to reduce injuries.
 - v. Electrofishing equipment shall be operated at the lowest possible effective settings to minimize injury or mortality to bull trout.
 - vi. Electrofishing shall be avoided in areas, such as the mouths of streams or deep pools, when adult bull trout may be staging as part of their spawning migration.
 - vii. Electrofishing shall not be conducted when the water conditions are turbid and visibility is poor. This condition may be experienced when the sampler cannot see the stream bottom in one foot of water.
 - viii. Electrofishing in spawning/rearing habitat must be approved by the appropriate Service Field or Division Supervisor and may only occur from May 1 (or after emergence occurs) to July 15 in known bull trout spawning areas. No electrofishing will occur in any bull trout habitat after August 15. Electrofishing during the spring in bull trout habitat and spawning areas runs the risk of injuring or killing alevins or fry that remain in or near the gravels. If salmonid alevins or fry are seen during spring electrofishing, the electrofishing activity shall immediately cease until the alevins or fry can be identified. If they are determined to be bull trout, electrofishing shall be

- terminated at the site until after the fry have fully emerged.
- ix. During the bull trout spawning season (typically August 15 to December 1), a cursory observation of the survey reach shall be completed before electrofishing. Electrofishing shall only be performed in areas where adult bull trout or their redds are not observed. If an adult bull trout is subsequently shocked, electrofishing at that site shall be suspended.
 - x. Electrofishing activities shall be minimized where larger, fluvial bull trout might be captured.
 - xi. Bull trout must not be handled when water temperatures exceed 15°C.
 - xii. Nets, hands, etc. must be free of insect repellent, sunscreen or any other substance that might harm fish.
 - xiii. Ice packs will be used to keep capture water <15°C.
- f. If buckets are used to transport fish:
- i. Minimize the time fish are in a transport bucket.
 - ii. Keep buckets in shaded areas or, if no shade is available, covered by a canopy.
 - iii. Limit the number of fish within a bucket; fish will be of relatively comparable size to minimize predation.
 - iv. Use aerators or replace the water in the buckets at least every 15 minutes with cold clear water.
 - v. Release fish in an area upstream with adequate cover and flow refuge; downstream is acceptable provided the release site is below the influence of construction.
 - vi. Be careful to avoid mortality counting errors.
- g. Monitor and record fish presence, handling, and injury during all phases of fish capture and submit a fish salvage report to the Corps and the Service within 60 days.
- h. Submit any take or salvage of individuals/specimens resulting in mortality to the appropriate designated fish repository listed below:

The Department of Fisheries and Wildlife, Nash Hall, Room #104, Oregon State University (OSU), Corvallis, Oregon 97331-3803.

Contact Brian Sidlauskas, Curator OSU Ichthyology Collection, by telephone at 541-737-1939, fax at 541-737-3590, or email at brian.sidlauskas@oregonstate.edu for specific instructions on preserving and shipping aquatic specimens to OSU. The following information should also be included with the specimen submission: date, time, and place of collection; name of authorized collector(s)/permittee(s); geographic coordinates of collection location; habitat associated with collection location; and weather conditions at the time of collection.

20G. Site restoration.

- a. Restore any significant disturbance of riparian vegetation, soils, stream banks or stream channel.
- b. Remove all project related waste; e.g., pick up trash, sweep roadways in the project area to avoid runoff-containing sediment, etc.
- c. Obliterate all temporary access roads, crossings, and staging areas.

- d. Loosen compacted areas of soil when necessary for revegetation or infiltration.
- e. Although no single criterion is sufficient to measure restoration success, the intent is that the following features should be present in the upland parts of the project area, within reasonable limits of natural and management variation:
 - i. Human and livestock disturbance, if any, are confined to small areas necessary for access or other special management situations.
 - ii. Areas with signs of significant past erosion are completely stabilized and healed, bare soil spaces are small and well-dispersed.
 - iii. Soil movement, such as active rills and soil deposition around plants or in small basins, is absent or slight and local.
 - iv. Native woody and herbaceous vegetation, and germination microsites, are present and well distributed across the site; invasive plants are absent.
 - v. Plants have normal, vigorous growth form, and a high probability of remaining vigorous, healthy and dominant over undesired competing vegetation.
 - vi. Plant litter is well distributed and effective in protecting the soil with little or no litter accumulated against vegetation as a result of active sheet erosion (“litter dams”).
 - vii. A continuous corridor of shrubs and trees appropriate to the site are present to provide shade and other habitat functions for the entire streambank.

21G. Revegetation.

- a. Plant and seed disturbed areas before or at the beginning of the first growing season after construction.
- b. Use species that will achieve shade and erosion control objectives, including forb, grass, shrub, or tree species that are appropriate for the site and native to the project area or region.
- c. Short-term stabilization measures may include use of non-native sterile seed mix if native seeds are not available, weed-free certified straw, jute matting, and similar methods.
- d. When feasible, use vegetation salvaged from local areas scheduled for clearing due to development.
- e. Do not apply surface fertilizer within 50 feet of any wetland or water body.
- f. Install fencing as necessary to prevent access to revegetated sites by livestock or unauthorized persons.
- g. Do not use invasive or non-native species for site restoration.
- h. Remove or control invasive plants until native plant species are well-established.

22G. Invasive and non-native plant control.

- a. **Non-herbicide methods.** Limit vegetation removal and soil disturbance within the riparian zone by limiting the number of workers there to the minimum necessary to complete manual and mechanical plant control (*e.g.*, hand pulling, clipping, stabbing, digging, brush-cutting, mulching or heating with radiant heat, pressurized hot water, or heated foam).
- b. **Herbicide Label.** Herbicide applicators must comply with all label instructions.
- c. **Power equipment.** Refuel gas-powered equipment with tanks larger than 5 gallons in

- a vehicle staging area placed 150-feet or more from any natural waterbody, or in an isolated hazard zone such as a paved parking lot.
- d. **Maximum herbicide treatment area.** For the total area treated with herbicides within riparian areas, do not exceed 10-acres above bankfull elevation and 2 acres below bankfull elevation, per 1.6-mile reach of a stream, per year.
 - e. **Herbicide applicator qualifications.** Herbicides may only be applied by an appropriately licensed applicator using an herbicide specifically targeted for a particular plant species that will cause the least impact. The applicator will be responsible for preparing and carrying out the herbicide transportation and safely plan, as follows.
 - f. **Herbicide transportation and safety plan.** The applicator will prepare and carry out an herbicide safety/spill response plan to reduce the likelihood of spills or misapplication, to take remedial actions in the event of spills, and to fully report the event.
 - g. **Herbicides.** The only herbicides proposed for use under this Opinion are (some common trade names are shown in parentheses):⁶
 - i. aquatic imazapyr (*e.g.*, Habitat)
 - ii. aquatic glyphosate (*e.g.*, AquaMaster, AquaPro, Rodeo)
 - iii. aquatic triclopyr-TEA (*e.g.*, Renovate 3)
 - iv. chlorsulfuron (*e.g.*, Telar, Glean, Corsair)
 - v. clopyralid (*e.g.*, Transline)
 - vi. imazapic (*e.g.*, Plateau)
 - vii. imazapyr (*e.g.*, Arsenal, Chopper)
 - viii. metsulfuron-methyl (*e.g.*, Escort)
 - ix. picloram (*e.g.*, Tordon)
 - x. sethoxydim (*e.g.*, Poast, Vantage)
 - xi. sulfometuron-methyl (*e.g.*, Oust, Oust XP)
 - h. **Herbicide adjuvants.** The only adjuvants proposed for use under this Opinion are as follows, with mixing rates described in label instructions (Table 2). Polyethoxylated tallow amine (POEA) surfactant and herbicides that contain POEA (*e.g.*, Roundup) will not be used.

Table 2. Herbicide adjuvants, trade names, and application areas.

Adjuvant Type	Trade Name	Application Areas
Surfactants	Agri-Dex	Riparian
	LI 700	Riparian
Drift Retardants	41-A	Riparian
	Vale	Upland

- i. **Herbicide carriers.** Herbicide carriers (solvents) are limited to water or specifically labeled vegetable oil. Use of diesel oil as an herbicide carrier is prohibited.
- j. **Herbicide mixing.** Mix herbicides more than 150-feet from any natural waterbody to

⁶ The use of trade, firm, or corporation names in this opinion is for the information and convenience of the action agency and applicants and does not constitute an official endorsement or approval by the U.S. Department of Interior or Service of any product or service to the exclusion of others that may be suitable.

- minimize the risk of an accidental discharge.
- k. **Dyes.** Use a non-hazardous indicator dye (*e.g.*, Hi-Light or Dynamark) with herbicides within 100-feet of live water. The presence of dye makes it easier to see where the herbicide has been applied and where or whether it has dripped, spilled, or leaked. Dye also makes it easier to detect missed spots, avoid spraying a plant or area more than once, and minimize over-spraying (SERA 1997).
 - l. **Spill Cleanup Kit.** Provide a spill cleanup kit whenever herbicides are used, transported, or stored. At a minimum, cleanup kits will include, Material Safety Data Sheets, the herbicide label, emergency phone numbers, and absorbent material such as cat litter to contain spills.
 - m. **Herbicide application rates.** Apply herbicides will be applied at the lowest effective label rates.
 - n. **Herbicide application methods.** Apply liquid or granular forms of herbicides as follows:
 - i. Broadcast spraying – hand held nozzles attached to back pack tanks or vehicles, or by using vehicle mounted booms.
 - ii. Spot spraying – hand held nozzles attached to back pack tanks or vehicles, hand-pumped spray, or squirt bottles to spray herbicide directly onto small patches or individual plants using.
 - iii. Hand/selective – wicking and wiping, basal bark, fill (“hack and squirt”), stem injection, cut-stump.
 - iv. Triclopyr – will not be applied by broadcast spraying.
 - v. Keep the spray nozzle within 4-feet of the ground; 6-feet for spot or patch spraying more than 15-feet of the high water mark (HWM) if needed to treat tall vegetation.
 - vi. Apply spray in swaths parallel towards the project area, away from the creek and desirable vegetation, i.e., the person applying the spray will generally have their back to the creek or other sensitive resource.
 - vii. Avoid unnecessary run off during cut surface, basal bark, and hack-squirt/injection applications.
 - o. **Washing spray tanks.** Wash spray tanks 300-feet or more away from any surface water.
 - p. **Minimization of herbicide drift and leaching.** Minimize herbicide drift and leaching as follows:
 - i. Do not spray when wind speeds exceed 10 miles per hour, or are less than 2 miles per hour.
 - ii. Be aware of wind directions and potential for herbicides to affect aquatic habitat area downwind.
 - iii. Keep boom or spray as low as possible to reduce wind effects.
 - iv. Increase spray droplet size whenever possible by decreasing spray pressure, using high flow rate nozzles, using water diluents instead of oil, and adding thickening agents.
 - v. Do not apply herbicides during temperature inversions, or when ground temperatures exceed 80 degrees Fahrenheit.
 - vi. Wind and other weather data will be monitored and reported for all broadcast applications.

- q. **Rain.** Do not apply herbicides when the soil is saturated or when a precipitation event likely to produce direct runoff to salmon bearing waters from the treated area is forecasted by the NOAA National Weather Service or other similar forecasting service within 48 hours following application. Soil-activated herbicides may follow label instructions. Do not conduct hack-squirt/injection applications during periods of heavy rainfall.
- r. **Herbicide buffer distances.** Observe the following no-application buffers, measured in feet and are based on herbicide formula, stream type, and application method, during herbicide applications (Table 3). Use the most conservative buffer for any herbicide included in a combination of approved herbicides. Buffer widths are in feet, measured as map distance perpendicular to the bankfull elevation for streams, the upland boundary for wetlands, or the upper bank for roadside ditches. Before herbicide application begins, flag or mark the upland boundary of each applicable herbicide buffer to ensure that all buffers are in place and functional during treatment.

Table 3. Herbicide buffer distances by herbicide formula, stream type, and application method.

Herbicide	No Application Buffer Width (feet)					
	Streams and Roadside Ditches with flowing or standing water present and Wetlands			Dry Streams, Roadside Ditches, and Wetlands		
	Broadcast Spraying	Spot Spraying	Hand Selective	Broadcast Spraying	Spot Spraying	Hand Selective
Labeled for Aquatic Use						
Aquatic Glyphosate	100	waterline	waterline	50	None	none
Aquatic Imazapyr	100	15	waterline	50	None	none
Aquatic Triclopyr-TEA	Not Allowed	15	waterline	Not Allowed	None	none
Low Risk to Aquatic Organisms						
Imazapic	100	15	bankfull elevation	50	None	none
Clopyralid	100	15	bankfull elevation	50	None	none
Metsulfuron-methyl	100	15	bankfull elevation	50	None	none
Moderate Risk to Aquatic Organisms						
Imazapyr	100	50	bankfull elevation	50	15	bankfull elevation
Sulfometuron-methyl	100	50	5	50	15	bankfull elevation
Chlorsulfuron	100	50	bankfull elevation	50	15	bankfull elevation
High Risk to Aquatic Organisms						
Picloram	100	50	50	100	50	50
Sethoxydim	100	50	50	100	50	50

23G. Actions That Require Compensatory Mitigation.

- a. The Corps will rely on 33 CFR 332 when considering appropriate mitigation. The first option for an applicant is to purchase credits from an appropriate mitigation bank. The second option is to purchase credits from an approved in-lieu-fee sponsor. The third option is permittee-responsible mitigation. The fourth option is a

combination of some or all of the above options that collectively satisfies the mitigation requirements.

24G. Cessation of work.

- b. Project operations will cease under the following conditions:
 - i. High flow conditions that may result in inundation of the project area, except for efforts to avoid or minimize resource damage;
 - ii. When allowable water quality impacts, as defined by the state CWA section 401 water quality certification, have been exceeded; or
 - iii. When “incidental take” limitations have been reached or exceeded.

1.2 Project Design Criteria I - Types of RES Actions

1R. Large Wood and Boulder placement.⁷

- a. Place LW and boulders in areas where they would naturally occur and in a manner that closely mimic natural accumulations for that particular stream type. For example, boulder placement may not be appropriate in low-gradient meadow streams.
- b. Structure types shall simulate disturbance events to the greatest degree possible and include, but are not limited to, log jams, debris flows, wind-throw, and tree breakage.
- c. No limits are to be placed on the size or shape of structures as long as such structures are within the range of natural variability of a given location and do not block fish passage.
- d. Projects can include grade control and bank stabilization structures, while size and configuration of such structures will be commensurate with scale of project site and hydraulic forces.
- e. The partial burial of LW and boulders is permitted and may constitute the dominant means of placement. This applies to all stream systems but more so for larger stream systems where use of adjacent riparian trees or channel features is not feasible or does not provide the full stability desired.
- f. LW includes whole conifer and hardwood trees, logs, and root wads. LW size (diameter and length) should account for bankfull width and stream discharge rates. When available, trees with root wads should be a minimum of 1.5 x bankfull channel width, while logs without root wads should be a minimum of 2.0 x bankfull width.
- g. Structures may partially or completely span stream channels or be positioned along stream banks.
- h. Stabilizing or key pieces of LW must be intact, hard, with little decay, and if possible have root wads (untrimmed) to provide functional refugia habitat for fish.
- i. Consider orienting key pieces such that the hydraulic forces upon the LW increases stability
- j. Anchoring LW – Anchoring alternatives may be used in preferential order:⁸
 - i. Use of adequate sized wood sufficient for stability
 - ii. Orient and place wood in such a way that movement is limited
 - iii. Ballast (gravel or rock) to increase the mass of the structure to resist movement
 - iv. Use of large boulders as anchor points for the LW

⁷ For additional information on design and methods for boulder placement, see “boulder clusters” in Cramer (2012).

⁸ Anchoring LW with cables is not included in this proposed action.

- v. Pin LW with rebar to large rock to increase its weight. For streams that are entrenched (Rosgen F, G, A, and potentially B) or for other streams with very low width to depth ratios (<12) an additional 60% ballast weight may be necessary due to greater flow depths and higher velocities.
- k. The cross-sectional area of boulders may not exceed 25% of the cross-sectional area of the low flow channel, or be installed to shift the stream flow to a single flow pattern in the middle or to the side of the stream.
- l. Boulders will be machine-placed (no end dumping allowed).

2R. Fish passage restoration: Step weir, fish ladder, and culvert replacement.

- a. Step Weirs for engineered riffles (3-5% slope) and cascades (>5% slope):
 - i. Grade control shall be provided using morphologically-appropriate constructed riffles for riffle-pool morphologies, rough constructed riffles/ramps for plane bed morphologies, wood/debris jams, rock bands, and boulder weirs for step-pool morphologies, and roughened channels for cascade morphologies.
 - ii. Construct weirs in a 'V' or 'U' shape, oriented with the apex upstream and lower in the center to direct flows to the middle of channel.
 - iii. Key weirs into the stream bed to minimize structure undermining due to scour, preferably at least 2.5x their exposure height. The weir should also be keyed into both banks—if feasible greater than 8 feet.
 - iv. If several structures will be used in series, space the weirs at the appropriate distances to promote fish passage of all life stages of native fish. Incorporate fish passage criteria (jump height, pool depth, etc.) in the design of weir structures. Recommended weir spacing should be no closer than the net drop divided by the channel slope (for example, a one-foot high weir in a stream with a two-percent gradient will have a minimum spacing of 50-feet).
 - v. Include gradated (cobble to fine) material in the weir material mix to help seal the weir/channel bed, thereby preventing subsurface flow and ensuring fish passage immediately following construction if natural flows are sufficient.
 - vi. If a project involves the removal of multiple barriers on one stream or in one watershed over the course of a work season, remove the most upstream barrier first if possible. This way, work at the upstream sites can be completed without listed fish in the project area.
 - vii. This consultation does not include structures that use gabion baskets, sheet pile, concrete, articulated concrete block, cable anchors, or straight weirs, which disperse flows and can cause channel widening and thus structure "flanking" (erosion around the ends of the structure).
- b. When a permanent stream crossing is replaced to provide fish passage, the new crossing must provide for a fully functional floodplain as follows:
 - i. Maintain a clear unobstructed opening above the general scour prism; streambank and channel stabilization may be applied below the general scour elevation.
 - ii. For a single span structure, including culverts, the necessary opening is presumed to be 1.5 times the active channel width, or wider.
 - iii. Entrenched Streams: If a stream is entrenched (entrenchment ratio of less than

- 1.4), the culvert must be greater in width than the bankfull channel width, allow sufficient vertical clearance to allow ease of construction and maintenance activities, provide adequate room for the construction of natural channel banks, and be reviewed by the Service.
- iv. For a multiple span structure, the necessary opening is presumed to be 2.2 times the active channel width, or wider, except for piers or interior bents.
 - v. Install relief conduits, as necessary, within existing road fill at potential flood flow pathways based on analysis of flow patterns or floodplain topography.
 - vi. Remove all other artificial constrictions within the functional floodplain that are not otherwise a component of the final design:
 - (1) Remove vacant bridge supports below total scour depth, unless the vacant support is part of the rehabilitated or replacement stream crossing.
 - (2) Remove existing roadway fill, embankment fill, approach fill, or other fill.
 - c. Reshape exposed floodplains and streambanks to match upstream and downstream conditions.
 - d. The Corps will not issue a permit to install or improve a step weir or fish ladder, or to replace or improve a culvert, unless it meets NMFS fish passage criteria (2011 or current version), site-specific designs as approved by USFWS and NMFS (if a minor variance is requested), or meets the Service's bull trout specific screening and passage criteria when developed.

3R. Off- or side-channel habitat restoration.⁹

- a. Reconnection of historical off- and side-channels habitats that have been blocked includes the removal of plugs, which impede water movement through off- and side-channels, and excavation within historical channels that does not exceed the thalweg depth in the main channel. The purpose of the additional sediment removal is to provide unimpeded flow through the side-channel to minimize fish entrapment.
- b. Excavated material removed from off- or side-channels shall be hauled to an upland site or spread across the adjacent floodplain in a manner that does not restrict floodplain capacity.
- c. Excavation depth will not exceed the maximum thalweg depth in the main channel.

4R. Set-back existing berm, dike, or levee.¹⁰

- a. To the greatest degree possible, non-native fill material, originating from outside the floodplain of the action area will be removed from the floodplain to an upland site.
- b. Where it is not possible to remove or set-back all portions of dikes and berms, or in areas where existing berms, dikes, and levees support abundant riparian vegetation, openings will be created with breaches.
 - i. Breaches shall be equal to or greater than the active channel width.
 - ii. In addition to other breaches, the berm, dike, or levee shall always be breached at the downstream end of the project and/or at the lowest elevation of the floodplain to ensure the flows will naturally recede back into the main

⁹ For additional information on methods and design considerations for off- and side-channel habitat restoration, see "side channel/off-channel habitat restoration" in Cramer (2012).

¹⁰ For additional information on methods and design considerations for levee removal and modification, see "levee removal and modification" in Cramer (2012).

- channel, thus minimizing fish entrapment.
- iii. When necessary, loosen compacted soils once overburden material is removed.
- c. Overburden or fill comprised of native materials, which originated from the project area, may be used within the floodplain to create set-back dikes and fill anthropogenic holes provided that does not impede floodplain function.

5R. Pile Removal

- a. Piles must be removed from the waterbody in their entirety unless otherwise waived by the Service on a case by case basis.
- b. If piling removal occurs in areas having contaminated substrate, the voids left in the substrate after pile removal must be sufficiently filled and capped with suitable clean material as to prevent release of those substances into the water column.

6R. Gravel Augmentation

- a. Gravel to be placed in streams must be obtained from an upland source outside of the channel and riparian area (gravel from any instream source is prohibited), sized such that 50% of the gradation becomes mobile at the dominant discharge event, rounded and uncrushed (less than 25% fractured face), and washed before instream placement.
- b. Gravel can be placed directly into the stream channel, at tributary junctions, or other areas in a manner that mimics natural debris flows and erosion.
- c. Augmentation will only occur in areas where the natural supply has been eliminated, significantly reduced through anthropogenic disruptions, or used to initiate gravel accumulations in conjunction with other projects, such as simulated log jams and debris flows.
- d. Gravel to be placed in streams shall be a properly sized gradation for that stream, clean, and non-angular. When possible use gravel of the same lithology as found in the watershed. Reference the Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings (USDA - Forest Service, 2008) to determine gravel sizes appropriate for the stream.
- e. Gravel can be mined from the floodplain at elevations above bankfull, but not in a manner that would cause stranding during future flood events. Crushed rock is not permitted.
- f. After gravel placement in areas accessible to higher stream flow, allow the stream to naturally sort and distribute the material.
- g. Do not place gravel directly on bars and riffles that are known spawning areas, which may cause fish to spawn on the unsorted and unstable gravel, thus potentially resulting in redd destruction.
- h. Imported gravel must be free of invasive species and non-native seeds. If necessary, wash gravel prior to placement.

7R. Streambank restoration.¹¹

- a. Without changing the location of the bank toe, restore damaged streambanks to a natural slope, pattern, and profile suitable for establishment of permanent woody vegetation.
- b. Complete all soil reinforcement earthwork and excavation in the dry. Use soil layers or lifts that are strengthened with biodegradable fabrics and penetrable by plant roots.
- c. Include large wood in each streambank restoration action to the maximum extent feasible. Large wood must be intact, hard, and undecayed to partly decaying, and should have untrimmed root wads to provide functional refugia habitat for fish. Use of decayed or fragmented wood found lying on the ground or partially sunken in the ground is not acceptable. Wood that is already within the stream or suspended over the stream may be repositioned to allow for greater interaction with the stream.
- d. Rock may not be used for streambank restoration, except as ballast to stabilize large wood.
- e. Use a diverse assemblage of species native to the action area or region, including trees, shrubs, and herbaceous species. Do not use noxious or invasive species.
- f. Do not apply surface fertilizer within 50 feet of any stream channel.
- g. Install fencing as necessary to prevent access to revegetated sites by livestock, native ungulates, or unauthorized persons.
- h. Conduct post-construction monitoring and treatment or removal of invasive plants until native plant species are well established.

8R. Water Control Structure (Dam and Legacy Structures).

- a. This includes removal of small dams, channel-spanning weirs; subsurface drainage features; tide gates; or instream flow redirection structures. Dams greater than 10-feet in height require a long-term monitoring and adaptive management plan that will be developed between the Services and the action agency.
- b. At a minimum, the following information will be necessary for review:
 - i. A longitudinal profile of the stream channel thalweg for 20 channel widths downstream of the structure and 20 channel widths upstream of the reservoir area (outside of the influence of the structure) shall be used to determine the potential for channel degradation.
 - ii. A minimum of three cross-sections – one downstream of the structure, one through the reservoir area upstream of the structure, and one upstream of the reservoir area (outside of the influence of the structure) to characterize the channel morphology and quantify the stored sediment.
 - iii. Sediment characterization to determine the proportion of coarse sediment (>2mm) in the reservoir area.
 - iv. A survey of any downstream spawning areas that may be affected by sediment released by removal of the water control structure or dam. Reservoirs with a d35 greater than 2 mm (i.e., 65% of the sediment by weight exceeds 2 mm in diameter) may be removed without excavation of stored

¹¹ For additional information on methods and design for bank shaping; installation of coir logs and soil reinforcements; anchoring and placement of large wood; woody plantings; and herbaceous cover, see Cramer *et al.* (2003), and “riparian restoration and management” in Cramer (2012).

material, if the sediment contains no contaminants; reservoirs with a d₃₅ less than 2 mm (i.e., 65% of the sediment by weight is less than 2 mm in diameter) will require partial removal of the fine sediment to create a pilot channel, in conjunction with stabilization of the newly exposed streambanks with native vegetation.

- c. If a project involves the removal of multiple barriers on one stream or in one watershed over the course of a work season, remove the most upstream barrier first if possible.
- d. If the structure being removed contains material (i.e., LW, boulders, concrete, etc.) not typically found within the stream or floodplain at that site, remove material from the 100-year floodplain.
- e. If the structure being removed contains material (i.e., LW, boulders, etc.) that is typically found within the stream or floodplain at that site, the material can be reused to implement habitat improvements described under the LW, Boulder, and Gravel Placement activity category in this proposed action.
- f. If the structure being removed is keyed into the bank, fill in “key” holes with native materials to restore contours of stream bank and floodplain. Compact the fill material adequately to prevent washing out of the soil during over-bank flooding. Do not mine material from the stream channel to fill in “key” holes.
- g. When removal of buried log structures may result in significant disruption to riparian vegetation or the floodplain, consider using a chainsaw to extract the portion of log within the channel and leaving the buried sections within the streambank.
- h. If a project involves the removal of multiple barriers on one stream or in one watershed over the course of a work season, remove the most upstream barrier first if possible.
- i. If the legacy structures (log, rock, or gabion weirs) were placed to provide grade control, evaluate the site for potential headcutting and incision due to structure removal. If headcutting and channel incision are likely to occur due to structure removal, additional measures must be taken to reduce these impacts.
- j. If the structure is being removed because it has caused an over-widening of the channel, consider implementing other ARBO II (UFWs, 2013) restoration categories to decrease the width to depth ratio of the stream to a level commensurate with the geomorphic setting.

9R. Road and Trail Erosion Control and Decommissioning.

- a. This includes hydrologically closing or decommissioning roads and trails, including culvert removal in perennial and intermittent streams; removing, installing or upgrading cross-drainage culverts; upgrading culverts on non-fish-bearing streams; constructing water bars and dips; reshaping road prisms; vegetating fill and cut slopes; removing and stabilizing of side-cast materials; grading or resurfacing roads that have been improved for aquatic restoration with gravel, bark chips, or other permeable materials; contour shaping of the road or trail base; removing road fill to native soils; soil stabilization and tilling compacted surfaces to reestablish native vegetation..
- b. Road Decommissioning and Stormproofing
 - i. For road decommissioning and hydrologic closure projects within riparian

- areas, recontour the affected area to mimic natural floodplain contours and gradient to the extent possible.
- ii. When obliterating or removing segments immediately adjacent to a stream, use sediment control barriers between the project and stream, if space is available.
- iii. Dispose of slide and waste material in stable sites out of the flood-prone area. Native material may be used to restore natural or near-natural contours.
- iv. Drainage features used for stormproofing and treatment projects should be spaced as to hydrologically disconnect road surface runoff from stream channels. If grading and resurfacing is required, use gravel, bark, or other permeable materials for resurfacing.
- v. Minimize disturbance of existing vegetation in ditches and at stream crossings.
- vi. Conduct activities during dry-field conditions (generally May 15 to October 15) when the soil is more resistant to compaction and soil moisture is low.
- vii. When removing a culvert from a first or second order, non-fishing bearing stream, project specialists shall determine if culvert removal should include stream isolation and rerouting in project design. Culvert removal on fish bearing streams shall adhere to the measures described in Fish Passage Restoration (PDC 2R).
- viii. For culvert removal projects, restore natural drainage patterns and channel morphology. Evaluate channel incision risk and construct in-channel grade control structures when necessary.
- c. Road Relocation
 - i. When a road is decommissioned in a floodplain and future vehicle access through the area is still required, relocate the road as far as practical away from the stream.
 - ii. The relocation will not increase the drainage network and will be constructed to hydrologically disconnect it from the stream network to the extent practical. New cross drains shall discharge to stable areas where the outflow will quickly infiltrate the soil and not develop a channel to a stream.
 - iii. This consultation does not cover new road construction (not associated with road relocation) or routine maintenance within riparian areas.

1.3 Project Design Criteria II - Types of STU Actions

1S. Streambank and Channel Stabilization

- a. The following streambank stabilization methods may be used individually or in combination:
 - i. Alluvium placement
 - ii. Large wood placement
 - iii. Vegetated riprap with large wood
 - iv. Roughened toe
 - v. Woody plantings
 - vi. Herbaceous cover, in areas where the native vegetation does not include trees or shrubs
 - vii. Bank reshaping and slope grading

- viii. Coir logs
 - ix. Deformable soil reinforcement
 - x. Engineered log jams (ELJ)
 - xi. Floodplain flow spreaders
 - xii. Floodplain roughness
- b. For more information on the above methods see Federal Emergency Management Agency (FEMA) (2009) or Cramer *et al.* (2003). Other than those methods relying solely upon woody and herbaceous plantings, streambank stabilization projects should be designed by a qualified engineer that is appropriately registered in the state where the work is performed.
- i. **Alluvium Placement** can be used as a method for providing bank stabilization using imported gravel/cobble/boulder-sized material of the same composition and size as that in the channel bed and banks, to halt or attenuate streambank erosion, and stabilize riffles. This method is predominantly for use in small to moderately sized channels and is not appropriate for application in mainstem systems. These structures are designed to provide roughness, redirect flow, and provide stability to adjacent streambed and banks or downstream reaches, while providing valuable fish and wildlife habitat.
- (1) **Fish passage review and approval.** The Service will review alluvium placement projects that would occupy more than 25% of the channel bed or more than 25% of the bankfull cross sectional area.
 - (2) This design method is only approved in those areas where the natural sediment supply has been eliminated, significantly reduced through anthropogenic disruptions, or used to initiate or simulate sediment accumulations in conjunction with other structures, such as LW placements and ELJs.
 - (3) Material used to construct the toe should be placed in a manner that mimics attached longitudinal bars or point bars.
 - (4) Size distribution of toe material will be diverse and predominately comprised of D84 to Dmax size class material.
 - (5) Spawning gravels will constitute at least one-third of the total alluvial material used in the design.
 - (6) Spawning gravels are to be placed at or below an elevation consistent with the water surface elevation of a bankfull event.
 - (7) Spawning size gravel can be used to fill the voids within toe and bank material and placed directly onto stream banks in a manner that mimics natural debris flows and erosion.
 - (8) All material will be clean alluvium with similar angularity as the natural bed material. When possible use material of the same lithology as found in the watershed. Reference Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings (USDA - Forest Service, 2008) to determine gravel sizes appropriate for the stream.
 - (9) Material can be mined from the floodplain at elevations above bankfull, but not in a manner that will cause stranding during future flood events.
 - (10) Crushed rock is not permitted.

- (11) After placement in areas accessible to higher stream flow, allow the stream to naturally sort and distribute the material.
 - (12) Do not place material directly on bars and riffles that are known spawning areas, which may cause fish to spawn on the unsorted and unstable gravel, thus potentially resulting in redd destruction.
 - (13) Imported material will be free of invasive species and non-native seeds. If necessary, wash prior to placement.
- ii. **Large Wood Placements** are defined as structures composed of LW that do not use mechanical methods as the means of providing structure stability (*i.e.*, large rock, rebar, rope, cable, *etc.*). The use of native soil, alluvium with similar angularity as the natural bed material, large wood, or buttressing with adjacent trees as methods for providing structure stability are authorized. This method is predominantly for use in small to moderately sized channels and is not appropriate for application in mainstem systems. These structures are designed to provide roughness, redirect flow, and provide stability to adjacent streambed and banks or downstream reaches, while providing valuable fish and wildlife habitat.
- (1) **Fish passage review and approval.** The Service will review LW placement projects that would occupy greater than 25% of the bankfull cross section area.
 - (2) Structure shall simulate disturbance events to the greatest degree possible and include, but not be limited to, log jams, debris flows, wind-throw, and tree breakage.
 - (3) Structures may partially or completely span stream channels or be positioned along stream banks.
 - (4) Where structures partially or completely span the stream channel LW should be comprised of whole conifer and hardwood trees, logs, and rootwads. LW size (diameter and length) should account for bankfull width and stream discharge rates.
 - (5) Structures will incorporate a diverse size (diameter and length) distribution of rootwad or non-rootwad, trimmed or untrimmed, whole trees, logs, snags, slash, *etc.*
 - (6) For individual logs that are completely exposed, or embedded less than half their length, logs with rootwads should be a minimum of 1.5 times bankfull channel width, while logs without rootwads should be a minimum of 2.0 times bankfull width.
 - (7) Consider orienting key pieces such that the hydraulic forces upon the LW increase stability.
- iii. **Vegetated riprap with large wood (LW)**
- (1) The Service will review and approve bank stabilization projects that use vegetated riprap with LW.
 - (2) When this method is necessary, limit installation to the areas identified as most highly erodible, with highest shear stress, or at greatest risk of mass-failure, and provide compensatory mitigation. The greatest risk of mass-failure will usually be at the toe of the slope and will not extend above OHW elevation except in incised streams.

- (3) Do not use invasive or non-native species for site restoration.
- (4) Remove or control invasive plants until native plant species are well-established.
- (5) Do not apply surface fertilizer within 50-feet of any stream channel.
- (6) Install fencing as necessary to prevent access to revegetated sites by livestock, native ungulates, or unauthorized persons.
- (7) Vegetated riprap with LW will be installed as follows:
 - a) When present, use natural hard points, such as large, stable trees or rock outcrops, to begin or end the toe of the revetment.
 - b) Develop rock size gradations for elevation zones on the bank, especially if the rock will extend above OHW – the largest rock should be placed at the toe of the slope, while small rock can be used higher in the bank where the shear stress is generally lower. Most upper bank areas will not require the use of any rock but can depend on the vegetation for erosion protection.
 - c) For bank areas above OHW where rock is still deemed necessary, mix rock with soil to provide a better growing medium for plants.
 - d) Minimum amount of wood incorporated into the treated area, for mitigation of riprap, is equal to the number of whole trees whose cumulative summation of rootwad diameters is equal to 80% of linear-feet of treated streambank or 20% of the treated area (square feet) of streambank, whichever is greater.
 - e) Where whole trees are not used (i.e., snags, logs, and partial trees) designers are required to estimate the dimensions of parent material based on rootwad diameter, and calculating a cumulative equivalency of whole trees.
 - f) LW should be distributed throughout the structure (not just concentrated at the toe) to engage flows up to the bankfull flow. LW placed above the toe may be in the form of rootwad or non-rootwad, trimmed or untrimmed, whole trees, logs, snags, slash, etc. Maximize the exposure of wood to water by placing and orienting wood to project into the water column up to the bankfull elevation.
 - g) Develop an irregular toe and bank line to increase roughness and habitat value.
 - h) Use LW and irregular rock to create large interstitial spaces and small alcoves to create planting spaces and habitat to mitigate for flood-refuge impacts – do not use geotextile fabrics as filter behind the riprap whenever possible, if a filter is necessary to prevent sapping, use a graduated gravel filter.
 - i) Structure toe will incorporate LW with intact rootwads. Minimum spacing between rootwads placed at the toe will be no greater than an average rootwad diameter.
 - j) Minimum rootwad diameter for LW placed at the toe of the structure shall be 1.0 times the bankfull depth, unless LW availability constrains the project to a smaller rootwad size. Where rootwad size is constrained due to availability, the largest diameter rootwads available should be used.

- k) LW placed at the toe will be sturdy material, intact, hard, and undecayed and should be sized or embedded sufficiently to withstand the design flood.
 - l) Space between root wads may be filled with large boulders, trimmed or untrimmed, whole trees, logs, snags, slash, etc. When used, diameter of boulders placed between toe logs with rootwads should be 1.5 to 2.0 times log diameter at breast height (dbh) of adjacent toe logs. A reasonable maximum rock size is 5-6 feet in diameter.
 - m) Plant woody vegetation in the joints between the rocks to enhance streambank vegetation.
 - n) Where possible, use terracing, or other bank shaping, to increase habitat diversity.
 - o) When possible, create or enhance a vegetated riparian buffer.
- (8) Monitor vegetated riprap each year following installation by visual inspection during low flows to examine transitions between undisturbed and treated banks to ensure that native soils above and behind the riprap are not collapsing, sinking, or showing other evidence of piping loss or movement of rock materials; and the overall integrity of the riprap treatment, including:
- a) Loss of rock materials
 - b) Survival rate of vegetation
 - c) Anchoring success of LW placed in the treatment.
 - d) Any channel changes since construction.
- iv. **Roughened toe**
- (1) Where designs use any of the approved streambank stabilization methods outlined in this section, in lieu of lining the bank with riprap above the toe, the design of any rock-filled toe will adhere to project criteria outlined in (f) Vegetated riprap with large wood (7-15, from above).
 - (2) Minimum amount of wood incorporated into the treated area, for mitigation of riprap, is equal to the number of whole trees whose cumulative summation of rootwad diameters is equal to 80% of linear-feet of treated streambank.
- v. **Engineered Logjams (ELJs)** ELJs within this BO are defined as: “any large wood structure that includes an anchoring system, such as rebar pinning, ballast rock, or vertical posts. Passive soil earth pressure (burying wood into a streambank) is not considered an anchoring system.” Further, only ELJs that occupy more than 25% of the bankfull cross-sectional area require Service review. These are structures designed to redirect flow and change scour and deposition patterns. To the extent practical, they are patterned after stable natural log jams and can be either unanchored or anchored in place using rebar, rock, or piles (driven into a dewatered area or the streambank, but not in water). Engineered log jams create a hydraulic shadow, a low-velocity zone downstream that allows sediment to settle out. Scour holes develop adjacent to the log jam. While providing valuable fish and wildlife habitat they also redirect flow and can provide stability to a streambank or downstream gravel bar.
- (1) **Fish passage review and approval.** The Service will review LW placement projects that would occupy greater than 25% of the bankfull cross section

- area. ELJs will be patterned, to the greatest degree possible, after stable natural log jams.
- (2) Grade control ELJs are designed to arrest channel down-cutting or incision by providing a grade control that retains sediment, lowers stream energy, and increases water elevations to reconnect floodplain habitat and diffuse downstream flood peaks.
 - (3) Stabilizing or key pieces of LW that will be relied on to provide streambank stability or redirect flows must be intact, solid (little decay). If possible, acquire LW with untrimmed root wads to provide functional refugia habitat for fish.
 - (4) When available, trees with root wads attached should be a minimum length of 1.5 times the bankfull channel width, while logs without root wads should be a minimum of 2.0 times the bankfull width.
 - (5) The partial burial of LW and boulders may constitute the dominant means of placement, and key boulders (footings) or LW can be buried into the stream bank or channel
 - (6) Angle and Offset – The LW portions of engineered log jam structures should be oriented such that the force of water upon the LW increases stability. If a root wad is left exposed to the flow, the bole placed into the streambank should be oriented downstream parallel to the flow direction so the pressure on the root wad pushes the bole into the streambank and bed. Wood members that are oriented parallel to flow are more stable than members oriented at 45 or 90 degrees to the flow.
 - (7) If LW anchoring is required, a variety of methods may be used. These include buttressing the wood between riparian trees, the use of manila, sisal or other biodegradable ropes for lashing connections. If hydraulic conditions warrant use of structural connections, such as rebar pinning or bolted connections, may be used. Rock may be used for ballast but is limited to that needed to anchor the LW.
- c. When a hole in the channel bed caused by local scour will be filled with rock to prevent damage to a culvert, road, or bridge foundation, the amount of rock will be limited to the minimum necessary to protect the integrity of the structure.
 - d. When a footing, facing, head wall, or other protection will be constructed with rock to prevent scouring or down-cutting of, or fill slope erosion or failure at, an existing culvert or bridge, the amount of rock used will be limited to the minimum necessary to protect the integrity of the structure. Whenever feasible, include soil and woody vegetation as a covering and throughout the structure.

2S. Road Maintenance, Rehabilitation and Replacement

- a. All maintenance and rehabilitation actions shall observe applicable criteria detailed in the most recent version of NMFS fish passage criteria (2011 or current version), site-specific designs as approved by USFWS and NMFS (if a minor variance is requested), or meets the Service's bull trout specific screening and passage criteria when developed.
 - i. Projects affecting fish passage shall adhere to industry design standards found in the most recent version of any of the following:

- (1) *Water Crossings Design Guidelines* (Barnard, et al., 2013)*Part XII, Fish Passage Design and Implementation, Salmonid Stream Habitat Restoration Manual* (California Department of Fish and Game, 2009)
 - (2) *Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream* (USDA - Forest Service, 2008) Or other design references approved by the Service.
- ii. Routine road surface, culvert and bridge maintenance activity will be completed in accordance with the *ODOT Routine Road Maintenance: Water Quality and Habitat Guide Best Management Practices* (ODOT, 2009) or the most recent version approved by the Service, unless maintenance activities and practices in that manual conflict with PDC in this Opinion.
 - iii. Any conflict between ODOT (2009) and this proposed action (*e.g.*, stormwater management for maintenance yards, erosion repair related to use of riprap, dust abatement, and use of pesticides) will be resolved in favor of PDC in this Opinion unless waived by the Service.
- b. Grade stabilization
- i. Grade control materials may include both rock and LW. Material shall not in any part consist of gabion baskets, sheet piles, concrete, articulated concrete blocks, or cable anchors.
 - ii. Grade control shall be provided using morphologically-appropriate constructed riffles for riffle-pool morphologies, rough constructed riffles/ramps for plane bed morphologies, wood/debris jams, rock bands, and boulder weirs for step-pool morphologies, and roughened channels for cascade morphologies.
 - iii. LW placements and ELJs may be used to control grade individually or together with other grade control methods by simulating natural log jams and debris accumulation that traps sediment and creates forced, riffle-pool, step-pool, or cascade-pool morphologies.
 - iv. Stream banks and bed shall be designed to be immobile at the design event to reduce undermining and flanking.
 - v. The crest of channel spanning structures will be slightly sloped on either side, with the low point in the center, to direct flows to the middle of channel and away from streambanks. Install these structures low in relation to channel dimensions so that they are completely overtopped during channel-forming flow events (approximately a 1.0- to 1.5-year flow event).
 - vi. Construct boulder weir structures in a 'V' or 'U' shape, oriented with the apex upstream.
 - vii. Key all structures into the streambed at a depth which minimizes structure undermining due to scour, at least 2.5 times their exposure height, or the Lower Vertical Adjustment Potential (LVAP) line with an offset of 2 times D90, whichever is deeper.
 - viii. LVAP, and 2 times D90 offset, as calculated in *Stream Simulation: An ecological approach to providing passage for aquatic organisms at road crossings* (USDA - Forest Service, 2008).
 - ix. Structures should be keyed into both banks—if feasible greater than 8 feet.
 - x. If several drop structures will be used in series, space them at the appropriate

- b) Single span structures will maintain a clear, unobstructed opening above the general scour elevation that is at least as wide as 1.5 times the active channel width.¹²
 - c) Multi-span structures will maintain clear, unobstructed openings above the general scour elevation (except for piers or interior bents) that are at least as wide as 2.2 times the active channel width.
 - d) Entrenched streams: If a stream is entrenched (entrenchment ratio of less than 1.4), the crossing width will accommodate the flood prone width. Flood prone width is the channel width measured at twice the maximum bankfull depth (Rosgen, 1996).
- (2) Bed Material
- a) Install clean alluvium with similar angularity as the natural bed material, no crushed rock.
 - b) Bed material shall be designed based on the native particle size distribution of the adjacent channel or reference reach, as quantified by a pebble count.
 - c) Rock band designs as detailed in Water Crossings Design Guidelines (Barnard, et al., 2013) are authorized.
 - d) Bed material in systems where stream gradient exceeds 3% may be conservatively sized to resist movement.
- (3) Scour Prism
- a) Designs shall maintain the general scour prism, as a clear, unobstructed opening (*i.e.*, free of any fill, embankment, scour countermeasure, or structural material to include abutments, footings, and culvert inverts). No scour or stream stability countermeasure may be applied above the general scour elevation.¹³
 - i. The lateral delineation of the scour prism is defined by the criteria span.
 - ii. The vertical delineation of the scour prism is defined by the Lower Vertical Adjustment Potential (LVAP) with an additional offset of 2 times D_{90} , as calculated in *Stream Simulation: An ecological approach to providing passage for aquatic organisms at road crossings* (USDA - Forest Service, 2008).
 - b) When bridge abutments or culvert footings are set back beyond the applicable criteria span they are outside the scour prism.
- (4) Embedment
- a) All abutments, footings, and inverts shall be placed below the thalweg a depth of 3 feet, or the LVAP line with an offset of 2 times D_{90} , whichever is deeper.

¹² Active channel width means the stream width measured perpendicular to stream flow between the OHW lines, or at the channel bankfull elevation if the OHW lines are indeterminate. This width includes the cumulative active channel width of all individual side- and off-channel components of channels with braided and meandering forms, and measure outside the area influence of any existing stream crossing, *e.g.*, five to seven channel widths upstream and downstream.

¹³ For guidance on how to complete bridge scour and stream stability analysis, see Lagasse *et al.* (2012) (HEC-20), Lagasse *et al.* (2001) (HEC-23), Richardson and Davis (2001) (HEC-18), ODOT (2011), and AASHTO (2013).

- i. LVAP, and 2 times D_{90} offset, as calculated in *Stream Simulation: An ecological approach to providing passage for aquatic organisms at road crossings* (USDA - Forest Service, 2008).
 - b) In addition to embedment depth, embedment of closed bottom culverts shall be between 30% and 50% of the culvert rise.
- (5) Bridges
 - a) Primary bridge structural elements will be concrete, metal, fiberglass, or timber. All concrete will be poured in the dry, or within confined waters not connected to surface waters, and will be allowed to cure a minimum of 7 days before contact with surface water as recommended by Washington State Department of Transportation (2016).
 - b) Riprap may only be placed below bankfull height of the stream when necessary for protection of abutments and pilings. The amount and placement of riprap will not constrict the bankfull flow.
 - c) Temporary work bridges will also meet the latest version of NMFS (2011 or current version), site-specific designs as approved by USFWS and NMFS (if a minor variance is requested), or meets the Service's bull trout specific screening and passage criteria when developed.
- iii. The electronic notification for each permanent stream crossing replacement will contain the following:
 - (1) Site sketches, drawings, aerial photographs, or other supporting specifications, calculations, or information that is commensurate with the scope of the action, that show the active channel, the 100-year floodplain, the functional floodplain, any artificial fill within the project area, the existing crossing to be replaced, and the proposed crossing.
 - (2) A completed scour and stream stability analysis for any crossing that includes scour or stream stability countermeasures within the crossing opening that shows the general scour elevation and the local scour elevation for any pier or interior bent.
 - (3) The name, address, and telephone number of a person responsible for designing this part of the action that the Service may contact if additional information is necessary to complete the effects analysis.

3S. Utility Line Stream Crossings

- a. Design utility line stream crossings in the following priority:
 - i. Aerial lines, including lines hung from existing bridges.
 - ii. Directional drilling, boring and jacking that spans the channel migration zone and any associated wetland.
 - iii. Trenching – this method is restricted to intermittent streams and may only be used when the stream is naturally dry, all trenches will be backfilled below the OHW line with native material and capped with clean gravel suitable for fish use in the project area.
- b. Align each crossing as perpendicular to the watercourse as possible. Ensure that the drilled, bored or jacked crossings are below the total scour prism.
- c. Any large wood displaced by trenching or plowing will be returned as nearly as possible to its original position, or otherwise arranged to restore habitat functions.

Any action involving a stormwater outfall will meet any stormwater management criteria outlined by the Corps, the Oregon Department of Environmental Quality, or any other applicable permitting agency.

1.4 Project Design Criteria III - Types of IWOW Actions

1I. Boat ramps.

All boat ramps must consist of pre-cast concrete slabs below ordinary high water, and may be cast-in-place above ordinary high water if completed in the dry. Rock may be used to prevent scouring, down-cutting, or failure at the boat ramp, provided that the rock is no larger than necessary and does not extend further than necessary from the edge of the ramp in any direction.

2I. Educational signs.

- a. To educate the public about pollution from boating activities and its prevention, the Corps shall install (Corps project) or require the following information or its equivalent to be posted on a permanent sign that will be maintained at each permitted facility that is used by the public (*e.g.*, a public boat ramp or marina):
 - i. A description of the ESA-listed species which are or may be present in the project area.
 - ii. Notice that adults and juveniles of these species are protected by the ESA and other laws so that they can successfully migrate, spawn, rear, and complete other behaviors necessary for their recovery.
 - iii. Therefore, all users of the facility are encouraged or required to:
 - (1) Follow procedures and rules governing use of sewage pump-out facilities;
 - (2) Minimize the fuel and oil released into surface waters during fueling, and from bilges and gas tanks;
 - (3) Avoid cleaning boat hulls in the water to prevent the release of cleaner, paint and solvent;
 - (4) Practice sound fish cleaning and waste management, including proper disposal of fish waste; and
 - (5) Dispose of all solid and liquid waste produced while boating in a proper facility away from surface waters.

3I. Flotation material.

All synthetic flotation material must be permanently encapsulated to prevent breakup into small pieces and dispersal in water.

4I. New or replacement floats.

- a. Any float wider than 6-feet must also include:
 - i. An open area of grating that is at least 50% of the total surface area; or
 - ii. Be placed where current velocity is at least 0.7 feet per second year-round.
 - iii. Floats shall be kept to the minimum footprint necessary to achieve the project purpose.

5I. Piscivorous birds.

All float pilings, mooring buoys, and navigational aids must be fitted with devices to prevent perching by piscivorous birds.

6I. Relocation of existing structures in a marina.

Any existing structure that is relocated in a marina must remain within the existing overall footprint.

7I. Dredging to Maintain Vessel Access.

- a. When dredging to maintain access to previously authorized docks, wharfs, mooring structures, and boat ramps, the following conditions apply:
 - i. All dredged materials and subsequent leave surface must be suitable and approved for in-water disposal using newly acquired or historical data based on criteria in the Sediment Evaluation Framework (USACE Northwest Division, 2009).
 - ii. Unless the project is in an accretion zone or otherwise waived by the Service, all dredged sediment and debris must be side cast or returned to the channel within the ordinary high-water line downstream from the dredging site where it will be recruited by the next annual high flow and continue to provide aquatic habitat functions.
 - iii. The dredging must not alter the character, scope, size, or location of the project area or previously authorized dredge prism.

8I. Dredging to Maintain Functionality.

- a. When discharging or excavating to maintain the functionality of a channel, culvert, intake, or outfall, the following conditions apply:
 - i. Either the discharge or excavation may not include any water intake or point of diversion that does not have a fish screen that is installed, operated and maintained according to NMFS (2011 or current version), site-specific designs as approved by USFWS and NMFS (if a minor variance is requested), or meets the Service's bull trout specific screening and passage criteria when developed. The Service may waive this requirement if a mutually agreeable plan is developed to install and/or upgrade appropriate fish screens meeting the criteria.
 - ii. All dredged materials and subsequent leave surface must be suitable and approved for in-water disposal using newly acquired or historical data based on criteria in the Sediment Evaluation Framework.
 - iii. Unless the project is in an accretion zone or otherwise waived by the Service, all dredged sediment and debris must be side cast or returned within the annual high flow channel downstream from the dredging site where it will continue to provide aquatic habitat functions.
 - iv. The dredging must not alter the character, scope, size, or location of the project area.

1.5 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). For this consultation, the overall program action area consists of the combined action areas for each action to be authorized or carried out in the Portland District of the Corps under this Opinion. This includes all upland, riparian and aquatic areas affected by site preparation, construction, and site restoration design criteria at each action site. This includes streams, rivers and estuaries of all waters within the State boundaries of Oregon, which comprise the jurisdictional boundary of the Service’s Region 1 (Figure 1). The waters that form the Klamath River drainage system that fall within the jurisdictional boundary of the Service’s Region 8 are excluded. This area does not fall within the action area of this Opinion, and thus projects having effects within that basin will not be authorized under SLOPES BT.

Individual action areas include riparian areas, banks, and the stream channel in area extending no more than 300 feet upstream and 300 feet downstream from the action footprint, where aquatic habitat conditions will be temporarily degraded until site restoration is complete, and sufficient time has passed for the system to rebound (although the USFWS acknowledges that some degree of adverse effects could extend much farther downstream). This estimate is partially based on an analysis of typical turbidity flux downstream allowable under State statutes of Oregon from a nonpoint discharge in a stream with a low flow channel that is greater than 200 feet, although the actual turbidity flux at each project site is likely to be proportionately smaller for streams with a smaller low flow channel width (Rosetta, 2005). The USFWS recognizes that many projects are capable of producing a turbidity flux of greater magnitude than this. In some cases projects such as culvert replacement may show effects 600 feet or more below the project. Larger projects that remove dams or that would realign a stream channel could produce sediment and cobble embeddedness much farther than 300 feet below the project site, and could show effects ¼ mile or more below the actual site. Because of the wide variability of stream types, project types and site-specific conditions the USFWS, in conjunction with the Corps has chosen to use 300 feet as an average distance, combined with turbidity monitoring criteria (see ITS section) that the USFWS believes will insure compliance with both EPA and State guidelines and therefore, allow for reasonable protection for ESA-listed fish.

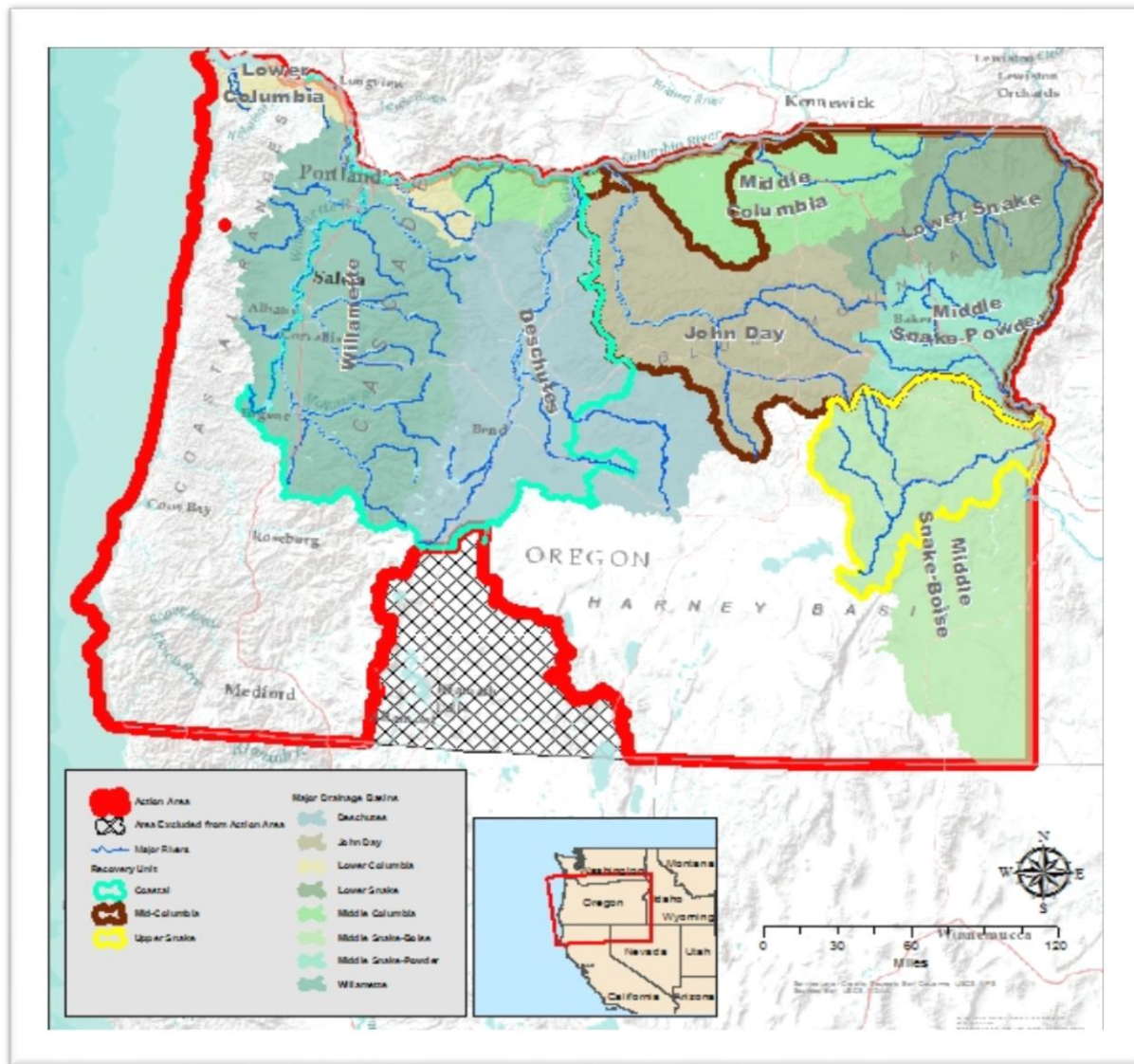


Figure 1. Action area consisting of major drainage basins and Bull Trout Recovery Units in Oregon

2.0 STATUS OF BULL TROUT

2.1 Analytical Framework for the Jeopardy and Adverse Modification Determinations

Jeopardy Determination

In accordance with policy and regulation, the jeopardy analysis in this Biological Opinion relies on four components: (1) the *Status of the Species*, which evaluates bull trout range-wide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of bull trout in the action area, the factors

responsible for that condition, and the relationship of the action area to the survival and recovery of bull trout; (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 bull trout; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the bull trout.

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 bull trout 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 bull trout in the wild.

The jeopardy analysis in this Biological Opinion places an emphasis on consideration of the range-wide survival and recovery needs of bull trout and the role of the action area in the survival and recovery of the bull trout 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 Determination

Section 7(a)(2) of the ESA requires that Federal agencies ensure that any action they authorize, fund, or carry out is not likely to destroy or to adversely modify designated critical habitat. A final rule revising the regulatory definition of “destruction or adverse modification of critical habitat” was published on February 11, 2016 (81 FR 7214). The final rule became effective on March 14, 2016. The revised definition states: “Destruction or adverse modification means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features.”

The destruction or adverse modification analysis in this Opinion relies on four components:

1. The *Status of Critical Habitat*, which describes the range-wide condition of designated critical habitat for the bull trout in terms of the key components of the critical habitat that provide for the conservation of the listed species, the factors responsible for that condition, and the intended value of the critical habitat overall for the conservation/recovery of the listed species;
2. the *Environmental Baseline*, which analyzes the condition of the critical habitat in the action area, the factors responsible for that condition, and the value of the critical habitat in the action area for the conservation/recovery of the listed 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 and interdependent activities on the key components of critical habitat that provide for the conservation of the listed species, and how those impacts are likely to influence the value of the affected critical habitat units for the conservation/recovery of the listed species; and
4. *Cumulative Effects*, which evaluate the effects of future non-Federal activities that are reasonably certain to occur in the action area on the key components of critical habitat that provide for the conservation of the listed species and how those impacts are likely to

influence the value of the affected critical habitat units for the conservation/recovery of the listed species.

For purposes of making the destruction or adverse modification determination, the effects of the proposed Federal action, together with any cumulative effects, are evaluated to determine if the value of the critical habitat rangewide for the conservation/recovery of the listed species would remain functional or would retain the current ability for the key components of the critical habitat that provide for the conservation of the listed species to be functionally re-established in areas of currently unsuitable but capable habitat.

Note: Past designations of critical habitat have used the terms "primary constituent elements" (PCEs), "physical and biological features" (PBFs) or "essential features" to characterize the key components of critical habitat that provide for the conservation of the listed species. The new critical habitat regulations (81 FR 7214) discontinue use of the terms "PCEs" or "essential features" and rely exclusively on use of the term PBFs for that purpose because that term is contained in the statute. To be consistent with that shift in terminology and in recognition that the terms PBFs, PCEs, and essential habitat features are synonymous in meaning, we are only referring to PBFs herein. Therefore, if a past critical habitat designation defined essential habitat features or PCEs, they will be referred to as PBFs in this document. This does not change the approach outlined above for conducting the "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs or essential features.

2.2 Status of the Species

This Opinion examines the status of bull trout and how they would be adversely affected by the proposed action. The status is the level of risk that bull trout face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The Opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value. One factor affecting the status of bull trout considered in this Opinion, and aquatic habitat at large is climate change.

2.2.1 Species Description

Taxonomy

The bull trout is a native char found in the coastal and intermountain west of North America. Dolly Varden (*Salvelinus malma*) and bull trout were previously considered a single species and were thought to have coastal and interior forms. However, Cavender (1978) described morphometric, meristic and osteological characteristics of the two forms, and provided evidence of specific distinctions between the two. Despite an overlap in the geographic range of bull trout and Dolly Varden in the Puget Sound area and along the British Columbia coast, there is little evidence of introgression (Haas and McPhail 1991, p. 2191). The Columbia River Basin is considered the region of origin for the bull trout. From the Columbia, dispersal to other drainage systems was accomplished by marine migration and headwater stream capture. Behnke (2002, p. 297) postulated dispersion to drainages east of the continental divide may have occurred through

the North and South Saskatchewan Rivers (Hudson Bay drainage) and the Yukon River system. Marine dispersal may have occurred from Puget Sound north to the Fraser, Skeena and Taku Rivers of British Columbia.

Species Description

Bull trout have unusually large heads and mouths for salmonids. Their body colors can vary tremendously depending on their environment, but are often brownish green with lighter (often ranging from pale yellow to crimson) colored spots running along their dorsa and flanks, with spots being absent on the dorsal fin, and light colored to white under bellies. They have white leading edges on their fins, as do other species of char. Bull trout have been measured as large as 103 centimeters (41 inches) in length, with weights as high as 14.5 kilograms (32 pounds) (Fishbase 2015, p. 1). Bull trout may be migratory, moving throughout large river systems, lakes, and even the ocean in coastal populations, or they may be resident, remaining in the same stream their entire lives (Rieman and McIntyre 1993, p. 2; Brenkman and Corbett 2005, p. 1077). Migratory bull trout are typically larger than resident bull trout (USFWS 1998a, p. 31668).

2.2.2 Legal Status

The coterminous United States population of the bull trout (*Salvelinus confluentus*) was listed as threatened on November 1, 1999 (USFWS 1999a). 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. 4; Brewin and Brewin 1997, pp. 209-216; Cavender 1978, pp. 165-166; Leary and Allendorf 1997, pp. 715-720).

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 (USFWS 1999a, p. 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, entire; Rieman et al. 2007, entire; Porter and Nelitz 2009, pages 4-8). Poaching and incidental mortality of bull trout during other targeted fisheries are additional threats.

2.2.3 Life History

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, p. 30; Pratt 1985, pp. 28-34). The largest verified bull trout is a 32-pound specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982, p. 95).

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. 141). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989, pp. 15-16; Pratt 1992, pp. 6-7; Rieman and McIntyre 1996, p. 133). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992, p. 1). 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 (Pratt 1992, p. 1; Ratliff and Howell 1992, p. 10).

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, p. 9) indicates that adverse effects of lower oxygen concentrations on embryo survival are magnified as temperatures increase above optimal (for incubation). 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, p. 10). 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, Ch 2 pp. 23-24). 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.

2.2.4 Population Dynamics

Population Structure

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, p. 2). 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 (Goetz 1989, p. 15). 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, p. 138; Goetz 1989, p. 24), or saltwater (anadromous form) to rear as subadults and to live

as adults (Brenkman and Corbett 2005, entire; McPhail and Baxter 1996, p. i; WDFW et al. 1997, p. 16). 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, p. 135; Leathe and Graham 1982, p. 95; Pratt 1992, p. 8; Rieman and McIntyre 1996, p. 133).

Bull trout are naturally migratory, which allows them to capitalize on temporally abundant food resources and larger downstream habitats. Resident forms may develop where barriers (either natural or manmade) occur or where foraging, migrating, or overwintering habitats for migratory fish are minimized (Brenkman and Corbett 2005, pp. 1075-1076; Goetz et al. 2004, p. 105). 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, pp. 96, 98-106). 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. 861-863; MBTSG 1998, p. 13; Rieman and McIntyre 1993, pp. 2-3). 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 size fish with higher fecundity is lost (Rieman and McIntyre 1993, p. 2).

Whitesel et al. (2004, p. 2) noted that although there are multiple resources that contribute to the subject, Spruell et al. (2003, entire) best summarized genetic information on bull trout population structure. Spruell et al. (2003, entire) analyzed 1,847 bull trout from 65 sampling locations, four located in three coastal drainages (Klamath, Queets, and Skagit Rivers), one in the Saskatchewan River drainage (Belly River), and 60 scattered throughout the Columbia River Basin. They concluded that there is a consistent pattern among genetic studies of bull trout, regardless of whether examining allozymes, mitochondrial DNA, or most recently microsatellite loci. Typically, the genetic pattern shows relatively little genetic variation within populations, but substantial divergence among populations. Microsatellite loci analysis supports the existence of at least three major genetically differentiated groups (or evolutionary lineages) of bull trout (Spruell et al. 2003, p. 17). They were characterized as:

- i. "Coastal", including the Deschutes River and all of the Columbia River drainage downstream, as well as most coastal streams in Washington, Oregon, and British Columbia. A compelling case also exists that the Klamath Basin represents a unique evolutionary lineage within the coastal group.
- ii. "Snake River", which also included the John Day, Umatilla, and Walla Walla rivers. Despite close proximity of the John Day and Deschutes Rivers, a striking level of divergence between bull trout in these two systems was observed.

- iii. “Upper Columbia River” which includes the entire basin in Montana and northern Idaho. A tentative assignment was made by Spruell et al. (2003, p. 25) of the Saskatchewan River drainage populations (east of the continental divide), grouping them with the upper Columbia River group.

Spruell et al. (2003, p. 17) noted that within the major assemblages, populations were further subdivided, primarily at the level of major river basins. Taylor et al. (1999, entire) surveyed bull trout populations, primarily from Canada, and found a major divergence between inland and coastal populations. Costello et al. (2003, p. 328) suggested the patterns reflected the existence of two glacial refugia, consistent with the conclusions of Spruell et al. (2003, p. 26) and the biogeographic analysis of Haas and McPhail (2001, entire). Both Taylor et al. (1999, p. 1166) and Spruell et al. (2003, p. 21) concluded that the Deschutes River represented the most upstream limit of the coastal lineage in the Columbia River Basin.

More recently, the Service identified additional genetic units within the coastal and interior lineages (Ardren et al. 2011, p. 18). Based on a recommendation in the Service’s 5-year review of the species’ status (USFWS 2008a, p. 45), the Service reanalyzed the 27 recovery units identified in the draft bull trout recovery plan (USFWS 2002a, p. 48) by utilizing, in part, information from previous genetic studies and new information from additional analysis (Ardren et al. 2011, entire). In this examination, the Service applied relevant factors from the joint Service and NMFS Distinct Population Segment (DPS) policy (USFWS 1996, entire) and subsequently identified six draft recovery units that contain assemblages of core areas that retain genetic and ecological integrity across the range of bull trout in the coterminous United States. These six draft recovery units were used to inform designation of critical habitat for bull trout by providing a context for deciding what habitats are essential for recovery (USFWS 2010a, p. 63898). The six draft recovery units identified for bull trout in the coterminous United States include: Coastal, Klamath, Mid-Columbia, Columbia Headwaters, Saint Mary, and Upper Snake. These six draft recovery units were also identified in the Service’s revised recovery plan (USFWS 2015, p. vii) and designated as final recovery units.

Population Dynamics

Although bull trout are widely distributed over a large geographic area, they exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993, p. 4). Increased habitat fragmentation reduces the amount of available habitat and increases isolation from other populations of the same species (Saunders et al. 1991, entire). Burkey (1989, entire) concluded that when species are isolated by fragmented habitats, low rates of population growth are typical in local populations and their probability of extinction is directly related to the degree of isolation and fragmentation. Without sufficient immigration, growth for local populations may be low and probability of extinction high (Burkey 1989, entire; Burkey 1995, entire).

Metapopulation concepts of conservation biology theory have been suggested relative to the distribution and characteristics of bull trout, although empirical evidence is relatively scant (Rieman and McIntyre 1993, p. 15; Dunham and Rieman 1999, entire; Rieman and Dunham 2000, entire). A metapopulation is an interacting network of local populations with varying frequencies of migration and gene flow among them (Meffe and Carroll 1994, pp. 189-190). For

inland bull trout, metapopulation theory is likely most applicable at the watershed scale where habitat consists of discrete patches or collections of habitat capable of supporting local populations; local populations are for the most part independent and represent discrete reproductive units; and long-term, low-rate dispersal patterns among component populations influences the persistence of at least some of the local populations (Rieman and Dunham 2000, entire). Ideally, multiple local populations distributed throughout a watershed provide a mechanism for spreading risk because the simultaneous loss of all local populations is unlikely. However, habitat alteration, primarily through the construction of impoundments, dams, and water diversions has fragmented habitats, eliminated migratory corridors, and in many cases isolated bull trout in the headwaters of tributaries (Rieman and Clayton 1997, pp. 10-12; Dunham and Rieman 1999, p. 645; Spruell et al. 1999, pp. 118-120; Rieman and Dunham 2000, p. 55).

Human-induced factors as well as natural factors affecting bull trout distribution have likely limited the expression of the metapopulation concept for bull trout to patches of habitat within the overall distribution of the species (Dunham and Rieman 1999, entire). However, despite the theoretical fit, the relatively recent and brief time period during which bull trout investigations have taken place does not provide certainty as to whether a metapopulation dynamic is occurring (e.g., a balance between local extirpations and recolonizations) across the range of the bull trout or whether the persistence of bull trout in large or closely interconnected habitat patches (Dunham and Rieman 1999, entire) is simply reflective of a general deterministic trend towards extinction of the species where the larger or interconnected patches are relics of historically wider distribution (Rieman and Dunham 2000, pp. 56-57). Recent research (Whiteley et al. 2003, entire) does, however, provide genetic evidence for the presence of a metapopulation process for bull trout, at least in the Boise River Basin of Idaho.

Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993, p. 4). 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, entire; Goetz 1989, pp. 23, 25; Hoelscher and Bjornn 1989, pp. 19, 25; Howell and Buchanan 1992, pp. 30, 32; Pratt 1992, entire; Rich 1996, p. 17; Rieman and McIntyre 1993, pp. 4-6; Rieman and McIntyre 1995, entire; Sedell and Everest 1991, entire; Watson and Hillman 1997, entire). Watson and Hillman (1997, pp. 247-250) 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, pp. 4-6), bull trout should not be expected to simultaneously occupy all available habitats.

Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993, p. 2). 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. 2; Spruell et al. 1999, entire). 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, and spawning habitats are generally characterized by temperatures that drop below 9 °C in the fall (Fraley and Shepard 1989, p. 137; Pratt 1992, p. 5; Rieman and McIntyre 1993, p. 2).

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 (Pratt 1992, pp 7-8; Rieman and McIntyre 1993, p. 7). Optimum incubation temperatures for bull trout eggs range from 2 °C to 6 °C whereas optimum water temperatures for rearing range from about 6 °C to 10 °C (Buchanan and Gregory 1997, p. 4; Goetz 1989, p. 22). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996, entire) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 °C to 9 °C, within a temperature gradient of 8 °C to 15 °C. In a landscape study relating bull trout distribution to maximum water temperatures, Dunham et al. (2003, p. 900) 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.

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, p. 2; Fraley and Shepard 1989, pp. 133, 135; Rieman and McIntyre 1993, pp. 3-4; Rieman and McIntyre 1995, p. 287). Availability and proximity of cold water patches and food productivity can influence bull trout ability to survive in warmer rivers (Myrick 2002, pp. 6 and 13).

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, p. 137; Goetz 1989, p. 19; Hoelscher and Bjornn 1989, p. 38; Pratt 1992, entire; Rich 1996, pp. 4-5; Sedell and Everest 1991, entire; Sexauer and James 1997, entire; Thomas 1992, pp. 4-6; Watson and Hillman 1997, p. 238). Maintaining bull trout habitat requires natural stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre 1993, pp. 5-6). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997, p. 364). 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, p. 141; Pratt 1992, p. 6; Pratt and Huston 1993, p. 70). Pratt (1992, p. 6) indicated that increases in fine sediment reduce egg survival and emergence.

Diet

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. Fish growth depends on the quantity and quality of food that is eaten, and as fish grow their foraging strategy changes as their food changes, in quantity, size, or other characteristics (Quinn 2005, pp. 195-200). 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. 242-243; Goetz 1989, pp. 33-34). Subadult and adult migratory bull trout feed on various fish species (Donald and Alger 1993, pp. 241-243; Fraley and Shepard 1989, pp. 135, 138; Leathe and Graham 1982, pp. 13, 50-56). Bull trout of all sizes other than fry have been found to eat fish half their length (Beauchamp and VanTassell 2001, p. 204). In nearshore marine areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasii*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) (Goetz et al. 2004, p. 105; 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. 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, p. 25). 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, pp. 1078-1079; Goetz et al. 2004, entire).

2.2.5 Status and Distribution

Distribution and Demography

The historical range of bull trout includes major river basins in the Pacific Northwest at about 41 to 60 degrees North latitude, from the southern limits in the McCloud River in northern California and the Jarbidge River in Nevada to the headwaters of the Yukon River in the Northwest Territories, Canada (Cavender 1978, pp. 165-166; Bond 1992, p. 2). To the west, the bull trout's range includes Puget Sound, various coastal rivers of British Columbia, Canada, and southeast Alaska (Bond 1992, p. 2). Bull trout occur in portions of the Columbia River and tributaries within the basin, including its headwaters in Montana and Canada. Bull trout also occur in the Klamath River basin of south-central Oregon. East of the Continental Divide, bull trout are found in the headwaters of the Saskatchewan River in Alberta and Montana and in the Mackenzie River system in Alberta and British Columbia, Canada (Cavender 1978, pp. 165-166; Brewin et al. 1997, entire).

Each of the following recovery units (below) 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. No new local populations have been identified and no local populations have been lost since listing.

Coastal Recovery Unit

The Coastal Recovery Unit is located within western Oregon and Washington. Major geographic regions include the Olympic Peninsula, Puget Sound, and Lower Columbia River basins. The Olympic Peninsula and Puget Sound geographic regions also include their associated marine waters (Puget Sound, Hood Canal, Strait of Juan de Fuca, and Pacific Coast), which are critical in supporting the anadromous¹⁴ life history form, unique to the Coastal Recovery Unit. The Coastal Recovery Unit is also the only unit that overlaps with the distribution of Dolly Varden (*Salvelinus malma*) (Ardren et al. 2011), another native char species that looks very similar to the bull trout (Haas and McPhail 1991). The two species have likely had some level of historic introgression in this part of their range (Redenbach and Taylor 2002). The Lower Columbia River major geographic region includes the lower mainstem Columbia River, an important migratory waterway essential for providing habitat and population connectivity within this region. In the Coastal Recovery Unit, there are 21 existing bull trout core areas which have been designated, including the recently reintroduced Clackamas River population, and 4 core areas have been identified that could be re-established. Core areas within the recovery unit are distributed among these three major geographic regions (Puget Sound also includes one core area that is actually part of the lower Fraser River system in British Columbia, Canada) (USFWS 2015a, p. A-1).

The current demographic status of bull trout in the Coastal Recovery Unit is variable across the unit. Populations in the Puget Sound region generally tend to have better demographic status, followed by the Olympic Peninsula, and finally the Lower Columbia River region. However, population strongholds do exist across the three regions. The Lower Skagit River and Upper Skagit River core areas in the Puget Sound region likely contain two of the most abundant bull trout populations with some of the most intact habitat within this recovery unit. The Lower Deschutes River core area in the Lower Columbia River region also contains a very abundant bull trout population and has been used as a donor stock for re-establishing the Clackamas River population (USFWS 2015a, p. A-6).

Puget Sound Region

In the Puget Sound region, bull trout populations are concentrated along the eastern side of Puget Sound with most core areas concentrated in central and northern Puget Sound.

Although the Chilliwack River core area is considered part of this region, it is technically connected to the Fraser River system and is transboundary with British Columbia making its distribution unique within the region. Most core areas support a mix of anadromous and fluvial life history forms, with at least two core areas containing a natural adfluvial life history (Chilliwack River core area [Chilliwack Lake] and Chester Morse Lake core area). Overall demographic status of core areas generally improves as you move from south Puget Sound to north Puget Sound. Although comprehensive trend data are lacking, the current condition of core areas within this region are likely stable overall, although some at depressed abundances. Two core areas (Puyallup River and Stillaguamish River) contain local populations at either

¹⁴ 1 Anadromous: Life history pattern of spawning and rearing in fresh water and migrating to salt water areas to mature.

very low abundances (Upper Puyallup and Mowich Rivers) or that have likely become locally extirpated (Upper Deer Creek, South Fork Canyon Creek, and Greenwater River). Connectivity among and within core areas of this region is generally intact. Most core areas in this region still have significant amounts of headwater habitat within protected and relatively pristine areas (e.g., North Cascades National Park, Mount Rainier National Park, Skagit Valley Provincial Park, Manning Provincial Park, and various wilderness or recreation areas) (USFWS 2015a, p. A-7).

Olympic Peninsula Region

In the Olympic Peninsula region, distribution of core areas is somewhat disjunct, with only one located on the west side of Hood Canal on the eastern side of the peninsula, two along the Strait of Juan de Fuca on the northern side of the peninsula, and three along the Pacific Coast on the western side of the peninsula. Most core areas support a mix of anadromous and fluvial life history forms, with at least one core area also supporting a natural adfluvial life history (Quinault River core area [Quinault Lake]). Demographic status of core areas is poorest in Hood Canal and Strait of Juan de Fuca, while core areas along the Pacific Coast of Washington likely have the best demographic status in this region. The connectivity between core areas in these disjunct regions is believed to be naturally low due to the geographic distance between them.

Internal connectivity is currently poor within the Skokomish River core area (Hood Canal) and is being restored in the Elwha River core area (Strait of Juan de Fuca). Most core areas in this region still have their headwater habitats within relatively protected areas (Olympic National Park and wilderness areas) (USFWS 2015a, p. A-7).

Lower Columbia River Region

In the Lower Columbia River region, the majority of core areas are distributed along the Cascade Crest on the Oregon side of the Columbia River. Only two of the seven core areas in this region are in Washington. Most core areas in the region historically supported a fluvial life history form, but many are now adfluvial due to reservoir construction. However, there is at least one core area supporting a natural adfluvial life history (Odell Lake) and one supporting a natural, isolated, resident⁴ life history (Klickitat River [West Fork Klickitat]). Status is highly variable across this region, with one relative stronghold (Lower Deschutes core area) existing on the Oregon side of the Columbia River. The Lower Columbia River region also contains three watersheds (North Santiam River, Upper Deschutes River, and White Salmon River) that could potentially become re-established core areas within the Coastal Recovery Unit. Although the South Santiam River has been identified as a historic core area, there remains uncertainty as to whether or not historical observations of bull trout represented a self-sustaining population. Current habitat conditions in the South Santiam River are thought to be unable to support bull trout spawning and rearing. Adult abundances within the majority of core areas in this region are relatively low, generally 300 or fewer individuals.

Most core populations in this region are not only isolated from one another due to dams or natural barriers, but they are internally fragmented as a result of manmade barriers. Local

populations are often disconnected from one another or from potential foraging habitat. In the Coastal Recovery Unit, adult abundance may be lowest in the Hood River and Odell Lake core areas, which each contain fewer than 100 adults. Bull trout were reintroduced in the Middle Fork Willamette River in 1990 above Hills Creek Reservoir. Successful reproduction was first documented in 2006, and has occurred each year since (USFWS 2015a, p. A-8). Natural reproducing populations of bull trout are present in the McKenzie River basin (USFWS 2008a, pp. 65-67). Bull trout were more recently reintroduced into the Clackamas River basin in the summer of 2011 after an extensive feasibility analysis (Shively et al. 2007, Hudson et al. 2015). Bull trout from the Lower Deschutes core area are being utilized for this reintroduction effort (USFWS 2015, p. A-8).

Klamath Recovery Unit

Bull trout in the Klamath Recovery Unit have been isolated from other bull trout populations for the past 10,000 years and are recognized as evolutionarily and genetically distinct (Minckley et al. 1986; Leary et al. 1993; Whitesel et al. 2004; USFWS 2008a; Ardren et al. 2011). As such, there is no opportunity for bull trout in another recovery unit to naturally re-colonize the Klamath Recovery Unit if it were to become extirpated. The Klamath Recovery Unit lies at the southern edge of the species range and occurs in an arid portion of the range of bull trout.

Bull trout were once widespread within the Klamath River basin (Gilbert 1898; Dambacher et al. 1992; Ziller 1992; USFWS 2002b), but habitat degradation and fragmentation, past and present land use practices, agricultural water diversions, and past fisheries management practices have greatly reduced their distribution. Bull trout abundance also has been severely reduced, and the remaining populations are highly fragmented and vulnerable to natural or manmade factors that place them at a high risk of extirpation (USFWS 2002a). The presence of nonnative brook trout (*Salvelinus fontinalis*), which compete and hybridize with bull trout, is a particular threat to bull trout persistence throughout the Klamath Recovery Unit (USFWS 2015b, pp. B-3-4).

Upper Klamath Lake Core Area

The Upper Klamath Lake core area comprises two bull trout local populations (Sun Creek and Threemile Creek). These local populations likely face an increased risk of extirpation because they are isolated and not interconnected with each other. Extirpation of other local populations in the Upper Klamath Lake core area has occurred in recent times (1970s). Populations in this core area are genetically distinct from those in the other two core areas in the Klamath Recovery Unit (USFWS 2008b), and in comparison, genetic variation within this core area is lowest. The two local populations have been isolated by habitat fragmentation and have experienced population bottlenecks. As such, currently unoccupied habitat is needed to restore connectivity between the two local populations and to establish additional populations. This unoccupied habitat includes canals, which now provide the only means of connectivity as migratory corridors. Providing full volitional connectivity for bull trout, however, also introduces the risk of invasion by brook trout, which are abundant in this core area.

Bull trout in the Upper Klamath Lake core area formerly occupied Annie Creek, Sevenmile Creek, Cherry Creek, and Fort Creek, but are now extirpated from these locations. The last

remaining local populations, Sun Creek and Threemile Creek, have received focused attention. Brook trout have been removed from bull trout occupied reaches, and these reaches have been intentionally isolated to prevent brook trout reinvasion. As such, over the past few generations these populations have become stable and have increased in distribution and abundance. In 1996, the Threemile Creek population had approximately 50 fish that occupied a 1.4-km (0.9-mile) reach (USFWS 2002b). In 2012, a mark-resight population estimate was completed in Threemile Creek, which indicated an abundance of 577 (95 percent confidence interval = 475 to 679) age-1+ fish (ODFW 2012). In addition, the length of the distribution of bull trout in Threemile Creek had increased to 2.7 km (1.7 miles) by 2012 (USFWS unpublished data). Between 1989 and 2010, bull trout abundance in Sun Creek increased approximately tenfold (from approximately 133 to 1,606 age-1+ fish) and distribution increased from approximately 1.9 km (1.2 miles) to 11.2 km (7.0 miles) (Buktenica et al. 2013) (USFWS 2015b, p. B-5)

Sycan River Core Area

The Sycan River core area is comprised of one local population, Long Creek. Long Creek likely faces greater risk of extirpation because it is the only remaining local population due to extirpation of all other historic local populations. Bull trout previously occupied Calahan Creek, Coyote Creek, and the Sycan River, but are now extirpated from these locations (Light et al. 1996). This core area's local population is genetically distinct from those in the other two core areas (USFWS 2008b). This core area also is essential for recovery because bull trout in this core area exhibit both resident¹⁵ and fluvial life histories, which are important for representing diverse life history expression in the Klamath Recovery Unit. Migratory bull trout are able to grow larger than their resident counterparts, resulting in greater fecundity and higher reproductive potential (Rieman and McIntyre 1993). Migratory life history forms also have been shown to be important for population persistence and resilience (Dunham et al. 2008).

The last remaining population (Long Creek) has received focused attention in an effort to ensure it is not also extirpated. In 2006, two weirs were removed from Long Creek, which increased the amount of occupied foraging, migratory, and overwintering (FMO) habitat by 3.2 km (2.0 miles). Bull trout currently occupy approximately 3.5 km (2.2 mi) of spawning/rearing habitat, including a portion of an unnamed tributary to upper Long Creek, and seasonally use 25.9 km (16.1 mi) of FMO habitat. Brook trout also inhabit Long Creek and have been the focus of periodic removal efforts. No recent statistically rigorous population estimate has been completed for Long Creek; however, the 2002 Draft Bull Trout Recovery Plan reported a population estimate of 842 individuals (USFWS 2002b). Currently unoccupied habitat is needed to establish additional local populations, although brook trout are widespread in this core area and their management will need to be considered in future recovery efforts. In 2014, the Klamath Falls Fish and the USFWS established an agreement with the U.S. Geological Survey to undertake a structured decision making process to assist with recovery planning of bull trout populations in the Sycan River core area (USFWS 2015b, p. B-6).

¹⁵ Resident: Life history pattern of residing in tributary streams for the fish's entire life without migrating.

Upper Sprague River Core Area

The Upper Sprague River core area comprises five bull trout local populations, placing the core area at an intermediate risk of extinction. The five local populations include Boulder Creek, Dixon Creek, Deming Creek, Leonard Creek, and Brownsworth Creek. These local populations may face a higher risk of extirpation because not all are interconnected. Bull trout local populations in this core area are genetically distinct from those in the other two Klamath Recovery Unit core areas (USFWS 2008b). Migratory bull trout have occasionally been observed in the North Fork Sprague River (USFWS 2002b). Therefore, this core area also is essential for recovery in that bull trout here exhibit a resident life history and likely a fluvial life history, which are important for conserving diverse life history expression in the Klamath Recovery Unit as discussed above for the Sycan River core area.

The Upper Sprague River core area population of bull trout has experienced a decline from historic levels, although less is known about historic occupancy in this core area. Bull trout are reported to have historically occupied the South Fork Sprague River, but are now extirpated from this location (Buchanan et al. 1997). The remaining five populations have received focused attention. Although brown trout (*Salmo trutta*) co-occur with bull trout and exist in adjacent habitats, brook trout do not overlap with existing bull trout populations. Efforts have been made to increase connectivity of existing bull trout populations by replacing culverts that create barriers. Thus, over the past few generations, these populations have likely been stable and increased in distribution. Population abundance has been estimated recently for Boulder Creek (372 + 62 percent; Hartill and Jacobs 2007), Dixon Creek (20 + 60 percent; Hartill and Jacobs 2007), Deming Creek (1,316 + 342; Moore 2006), and Leonard Creek (363 + 37 percent; Hartill and Jacobs 2007). No statistically rigorous population estimate has been completed for the Brownsworth Creek local population; however, the 2002 Draft Bull Trout Recovery Plan reported a population estimate of 964 individuals (USFWS 2002b). Additional local populations need to be established in currently unoccupied habitat within the Upper Sprague River core area, although brook trout are widespread in this core area and will need to be considered in future recovery efforts (USFWS 2015b, p. B-7).

Mid-Columbia Recovery Unit

The Mid-Columbia RU comprises 24 bull trout core areas, as well as 2 historically occupied core areas and 1 research needs area. The Mid-C RU is recognized as an area where bull trout have co-evolved with salmon, steelhead, lamprey, and other fish populations. Reduced fish numbers due to historic overfishing and land management changes have caused changes in nutrient abundance for resident migratory fish like the bull trout. The recovery unit is located within eastern Washington, eastern Oregon, and portions of central Idaho. Major drainages include the Methow River, Wenatchee River, Yakima River, John Day River, Umatilla River, Walla Walla River, Grande Ronde River, Imnaha River, Clearwater River, and smaller drainages along the Snake River and Columbia River (USFWS 2015c, p. C-1).

The Mid-Columbia RU can be divided into four geographic regions the Lower Mid-Columbia, which includes all core areas that flow into the Columbia River below its confluence with the Snake River; 2) the Upper Mid-Columbia, which includes all core areas that flow into the

Columbia River above its confluence with the Snake River; 3) the Lower Snake, which includes all core areas that flow into the Snake River between its confluence with the Columbia River and Hells Canyon Dam; and 4) the Mid-Snake, which includes all core areas in the Mid-C RU that flow into the Snake River above Hells Canyon Dam. These geographic regions are composed of neighboring core areas that share similar bull trout genetic, geographic (hydrographic), and/or habitat characteristics. Conserving bull trout in geographic regions allows for the maintenance of broad representation of genetic diversity, provides neighboring core areas with potential source populations in the event of local extirpations, and provides a broad array of options among neighboring core areas to contribute recovery under uncertain environmental change USFWS 2015c, pp. C-1-2).

The current demographic status of bull trout in the Mid-Columbia Recovery Unit is highly variable at both the RU and geographic region scale. Some core areas, such as the Umatilla, Asotin, and Powder Rivers, contain populations so depressed they are likely suffering from the deleterious effects of small population size. Conversely, strongholds do exist within the recovery unit, predominantly in the Lower Snake geographic area. Populations in the Imnaha, Little Minam, Clearwater, and Wenaha Rivers are likely some of the most abundant. These populations are all completely or partially within the bounds of protected wilderness areas and have some of the most intact habitat in the recovery unit. Status in some core areas is relatively unknown, but all indications in these core areas suggest population trends are declining, particularly in the core areas of the John Day Basin (USFWS 2015c, p. C-5).

Lower Mid-Columbia Region

In the Lower Mid-Columbia Region, core areas are distributed along the western portion of the Blue Mountains in Oregon and Washington. Only one of the six core areas is located completely in Washington. Demographic status is highly variable throughout the region. Status is the poorest in the Umatilla and Middle Fork John Day Core Areas. However, the Walla Walla River core area contains nearly pristine habitats in the headwater spawning areas and supports the most abundant populations in the region. Most core areas support both a resident and fluvial life history; however, recent evidence suggests a significant decline in the resident and fluvial life history in the Umatilla River and John Day core areas respectively. Connectivity between the core areas of the Lower Mid-Columbia Region is unlikely given conditions in the connecting FMO habitats. Connection between the Umatilla, Walla Walla and Touchet core areas is uncommon but has been documented, and connectivity is possible between core areas in the John Day Basin. Connectivity between the John Day core areas and Umatilla/Walla Walla/Touchet core areas is unlikely (USFWS 2015c, pp. C-5-6).

Upper Mid-Columbia Region

In the Upper Mid-Columbia Region, core areas are distributed along the eastern side of the Cascade Mountains in Central Washington. This area contains four core areas (Yakima, Wenatchee, Entiat, and Methow), the Lake Chelan historic core area, and the Chelan River, Okanogan River, and Columbia River FMO areas. The core area populations are generally considered migratory, though they currently express both migratory (fluvial and adfluvial) and resident forms. Residents are located both above and below natural barriers (*i.e.*, Early Winters

Creek above a natural falls; and Ahtanum in the Yakima likely due to long lack of connectivity from irrigation withdrawal). In terms of uniqueness and connectivity, the genetics baseline, radio-telemetry, and PIT tag studies identified unique local populations in all core areas. Movement patterns within the core areas; between the lower river, lakes, and other core areas; and between the Chelan, Okanogan, and Columbia River FMO occurs regularly for some of the Wenatchee, Entiat, and Methow core area populations. This type of connectivity has been displayed by one or more fish, typically in non-spawning movements within FMO. More recently, connectivity has been observed between the Entiat and Yakima core areas by a juvenile bull trout tagged in the Entiat moving in to the Yakima at Prosser Dam and returning at an adult size back to the Entiat. Genetics baselines identify unique populations in all four core areas (USFWS 2015c, p. C-6).

The demographic status is variable in the Upper-Mid Columbia region and ranges from good to very poor. The USFWS 5-year Review and Conservation Status Assessment (USFWS 2008a) described the Methow and Yakima at risk, with a rapidly declining trend. The Entiat was listed at risk with a stable trend, and the Wenatchee as having a potential risk, and with a stable trend. Currently, the Entiat is considered to be declining rapidly due to much reduced redd counts. The Wenatchee is able to exhibit all freshwater life histories with connectivity to Lake Wenatchee, the Wenatchee River and all its local populations, and to the Columbia River and/or other core areas in the region. In the Yakima core area some populations exhibit life history forms different from what they were historically. Migration between local populations and to and from spawning habitat is generally prevented or impeded by headwater storage dams on irrigation reservoirs, connectivity between tributaries and reservoirs, and within lower portions of spawning and rearing habitat and the mainstem Yakima River due to changed flow patterns, low instream flows, high water temperatures, and other habitat impediments. Currently, the connectivity in the Yakima Core area is truncated to the degree that not all populations are able to contribute gene flow to a functional metapopulation (USFWS 2015c, pp. C-6-7)

Lower Snake Region

Demographic status is variable within the Lower Snake Region. Although trend data are lacking, several core areas in the Grande Ronde Basin and the Imnaha core area are thought to be stable. The upper Grande Ronde Core Area is the exception where population abundance is considered depressed. Wenaha, Little Minam, and Imnaha are strongholds (as mentioned above), as are most core areas in the Clearwater River basin. Most core areas contain populations that express both a resident and fluvial life history strategy. There is potential that some bull trout in the upper Wallowa River are adfluvial. There is potential for connectivity between core areas in the Grande Ronde basin, however conditions in FMO are limiting (USFWS 2015c, p. C-7).

Middle Snake Region

In the Middle Snake Region, core areas are distributed along both sides of the Snake River above Hells Canyon Dam. The Powder River and Pine Creek basins are in Oregon and Indian Creek and Wildhorse Creek are on the Idaho side of the Snake River. Demographic status of the core areas is poorest in the Powder River Core Area where populations are highly fragmented and severely depressed. The East Pine Creek population in the Pine-Indian- Wildhorse core area is

likely the most abundant within the region. Populations in both core areas primarily express a resident life history strategy; however, some evidence suggests a migratory life history still exists in the Pine Creek-Indian-Wildhorse core area. Connectivity is severely impaired in the Middle Snake Region. Dams, diversions and temperature barriers prevent movement among populations and between core areas. Brownlee Dam isolates bull trout in Wildhorse Creek from other populations (USFWS 2015c, p. C-7).

Columbia Headwaters Recovery Unit

The Columbia Headwaters Recovery Unit (CHRU) includes western Montana, northern Idaho, and the northeastern corner of Washington. Major drainages include the Clark Fork River basin and its Flathead River contribution, the Kootenai River basin, and the Coeur d'Alene Lake basin. In this implementation plan for the CHRU we have slightly reorganized the structure from the 2002 Draft Recovery Plan, based on latest available science and fish passage improvements that have rejoined previously fragmented habitats. We now identify 35 bull trout core areas (compared to 47 in 2002) for this recovery unit. Fifteen of the 35 are referred to as "complex" core areas as they represent large interconnected habitats, each containing multiple spawning streams considered to host separate and largely genetically identifiable local populations. The 15 complex core areas contain the majority of individual bull trout and the bulk of the designated critical habitat (USFWS 2010a).

However, somewhat unique to this recovery unit is the additional presence of 20 smaller core areas, each represented by a single local population. These "simple" core areas are found in remote glaciated headwater basins, often in Glacier National Park or federally-designated wilderness areas, but occasionally also in headwater valley bottoms. Many simple core areas are upstream of waterfalls or other natural barriers to fish migration. In these simple core areas bull trout have apparently persisted for thousands of years despite small populations and isolated existence. As such, simple core areas meet the criteria for core area designation and continue to be valued for their uniqueness, despite limitations of size and scope. Collectively, the 20 simple core areas contain less than 3 percent of the total bull trout core area habitat in the CHRU, but represent significant genetic and life history diversity (Meeuwig et al. 2010). Throughout this recovery unit implementation plan, we often separate our analyses to distinguish between complex and simple core areas, both in respect to threats as well as recovery actions (USFWS 2015d, pp. D-1-2).

In order to effectively manage the RUIP structure in this large and diverse landscape, the core areas have been separated into the following five natural geographic assemblages.

Upper Clark Fork Geographic Region

Starting at the Clark Fork River headwaters, the *Upper Clark Fork Geographic Region* comprises seven complex core areas, each of which occupies one or more major watersheds contributing to the Clark Fork basin (*i.e.*, Upper Clark Fork River, Rock Creek, Blackfoot River, Clearwater River and Lakes, Bitterroot River, West Fork Bitterroot River, and Middle Clark Fork River core areas) (USFWS 2015d, p. D-2).

Lower Clark Fork Geographic Region

The seven headwater core areas flow into the *Lower Clark Fork Geographic Region*, which comprises two complex core areas, Lake Pend Oreille and Priest Lake. Because of the systematic and jurisdictional complexity (three States and a Tribal entity) and the current degree of migratory fragmentation caused by five mainstem dams, the threats and recovery actions in the Lake Pend Oreille (LPO) core area are very complex and are described in three parts. LPO-A is upstream of Cabinet Gorge Dam, almost entirely in Montana, and includes the mainstem Clark Fork River upstream to the confluence of the Flathead River as well as the portions of the lower Flathead River (*e.g.*, Jocko River) on the Flathead Indian Reservation. LPO-B is the Pend Oreille lake basin proper and its tributaries, extending between Albeni Falls Dam downstream from the outlet of Lake Pend Oreille and Cabinet Gorge Dam just upstream of the lake; almost entirely in Idaho. LPO-C is the lower basin (*i.e.*, lower Pend Oreille River), downstream of Albeni Falls Dam to Boundary Dam (1 mile upstream from the Canadian border) and bisected by Box Canyon Dam; including portions of Idaho, eastern Washington, and the Kalispel Reservation (USFWS 2015d, p. D-2).

Historically, and for current purposes of bull trout recovery, migratory connectivity among these separate fragments into a single entity remains a primary objective.

Flathead Geographic Region

The *Flathead Geographic Region* includes a major portion of northwestern Montana upstream of Kerr Dam on the outlet of Flathead Lake. The complex core area of Flathead Lake is the hub of this area, but other complex core areas isolated by dams are Hungry Horse Reservoir (formerly South Fork Flathead River) and Swan Lake. Within the glaciated basins of the Flathead River headwaters are 19 simple core areas, many of which lie in Glacier National Park or the Bob Marshall and Great Bear Wilderness areas and some of which are isolated by natural barriers or other features (USFWS 2015d, p. D-2).

Kootenai Geographic Region

To the northwest of the Flathead, in an entirely separate watershed, lies the *Kootenai Geographic Region*. The Kootenai is a uniquely patterned river system that originates in southeastern British Columbia, Canada. It dips, in a horseshoe configuration, into northwest Montana and north Idaho before turning north again to re-enter British Columbia and eventually join the Columbia River headwaters in British Columbia. The *Kootenai Geographic Region* contains two complex core areas (Lake Koocanusa and the Kootenai River) bisected since the 1970's by Libby Dam, and also a single naturally isolated simple core area (Bull Lake). Bull trout in both of the complex core areas retain strong migratory connections to populations in British Columbia (USFWS 2015d, p. D-3).

Coeur d'Alene Geographic Region

Finally, the *Coeur d'Alene Geographic Region* consists of a single, large complex core area centered on Coeur d'Alene Lake. It is grouped into the CHRU for purposes of physical and

ecological similarity (adfluvial bull trout life history and nonanadromous linkage) rather than due to watershed connectivity with the rest of the CHRU, as it flows into the mid-Columbia River far downstream of the Clark Fork and Kootenai systems (USFWS 2015d, p. D-3).

Upper Snake Recovery Unit

The Upper Snake Recovery Unit includes portions of central Idaho, northern Nevada, and eastern Oregon. Major drainages include the Salmon River, Malheur River, Jarbidge River, Little Lost River, Boise River, Payette River, and the Weiser River. The Upper Snake Recovery Unit contains 22 bull trout core areas within 7 geographic regions or major watersheds: Salmon River (10 core areas, 123 local populations), Boise River (2 core areas, 29 local populations), Payette River (5 core areas, 25 local populations), Little Lost River (1 core area, 10 local populations), Malheur River (2 core areas, 8 local populations), Jarbidge River (1 core area, 6 local populations), and Weiser River (1 core area, 5 local populations). The Upper Snake Recovery Unit includes a total of 206 local populations, with almost 60 percent being present in the Salmon River watershed (USFWS 2015e, p. E-1).

Three major bull trout life history expressions are present in the Upper Snake Recovery Unit, adfluvial¹⁶, fluvial¹⁷, and resident populations. Large areas of intact habitat exist primarily in the Salmon drainage, as this is the only drainage in the Upper Snake Recovery Unit that still flows directly into the Snake River; most other drainages no longer have direct connectivity due to irrigation uses or instream barriers. Bull trout in the Salmon basin share a genetic past with bull trout elsewhere in the Upper Snake Recovery Unit. Historically, the Upper Snake Recovery Unit is believed to have largely supported the fluvial life history form; however, many core areas are now isolated or have become fragmented watersheds, resulting in replacement of the fluvial life history with resident or adfluvial forms. The Weiser River, Squaw Creek, Pahsimeroi River, and North Fork Payette River core areas contain only resident populations of bull trout (USFWS 2015e, pp. E-1-2).

Salmon River

The Salmon River basin represents one of the few basins that are still free-flowing down to the Snake River. The core areas in the Salmon River basin do not have any major dams and a large extent (approximately 89 percent) is federally managed, with large portions of the Middle Fork Salmon River and Middle Fork Salmon River - Chamberlain core areas occurring within the Frank Church River of No Return Wilderness. Most core areas in the Salmon River basin contain large populations with many occupied stream segments. The Salmon River basin contains 10 of the 22 core areas in the Upper Snake Recovery Unit and contains the majority of the occupied habitat. Over 70 percent of occupied habitat in the Upper Snake Recovery Unit occurs in the Salmon River basin as well as 123 of the 206 local populations. Connectivity between core areas in the Salmon River basin is intact; therefore it is possible for fish in the mainstem Salmon to migrate to almost any Salmon River core area or even the Snake River.

¹⁶ Adfluvial: Life history pattern of spawning and rearing in tributary streams and migrating to lakes or reservoirs to mature.

¹⁷ Fluvial: Life history pattern of spawning and rearing in tributary streams and migrating to larger rivers to mature.

Connectivity within Salmon River basin core areas is mostly intact except for the Pahsimeroi River and portions of the Lemhi River. The Upper Salmon River, Lake Creek, and Opal Lake core areas contain adfluvial populations of bull trout, while most of the remaining core areas contain fluvial populations; only the Pahsimeroi contains strictly resident populations. Most core areas appear to have increasing or stable trends but trends are not known in the Pahsimeroi, Lake Creek, or Opal Lake core areas. The Idaho Department of Fish and Game reported trend data from 7 of the 10 core areas. This trend data indicated that populations were stable or increasing in the Upper Salmon River, Lemhi River, Middle Salmon River-Chamberlain, Little Lost River, and the South Fork Salmon River (High et al. 2008). Trends were stable or decreasing in the Little-Lower Salmon River, Middle Fork Salmon River, and the Middle Salmon River-Panther (High et al. 2008).

Boise River

In the Boise River basin, two large dams are impassable barriers to upstream fish movement: Anderson Ranch Dam on the South Fork Boise River, and Arrowrock Dam on the mainstem Boise River. Fish in Anderson Ranch Reservoir have access to the South Fork Boise River upstream of the dam. Fish in Arrowrock Reservoir have access to the North Fork Boise River, Middle Fork Boise River, and lower South Fork Boise River. The Boise River basin contains 2 of the 22 core areas in the Upper Snake Recovery Unit. The core areas in the Boise River basin account for roughly 12 percent of occupied habitat in the Upper Snake Recovery Unit and contain 29 of the 206 local populations. Approximately 90 percent of both Arrowrock and Anderson Ranch core areas are federally owned; most lands are managed by the Forest Service, with some portions occurring in designated wilderness areas. Both the Arrowrock core area and the Anderson Ranch core area are isolated from other core areas. Both core areas contain fluvial bull trout that exhibit adfluvial characteristics and numerous resident populations. The Idaho Department of Fish and Game in 2014 determined that the Anderson Ranch core area had an increasing trend while trends in the Arrowrock core area is unknown (USFWS 2015e).

Payette River

The Payette River basin contains three major dams that are impassable barriers to fish: Deadwood Dam on the Deadwood River, Cascade Dam on the North Fork Payette River, and Black Canyon Reservoir on the Payette River. Only the Upper South Fork Payette River and the Middle Fork Payette River still have connectivity, the remaining core areas are isolated from each other due to dams. Both fluvial and adfluvial life history expression are still present in the Payette River basin but only resident populations are present in the Squaw Creek and North Fork Payette River core areas. The Payette River basin contains 5 of the 22 core areas and 25 of the 206 local populations in the recovery unit. Less than 9 percent of occupied habitat in the recovery unit is in this basin. Approximately 60 percent of the lands in the core areas are federally owned and the majority is managed by the Forest Service. Trend data are lacking and the current condition of the various core areas is unknown, but there is concern due to the current isolation of three (North Fork Payette River, Squaw Creek, Deadwood River) of the five core areas; the presence of only resident local populations in two (North Fork Payette River, Squaw Creek) of the five core areas; and the relatively low numbers present in the North Fork core area (USFWS 2015e, p. E-8).

Jarbridge River

The Jarbridge River core area contains two major fish barriers along the Bruneau River: the Buckaroo diversion and C. J. Strike Reservoir. Bull trout are not known to migrate down to the Snake River. There is one core area in the basin, with populations in the Jarbridge River; this watershed does not contain any barriers. Approximately 89 percent of the Jarbridge core area is federally owned. Most lands are managed by either the Forest Service or Bureau of Land Management. A large portion of the core area is within the Bruneau-Jarbridge Wilderness area. A tracking study has documented bull trout population connectivity among many of the local populations, in particular between West Fork Jarbridge River and Pine Creek. Movement between the East and West Fork Jarbridge River has also been documented; therefore both resident and fluvial populations are present. The core area contains six local populations and 3 percent of the occupied habitat in the recovery unit. Trend data are lacking within this core area (USFWS 2015e, p. E-9).

Little Lost River

The Little Lost River basin is unique in that the watershed is within a naturally occurring hydrologic sink and has no connectivity with other drainages. A small fluvial population of bull trout may still exist, but it appears that most populations are predominantly resident populations. There is one core area in the Little Lost basin, and approximately 89 percent of it is federally owned by either the Forest Service or Bureau of Land Management. The core area contains 10 local populations and less than 3 percent of the occupied habitat in the recovery unit. The current trend condition of this core area is likely stable, with most bull trout residing in Upper Sawmill Canyon (IDFG 2014).

Malheur River

The Malheur River basin contains major dams that are impassable to fish. The largest are Warm Springs Dam, impounding Warm Springs Reservoir on the mainstem Malheur River, and Agency Valley Dam, impounding Beulah Reservoir on the North Fork Malheur. The dams result in two core areas that are isolated from each other and from other core areas. Local populations in the two core areas are limited to habitat in the upper watersheds. The Malheur River basin contains 2 of the 22 core areas and 8 of the 206 local populations in the recovery unit. Fluvial and resident populations are present in both core areas while adfluvial populations are present in the North Fork Malheur. This basin contains less than 3 percent of the occupied habitat in the recovery unit, and approximately 60 percent of lands in the two core areas are federally owned. Trend data indicates that populations are declining in both core areas (USFWS 2015e, p. E-9).

Weiser River

The Weiser River basin contains local populations that are limited to habitat in the upper watersheds. The Weiser River basin contains only a single core area that consists of 5 of the 206 local populations in the recovery unit. Local populations occur in only three stream complexes in the upper watershed: 1) Upper Hornet Creek, 2) East Fork Weiser River, and 3) Upper Little Weiser River. These local populations include only resident life histories. This basin contains

less than 2 percent of the occupied habitat in the recovery unit, and approximately 44 percent of lands are federally owned. Trend data from the Idaho Department of Fish and Game indicate that the populations in the Weiser core area are increasing (IDFG 2014) but it is considered vulnerable because local populations are isolated and likely do not express migratory life histories (USFWS 2015e, p.E-10).

St. Mary Recovery Unit

The Saint Mary Recovery Unit is located in northwest Montana east of the Continental Divide and includes the U.S. portions of the Saint Mary River basin, from its headwaters to the international boundary with Canada at the 49th parallel. The watershed and the bull trout population are linked to downstream aquatic resources in southern Alberta, Canada; the U.S. portion includes headwater spawning and rearing (SR) habitat in the tributaries and a portion of the foraging, migrating, and overwintering (FMO) habitat in the mainstem of the Saint Mary River and Saint Mary lakes (Mogen and Kaeding 2001).

The Saint Mary Recovery Unit comprises four core areas; only one (Saint Mary River) is a complex core area with five described local bull trout populations (Divide, Boulder, Kennedy, Otatso, and Lee Creeks). Roughly half of the linear extent of available FMO habitat in the mainstem Saint Mary system (between Saint Mary Falls at the upstream end and the downstream Canadian border) is comprised of Saint Mary and Lower Saint Mary Lakes, with the remainder in the Saint Mary River. The other three core areas (Slide Lakes, Cracker Lake, and Red Eagle Lake) are simple core areas. Slide Lakes and Cracker Lake occur upstream of seasonal or permanent barriers and are comprised of genetically isolated single local bull trout populations, wholly within Glacier National Park, Montana. In the case of Red Eagle Lake, physical isolation does not occur, but consistent with other lakes in the adjacent Columbia Headwaters Recovery Unit, there is likely some degree of spatial separation from downstream Saint Mary Lake. As noted, the extent of isolation has been identified as a research need (USFWS 2015f, p. F-1).

Bull trout in the Saint Mary River complex core area are documented to exhibit primarily the migratory fluvial life history form (Mogen and Kaeding 2005a, 2005b), but there is doubtless some occupancy (though less well documented) of Saint Mary Lakes, suggesting a partly adfluvial adaptation. Since lake trout and northern pike are both native to the Saint Mary River system (headwaters of the South Saskatchewan River drainage draining to Hudson Bay), the conventional wisdom is that these large piscivores historically outcompeted bull trout in the lacustrine environment (Donald and Alger 1993, Martinez et al. 2009), resulting in a primarily fluvial niche and existence for bull trout in this system. This is an untested hypothesis and additional research into this aspect is needed (USFWS 2015f, p. F-3).

Bull trout populations in the simple core areas of the three headwater lake systems (Slide, Cracker, and Red Eagle Lakes) are, by definition, adfluvial; there are also resident life history components in portions of the Saint Mary River system such as Lower Otatso Creek (Mogen and Kaeding 2005a), further exemplifying the overall life history diversity typical of bull trout. Mogen and Kaeding (2001) reported that bull trout continue to inhabit nearly all suitable habitats accessible to them in the Saint Mary River basin in the United States. The possible exception is portions of Divide Creek, which appears to be intermittently occupied despite a lack of

permanent migratory barriers, possibly due to low population size and erratic year class production (USFWS 2015f, p. F-3).

It should be noted that bull trout are found in minor portions of two additional U.S. watersheds (Belly and Waterton rivers) that were once included in the original draft recovery plan (USFWS 2002a) but are no longer considered core areas in the final recovery plan (USFWS 2015a) and are not addressed in that document. In Alberta, Canada, the Saint Mary River bull trout population is considered at “high risk,” while the Belly River is rated as “at risk” (ACA 2009). In the Belly River drainage, which enters the South Saskatchewan system downstream of the Saint Mary River in Alberta, some bull trout spawning is known to occur on either side of the international boundary. These waters are in the drainage immediately west of the Saint Mary River headwaters. However, the U.S. range of this population constitutes only a minor headwater migratory SR segment of an otherwise wholly Canadian population, extending less than 1 mile (0.6 km) into backcountry waters of Glacier National Park. The Belly River population is otherwise totally dependent on management within Canadian jurisdiction, with no natural migratory connection to the Saint Mary (USFWS 2015f, p. F-3).

Current status of bull trout in the Saint Mary River core area (U.S.) is considered strong (Mogen 2013). Migratory bull trout redd counts are conducted annually in the two major SR streams, Boulder and Kennedy creeks. Boulder Creek redd counts have ranged from 33 to 66 in the past decade, with the last 4 counts all 53 or higher. Kennedy Creek redd counts are less robust, ranging from 5 to 25 over the last decade, with a 2014 count of 20 (USFWS 2015f, p. F-3).

Generally, the demographic status of the Saint Mary River core area is believed to be good, with the exception of the Divide Creek local population. In this local population, there is evidence that a combination of ongoing habitat manipulation (Smillie and Ellerbroek 1991, F-5 NPS 1992) resulting in occasional historical passage issues, combined with low and erratic recruitment (DeHaan et al. 2011) has caused concern for the continuing existence of the local population.

While less is known about the demographic status of the three simple cores where redd counts are not conducted, all three appear to be self-sustaining and fluctuating within known historical population demographic bounds. Of the three simple core areas, demographic status in Slide Lakes and Cracker Lake appear to be functioning appropriately, but the demographic status in Red Eagle Lake is less well documented and believed to be less robust (USFWS 2015f, p. F-3).

Reasons for Listing

Bull trout distribution, abundance, and habitat quality have declined rangewide (Bond 1992, pp. 2-3; Schill 1992, p. 42; Thomas 1992, entire; Ziller 1992, entire; Rieman and McIntyre 1993, p. 1; Newton and Pribyl 1994, pp. 4-5; McPhail and Baxter 1996, p. 1). Several local extirpations have been documented, beginning in the 1950s (Rode 1990, pp. 26-32; Ratliff and Howell 1992, entire; Donald and Alger 1993, entire; Goetz 1994, p. 1; Newton and Pribyl 1994, pp. 8-9; Light et al. 1996, pp. 6-7; Buchanan et al. 1997, p. 15; WDFW 1998, pp. 2-3). Bull trout were extirpated from the southernmost portion of their historic range, the McCloud River in California, around 1975 (Rode 1990, p. 32). Bull trout have been functionally extirpated (i.e., few individuals may occur there but do not constitute a viable population) in the Coeur d'Alene

River basin in Idaho and in the Lake Chelan and Okanogan River basins in Washington (USFWS 1999a, pp. 31651-31652).

These declines result from the combined effects of habitat degradation and fragmentation, the blockage of migratory corridors; poor water quality, angler harvest and poaching, entrainment (process by which aquatic organisms are pulled through a diversion or other device) into diversion channels and dams, and introduced nonnative species. Specific land and water management activities that depress bull trout populations and degrade habitat include the effects of dams and other diversion structures, forest management practices, livestock grazing, agriculture, agricultural diversions, road construction and maintenance, mining, and urban and rural development (Beschta et al. 1987, entire; Chamberlain et al. 1991, entire; Furniss et al. 1991, entire; Meehan 1991, entire; Nehlsen et al. 1991, entire; Sedell and Everest 1991, entire; Craig and Wissmar 1993pp, 18-19; Henjum et al. 1994, pp. 5-6; McIntosh et al. 1994, entire; Wissmar et al. 1994, entire; MBTSG 1995a, p. 1; MBTSG 1995b, pp. i-ii; MBTSG 1995c, pp. i-ii; MBTSG 1995d, p. 22; MBTSG 1995e, p. i; MBTSG 1996a, p. i-ii; MBTSG 1996b, p. i; MBTSG 1996c, p. i; MBTSG 1996d, p. i; MBTSG 1996e, p. i; MBTSG 1996f, p. 11; Light et al. 1996, pp. 6-7; USDA and USDI 1995, p. 2).

Emerging Threats

Climate Change

Climate change was not addressed as a known threat when bull trout was listed. The 2015 bull trout recovery plan and RUIPs summarize the threat of climate change and acknowledges that some extant bull trout core area habitats will likely change (and may be lost) over time due to anthropogenic climate change effects, and use of best available information will ensure future conservation efforts that offer the greatest long-term benefit to sustain bull trout and their required coldwater habitats (USFWS 2015, p. vii, and pp. 17-20, USFWS 2015a-f).

Global climate change and the related warming of global climate have been well documented (IPCC 2007, entire; ISAB 2007, entire; Combes 2003, entire). Evidence of global climate change/warming includes widespread increases in average air and ocean temperatures and accelerated melting of glaciers, and rising sea level. Given the increasing certainty that climate change is occurring and is accelerating (IPCC 2007, p. 253; Battin et al. 2007, p. 6720), we can no longer assume that climate conditions in the future will resemble those in the past.

Patterns consistent with changes in climate have already been observed in the range of many species and in a wide range of environmental trends (ISAB 2007, entire; Hari et al. 2006, entire; Rieman et al. 2007, entire). In the northern hemisphere, the duration of ice cover over lakes and rivers has decreased by almost 20 days since the mid-1800's (Magnuson et al. 2000, p. 1743). The range of many species has shifted poleward and elevationally upward. For cold-water associated salmonids in mountainous regions, where their upper distribution is often limited by impassable barriers, an upward thermal shift in suitable habitat can result in a reduction in range, which in turn can lead to a population decline (Hari et al. 2006, entire).

In the Pacific Northwest, most models project warmer air temperatures and increases in winter precipitation and decreases in summer precipitation. Warmer temperatures will lead to more precipitation falling as rain rather than snow. As the seasonal amount of snow pack diminishes, the timing and volume of stream flow are likely to change and peak river flows are likely to increase in affected areas. Higher air temperatures are also likely to increase water temperatures (ISAB 2007, pp. 15-17). For example, stream gauge data from western Washington over the past 5 to 25 years indicate a marked increasing trend in water temperatures in most major rivers.

Climate change has the potential to profoundly alter the aquatic ecosystems upon which the bull trout depends via alterations in water yield, peak flows, and stream temperature, and an increase in the frequency and magnitude of catastrophic wildfires in adjacent terrestrial habitats (Bisson et al. 2003, pp 216-217).

All life stages of the bull trout rely on cold water. Increasing air temperatures are likely to impact the availability of suitable cold water habitat. For example, ground water temperature is generally correlated with mean annual air temperature, and has been shown to strongly influence the distribution of other chars. Ground water temperature is linked to bull trout selection of spawning sites, and has been shown to influence the survival of embryos and early juvenile rearing of bull trout (Baxter 1997, p. 82). Increases in air temperature are likely to be reflected in increases in both surface and groundwater temperatures.

Climate change is likely to affect the frequency and magnitude of fires, especially in warmer drier areas such as are found on the eastside of the Cascade Mountains. Bisson et al. (2003, pp. 216-217) note that the forest that naturally occurred in a particular area may or may not be the forest that will be responding to the fire regimes of an altered climate. In several studies related to the effect of large fires on bull trout populations, bull trout appear to have adapted to past fire disturbances through mechanisms such as dispersal and plasticity. However, as stated earlier, the future may well be different than the past and extreme fire events may have a dramatic effect on bull trout and other aquatic species, especially in the context of continued habitat loss, simplification and fragmentation of aquatic systems, and the introduction and expansion of exotic species (Bisson et al. 2003, pp. 218-219).

Migratory bull trout can be found in lakes, large rivers and marine waters. Effects of climate change on lakes are likely to impact migratory adfluvial bull trout that seasonally rely upon lakes for their greater availability of prey and access to tributaries. Climate-warming impacts to lakes will likely lead to longer periods of thermal stratification and coldwater fish such as adfluvial bull trout will be restricted to these bottom layers for greater periods of time. Deeper thermoclines resulting from climate change may further reduce the area of suitable temperatures in the bottom layers and intensify competition for food (Shuter and Meisner 1992. p. 11).

Bull trout require very cold water for spawning and incubation. Suitable spawning habitat is often found in accessible higher elevation tributaries and headwaters of rivers. However, impacts on hydrology associated with climate change are related to shifts in timing, magnitude and distribution of peak flows that are also likely to be most pronounced in these high elevation stream basins (Battin et al. 2007, p. 6720). The increased magnitude of winter peak flows in high elevation areas is likely to impact the location, timing, and success of spawning and

incubation for the bull trout and Pacific salmon species. Although lower elevation river reaches are not expected to experience as severe an impact from alterations in stream hydrology, they are unlikely to provide suitably cold temperatures for bull trout spawning, incubation and juvenile rearing.

As climate change progresses and stream temperatures warm, thermal refugia will be critical to the persistence of many bull trout populations. Thermal refugia are important for providing bull trout with patches of suitable habitat during migration through or to make feeding forays into areas with greater than optimal temperatures.

There is still a great deal of uncertainty associated with predictions relative to the timing, location, and magnitude of future climate change. It is also likely that the intensity of effects will vary by region (ISAB 2007, p 7) although the scale of that variation may exceed that of States. For example, several studies indicate that climate change has the potential to impact ecosystems in nearly all streams throughout the State of Washington (ISAB 2007, p. 13; Battin et al. 2007, p. 6722; Rieman et al. 2007, pp. 1558-1561). In streams and rivers with temperatures approaching or at the upper limit of allowable water temperatures, there is little if any likelihood that bull trout will be able to adapt to or avoid the effects of climate change/warming. There is little doubt that climate change is and will be an important factor affecting bull trout distribution. As its distribution contracts, patch size decreases and connectivity is truncated, bull trout populations that may be currently connected may face increasing isolation, which could accelerate the rate of local extinction beyond that resulting from changes in stream temperature alone (Rieman et al. 2007, pp. 1559-1560). Due to variations in land form and geographic location across the range of the bull trout, it appears that some populations face higher risks than others. Bull trout in areas with currently degraded water temperatures and/or at the southern edge of its range may already be at risk of adverse impacts from current as well as future climate change.

The ability to assign the effects of gradual global climate change to bull trout or to a specific location on the ground is beyond our technical capabilities at this time.

Conservation

Conservation Needs

The 2015 recovery plan for bull trout established the primary strategy for recovery of bull trout in the coterminous United States: (1) conserve bull trout so that they are geographically widespread across representative habitats and demographically stable¹ in six recovery units; (2) effectively manage and ameliorate the primary threats in each of six recovery units at the core area scale such that bull trout are not likely to become endangered in the foreseeable future; (3) build upon the numerous and ongoing conservation actions implemented on behalf of bull trout since their listing in 1999, and improve our understanding of how various threat factors potentially affect the species; (4) use that information to work cooperatively with our partners to design, fund, prioritize, and implement effective conservation actions in those areas that offer the greatest long-term benefit to sustain bull trout and where recovery can be achieved; and (5) apply

adaptive management principles to implementing the bull trout recovery program to account for new information (USFWS 2015, p. v.).

Information presented in prior draft recovery plans published in 2002 and 2004 (USFWS 2002a, 2004, 2004a) have served to identify recovery actions across the range of the species and to provide a framework for implementing numerous recovery actions by our partner agencies, local working groups, and others with an interest in bull trout conservation.

The 2015 recovery plan (USFWS 2015) integrates new information collected since the 1999 listing regarding bull trout life history, distribution, demographics, conservation successes, etc., and integrates and updates previous bull trout recovery planning efforts across the range of the single DPS listed under the Act.

The Service has developed a recovery approach that: (1) focuses on the identification of and effective management of known and remaining threat factors to bull trout in each core area; (2) acknowledges that some extant bull trout core area habitats will likely change (and may be lost) over time; and (3) identifies and focuses recovery actions in those areas where success is likely to meet our goal of ensuring the certainty of conservation of genetic diversity, life history features, and broad geographical representation of remaining bull trout populations so that the protections of the Act are no longer necessary (USFWS 2015, p. 45-46).

To implement the recovery strategy, the 2015 recovery plan establishes categories of recovery actions for each of the six Recovery Units (USFWS 2015, p. 50-51):

1. Protect, restore, and maintain suitable habitat conditions for bull trout.
2. Minimize demographic threats to bull trout by restoring connectivity or populations where appropriate to promote diverse life history strategies and conserve genetic diversity.
3. Prevent and reduce negative effects of nonnative fishes and other nonnative taxa on bull trout.
4. Work with partners to conduct research and monitoring to implement and evaluate bull trout recovery activities, consistent with an adaptive management approach using feedback from implemented, site-specific recovery tasks, and considering the effects of climate change.

Bull trout recovery is based on a geographical hierarchical approach. Bull trout are listed as a single DPS within the five-state area of the coterminous United States. The single DPS is subdivided into six biologically-based recovery units: (1) Coastal Recovery Unit; (2) Klamath Recovery Unit; (3) Mid-Columbia Recovery Unit; (4) Upper Snake Recovery Unit; (5) Columbia Headwaters Recovery Unit; and (6) Saint Mary Recovery Unit (USFWS 2015, p. 23). A viable recovery unit should demonstrate that the three primary principles of biodiversity have been met: representation (conserving the genetic makeup of the species); resiliency (ensuring that each population is sufficiently large to withstand stochastic events); and redundancy (ensuring a sufficient number of populations to withstand catastrophic events) (USFWS 2015, p. 33).

Each of the six recovery units contain multiple bull trout core areas, 116 total, which are non-overlapping watershed-based polygons, and each core area includes one or more local populations. Currently there are 109 occupied core areas, which comprise 611 local populations

(USFWS 2015, p. 3). There are also six core areas where bull trout historically occurred but are now extirpated, and one research needs area where bull trout were known to occur historically, but their current presence and use of the area are uncertain (USFWS 2015, p. 3). Core areas can be further described as complex or simple (USFWS 2015, p. 3-4). Complex core areas contain multiple local bull trout populations, are found in large watersheds, have multiple life history forms, and have migratory connectivity between spawning and rearing habitat and foraging, migration, and overwintering habitats (FMO). Simple core areas are those that contain one bull trout local population. Simple core areas are small in scope, isolated from other core areas by natural barriers, and may contain unique genetic or life history adaptations.

A local population is a group of bull trout that spawn within a particular stream or portion of a stream system (USFWS 2015, p. 73). A local population is considered to be the smallest group of fish that is known to represent an interacting reproductive unit. For most waters where specific information is lacking, a local population may be represented by a single headwater tributary or complex of headwater tributaries. Gene flow may occur between local populations (e.g., those within a core population), but is assumed to be infrequent compared with that among individuals within a local population.

Population Units

The final recovery plan (USFWS 2015) designates six bull trout recovery units as described above. These units replace the 5 interim recovery units previously identified (USFWS 1999a). The Service will address the conservation of these final recovery units in our section 7(a)(2) analysis for proposed Federal actions. The recovery plan (USFWS 2015, identified threats and factors affecting the bull trout within these units. A detailed description of recovery implementation for each recovery unit is provided in separate recovery unit implementation plans (RUIPs)(USFWS 2015a-f), which identify conservation actions and recommendations needed for each core area, forage/ migration/ overwinter (FMO) areas, historical core areas, and research needs areas. Each of the following recovery units (below) 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.

Coastal Recovery Unit

The coastal recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015a). The Coastal Recovery Unit is located within western Oregon and Washington. The Coastal Recovery Unit is divided into three regions: Puget Sound, Olympic Peninsula, and the Lower Columbia River Regions. This recovery unit contains 20 core areas comprising 84 local populations and a single potential local population in the historic Clackamas River core area where bull trout had been extirpated and were reintroduced in 2011, and identified four historically occupied core areas that could be re-established (USFWS 2015, pg. 47; USFWS 2015a, p. A-2). Core areas within Puget Sound and the Olympic Peninsula currently support the only anadromous local populations of bull trout. This recovery unit also contains ten shared FMO habitats which are outside core areas and allows for the continued natural population dynamics in which the core areas have evolved (USFWS 2015a, p. A-5). There are four core

areas within the Coastal Recovery Unit that have been identified as current population strongholds: Lower Skagit, Upper Skagit, Quinault River, and Lower Deschutes River (USFWS 2015, p.79). These are the most stable and abundant bull trout populations in the recovery unit. The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change, loss of functioning estuarine and nearshore marine habitats, development and related impacts (e.g., flood control, floodplain disconnection, bank armoring, channel straightening, loss of instream habitat complexity), agriculture (e.g., diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation, livestock grazing), fish passage (e.g., dams, culverts, instream flows) residential development, urbanization, forest management practices (e.g., timber harvest and associated road building activities), connectivity impairment, mining, and the introduction of non-native species. Conservation measures or recovery actions implemented include relicensing of major hydropower facilities that have provided upstream and downstream fish passage or complete removal of dams, land acquisition to conserve bull trout habitat, floodplain restoration, culvert removal, riparian revegetation, levee setbacks, road removal, and projects to protect and restore important nearshore marine habitats.

Klamath Recovery Unit

The Klamath recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015a). The Klamath Recovery Unit is located in southern Oregon and northwestern California. The Klamath Recovery Unit is the most significantly imperiled recovery unit, having experienced considerable extirpation and geographic contraction of local populations and declining demographic condition, and natural re-colonization is constrained by dispersal barriers and presence of nonnative brook trout (USFWS 2015, p. 39). This recovery unit currently contains three core areas and eight local populations (USFWS 2015, p. 47; USFWS 2015b, p. B-1). Nine historic local populations of bull trout have become extirpated (USFWS 2015b, p. B-1). All three core areas have been isolated from other bull trout populations for the past 10,000 years (USFWS 2015b, p. B-3). The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change, habitat degradation and fragmentation, past and present land use practices, agricultural water diversions, nonnative species, and past fisheries management practices. Conservation measures or recovery actions implemented include removal of nonnative fish (e.g., brook trout, brown trout, and hybrids), acquiring water rights for instream flows, replacing diversion structures, installing fish screens, constructing bypass channels, installing riparian fencing, culver replacement, and habitat restoration.

Mid-Columbia Recovery Unit

The Mid-Columbia recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015c). The Mid-Columbia Recovery Unit is located within eastern Washington, eastern Oregon, and portions of central Idaho. The Mid-Columbia Recovery Unit is divided into four geographic regions: Lower Mid-Columbia, Upper Mid-Columbia, Lower Snake, and Mid-Snake Geographic Regions. This recovery unit contains 24 occupied core areas comprising 142 local populations, two historically occupied core areas, one research needs area, and seven FMO habitats (USFWS

2015, pg. 47; USFWS 2015c, p. C-1–4). The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change, agricultural practices (e.g. irrigation, water withdrawals, livestock grazing), fish passage (e.g. dams, culverts), nonnative species, forest management practices, and mining. Conservation measures or recovery actions implemented include road removal, channel restoration, mine reclamation, improved grazing management, removal of fish barriers, and instream flow requirements.

Columbia Headwaters Recovery Unit

The Columbia headwaters recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015d, entire). The Columbia Headwaters Recovery Unit is located in western Montana, northern Idaho, and the northeastern corner of Washington. The Columbia Headwaters Recovery Unit is divided into five geographic regions: Upper Clark Fork, Lower Clark Fork, Flathead, Kootenai, and Coeur d'Alene Geographic Regions (USFWS 2015d, pp. D-2 – D-4). This recovery unit contains 35 bull trout core areas; 15 of which are complex core areas as they represent larger interconnected habitats and 20 simple core areas as they are isolated headwater lakes with single local populations. The 20 simple core areas are each represented by a single local population, many of which may have persisted for thousands of years despite small populations and isolated existence (USFWS 2015d, p. D-1). Fish passage improvements within the recovery unit have reconnected some previously fragmented habitats (USFWS 2015d, p. D-1), while others remain fragmented. Unlike the other recovery units in Washington, Idaho and Oregon, the Columbia Headwaters Recovery Unit does not have any anadromous fish overlap. Therefore, bull trout within the Columbia Headwaters Recovery Unit do not benefit from the recovery actions for salmon (USFWS 2015d, p. D-41). The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change, mostly historical mining and contamination by heavy metals, expanding populations of nonnative fish predators and competitors, modified instream flows, migratory barriers (e.g., dams), habitat fragmentation, forest practices (e.g., logging, roads), agriculture practices (e.g. irrigation, livestock grazing), and residential development. Conservation measures or recovery actions implemented include habitat improvement, fish passage, and removal of nonnative species.

Upper Snake Recovery Unit

The Upper Snake recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015e, entire). The Upper Snake Recovery Unit is located in central Idaho, northern Nevada, and eastern Oregon. The Upper Snake Recovery Unit is divided into seven geographic regions: Salmon River, Boise River, Payette River, Little Lost River, Malheur River, Jarbidge River, and Weiser River. This recovery unit contains 22 core areas and 207 local populations (USFWS 2015, p. 47), with almost 60 percent being present in the Salmon River Region. The current condition of the bull trout in this recovery unit is attributed to the adverse effects of climate change; dams, mining, forest management practices, nonnative species, and agriculture (e.g., water diversions, grazing). Conservation measures or recovery actions implemented include

instream habitat restoration, instream flow requirements, screening of irrigation diversions, and riparian restoration.

St. Mary Recovery Unit

The St. Mary recovery unit implementation plan describes the threats to bull trout and the site-specific management actions necessary for recovery of the species within the unit (USFWS 2015f). The Saint Mary Recovery Unit is located in Montana but is heavily linked to downstream resources in southern Alberta, Canada. Most of the Saskatchewan River watershed which the St. Mary flows into is located in Canada. The United States portion includes headwater spawning and rearing habitat and the upper reaches of FMO habitat. This recovery unit contains four core areas, and seven local populations (USFWS 2015f, p. F-1) in the U.S. Headwaters. The current condition of the bull trout in this recovery unit is attributed primarily to the outdated design and operations of the Saint Mary Diversion operated by the Bureau of Reclamation (e.g., entrainment, fish passage, instream flows), and, to a lesser extent habitat impacts from development and nonnative species.

Tribal Conservation Activities

Many Tribes throughout the range of the bull trout are participating on bull trout conservation working groups or recovery teams in their geographic areas of interest. Some tribes are also implementing projects which focus on bull trout or that address anadromous fish but benefit bull trout (e.g., habitat surveys, passage at dams and diversions, habitat improvement, and movement studies).

2.3 Status of Bull Trout Critical Habitat

2.3.1 Current legal status of critical habitat

Current Designation

The Service published a final critical habitat designation for the coterminous United States population of the bull trout on October 18, 2010 (USFWS 2010a, entire); the rule became 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 Coastal, Klamath, Mid-Columbia, Upper Snake, Columbia Headwaters and St. Mary's Recovery Unit population segments. Rangewide, the Service designated reservoirs/lakes and stream/shoreline miles as bull trout critical habitat (Table 4). Designated bull trout critical habitat is of two primary use types: 1) spawning and rearing, and 2) foraging, migration, and overwintering (FMO).

Table 4. Stream/Shoreline Distance and Reservoir/Lake Area Designated as Bull Trout Critical Habitat.

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

State	Stream/Shoreline Miles	Stream/Shoreline Kilometers	Reservoir/Lake Acres	Reservoir/Lake Hectares
Montana	3,056.5	4,918.9	221,470.7	89,626.4
Nevada	71.8	115.6	-	-
Oregon ¹	2,835.9	4,563.9	30,255.5	12,244.0
Oregon/Idaho ²	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 ³	19,729.0	31,750.8	488,251.7	197,589.2

¹No shore line is included in Oregon

²Pine Creek Drainage which falls within Oregon

³Total of freshwater streams: 18,975

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.

The final 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 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 (USFWS 2010a, p. 63903). 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. 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.

2.3.2 The Physical and Biological Features (PBFs)

Conservation Role and Description of Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (USFWS 2010a, p. 63898). 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 physical and biological features (PBFs) 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).

Physical and Biological Features for Bull Trout

Within the designated critical habitat areas, the PBFs 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 PBFs, as described within the revised designation of critical habitat for bull trout in the coterminous United States (USFWS 2010a), are essential for the conservation of bull trout. A summary of those PBFs follows.

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, 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 PBF's are similar to those previously in effect under the 2005 designation. The most significant modification is the addition of a ninth PBF to address the presence of nonnative predatory or competitive fish species. Although this PBF 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 PBFs 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 PBFs 1 and 6. Additionally, all except PBF 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 PBFs 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 PBFs to such an extent that the conservation value of critical habitat is appreciably reduced (USFWS 2010a, pp. 63898:63943; USFWS 2004a, pp. 140-193; USFWS 2004b, 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, Ch. 4 p. 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 (USFWS 2010a, pp. 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 (USFWS 2010a, pp. 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 (Ratliff and Howell 1992, entire; Schill 1992, p. 40; Thomas 1992, p. 28; Buchanan et al. 1997, p. vii; Rieman et al. 1997, pp. 15-16; Quigley and Arbelbide 1997, pp. 1176-1177). 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 (USFWS 1999a, pp. 31648-31649; USFWS 1999b, p. 17111).

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 PBFs, 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 and McIntyre 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 PBFs 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).

Many of the PBFs for bull trout may be affected by the presence of toxics and/or increased water temperatures within the environment. The effects will vary greatly depending on a number of factors which include which toxic substance is present, the amount of temperature increase, the likelihood that critical habitat would be affected (probability), and the severity and intensity of any effects that might occur (magnitude).

The ability to assign the effects of gradual global climate change bull trout critical habitat or to a specific location on the ground is beyond our technical capabilities at this time.

3.0 Environmental Baseline

The preamble to the implementing regulations for section 7 (51 FR 19932; third paragraph, left column) contemplates that the evaluation of "...the present environment in which the species or critical habitat exists, as well as the environment that will exist when the action is completed, in terms of the totality of factors affecting the species or critical habitat...will serve as the baseline for determining the effects of the action on the species or critical habitat." The regulations at 50 CFR 402.02 define the environmental baseline to include "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." The analyses presented in this section supplement the above *Status of the Species* and *Status of Critical Habitat* evaluations by focusing on the current condition of the bull trout and its critical habitat in the action area, the factors responsible for that condition (inclusive of the factors cited above in the regulatory definition of environmental baseline), and the role the action area plays in the survival and recovery of the bull trout and in the recovery support function of designated critical habitat. Relevant factors on lands surrounding the action area that are influencing the condition of the bull trout and its critical habitat were also considered in completing the status and baseline evaluations herein.

As previously noted, the action area of this programmatic consultation includes the Columbia River Basin in Oregon (see figure 1, section 1.5). As previously stated, the five recovery units (RUs) for bull trout in the coterminous U.S. include: 1) Saint Mary Belly; 2) Klamath; 3) Jarbidge; 4) Columbia River; and 5) Coastal. The action area of this programmatic consultation encompasses portions of the Coastal, Mid-Columbia, and Upper Snake RUs. The Status of the Species section (Section 2.2) provides a fairly comprehensive assessment of the environmental baseline of bull trout in these areas.

Among the most important of these are the combined effects of habitat degradation and fragmentation, the blockage of migratory corridors, poor water quality, angler harvest and poaching, and entrainment. Land management activities that contribute to habitat degradation and fragmentation include the recent and past effects from dams and other diversion structures, forest management practices, livestock grazing, agriculture, road construction and maintenance, mining, and urban and rural development. Climate change is likely to play an increasingly important role in determining the abundance of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest.

Bull trout are exposed to high rates of predation during all life stages. Nonnative fish are the main predators of juveniles and adults, however small mammals may also contribute. The included river basins have a diverse assemblage of native and introduced fish species, some of which prey on bull trout. The primary resident fish predators of bull trout in many areas of the State of Oregon inhabited by bull trout are brook trout (introduced), lake trout (introduced), brown trout (introduced), northern pike (introduced), smallmouth bass (introduced), and walleye (introduced). Increased predation by non-native predators has and continues to decrease population abundance and productivity.

Water quality throughout most of the program action area is degraded to various degrees because of contaminants that are harmful to bull trout considered in this consultation. Aerial deposition, discharges of treated effluents, and stormwater runoff from residential, commercial, industrial, agricultural, recreational, and transportation land uses are all source of these contaminants. For example, 4.7 million pounds of toxic chemicals were discharged into surface waters of the Columbia River Basin (a 39% decrease from 2003) and another 91.7 million pounds were discharged in the air and on land in 2011 (USEPA 2011b). This reduction can be attributed, in part, to significant state, local and private efforts to modernize and strengthen tools available to treat and manage stormwater runoff (USEPA 2009; USEPA 2011b).

The role of stormwater runoff in degrading water quality has been known for years but reducing that role has been notoriously difficult because the runoff is produced everywhere in the developed landscape, the production and delivery of runoff are episodic and difficult to attenuate, and runoff accumulates and transports much of the collective waste of the developed environment (NRC 2009). In most rivers in Oregon, the full spatial distribution and load of contaminants is not well understood. Hydrologically low-energy areas, where fine-grained sediment and associated contaminants settle, are more likely to have high water temperatures, concentrations of nitrogen and phosphorus that may promote algal blooms, and concentrations of aluminum, iron, copper, and lead that exceed ambient water quality criteria for chronic toxicity to aquatic life (Fuhrer et al. 1996). Even at extremely low levels, contaminants still make their way into salmonid tissues at levels that are likely to have sublethal and synergistic effects on individual bull trout, such as immune toxicity, reproductive toxicity, and growth inhibition (Baldwin et al. 2011; Carls and Meador 2009; Hicken et al. 2011; Johnson et al. 2013), that may be sufficient to reduce their survival and therefore the abundance and productivity of some populations (Baldwin et al. 2009; Spromberg and Meador 2006). The adverse effect of contaminants on aquatic life often increases with temperature because elevated temperatures accelerate metabolic processes and thus the penetration and harmful action of toxicants. The full presence of contaminants throughout the program action area is poorly understood, but the concentration of many increase in downstream reaches (Fuhrer et al. 1996; Johnson et al. 2013; Johnson et al. 2005; Morace 2012). The fate and transport of contaminants varies by type, but are all determined by similar biogeochemical processes (Alpers et al. 2000b; Alpers et al. 2000a; Bricker 1999; Chadwick et al. 2004; Johnson et al. 2005). After deposition, each contaminant typically processes between aqueous and solid phases, sorption and deposition into active or deep sediments, diffusion through interstitial pore space, and re-suspension into the water column. Uptake by benthic organisms, plankton, fish, or other species may occur at any stage except deep sediment, although contaminants in deep sediments become available for biotic uptake when re-suspended by dredging or other disturbances.

The existing highway system contributes to a poor environmental baseline condition in several significant ways. Many miles of highway that parallel streams have degraded stream bank conditions by armoring the banks with rip rap, degraded floodplain connectivity by adding fill to floodplains, and discharge untreated or marginally treated highway runoff to streams. Culvert and bridge stream crossings have similar effects, and create additional problems for fish when they act as physical or hydraulic barriers that prevent fish access to spawning or rearing habitat, or contribute to adverse stream morphological changes upstream and downstream of the crossing itself.

The environmental baseline includes the anticipated impacts of all Federal actions in the action area that have already undergone formal consultation. The USFWS has not previously consulted in a programmatic nature for Corps actions covered under this BO; however, NMFS has had multiple iterations of similar programmatic consultations for salmon and steelhead. While bull trout distribution and critical habitat is not as wide-ranging as some salmon and steelhead species, the consultations under NMFS SLOPES BOs may provide some insight into the scope and scale of Corps authorized actions, but to a lesser extent for bull trout. For example, from 2007 through 2012, the Corps authorized 280 restoration actions in Oregon under the NMFS SLOPES programmatic consultation and another 397 actions for construction, minor discharge, over- and in-water structures, transportation, streambank stabilization, surveys, and utility lines in habitat affecting ESA-listed fish species. The Corps, Bonneville Power Administration (BPA), and Bureau of Reclamation have consulted on large water management actions, such as operation of the Federal Columbia River Power System, the Umatilla Basin Project, and the Deschutes Project. The BIA, BLM, and the USFS have consulted on Federal land management throughout Oregon, including restoration actions, forest management, livestock grazing, and special use permits. The BPA, NOAA Restoration Center, and USFWS have also consulted on large restoration programs that consist of actions designed to address species limiting factors or make contributions that would aid in species recovery. Restoration actions may have short term adverse effects, but generally result in long-term improvements to habitat condition and population abundance, productivity, and spatial structure. After going through multiple individual consultations for ongoing actions covered by STU and IWOW, the USFWS has previously determined that these actions will have beneficial, neutral or negligible impacts on bull trout.

The precise project-level action area for each activity category is not yet known, so the current condition of fish or critical habitats in each project area, the factors responsible for that condition, and the conservation value of each site can only be partially described. Therefore, to complete the jeopardy and destruction or adverse modification of critical habitat analyses in this consultation, USFWS made the following assumptions regarding the environmental baseline conditions in specific areas where projects will be carried out consistent with the proposed action:

1. Projects will occur at sites where the biological requirements of individual fish bull trout are not being fully met due, in part, to the presence of impaired fish passage, floodplain fill, streambank degradation, or degraded channel or riparian conditions, or

2. Projects will occur at sites where the biological requirements of individual bull trout are not being met due to one or more impaired aquatic habitat functions related to any of the habitat factors limiting the recovery of the species in that area, or
Projects related to STU or IWOW actions will occur at sites where the biological requirements of bull trout or bull trout critical habitat may not be the driving force. The Corps proposed actions in these categories are related to construction of or maintenance of existing infrastructure due to human development and population growth, public safety, recreational related use, other natural resources management, or a combination of these factors.

4.0 Effects of the Action on the Species and Designated Critical Habitats

“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.

The actions covered by this Opinion have predictable effects. The USFWS has conducted individual and/or programmatic consultations on RES actions, STU actions, and IWOW actions similar to those in the proposed action throughout the action area over the past 15 years, and the information gained from monitoring and feedback has been applied by the USFWS, NMFS, USFS, USACE, BPA, and BLM to refine design criteria and conservation measures for this consultation.

This analysis begins with an overview of the scope of the different SLOPES BT actions, deconstructs the program and individual types of actions, then examines the general environmental impacts of each of those elements in detail before analyzing their combined impact on bull trout and designated critical habitat.

The RES addressed by this Opinion will all have long-term beneficial effects to bull trout and their habitat. These beneficial effects will improve three parameters: abundance, productivity of the fish populations, and spatial structure. These improvements will translate into decreased risk of extinction for bull trout. Restoration projects carried out in critical habitat will improve the condition of that habitat at the site and watershed scale. In watersheds where multiple restoration projects are carried out, greater improvement of the condition of critical habitat at the watershed scale will be realized. STU and IWOW actions will have less effect on bull trout and critical habitat at these scales, yet these types of project activities will be analyzed for effects.

Under the administrative portion of this action, the Corps will evaluate each individual action to ensure that the following conditions are complied with:

1. The PDC and this Opinion are applied where bull trout or their designated critical habitats, or both, are present;
2. the anticipated range of effects is within the range considered in this Opinion;
3. the action is carried out consistent with the PDC; and
4. action and program level monitoring and reporting requirements are met.

These procedures are a central part of the SLOPES program and function to ensure that individual projects covered by SLOPES BT and this Opinion remain within the scope of effects considered here, and to ensure that the aggregate or program-level effects of those individual projects are also accounted for. Activities that fall within the SLOPES BT proposed action, and otherwise comply with this Opinion and ITS do not require further consultation. Activities that do not meet these criteria, including those that are expressly identified as exclusions, are not covered by this Opinion, but can be the subject of individual consultations.

Construction of each action will begin after the Corps' approval. The discussion of the direct physical and chemical effects of this part of the action on the environment will vary depending on the type of action being performed, but will all be based on a common set of effects related to construction. Construction will have direct physical and chemical effects on the environment that commonly begin with pre-construction activity, such as surveying, minor vegetation clearing, and placement of stakes and flagging guides. This requires movement of personnel and sometimes machines over the action area. The next stage, site preparation, may require development of access roads, construction staging areas, and materials storage areas that affect more of the action area. If additional earthwork is necessary to clear, excavate, fill, or shape the site, more vegetation and topsoil may be removed, deeper soil layers exposed, and operations extended into the active channel. The final stage of construction is site restoration. This stage consists of any action necessary to undo disturbance caused by the action, may include replacement of LW, native vegetation, topsoil, and native channel material displaced by construction, and otherwise restoring ecosystem processes that form and maintain productive fish habitats.

The actions selected for this programmatic consultation all have predictable effects regardless of where on Federal, state, or private lands in the action area they are carried out. Most of the adverse effects from the proposed action are short-term in nature and are caused by construction activities or other management actions carried out in or adjacent to the stream. The physical, chemical, and biotic effects of each individual project the Corps authorizes under SLOPES BT will vary according to the number and type of elements present, although each element will share, in relevant part, a common set of effects related to pre-construction and construction (Darnell 1976; Spence et al. 1996), site restoration (Cramer et al. 2003; Cramer 2012), and operation and maintenance. USFWS assumes that every individual project will share some the effects described here in proportion to the project's complexity and footprint proximity to bull trout and critical habitat, but that no action will have effects that are greater than the full range of effects described here, because every action is based on the same set of underlying construction activities or elements, and each element is limited by the same design criteria. The duration of construction required to complete most projects will normally be less than one year, although significant fish passage projects may require additional in-water work or upland work to complete. Projects requiring an environmental impact statement pursuant to the National Environmental Policy Act would be ineligible for coverage under this consultation.

4.1 Effects of Near and Instream Construction

Fish passage will be provided for any adult or juvenile fish likely to be present in the action area during construction, unless passage did not exist before construction, stream isolation and

dewatering is required during project implementation, or where the stream reach is dry at the time of construction. When isolation and fish relocation are required, juvenile fish are likely to receive some mechanical injury during capture, holding, or release, and potential horizontal transmission of disease and pathogens and stress-related phenomena. All aspects of fish handling, such as dip netting, time out of water, and data collection (*e.g.*, measuring fish length), are stressful and can lead to immediate or delayed mortality (Murphy and Willis 1996). Electrofishing causes physiological stress and can cause physical injury or death, including cardiac or respiratory failure (Snyder 2003). There is also potential that some fish would be missed or stranded in substrate interstices after a site is dewatered. Although some ESA-listed fish will die during dewatering and relocation, fish will only be exposed to the stress caused by these activities once and the procedure is only expected to last a few hours. If construction took place without work area isolation, more fish would be injured or killed (NMFS 2013a).

Vegetation, soil and channel disturbance caused by construction can disrupt the vegetative and fluvial processes in the action area that create and maintain habitat function, such as delivery of wood, particulate organic matter, and shade to a riparian area and stream; development of root strength for slope and bank stability; and sediment filtering and nutrient absorption from runoff (Darnell 1976; Spence et al. 1996). Although the sizes of areas likely to be adversely affected by actions proposed to be funded or carried out under this Opinion are small, and those effects are likely to be short lived (weeks or months), even small denuded areas will lose organic matter and dissolved minerals, such as nitrates and phosphates. The microclimate at each action site where vegetation is removed is likely to become drier and warmer, with a corresponding increase in wind speed, and soil and water temperature. Water tables and spring flows (if present) in the immediate area are likely temporarily reduced. Loose soil will temporarily accumulate in the construction area. In dry weather, this soil is likely to be dispersed as dust and, in wet weather; loose soil will be transported to streams by erosion and runoff, particularly in steep areas.

Erosion and runoff during precipitation and snowmelt will increase the supply of sediment streams and rivers, where they will increase total suspended solids and sedimentation. Increased runoff also increases the frequency and duration of high stream flows and wetland inundation in construction areas. Higher stream flows increase stream energy that can scour stream bottoms and transport greater sediment loads farther downstream than would otherwise occur. Sediments in the water column reduce light penetration, and can increase water temperature and modify water chemistry. Redeposited sediments can fill pools, reduce the width to depth ratio of streams, and change the distribution of pools, riffles, and glides.

During dry weather, the physical effects of increased runoff will reduce ground water storage, lower stream flows, and lower wetland water levels. The combination of erosion and mineral loss can reduce soil quality and site fertility in upland and riparian areas. Concurrent in-water work can compact or dislodge channel sediments, thus increasing total suspended solids and allowing currents to transport sediment downstream where it will eventually be redeposited. Continued operations when the construction site is inundated can significantly increase the likelihood of severe erosion and contamination (NMFS 2013a).

Using heavy equipment for vegetation removal and earthwork will compact soils, reducing soil permeability and infiltration. The use of heavy equipment also creates a risk that accidental spills

of fuel, lubricants, hydraulic fluid, coolants, and other contaminants are likely to occur. Petroleum-based contaminants, such as fuel, oil, and some hydraulic fluids, contain polycyclic aromatic hydrocarbons (PAHs), which can be acutely toxic to fish and other aquatic organisms at high levels of exposure and can cause sublethal adverse effects to aquatic organisms at lower concentrations (Heintz et al. 1999; Incardona et al. 2005; Incardona et al. 2004; Incardona et al. 2006). The discharge of construction water used for vehicle washing, concrete washout, pumping for work area isolation, and other purposes can carry sediments and a variety of contaminants to riparian areas and streams. Cement is highly alkaline (commonly exceeding pH of 10) and can be harmful to aquatic life if not properly maintained on-site or treated prior to discharge. High pH effects on fish include death, damage to gills, eyes and skin; and inability to dispose of metabolic wastes (NMFS 2013a).

Some of these adverse effects will abate almost immediately, such as increased total suspended solids caused by boulder or LW placement. Others will create long-term conditions that decline quickly but persist at some level for weeks, months, or years, until riparian and floodplain vegetation are fully reestablished. Failure to complete site restoration, or to prevent disturbance of newly-restored areas by ungulates or unauthorized persons, will delay or prevent recovery of processes that form and maintain productive fish habitats (NMFS 2013a).

For actions that include a construction phase, the direct physical and chemical effects of site clean-up after construction is complete are essentially the reverse of the construction activities that go before it. Bare earth will be protected by various methods, including seeding, planting woody shrubs and trees, and mulching. This will dissipate erosive energy associated with precipitation and increase soil infiltration. It also will accelerate vegetative succession necessary to restore root strength necessary for slope and bank stability, delivery of leaf and other particulate organic matter to riparian areas and streams, shade, and sediment filtering and nutrient absorption from runoff. Microclimates will become cooler and moister, and wind speed will decrease. Whether recovery occurs over weeks, months or years, the disturbance frequency (*i.e.*, the number of restoration actions per unit of time, at any given site) is likely to be extremely low, as is the intensity of the disturbance as a function of the quantity and quality of overall habitat conditions present within an action area (NMFS 2013a).

Restoration of aquatic habitats is fundamentally about allowing stream systems to express their capacities, *i.e.*, the relief of human influences that have suppressed the development of desired habitat mosaics (Ebersole et al. 1997). The time necessary for recovery of functional habitat attributes sufficient to support species recovery following any disturbance, including construction necessary to complete a RES, will vary by the potential capacity of each habitat attribute. Recovery mechanisms such as soil stability, sediment filtering and nutrient absorption, and vegetation succession generally recover quickly (*i.e.*, months to years) after completion of the proposed actions. Recovery of functions related to wood recruitment and microclimate require decades or longer. Functions related to shading of the riparian area and stream, root strength for bank stabilization, and organic matter input generally require intermediate lengths of time.

The indirect effects or effectiveness of habitat restoration, in general, have not been well documented, in part because they often concentrate on instream habitat without addressing the

processes that led to the loss of the habitat (Cederholm et al. 1997; Roper et al. 1997; Simenstad and Thom 1996; Zedler 1996). Nonetheless, the careful, interagency process used by the Corps and other Action Agencies, along with cooperation with USFWS and NMFS, to develop proposed actions ensures that they are reasonably certain to lead to some degree of ecological recovery within each action area, including the establishment or restoration of environmental conditions associated with functional habitat and high conservation value.

Additionally, the Corps proposes a suite of conservation measures intended to reduce the short-term effects caused by near and instream construction. Limiting instream construction to low flow periods and using sediment control measures greatly reduces the amount of suspended sediment created by the PA. Refueling and servicing equipment outside the riparian area reduces the chance of spilling toxic fuels and lubricants. Development and implementation of a pollution and erosion control plan limit any potential adverse effects of a toxic material spill by ensuring that spill response materials are on site during all construction activities. Ensuring that all heavy equipment that will operate instream is cleaned and free of leaks will also reduce the introduction of contaminants into the aquatic environment. The Corps proposes several conservation measures to limit stress and mortality during work area isolation and fish relocation. Limiting in-water work activities to in-water work periods will greatly reduce the chance of affecting adult fish, as these periods are designated to avoid times when most adult fish are present.

4.2 Activity Category Specific Effects

Some of the individual project actions discussed below have similar effects whether they are carried out as a RES; STU; or IWOW action. These similar specific effects have been combined to address all effects, regardless of the activity category in which they fall.

1. Large Wood (LW), Boulder, and Gravel Placement; Porous Boulder Step Structures and Vanes; Engineered Logjams (ELJs); Tree Removal for LW Projects. Installation of wood and boulder instream structures is likely to require entry of personnel into the riparian area and channel which will result in unavoidable short-term construction related effects as described above, but will increase stream habitat complexity, increase overhead cover, increase terrestrial insect drop, and help reestablish natural hydraulic processes in streams over time. LW, in a stream, can accomplish multiple purposes by trapping gravel above the structure, creating pools and increasing the connection with the floodplain vegetation. Wood placement is likely to cause minor damage to riparian soil and vegetation, and minor disturbance of streambank or channel substrate. However, the intensity and duration of disturbance is unlikely to increase total suspended solids, or otherwise impair aquatic habitats or freshwater rearing and migration.

No matter where these activities occur on Federal lands in action area, we expect an increase in habitat functions, improvements to biological parameters, and a reduction in the risk of extinction to listed species. Numerous authors have highlighted the importance of LW to lotic ecosystems (Bilby 1984; Keller et al. 1985; Lassetre and Harris 2001; Spence et al. 1996), which influences channel morphology, traps and retains spawning gravels, and provides food for aquatic invertebrates that in turn provide food for bull trout. LW, boulders, and other structures provide hydraulic complexity and pool habitats that serve as resting and feeding stations for bull trout as they rear or migrate upstream to spawn (Spence et al. 1996).

Land management actions such as logging, road building, stream clearing, and splash damming carried out over the last 150 years have greatly reduced the amount of LW and boulders in streams in the action area (McIntosh et al. 1994; Murphy 1995). The Corps proposes this activity category to return these important elements to stream ecosystems. Addition of LW is a common and effective restoration technique used throughout the Pacific Northwest (Roni et al. 2002). Roni and Quinn (2001a) found that LW placement can lead to higher densities of juvenile coho salmon during summer and winter and higher densities of steelhead and cutthroat trout in the winter, and similar density increases can be said of bull trout. These authors also found that the addition of LW to streams with low levels of wood can lead to greater fish growth and less frequent and shorter fish movements (Roni and Quinn 2001b).

ELJs are an effective tool for restoring physical and biological conditions critical to salmonid recovery in large alluvial rivers. Placement of a single log can provide benefits in certain situations but a logjam typically provides more habitat value. This diverse bio-structure provides the base for different aquatic life to find food, shelter, and space to thrive. A logjam also changes water velocity and direction to sort gravels and creates pool and riffle habitat. On the Elwha River, ELJs have proved to be stable with little significant change in position or surface area noted despite frequent inundation from floods including two peak floods that rank within the top 10% of floods recorded for over 100 years of record. The ELJs have retarded bank erosion along two outside meanders. The ELJs have also helped maximize habitat area by partially balancing flows between two major channels. During flood flows, ELJs have increased exchange of water with floodplain surfaces, primarily through backwatering. This has resulted in the expansion of side-channel habitats, including groundwater fed channels that provide important habitats for multiple salmonid species. The ELJs developed scour pools, stored gravel, and reduced bed substrate grain size in the vicinity of several ELJs, with the mean particle size changing from large cobble to gravel. ELJs also had a measurable and significant positive effect on primary productivity, secondary productivity and juvenile fish populations (McHenry et al. 2007).

Live conifers and other trees can be felled or pulled/pushed over in the RRs, RHCAs, and upland areas for in-channel LW placement only when conifers and trees are fully stocked. This action would result in increased LW. If the riparian zone is fully stocked, the action would not likely result in increased sedimentation or an increase in stream temperature.

As with LW, the addition of boulders, gravel, and properly designed rock structures can help restore natural stream processes and provide cover for rearing bull trout. Boulders can accomplish the retention of gravel by physically intercepting the bed load or slowing the water, increase the interaction with the floodplain habitat by increasing the bed elevation and providing pool habitat. Boulders are most effective in high velocity or bedrock dominated streams. Roni et al. (2006) found that placement of boulder step structures in highly disturbed streams of Western Oregon led to increased pool area and increased abundance of trout and coho salmon. The addition of gravel in areas where it is lacking, such as below impoundments, will provide substrate for food organisms, fill voids in wood and boulder habitat structures to slow water and create pool habitat and provide spawning substrate for fish. Although little research has been conducted on the effectiveness of gravel augmentation in improving salmonid spawning, Merz and Chan (2005) found that gravel augmentation can result in increased macroinvertebrate densities and biomass, thus leading to more food for juvenile fishes.

The proposed design criteria and conservation measures ensure that the Action Agencies will place LW, boulders, and gravel in a natural manner to avoid unintended negative consequences. This activity category will result in numerous long-term beneficial effects including increased cover and resting areas for rearing and migrating fish and restoration of natural stream processes.

2. Fish Passage Restoration. The Corps aquatic restoration program of fish passage includes a broad range of activities to restore or improve juvenile and adult fish passage as described in the proposed action. Such projects will take place where fish passage has been partially or completely eliminated through road construction, stream degradation, creation of small dams and step structures, and irrigation diversions. Equipment such as excavators, bull dozers, dump trucks, front-end loaders and similar equipment may be used to implement such projects.

These activities usually require isolation of the work area from flowing water, relocation of fish, and significant instream construction. The construction-related effects described in the above section on restoration construction effects will occur at all culvert and bridge project sites. The Corps proposes to replace culverts and bridges using the stream simulation method when applicable, in which natural stream substrates will be placed in the bottom of these structures.

Under this activity category, artificial obstructions that block fish passage will be removed or replaced with facilities that restore or improve fish passage. The beneficial effects of this activity category include improved fish passage, restoration of natural bedload movement in streams, and restoration of tidal influence in estuarine areas. Removal of these structures requires instream construction with effects as described earlier. Culverts and bridges, other than stream simulation design crossings that meet the proposed action criteria, will require review and approval by USFWS.

Culverts and Bridges. Long-term beneficial effects of culvert and bridge replacement or removal projects include restoration of fish passage and restoration of natural stream channel processes through removal of channel constricting structures. Removing fish-passage blockages will restore spatial and temporal connectivity of streams within and between watersheds where fish movement is currently obstructed. This, in turn, will permit fish access to areas critical for fulfilling their life history requirements, especially foraging, spawning, and rearing. At a larger scale this will improve population spatial structure.

However, the removal of fish passage barriers could have short-term (typically lasting less than one week, depending on the duration of instream work), temporary effects to fish and their habitat. Heavy equipment might be used in the stream for unblocking, removing and replacing culverts and bridges. In-water equipment use could temporarily affect bull trout and critical habitat including: impacts on redds, smothered or crushed eggs and alevins (or larvae), increased suspended sediment and deposition, blocked migration, reduced foraging, and disrupted or disturbed overwintering behavior. The PDCs will help lessen the amount of sediment, and thus any associated adverse effects to bull trout. Bull trout are particularly vulnerable during the migration back to spawning areas during late summer and early fall, and when their resident life form is present in the project location. Bull trout would also be vulnerable during the spring,

when eggs and fry are still present in the substrate. The activities could move juveniles out of overwintering habitats such as side channels and deep pools, into inferior habitats or high velocity waters. Seasonal restrictions imposed by in-water work windows may lessen the effects to some degree in FMO habitat; however, they will not fully protect bull trout, and will provide little protection in SR habitat.

Fish passage impediments are common throughout the action area and restoration planning efforts have highlighted the need to restore fish passage, particularly when the blockage occurs low in a watershed.

Fish Screen Installation/Replacement. Unscreened or improperly screened irrigation diversion structures can entrain fish into canals where they become trapped and die. If approach velocities are too fast, fish can also be impinged against the screen surface. To avoid any effects from improperly designed screens, all proposed screen installations or replacements must meet NMFS fish passage criteria (NMFS 2011a). No additional water withdrawals points will be established and no greater rate or duty of water withdrawal will be authorized under this consultation.

Replacing, relocating, or constructing fish screens and irrigation diversions activities will require near or instream construction, so related effects as described above will occur. This consultation does not consider the effects of stream flow diminution caused by water withdrawals on bull trout, or their habitat. These effects would be the subject of a site-specific consultation on the issuance of special use permits or easements granted for diversions on, or crossing, Federal lands. Installation of screens will occur only on existing diversions, and no additional water withdrawals points will be established and no greater rates of water withdrawal will be authorized under this consultation.

The primary long-term beneficial effect of properly screening diversions is decreased fish mortality. Although it is well accepted that screens prevent fish from dying, USFWS cannot predict exactly how many fish would be saved by installing screens on project lands in the action area. Despite millions of dollars spent on fish screening of water diversions in the Pacific Northwest and California, there have been few quantitative studies conducted on how screening actually affects fish populations (Moyle and Israel 2005). One recent study, (Walters et al. 2012) examined potential losses of Chinook salmon juveniles to unscreened diversions and found that about 71% of out-migrating smolts could be lost each year within a given river basin. The authors also found that screening was an effective mitigation strategy and reduced estimated mortality to less than 2% when all diversions within the basin were screened. Even though the effects of screening have not been well studied, USFWS recognizes the value of screening and supports the Corps' precautionary approach to screen diversions that may affect bull trout. The removal of unneeded diversion structures improves fish passage and restores natural bedload movement which benefits the aquatic ecosystem.

Head-cut and Grade Stabilization. The stabilization of active or potential head-cuts with LW, rock, or step structures primarily takes place in Rosgen (1994) C- and E-type channels in areas east of the Cascade Mountains in the action area. In these areas, historic land management such as heavy livestock grazing and road construction has destabilized stream channels and

increased the chance of head-cut formation. Stabilization requires instream construction, so short-term construction-related adverse effects as described earlier will occur.

The Corps proposes aggressive treatments to prevent further incision of stream channels including use of rock and log step structures. These aggressive restoration techniques are sometimes necessary to stop the ongoing damage caused by migrating head-cuts. The Corps also proposes temporary head-cut stabilization, in which case fish passage may be blocked. In these circumstances, the fish passage must be reestablished during the subsequent in-water work period. This may block fish passage for several months, but without this treatment, head-cut formation might also block fish passage.

The beneficial effects of this proposed activity result primarily from the action's prophylactic nature. Left unchecked, head-cuts lead to channel incision, deposition of fine sediments in downstream substrates, and disconnection of a stream from its floodplain. Stabilizing head-cuts will stop the progression of these adverse effects. No matter where these activities occur on Federal lands within the action area, we expect an increase in habitat functions, improvements to biologic parameters, and a reduction in the risk of extinction to listed species.

Fish Ladders. Installation of a fish ladder and its subsequent operation increases the number of individual fish that are able to move upstream. This, in turn, would increase the number of fish that populate areas upstream from a dam, either because the fish continue to reside in the newly available habitat or because they reproduce in formerly unutilized spawning habitat. Short-term construction related adverse effects as described earlier will occur. Restoration of passage through constructing a ladder will improve population spatial structure and possible abundance and productivity if additional spawning habitat is made available.

3. Off- and Side-Channel Habitat Restoration. The proposed action includes reconnecting existing stream channels to historical off- and side-channels, but not the creation of off- and side-channel habitats. Side channel wetlands and ponds provide important habitats for juvenile fish. Many historical off- and side-channels have been blocked from main stream channels for flood control or by other land management activities, or have ceased functioning due to other in-stream sediment imbalances. When these areas are more regularly and permanently available, as in larger river basins, they can provide additional benefits such as high quality protected spawning habitat (Cramer 2012).

The direct effects of reconnecting stream channels using the proposed PDC (see 3R) with historical river floodplain swales, abandoned side channels, and floodplain channels are likely to include relatively intense restoration construction effects, as discussed above. Indirect effects are likely to include equally intense beneficial effects to habitat diversity and complexity (Cramer 2012), including increased overbank flow and greater potential for groundwater recharge in the floodplain; attenuation of sediment transport downstream due to increased sediment storage; greater channel complexity or increased shoreline length; increased floodplain functionality reduction of chronic bank erosion and channel instability due to sediment deposition; and increased width of riparian corridors. Increased riparian functions are likely to include increased shade and hence moderated water temperatures and microclimate; increased abundance and retention of wood; increased organic material supply; water quality improvement; filtering of

sediment and nutrient inputs; more efficient nutrient cycling; and restoration of flood-flow refuge for ESA-listed fish (Cramer 2012).

4. Piling and other Structure Removal and Installation.

Removal

This category includes the removal of untreated and chemically treated wood pilings, piers, boat docks as well as similar structures comprised of plastic, concrete and other material. The proposed PDC mainly focus on the removal of intact and broken piles which are typically treated with a toxic preservative. Removal of piles using the proposed PDC will re-suspend sediments that are inevitably pulled up with, or attached to, the piles. If sediment in the vicinity of a pile is contaminated, or if the pile is creosote treated, those contaminants will be included with the re-suspended sediments, especially if a creosote-treated pile is damaged during removal, or if debris from a broken pile is allowed to re-enter or remain in the water. Turbidity generated from pile driving or removal is temporary and confined to the area close to the operation. USFWS expects that some individual bull trout, both adult and juvenile, may be harassed by turbidity plumes resulting from pile driving or removal. Indirect lethal take can occur if individual juvenile fish are preyed on when they leave the work area to avoid temporary turbidity plumes. The proposed requirements for completing the work during the preferred in-water work window will minimize the effects of turbidity on listed species. The indirect effects of structure removal are likely to be beneficial and include reduction of resting and areas for piscivorous birds, hiding habitat for aquatic predators such as large and smallmouth bass, and, in the case of creosote piles, a chronic source of PAH pollution.

Piling Installation

The USFWS expects reasonably few projects per year that would involve pile driving and installation due to limited project areas where this activity and bull trout habitat coincide. However, benthic invertebrates in shallow-water habitats are key food sources for juvenile bull trout and new pilings may reduce the substrate available to benthic aquatic organisms and, therefore, the food available for juvenile bull trout in the project area. USFWS believes that some effect on bull trout productivity may occur due to suppression of benthic prey species. Most existing commercial dock structures have a high density of existing piles and are not likely to provide significant habitat for bull trout. There are few areas, other than reservoirs that are used for overwintering or large rivers (*i.e.*, the Columbia and Snake Rivers) that contain docks or other multiple-piling features. Areas of these structures and associated pilings that may affect bull trout likely take place in areas of diminished light intensity and deeper water along the outer margin of the structure, where they may have higher predation.

Pile driving often generates intense sound pressure waves that can injure or kill fish (Reyff 2003, Abbott and Bing-Sawyer 2002, Caltrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001). The type and size of the pile, the firmness of the substrate into which the pile is being driven, the depth of water, and the type and size of the pile-driving hammer all influence the sounds produced during pile driving. Fishes with swimbladders (including bull trout) are sensitive to underwater impulsive sounds, *i.e.*, sounds with a sharp sound pressure peak occurring in a short interval of time, (Caltrans 2001). As the pressure wave passes through a fish, the swimbladder is rapidly squeezed due to the high pressure, and then rapidly expanded as the

under pressure component of the wave passes through the fish. The pneumatic pounding may rupture capillaries in the internal organs as indicated by observed blood in the abdominal cavity, and maceration of the kidney tissues (Caltrans 2001). The injuries caused by such pressure waves are known as barotraumas, and include hemorrhage and rupture of internal organs, as described above, and damage to the auditory system. Death can be instantaneous, can occur within minutes after exposure, or can occur several days later.

Fish respond differently to sounds produced by impact hammers than to sounds produced by vibratory hammers. Fish consistently avoid sounds like those of a vibratory hammer (Enger et al. 1993; Dolat 1997; Knudsen et al. 1997; Sand et al. 2000) and appear not to habituate to these sounds, even after repeated exposure (Dolat 1997; Knudsen et al. 1997). On the other hand, fish may respond to the first few strikes of an impact hammer with a startle response, but then the startle response wanes and some fish remain within the potentially harmful area (Dolat 1997). Compared to impact hammers, vibratory hammers make sounds that have a longer duration (minutes vs. milliseconds) and have more energy in the lower frequencies (15-26 Hz vs. 100-800 Hz) (Würsig et al. 2000).

Sound pressure levels (SPLs) greater than 150 decibels (dB)¹⁸ root mean square (RMS) produced when using an impact hammer to drive a pile are thought to affect fish behavior. A multi-agency work group determined that to protect listed species, sound pressure waves should be within a single strike threshold of 206 decibels (dB), and for cumulative strikes either 187 dB sound exposure level (SEL) where fish are larger than 2 grams or 183 dB SEL where fish are smaller than 2 grams (NMFS 2008).

Surrounding the pile with a bubble curtain can attenuate the peak SPLs by approximately 28 dB and is equivalent to a 97% reduction in sound energy. Whether confined inside a sleeve made of metal or fabric or unconfined, these systems have been shown to reduce underwater sound pressure (Würsig et al. 2000; Longmuir and Lively 2001; Christopherson and Wilson 2002; Reyff and Donovan 2003). However, the sound attenuation achieved by bubble curtains varies greatly depending on design and location. Thus, a bubble curtain may not bring the peak and RMS SPLs below the established thresholds, and take may still occur. Studies on pile driving and underwater explosions suggest that, besides attenuating peak pressure, bubble curtains also reduce the impulse energy and, therefore, the likelihood of injury (Keevin 1998). Because sound pressure attenuates more rapidly in shallow water (Rogers and Cox 1988), it may have fewer deleterious effects there.

Unconfined bubble curtains lower sound pressure by as much as 17 dB (85%) (Würsig et al. 2000, Longmuir and Lively 2001), while bubble curtains contained between two layers of fabric reduce sound pressure up to 22 dB (93%) (Christopherson and Wilson 2002). However, an unconfined bubble curtain can be disrupted and rendered ineffective by currents greater than 1.15 miles per hour (Christopherson and Wilson 2002). When using an unconfined air bubble system in areas of strong currents, it is essential that the pile be fully contained within the bubble curtain, and that the curtain have adequate air flow, and horizontal and vertical ring spacing around the pile.

¹⁸ All decibels have a reference pressure of one micro Pascal

NMFS developed a spreadsheet to assess the potential effect to fishes exposed to elevated levels of underwater sound (peak and RMS pressure as well as sound exposure level (SEL)) resulting from pile driving. The distance to the thresholds of behavioral impacts and onset of physical injury can be calculated with the following information:

- Number of impact hammer strikes per pile?
- Number of hours/minutes required to drive one pile and all piles?
- Number of hours per day pile driving will occur?
- Depth of water and type of substrate the piles will be driven in?
- If an impact hammer is used, will it be the entire pile or just the last few hits per pile?
- Diameter of pile?
- Will pile-driving be continuous?
- Will pile be straight or battered?
- Will a template be used?
- Pile type?
- When is pile-driving proposed?
- What life-stages are known to occur within the action area?
- If provided, what is the source of hydroacoustic assumptions?
- Installation plan/ schematics included?
- Pile spacing?

Bull trout occur year-round in many waters covered by this Opinion. However, the likelihood of take resulting from pile driving and removal will be minimized by completing the work during preferred in-water work windows, using a vibratory hammer where possible, using sound attenuators where an impact hammer is necessary, and limiting the number of strikes per day.

5. Use of Treated Wood. Use of treated wood in the proposed action categories is expected to be minimal due to the increase in other materials with longer life expectancies and less harmful effects to aquatic habitat. Nonetheless, the effects discussed here contain a wide ranging discussion regarding effects of different treatments commonly used in treated wood application.

Pesticide treatments in common use include water-based wood preservatives, such as chromated copper arsenate (CCA), ammoniacal copper zinc arsenate (ACZA), alkaline copper quat (ACQ-B and ACQ-D), ammoniacal copper citrate (CC), copper azole (CBA-A), copper dimethyldithiocarbamate (CDDC), borate preservatives, and oil-type wood preservatives, such as creosote, pentachlorophenol, and copper naphthenate (FPL 2000). Acid copper chromate (ACC) and copper HDO (CX-A) are more recent compounds not yet in wide use (Lebow 2004). Withdrawal of CCA from most residential applications has increased interest in arsenic-free preservative systems that all rely on copper as their primary active ingredient (FPL 2003, Lebow 2004) with the proportion of preservative component ranging from 17% copper oxide in some CDDC formulations, to 96% copper oxide in CA-B (Lebow 2004).

A pesticide-treated wood structure placed in or over flowing water will leach copper and a

variety of other toxic compounds directly into the stream (Weis and Weis 1998, Hingston et al. 2001, Poston 2001, NOAA 2003). Although the likelihood of leaching pesticides, including copper, from wood used above or over the water is different than splash zone or in-water applications (WWPI 1996), these accumulated materials add to the background loads of receiving streams. Movements of leached preservative components are generally limited in soil but are greater in soils with high permeability and low organic content. Mass flow with a water front is probably most responsible for moving metals appreciable distances in soil, especially in permeable, porous soils. Preservatives leached into water are more likely to migrate downstream compared with preservative leached into soil, with much or the mobility occurring in the form of suspended sediment.

If treated wood sawdust or shavings generated during construction are allowed to enter soil or water below at treated structure, they make a disproportionately large contribution to environmental contamination, with leaching of construction debris immersed in water being vastly greater than from solid wood (FPL 2001a, Lebow and Tippie 2001, Lebow et al. 2004). Because construction debris may release 30 to 100 times more preservative than leaching, collection of construction debris should be stressed during project planning and budgeting. Storing treated wood shipped to the project area out of contact with standing water and wet soil, and protected from precipitation also significantly reduces the likelihood of chemical leaching during construction (Lebow and Tippie 2001, FPL 2001a).

Wooden bridges built without a wearing surface where vehicles ride directly on a creosote-treated wood deck show wear from vehicle tracking and debris abrasion that will wear away the preservative treatment envelope over time and expose new surfaces of the wood to leaching (Brooks 2000, Ritter et al. 1996a and 1996b). Similarly, foot traffic will abrade treated wood used in pedestrian bridges unless prevented by a wearing surface such as synthetic mats, coatings, metal sheets, or sacrificial plywood sheets (DeVenzio undated, Lebow 2004). Cleaning and maintenance activities, such as aggressive scrubbing, power-washing, or sanding can also remove particles of treated wood and deposit them in soil or water beneath a treated wood structure (Lebow et al. 2004).

Application of finishes, such as semi-transparent penetrating stains, latex paint, oil-based paint, decrease environmental releases (FPL 2001a and 2001b, Lebow et al. 2004). Coatings minimize the loss of metals by forming a barrier between the treated wood and the environment (Stilwell and Musante 2004). In general, opaque polyurethane and acrylic finishes form the most durable coatings, presumably because of their ability to protect wood from ultraviolet radiation, although for some surfaces, particularly horizontal ones subjected to foot traffic, use of a penetrating stain that results in a slow wearing of the coating may be preferable (Stilwell and Musante 2004). Experiments to test the ability of coatings to minimize leaching from CCA-treated wood found that one coat of latex primer followed by one coat of oil-based paint or two coats of penetrating, water-repellent deck stain were both effective for reducing the leaching of copper, arsenic and chromium by more than 99% (FPL 2001a). Coatings and any paint-on field treatment must be carefully applied and contained to reduce contamination (Lebow and Tippie 2001, FPL 2001b).

Few wharves and other large structures are being constructed on wooden piling today because

concrete and steel have greater load bearing capacity (Brooks 2003). Most projects involving treated wood pilings, such as rural bridges, small ferry terminals, marinas, and personal use docks, involve two to five piling bents spaced at least four meters apart (Brooks 2003). These pilings are also subject to abrasion when they are allowed to come into direct contact with boats, float rings, debris, *etc.*, although the degree of abrasion is difficult to predict and therefore not susceptible to risk assessment (Brooks 2004). Nonetheless, pilings may be easily protected from abrasion by, for example, using half-inch thick polyethylene strips installed down the length of the piling to serve as wearing surfaces, thus improving environmental performance and extending the life of the piling (Brooks 2004).

Evaluation of in-service structures show that leaching rates vary by wood dimensions, wood species, treatment practices, fixation, age of the structure, type of exposure, construction and maintenance practices, and site-specific conditions (Lebow 1996, Lebow et al. 2004). Brooks (2004) reported significantly more copper (13.9 micrograms per gram of dry sediment) below the center of an ACZA four-piling dolphin placed in a rural area than at the subtidal reference site (6.4 micrograms per gram of dry sediment). Three other sites tested did not show significant differences. That amount of copper meets Washington State sediment quality standards but exceeds 8.2 micrograms per gram of dry sediment, the amount where, according to NOAA Screening Quick Reference Table for Inorganic Solids (“SQuiRTS”), toxic effects in sensitive species may be expected.

Copper is a widespread source of water pollution in salmon habitat where it is deposited by mines, urban stormwater runoff, treated wood leachate, and from algicides used in waterways and as fungicides applied to cropland (WWPI 1996, Weis and Weis 1998, Baldwin et al. 2003, Weis and Weis 2004). Copper is the most frequently detected trace element at agricultural and mixed use sites in the Willamette River Basin (Wentz et al. 1998). Metals leached into sediments near CCA-treated wood in aquatic environments have been shown to accumulate in organisms, including epibiota and benthic organisms (Weis and Weis 2004). Other animals can acquire elevated levels of these metals indirectly through trophic transfer, and may exhibit toxic effects at the cellular level (DNA damage), tissue level (pathology), organismal level (reduced growth, altered behavior and mortality) and community level (reduced abundance, reduced species richness, and reduced diversity) (Weis et al. 1998, Weis and Weis 2004). Effects are more severe in poorly flushed areas and in areas where the wood is relatively new, and reduces after the wood has leached a few months (Weis and Weis 2004).

Wood impregnated with other chemicals such as copper, zinc, arsenic and chromium may directly affect salmon that spawn, rear, or migrate by those structures, or indirectly when the salmon ingest contaminated prey (Poston 2001). Copper has been shown to impair the olfactory nervous system and olfactory-mediated behaviors in salmonids (Hara et al. 1975, Winberg et al. 1992, Hansen et al. 1999a and 1999b, Baldwin et al. 2003). Salmon will actively avoid copper (Hansen et al. 1999a and 1999b), suggesting that low levels of copper present in distinct gradients, such as near a point-source discharges, may act as migratory barriers to salmon. However, behavioral avoidance is not likely to be an adequate defense against non-point sources of copper in lakes, rivers and estuaries (Baldwin et al. 2003).

Even transient exposure lasting just a few minutes to copper at levels typical for surface waters

from urban and agricultural watersheds, and within the U.S. Environmental Agency water quality criterion for copper, will cause greater than 50% loss of sensory capacity among resident coho in freshwater habitats (Baldwin et al. 2003). While that loss may be at least partially reversible, longer exposures lasting hours have caused cell death in the olfactory receptor neurons of other salmonid species (Julliard et al. 1996, Hansen et al. 1999b, Moran et al. 1992). Therefore, olfactory function will be impaired if salmon are unable to avoid copper pollution within the first few minutes of exposure and, if copper levels subsequently exceed a threshold for sensory cell death, it may take weeks before the functional properties of the olfactory system recover (Baldwin et al. 2003). Because olfactory cues convey important information about habitat quality (*e.g.*, pollution), predators, conspecifics, mates, and the animal's natal stream, substantial copper-induced loss of olfactory capacity is likely to impair behaviors essential for the survival or reproductive success of salmon and steelhead (Baldwin et al. 2003).

PAHs are commonly released from wood treated with creosote. PAHs may cause cancer, reproductive anomalies, immune dysfunction, growth and development impairment, and other impairments to exposed fish (Johnson et al. 1999, Johnson 2000, Stehr et al. 2000, Collier et al. 2002, Johnson et al. 2002).

Alternatives are available to for most applications involving pesticide treated wood. These include the use of wood products produced from naturally durable species, such as redwood and cedar, or alternative materials such as fiberglass, steel, or plastic.

The proposed action will avoid or minimize the adverse effects of pesticide treated wood installation (see PA 4(b)(vii)) and will follow the guidelines established therein.

6. *Set-back or Removal of Existing Berms, Dikes, and Levees.* Channelization of streams through levee construction means that the floodplain no longer benefits from floods, producing many of the changes to living communities and ecosystems as those resulting from dams. Levees, berms, and dikes are commonly found along mid- to large-sized rivers for flood control or infrastructure protection and can severely disrupt ecosystem function (Gergel et al. 2002) and fish community structure (Freyer and Healey 2003). Similarly, mine tailings left by dredging for precious metals can have comparable effects on small streams.

Under this activity category, the Corps proposes to remove dikes, berms, mine tailings or other floodplain overburden to restore river-floodplain interactions and natural channel-forming processes. This action category may often be combined with the stream channel reconstruction/relocation category above. The direct and indirect effects of this type of proposed action are also very similar to off- and side-channel habitat restoration discussed above, although the effects of this type of action may also include short-term or chronic instability of affected streams and rivers as channels adjust to the new hydrologic conditions. Moreover, this type of action is likely to affect larger areas overall because the area isolated by a berm, dike or levee is likely to be larger than that included in an off- or side-channel feature.

In the long-term, removal of floodplain overburden will improve connection between the stream and its floodplain, and allow reestablishment of riparian vegetation. Over time, the removal of

overburden will also allow for the restoration of natural channel forming processes. Over the course of many decades, degraded and incised channels will be able to regain meanders, aggrade to the proper elevation, and resume natural formation of habitat features. Ultimately, this will result in more functional fish habitat – streams with overhead cover and undercut banks to provide protection for juvenile fish, low width-to-depth ratios that provide cool and deep refugia for migrating juveniles and healthy riparian plant communities that provide nutrient inputs to the food base that juvenile fish may consume when rearing. More immediate beneficial effects will result from the restoration of “flood pulses” that periodically deliver water, nutrients, and sediment to floodplains.

7. Streambank Restoration. In addition to restoration construction effects discussed above, the proposed streambank RES is likely to allow reestablishment of native riparian forests or other appropriate native riparian plant communities, provide increased cover (LW, boulders, vegetation, and bank protection structures) and a long-term source of all sizes of instream wood, reduce fine sediment supply, increase shade, moderate microclimate effects, and provide more normative channel migration over time.

The Corps proposes to stabilize eroding streambanks using bioengineering methods. This requires instream construction with short-term effects as described above. Heavy equipment might be used in the stream for this activity. In-water equipment use could temporarily affect bull trout and critical habitat, including impacts on redds, smothered or crushed eggs and alevins, increased suspended sediment and deposition, blocked migration, and disrupted or disturbed overwintering behavior. Bull trout are particularly vulnerable during the fall and winter, when adults are migrating and spawning, and the spring, when eggs and fry are still present in the substrate. Seasonal restrictions imposed by in-water work windows may afford some protection in bull trout FMO habitat, but cannot fully protect bull trout in SR habitat.

The use of rock groins, weirs, rock toes, and riprap to avoid the potential negative effects of using hard structures to stabilize streambanks has been excluded from consideration within this consultation by the Corps. Long-term beneficial effects of stabilizing eroding streambanks include reductions in fine sediment inputs. Eliminating a sediment source will help to increase the diversity and densities of aquatic macroinvertebrates, which are used as a food source by bull trout. It will also maintain or increase the amount of interstitial cover available to juveniles and juvenile emergence success. Suffocation of fry and entombment caused by excessive siltation of spawning gravels will also be reduced or eliminated. Light penetration, which, in turn, affects the feeding abilities of covered fish species and juvenile growth rates, will improve.

By limiting bank restoration to bioengineering methods such as placement of LW and riparian plantings, overhead cover for fish will be increased and streambank stability will improve.

8. Dam, Tide gate, and Legacy Structure Removal. This category of actions includes removal of small dams, channel-spanning weirs; subsurface drainage features; tide gates; or instream flow redirection structures (*e.g.*, drop structure, gabion, groin), or similar devices used to control, discharge, or maintain water levels. Projects will be implemented to reconnect stream corridors, floodplains, and estuaries, reestablish wetlands, improve aquatic organism passage, and restore more natural channel and flow conditions. Any instream water control structures that

impound substantial amounts of contaminated sediment are not covered by this BO. Equipment such as excavators, bull dozers, dump trucks, front-end loaders and similar equipment may be used to implement such projects. Dams greater than 10-feet in height require a long-term monitoring and adaptive management plan that will be developed between the Service and the action agency.

Dam Removal. In addition to the restoration construction effects discussed above, removing a water control structure (*e.g.*, small dam, earthen embankment, subsurface drainage features tide gate, gabion) using the proposed PDC is likely to have significant local and landscape-level effects to processes related to sediment transport, energy flow, stream flow, temperature, and biotic fragmentation (Poff and Hart 2002). The diversity of water control structures distributed on the landscape combined with the relative scarcity of knowledge about the environmental response to their removal makes it difficult to generalize about the ecological harm or benefits of their removal. However, many small water control structures are nearing the end of their useful life, due to sediment accumulation and general deterioration. They can either be removed intentionally by parties concerned about liability, or fail due to lack of maintenance. Thus, it is likely that in some cases the best outcome of these RES will be a minimization of adverse effects that follow unplanned failures, such as reducing the size of a contaminated sediment release, preventing an unplanned sediment pulse, controlling undesirable species, or ensuring fish passage around remnants of the structure, or dictating the timing of the sediment release to minimize the effects to listed species.

Whether a water control structure is removed for restoration, safety or economic reasons, neither action is likely to entirely restore pristine conditions. The legacy of flow control includes altered riparian soils and vegetation, channel morphology, and plant and animal species composition that frequently take many years or decades to fully respond to restoration of a more natural flow regime. The indirect effects or long-term consequences of water control structure removal will depend on the long-term progression of climatic factors and the success of follow-up management actions to manage sediments, exclude undesirable species, revegetate/restore vegetation, and ensure that continuing water and land use impacts do not impair ecological recovery.

Removal of Legacy Structures

During the 1980s and early 1990s, many habitat-forming structures such as log weirs, boulder weirs, and gabions were placed in streams to create pool habitat. Many of these structures were placed perpendicular to stream flow or placed in a manner that interfered with natural stream function. The Corps proposes to remove these structures to restore natural stream function. This activity type requires instream construction causing the short-term effects described earlier. Long-term beneficial effects of removing these structures include decreased streambank erosion, decreased stream width-to-depth ratios, and restoration of natural stream processes. Decreasing erosion will increase the survival of eggs and alevins and reduce interference with feeding, behavioral avoidance and the breakdown of social organization. Decreasing the stream width-to-depth ratios will increase adult holding areas and improve rearing sites for yearling and older juveniles.

9. Road and Trail Erosion Control and Decommissioning. Road and trail erosion control and decommissioning typically includes one or more of the following actions – culvert removal in perennial and intermittent streams; removing, installing or upgrading cross-drainage culverts; upgrading culverts on non-fish-bearing streams; constructing water bars and dips; reshaping road prisms; vegetating fill and cut slopes; removing and stabilizing of side-cast materials; grading or resurfacing roads that have been improved for aquatic restoration with gravel, bark chips, or other permeable materials; contour shaping of the road or trail base; removing road fill to native soils; soil stabilization and tilling compacted surfaces to reestablish native vegetation. A significant amount of information is available regarding the adverse effects of roads on aquatic habitats (Gucinski et al. 2001; Jones et al. 2000; Trombulak and Frissell 2000). Increased introduction of invasive species and delivery of fine sediment derived from roads has been linked with decreased fry emergence, decreased juvenile densities, loss of winter carrying capacity, increased predation of fishes, decreased benthic production, and increased algal production. Improper culvert placement can limit or eliminate fish passage. Moreover, roads can greatly increase the frequency of landslides, debris flows, and other mass movements.

Unfortunately, much less information is available on the specific effects of road and trail restoration or removal, and its effectiveness for reversing adverse habitat conditions attributed to the presence of road and trail systems. The short-term effects of these actions using the proposed PDC (see PDC 9R) will include the restoration construction effects and, in the case of culvert removal, fish passage restoration, discussed above. The long-term effects of road and trail restoration or removal appear to include mitigation of many of the negative effects to aquatic habitats that have been associated with roads (Madej 2001; McCaffery et al. 2007), but the large variance stream between substrate conditions and other stream habitat characteristics that are important to fish make it difficult to assign measurable effects to road decommissioning (Madej 2001; McCaffery et al. 2007). Thus, road and trail erosion control and decommissioning are likely to result in restoration of riparian and stream functions as a result of reduced sediment yield and improved fish passage.

10. Non-native Invasive Plant Control. The proposed action includes manual, mechanical, biological and herbicidal treatments of invasive and non-native plants. NMFS has recently analyzed the effects of these activities using the similar active ingredients and PDC for proposed USFS and BLM invasive plant control programs (NMFS 2010; NMFS 2012). The types of plant control actions analyzed here are a conservative (*i.e.*, less aggressive) subset of the types of actions considered in those analyses, and the effects presented here are summarized from those analyses. Each type of treatment is likely to affect fish and aquatic macrophytes through a combination of pathways, including disturbance, chemical toxicity, dissolved oxygen and nutrients, water temperature, sediment, instream habitat structure, forage, and riparian and emergent vegetation (Table 5).

Table 5. Potential pathways of effects of invasive and non-native plant control.

Treatment Methods	Pathways of Effects							
	Disturbance*	Chemical toxicity	Dissolved oxygen and nutrients	Water temperature	Fine sediment and turbidity	Instream habitat structure	Forage	Riparian and emergent vegetation
Manual	X					X	X	X
Mechanical	X			X	X		X	X
Biological				X	X			
Herbicides		X	X	X	X	X	X	X

*Stepping on redds, displacing fish, interrupting fish feeding, or disturbing banks.

Short-term displacement or disturbance of threatened and endangered fish are likely to occur from activities in the area that disturb or displace fish that are feeding, resting or moving through the area. Due to the proposed PDC, mechanical and herbicidal treatments of invasive plant species in riparian areas are not likely to substantially decrease shading of streams in most cases. Significant shade loss is likely to be rare, occurring primarily from treating streamside knotweed and blackberry monocultures, and possibly from cutting streamside woody species (tree of heaven, scotch broom, etc.). Most invasive plants are understory species of streamside vegetation that do not provide the majority of streamside shade and, furthermore will be replaced by planted native vegetation or vegetation. The loss of shade would persist until native vegetation reaches and surpasses the height of the invasive plants that were removed. Shade recovery may take one to several years, depending on the success of invasive plant treatment, stream size and location, topography, growing conditions for the replacement plants, and the density and height of the invasive plants when treated. However, short-term shade reduction is likely to occur due to removal of riparian weeds, which could slightly affect stream temperatures or dissolved oxygen levels, which could cause short-term stress to fish adults, juveniles and eggs. NMFS did not identify adverse effects to macroinvertebrates from herbicide applications that follow these proposed PDC. Effects pathways are described in detail below.

Manual and mechanical treatments are likely to result in mild restoration construction effects (discussed above). Hand pulling of emergent vegetation is likely to result in a localized mobilization of suspended sediments. Treatment of knotweed and other streamside invasive species with herbicides (by stem injection or spot spray) or heavy machinery is likely to result in short-term releases of suspended sediment when treatment of locally extensive streamside monocultures occurs. Thus, these treatments are likely to affect a definite, broad area, and to produce at least minor damage to riparian soil and vegetation. In some cases, this will decrease stream shade, increase suspended sediment and temperature in the water column, reduce organic inputs (e.g., insects, leaves, woody material), and alter streambanks and the composition of stream substrates. However, these circumstances are likely to occur only in rare circumstances, such as treatment of an invasive plant monoculture that encompasses a small stream channel.

This effect would vary depending on site aspect, elevation, and amount of topographic shading, but is likely to decrease over time at all sites as shade from native vegetation is reestablished.

Biological controls work slowly, typically over several years, and are designed to work only on the target species. Thus, biological controls produce a smaller reduction of riparian and instream vegetation over a smaller area than manual and mechanical treatments and are unlikely to lead to bare ground and surface erosion that would release suspended sediment to streams. As treated invasive plants die, native plants are likely to become reestablished at each site, and they will restore soil and bank stability from root systems, and stream shade. Therefore, any adverse effects due to biological treatments, by themselves, are likely to be very mild. Biological controls typically work slowly over a period of years, and only on target species, and results in minimal impact to soils and vegetation from the actual release. Over time, successful biological control agents will reduce the size and vigor of host noxious weeds with minimal or no impact to other plant species.

Herbicide applications. USFWS identified three scenarios for the analysis of herbicide application effects: (1) Runoff from riparian application; (2) application within perennial stream channels; and (3) runoff from intermittent stream channels and ditches. Stream margins often provide shallow, low-flow conditions, have a slow mixing rate with mainstem waters, and are the site at which subsurface runoff is introduced. Juvenile fish, particularly recently emerged fry, often use low-flow areas along stream margins. For example, certain salmonids rear near stream margins until they reach about 60 mm in length. As juveniles grow, they migrate away from stream margins and occupy habitats with progressively higher flow velocities. Nonetheless, stream margins continue to be used by larger bull trout for a variety of reasons, including nocturnal resting, summer and winter thermal refuge, predator avoidance, and flow refuge (NMFS 2013a).

Spray and vapor drift are important pathways for herbicide entry into aquatic habitats. Several factors influence herbicide drift, including spray droplet size, wind and air stability, humidity and temperature, physical properties of herbicides and their formulations, and method of application. For example, the amount of herbicide lost from the target area and the distance the herbicide moves both increase as wind velocity increases. Under inversion conditions, when cool air is near the surface under a layer of warm air, little vertical mixing of air occurs. Spray drift is most severe under these conditions, since small spray droplets will fall slowly and move to adjoining areas even with very little wind. Low relative humidity and high temperature cause more rapid evaporation of spray droplets between sprayer and target. This reduces droplet size, resulting in increased potential for spray drift. Vapor drift can occur when herbicide volatilizes. The formulation and volatility of the compound will determine its vapor drift potential. The potential for vapor drift is greatest under high air temperatures and low humidity and with ester formulations. For example, ester formulations of triclopyr are very susceptible to vapor drift, particularly at temperatures above 80°F. When temperatures go above 75°F, 2,4-D ester chemicals evaporate and drift as vapor. Even a few days after spraying, ester-based phenoxy-type herbicides still release vapor from the leaf surface of the sprayed weed (DiTomaso et al. 2006). 2,4-D and triclopyr, which are included in the proposed action, as well as many other herbicides and pesticides are detected frequently in freshwater habitats within the four western states where listed Pacific salmonids are distributed (NMFS 2011b).

When herbicides are applied with a sprayer, nozzle height controls the distance a droplet must fall before reaching the weeds or soil. Less distance means less travel time and less drift. Wind velocity is often greater as height above ground increases, so droplets from nozzles close to the ground would be exposed to lower wind speed. The higher that an application is made above the ground, the more likely it is to be above an inversion layer that will not allow herbicides to mix with lower air layers and will increase long distance drift. Several proposed PDC address these concerns by ensuring that herbicide treatments will be made using ground equipment or by hand, under calm conditions, preferably when humidity is high and temperatures are relatively low. Ground equipment reduces the risk of drift, and hand equipment nearly eliminates it.

Surface water contamination with herbicides can occur when herbicides are applied intentionally or accidentally into ditches, irrigation channels or other bodies of water, or when soil-applied herbicides are carried away in runoff to surface waters. Direct application into water sources is generally used for control of aquatic species. Accidental contamination of surface waters can occur when irrigation ditches are sprayed with herbicides or when buffer zones around water sources are not wide enough. In these situations, use of hand application methods will greatly reduce the risk of surface water contamination.

The contribution from runoff will vary depending on site and application variables, although the highest pollutant concentrations generally occur early in the storm runoff period when the greatest amount of herbicide is available for dissolution (Stenstrom and Kayhanian 2005; Wood 2001). Lower exposures are likely when herbicide is applied to smaller areas, when intermittent stream channel or ditches are not completely treated, or when rainfall occurs more than 24 hours after application. Under the proposed action, some formulas of herbicide can be applied within the bankfull elevation of streams, in some cases up to the water's edge. Any juvenile fish in the margins of those streams are more likely to be exposed to herbicides as a result of overspray, inundation of treatment sites, percolation, surface runoff, or a combination of these factors. Overspray and inundation will be minimized through the use of dyes or colorants.

In a typical year in the U.S., pesticides are applied at a rate of approximately five billion pounds of active ingredients per year (Kiely et al. 2004). Therefore, pesticide contamination in the nation's freshwater habitats is ubiquitous and pesticides usually occur in the environment as mixtures. The USGS National Water-Quality Assessment (NAWQA) Program conducted studies and monitoring to build on the baseline assessment established during the 1990s to assess trends of pesticides in basins across the Nation, including the Willamette River basin. More than 90 percent of the time, water from streams with agricultural, urban, or mixed-land-use watersheds had detections of 2 or more pesticides or degradates, and about 20 percent of the time they had detections of 10 or more. 57 percent of 83 agricultural streams had concentrations of at least one pesticide that exceeded one or more aquatic-life benchmarks at least one time during the year (68 percent of sites sampled during 1993–1994, 43 percent during 1995–1997, and 50 percent during 1998–2000). 2,4D is one the pesticides detected most frequently in stream water (Gilliom et al. 2006). In the Willamette Basin 34 herbicides were detected. Forty-nine pesticides were detected in streams draining predominantly agricultural land (Rinella and Janet 1998). In the lower Clackamas River basin, Oregon (2000–2005), USGS detected 63 pesticide compounds, including

33 herbicides. High-use herbicides such as glyphosate, triclopyr, 2,4-D, and metolachlor were frequently detected, particularly in the lower-basin tributaries (Carpenter et al. 2008).

Groundwater contamination is another important pathway. Most herbicide groundwater contamination is caused by “point sources,” such as spills or leaks at storage and handling facilities, improperly discarded containers, and rinses of equipment in loading and handling areas, often into adjacent drainage ditches. Point sources are discrete, identifiable locations that discharge relatively high local concentrations. In soil and water, herbicides persist or are decomposed by sunlight, microorganisms, hydrolysis, and other factors. 2,4-D and triclopyr are detected frequently in freshwater habitats within the four western states where listed Pacific salmonids are distributed (NMFS 2011b). Proposed PDC minimize these concerns by ensuring proper calibration, mixing, and cleaning of equipment. Non-point source groundwater contamination of herbicides is relatively uncommon but can occur when a mobile herbicide is applied in areas with a shallow water table. Proposed PDC minimize this danger by restricting the formulas used, and the time, place and manner of their application to minimize offsite movement.

Herbicide toxicity. Herbicides included in the invasive plant programmatic activity were selected due to their low to moderate aquatic toxicity to bull trout and other ESA-listed fish. The risk of adverse effects from the toxicity of herbicides and other compounds present in formulations to listed aquatic species is minimized in this programmatic activity by reducing stream delivery potential by restricting application methods. Only aquatic labeled herbicides are to be applied within wet stream channels. Aquatic glyphosate and aquatic imazapyr can be applied up to the waterline using spot spray or hand selective application methods in both perennial and intermittent channels. Triclopyr TEA and 2,4-D amine can be applied up to the waterline, but only using hand selective techniques. The associated application methods were selected for their low risk of contaminating soils and subsequently introducing herbicides to streams. However, direct and indirect exposure and toxicity risks are inherent in some application scenarios.

Generally, herbicide active ingredients have been tested on only a limited number of species and mostly under laboratory conditions. While laboratory experiments can be used to determine acute toxicity and effects to reproduction, cancer rates, birth defect rates, and other effects to fish and wildlife, laboratory experiments do not typically account for species in their natural environments and little data is available from studies focused specifically on the listed species in this Opinion. This leads to uncertainty in risk assessment analyses. Environmental stressors increase the adverse effects of contaminants, but the degree to which these effects are likely to occur for various herbicides is largely unknown.

The effects of the herbicide applications to various representative groups of species have been evaluated for each proposed herbicide. The effects of herbicide applications using spot spray, hand/select, and broadcast spray methods were evaluated under several exposure scenarios: (1) runoff from riparian (above HWM) application along streams, lakes and ponds, (2) runoff from treated ditches and dry intermittent streams, and (3) application within perennial streams (dry areas within channel and emergent plants). The potential for herbicide movement from broadcast

drift was also evaluated. Risks associated with exposure and associated effects were also evaluated for terrestrial species.

Although the PDC would minimize drift and contamination of surface and ground water, herbicides reaching surface waters would likely result in mortality to fish during incubation, or lead to altered development of embryos. Stehr et al. (2009) found that the low levels of herbicide delivered to surface waters are unlikely to be toxic to the embryos of bull trout. However, mortality or sub-lethal effects such as reduced growth and development, decreased predator avoidance, or modified behavior are likely to occur. Herbicides are likely to also impact the food base for listed salmonids and other fish, which includes terrestrial organisms of riparian origin, aquatic macroinvertebrates and forage fish.

Adverse effect threshold values for each species group were defined as either 1/20th of the LC50 value for listed salmonids, 1/10th of the LC50 value for non-listed aquatic species, or the lowest acute or chronic “no observable effect concentration,” whichever was lower, found in Syracuse Environmental Research Associates, Inc. (SERA) risk assessments that were completed for the USFS; i.e., sethoxydim (SERA 2001), sulfometuron-methyl (SERA 2004d) imazapic (SERA 2004a), chlorsulfuron (SERA 2004b), dicamba (SERA 2004c), 2,4D (USFS 2006) aminopyralid (SERA 2007), imazapyr (SERA 2011d), glyphosate (SERA 2011b), and triclopyr (SERA 2011c). These assessments form the basis of the analysis in the Corps PA and this Opinion. Generally, effect threshold values for listed salmonids were lower than values for other fish species groups, so values for salmonids were also used to evaluate potential effects to bull trout. In the case of sulfometuron-methyl, threshold values for fathead minnow (surrogate) were lower than salmonid values, so threshold values for minnow were used to evaluate effects to bull trout.

Data on toxicity to wild fish under natural conditions are limited and most studies are conducted on lab specimens. Adverse effects could be observed in stressed populations of fish, and it is less likely that effects would be noted in otherwise healthy populations of fish. Chronic studies or even long-term studies on fish egg-and-fry are seldom conducted. Risk characterizations for both terrestrial and aquatic species are limited by the relatively few animal and plant species on which data are available, compared to the large number of species that could potentially be exposed. This limitation and consequent uncertainty is common to most if not all ecological risk assessments. Additionally, in laboratory studies, test animals are exposed to only a single chemical. In the environment, humans and wildlife may be exposed to multiple toxicants simultaneously, which can lead to additive or synergistic effects.

The effects of herbicides on salmonids were fully described by NMFS in other recent opinions with the U.S. Environmental Protection Agency (EPA) and USFS (NMFS 2010; NMFS 2011b; NMFS 2011c; NMFS 2012) and in SERA reports. For the 2007 ARBO the Action Agencies evaluated the risk of adverse effects to listed salmonids and their habitat in terms of hazard quotient (HQ) values (NMFS 2008).

Hazard quotients (HQ) evaluations are summarized below for the herbicides used in the 2007 ARBO (chlorsulfuron, clopyralid, glyphosate, imazapyr, metsulfuron methyl, sethoxydim, and sulfometuron methyl). HQ were calculated by dividing the expected environmental concentration by the effects threshold concentration. Adverse effect threshold concentrations are 1/20th (for

ESA listed aquatic species) or 1/10th (all other species) of LC50 values, or “no observable adverse effect” concentrations, whichever concentration was lower. The WCR values are categorized by herbicide, annual rainfall level, and soil type. Variation of herbicide delivery to streams among soil types (clay, loam, and sand) is displayed as low and high water contamination rate (WCR) values. All WCR values are from risk assessments conducted by SERA. Given that there are HQ values >1 adverse effects are likely to occur. Hazard quotient values were calculated for fish, aquatic invertebrates, algae, and aquatic macrophytes. Adverse effect threshold values for each species group were defined as either 1/20th of the LC50 value for listed salmonids, 1/10th of the LC50 value for non-listed aquatic species, or the lowest “no observable effect concentration,” whichever was lower, found in available literature.

For aminopyralid, dicamba, diflufenzopyr + dicamba, imazapic, picloram, triclopyr, and 2,4D, which were added to list, we referred to the NMFS’s opinions, SERA reports, various other literature sources, and the 2013 BA (USFS et al. 2013) to characterize risk to bull trout.

Aminopyralid

Aminopyralid has is closely related chemically to clopyralid and picloram. It is considered to have slightly longer soil residual activity than clopyralid but considerably less soil activity than picloram. Many other characteristics of the herbicide are similar to clopyralid, including the soil mobility and toxicological properties. Aminopyralid was designated a reduced risk pesticide by U.S. Environmental Protection Agency (EPA) because of its toxicological and environmental profile (DiTomaso et al. 2006; SERA 2007). SERA (2007) summarized several acute exposure studies that reported no mortality to organisms exposed to aminopyralid in concentrations up to 100 mg/L. Aminopyralid has a low order of acute toxicity to aquatic animals. Therefore, aminopyralid fits into the “low risk to aquatic organisms” group.

Chlorsulfuron

No chlorsulfuron HQ exceedances occur for fish or aquatic invertebrates. HQ exceedances occur for algae at rainfall rates of 50 and 150 inches per year and for aquatic macrophytes at rainfall rates of 15, 50, and 150 inches per year.

The HQ values predicted for algae at 50 inches per year ranged from 0.002 to 2.8, and the HQ exceedance occurred at the maximum application rate on clay soils. The HQ values predicted for algae at 150 inches per year ranged from 0.02 – 5.0, and HQ exceedances occurred at both the typical (HQ of 1.1) and maximum (HQ of 5.0) application rates on clay soils. Application of chlorsulfuron adjacent to stream channels at the typical and maximum application rates, in rainfall regimes of 50 to 150 inches per year, is likely adversely affect algal production when occurring on soils with poor infiltration.

The HQ values predicted for aquatic macrophytes at 15 inches per year ranged from 0 to 64, and HQ exceedances occurred at both the typical and maximum application rates on clay soils. The HQ values for aquatic macrophytes at 50 inches per year ranged from 0.5 to 585, and ranged from 4.8 to 1,064 at 150 inches per year. The HQ exceedances at 50 and 150 inches per year occurred at both typical and maximum application rates, with lower HQ values occurring on loam soils, and the highest values on clay soils. Given the wide range of HQ values observed among soil types at a given rainfall rate, soil type is clearly a major driver of exposure risk for

chlorsulfuron, with low permeability soils markedly increasing exposure levels. Application of chlorsulfuron adjacent to stream channels at the typical and maximum application rates, in rainfall regimes of 15 to 150 inches per year, is likely to adversely affect aquatic macrophytes. Application on soils with low infiltration rates will have a substantially higher risk of resulting in adverse effects.

Clopyralid

Application of clopyralid under the modeled scenario did not result in any HQ exceedances for any of the species groups. Clopyralid applications are not likely to adversely affect listed salmonids or their habitat because HQ values are less than 1.

Dicamba

Dicamba is a growth regulator selective herbicide that controls many broadleaf plants, but generally will not harm grasses. Its soil activity is very short. Like 2,4-D, it also is available as both an amine and ester formulation. Drift from dicamba applications is common, especially from the ester formulation (DiTomaso et al. 2006). The Washington State Department of Agriculture has added dicamba to its list of Pesticides of Concern because it is being increasingly detected in most of the streams sampled in Washington (Sargeant et al. 2013).

The risk characterization for aquatic animals is extremely limited by the available toxicity data. Another very substantial limitation in the risk characterization is that no information is available on the chronic toxicity of dicamba to aquatic animals and the available acute toxicity data do not permit reasonable estimates of toxicity values for chronic toxicity. Acute toxicity studies in fish indicate that dicamba is relatively non-toxic, although salmonids appear to be more sensitive than other freshwater fish to the acute toxicity of dicamba (SERA 2004c). However, the EPA concluded that dicamba compounds with currently registered uses will have "no effect" on listed ESA-listed fish and their critical habitat, and therefore consultation with the National Marine Fisheries Service is not necessary (USEPA 2003). Therefore, dicamba likely fits into the "low" risk group.

diflufenzopyr + dicamba

Diflufenzopyr, typically used together with dicamba, is a selective systematic herbicide used for the control of annual broad-leaf weeds post-emergence, the suppression or control of many perennial broad-leaf weeds, and the suppression of annual grasses. Test results on coldwater and warmwater fish species suggest that diflufenzopyr has relatively low toxicity to fish species (BLM 2005). USEPA characterizes diflufenzopyr as slightly toxic to practically non-toxic for both freshwater and marine/estuarine organisms. For freshwater organisms, LC50 values ranged from 15 to >135 mg/L. The LC50 values for marine/estuarine organisms ranged from 18.9 to >138 mg/L (USEPA 1999). The species tested in these studies was not provided and additional toxicity data were not identified. Microbes and sunlight break down diflufenzopyr in the environment. Diflufenzopyr's potential to leach to groundwater is low; surface runoff potential is high, and potential for loss on eroded soil is low. Diflufenzopyr has moderate volatility and the potential for loss to the atmosphere is moderate. Diflufenzopyr does not bioaccumulate (build up) in aquatic animals and is not persistent in the environment.

Glyphosate

Glyphosate HQ exceedances occurred for fish and algae at a rainfall rate of 150 inches per year, and no HQ exceedances occurred for aquatic invertebrates or aquatic macrophytes. The HQ exceedances occurred at the maximum application rates only. The HQ values for fish at 150 inches per year ranged from 1.5 to 3.6, and occurred within a narrow range on all soil types. The HQ values for algae at 150 inches per year ranged from 0.8 to 2.0 in sand. Application of glyphosate adjacent to stream channels at application rates approaching the maximum, in rainfall regimes approaching 150 inches per year, on all soil types is likely to adversely affect listed salmonids. When glyphosate is applied adjacent to stream channels at rates approaching the maximum on sandy soils, in rainfall regimes approaching 150 inches per year, adverse effects to algal production will occur.

Imazapic

Aquatic animals appear to be relatively insensitive to imazapic exposures, with LC50 values of >100 mg/L for both acute toxicity and reproductive effects. Aquatic macrophytes may be much more sensitive, with an acute EC50 of 6.1 :g/L in duck weed (*Lemna gibba*). Aquatic algae appear to be much less sensitive, with EC50 values of greater than 45 :g/L. No toxicity studies have been located on the effects of imazapic on amphibians or microorganisms (SERA 2004a).

Imazapyr

No HQ exceedances occurred for imazapyr for fish or aquatic invertebrates. HQ exceedances occurred for algae and aquatic macrophytes at a rainfall rate of 150 inches per year.

The HQ values for algae at 150 inches per year ranged from 0 to 1.3. The HQ exceedance at 150 inches per year occurred only at the maximum application rate on clay soils. The HQ values for aquatic macrophytes at 150 inches per year ranged from 0 to 2.0. The HQ exceedance at 150 inches per year occurred only at the maximum application rate on clay soils. Given the range of HQ values observed for imazapyr at a rainfall rate of 150 inches per year, soil type is an important factor in determining exposure risk, with low permeability soils markedly increasing exposure levels. Application of imazapyr adjacent to stream channels at application rates approaching the maximum on soils with low permeability, in rainfall regimes approaching 150 inches per year, is likely to adversely affect algal production and aquatic macrophytes.

Algae and macrophytes provide food for aquatic macroinvertebrates, particularly those in the scraper feeding guild (Williams and Feltmate 1992). These macroinvertebrates in turn provide food for rearing juvenile salmonids. Consequently, adverse effects on algae and aquatic macrophyte production may cause a reduction in availability of forage for juvenile salmonids. Over time, juvenile salmonids that receive less food have lower body condition and smaller size at smoltification. However, the small amount of imazapyr expected to reach the water should not result in effects this severe.

Metsulfuron methyl

No HQ exceedances occurred for metsulfuron for fish, aquatic invertebrates, or algae. The HQ exceedances for aquatic macrophytes occurred at the maximum application rate on clay soils at rainfall rates of 50 and 150 inches per year. The HQ values ranged from 0.009 to 1.0 at 50 inches, and from 0.02 to 1.9 at 150 inches per year.

Given the range of HQ values observed for metsulfuron at each rainfall level, soil type is an important factor in determining exposure risk, with low permeability soils markedly increasing exposure levels. In areas with rainfall rates between 50 and 150 inches per year, application of metsulfuron adjacent to stream channels on soils with low permeability at application rates approaching the maximum is likely to adversely affect aquatic macrophytes. A slight decrease in forage availability for juvenile salmonids will result from adverse effects to aquatic macrophytes.

Picloram

Based on expected concentrations of picloram in surface water, all central estimates of the HQs are below the level of concern for fish, aquatic invertebrates, and aquatic plants. No risk characterization for aquatic-phase amphibians can be developed because no directly useful data are available. Upper bound HQs exceed the level of concern for longer-term exposures in sensitive species of fish (HQ=3) and peak exposures in sensitive species of algae (HQ=8). It does not seem likely that either of these HQs would be associated with overt or readily observable effects in either fish or algal populations. In the event of an accidental spill, substantial mortality would be likely in both sensitive species of fish and sensitive species of algae (SERA 2011a).

Sethoxydim

No HQ exceedances occurred for sethoxydim for aquatic invertebrates, algae, or aquatic macrophytes. The HQ exceedances for fish occurred at rainfall rates of 50 and 150 inches per year, and ranged from 0.3 to 1.0, and from 1.1 to 3.0, respectively. The HQ exceedance at 50 inches per year occurred only at the maximum application rate on loam soils. The HQ exceedances at 150 inches per year occurred at the typical application rate on sand, and at the maximum application rate on loam soil.

The HQ values for sethoxydim were calculated using the toxicity data for the Poast formulation, and incorporates the toxicity of naphtha solvent. The toxicity of sethoxydim alone for fish and aquatic invertebrates is much less than that of the formulated product (about 30 times less toxic for invertebrates, and about 100 times less toxic for fish). Since the naphtha solvent tends to volatilize or adsorb to sediments, using Poast formulation data to predict indirect aquatic effects from runoff leaching is likely to overestimate adverse effects (SERA 2001). Project design criteria sharply reduce the risk of naphtha solvent presence in percolation runoff reaching streams. When design criteria to reduce naphtha solvent exposure are employed, application of sethoxydim adjacent to stream channels will not affect listed salmonids or their habitat.

Sulfometuron

No HQ exceedances occurred for sulfometuron for fish, aquatic invertebrates, or algae. The HQ exceedance for aquatic macrophytes occurred at a rainfall rate of 150 inches per year on clay soils, and HQ values ranged from 0.007 to 3.8. Considering the range of HQ values observed for sulfometuron at each rainfall level, soil type is an important factor in determining exposure risk, with low permeability soils markedly increasing exposure levels. In areas with a rainfall rate approaching 150 inches per year, application of metsulfuron adjacent to stream channels on soils with low permeability at application rates approaching the maximum is likely to adversely affect aquatic macrophytes. A slight decrease in forage availability for juvenile salmonids will result from adverse effects to aquatic macrophytes.

Triclopyr

With the exception of aquatic plants, substantial risks to nontarget species (including humans) associated with the contamination of surface water are low, relative to risks associated with contaminated vegetation. Applications of triclopyr BEE in excess of about 1.5 to 3 lbs. acid equivalent/acre could be associated with acute effects in sensitive species of fish or invertebrates, in cases of substantial drift or off-site transport of triclopyr via runoff (SERA 2011c). Stehr et al. (2009) observed no developmental effects at nominal concentrations of 10 mg/L or less for purified triclopyr alone or for the TEA formulations Garlon 3A and Renovate. However, the developmental toxicity of other triclopyr-containing herbicides, especially formulations based on BEE (e.g., Garlon 4), rewash were not determined. NMFS (2011b) determined that triclopyr BEE (esters) posed a medium risk to fish. However, given the uses, fate, and toxicity of triclopyr BEE, NMFS did not expect mortality to be a common occurrence.

2,4-D

Drift and runoff are the most likely pathways of deposition of 2,4-D into aquatic habitats (USEPA 2009) and it is detected frequently in freshwater habitats within the four western states where listed Pacific salmonids are distributed. 2,4-D acid, salts, and esters are toxic to aquatic animals, with esters having greater toxicity than 2,4-D acid and salts. 2,4-D amine fits into the “moderate” risk group. Given their long residency period and use of freshwater, estuarine, and nearshore areas, juveniles and migrating adults have a high probability of exposure to herbicides that are applied near their habitats. The risk of adverse effects to fish and their habitats was evaluated in terms of hazard quotient values and “no observable effect concentration” levels. Over the range of 2,4-D acid/salt application rates used in USFS programs (0.5-4 lb. acid equivalent/acre), adverse effects on fish, amphibians, and aquatic invertebrates are likely only in the event of an accidental spill. With regard to 2,4-D esters, however, adverse effects on aquatic animals (fish, invertebrates, amphibians) are plausible in association with runoff (all application rates) and would be expected in direct application for weed control and in cases of relatively large accidental spills (USFS 2006). NMFS (2011b) determined that 2,4-D BEE posed a medium risk to fish. NMFS also determined that multiple populations of salmon could be exposed to direct water applications of 2,4-D within a single year, resulting in a decrease in population numbers significant enough to jeopardize the ESA-listed fish species. Based on risk from all use patterns, NMFS rated the likelihood of 2,4-D BEE affecting listed salmon as “medium” (NMFS 2011b). Here, 2,4-D amine is labeled for aquatic use and 2,4D ester is characterized as high risk to all ESA-listed fish due to the proposed no-spray buffers.

Summary. Stehr et al. (2009) studied developmental toxicity in zebrafish (*Danio rerio*), which involved conducting rapid and sensitive phenotypic screens for potential developmental defects resulting from exposure to six herbicides (picloram, clopyralid, imazapic, glyphosate, imazapyr, and triclopyr) and several technical formulations. Available evidence indicates that zebrafish embryos are reasonable and appropriate surrogates for embryos of other fish, including salmonids. The absence of detectable toxicity in zebrafish screens is unlikely to represent a false negative in terms of toxicity to early developmental stages of threatened or endangered salmonids. Their results indicate that low levels of noxious weed control herbicides are unlikely to be toxic to the embryos of ESA-listed fish. Those findings do not necessarily extend to other

life stages or other physiological processes (*e.g.*, smoltification, disease susceptibility, behavior, *etc.*) (NMFS 2013a).

The proposed PDC, including limitations on the herbicides, adjuvants, carriers, handling procedures, application methods, drift minimization measures, and riparian buffers, will greatly reduce the likelihood that significant amounts of herbicide will be transported to aquatic habitats, although some herbicides are still likely to enter streams through aerial drift, in association with eroded sediment in runoff, and dissolved in runoff, including runoff from intermittent streams and ditches. The indirect effects or long-term consequences of invasive, non-native plant control will depend on the long-term progression of climatic factors and the success of follow-up management actions to exclude undesirable species from the action area, provide early detection and rapid response before such species establish a secure position in the plant community, eradicate incipient populations, and control existing populations.

11. Riparian Vegetative Planting. The Corps proposes to plant riparian vegetation that would naturally occur in the treatment area. Many authors have discussed the importance of riparian vegetation to stream ecosystems (Dosskey et al. 2010; Hicks et al. 1991; Murphy and Meehan 1991; Spence et al. 1996; Swanston 1991). Streambanks covered with well-rooted woody vegetation have an average critical shear stress three times that of streambanks weakly vegetated or covered with grass (Millar and Quick 1998). Riparian vegetation also plays an important role in protecting streams from nonpoint source pollutants and in improving the quality of degraded stream water (Dosskey et al. 2010).

Planting in riparian areas may result in very minor fine sediment delivery to streams. It could also temporarily flush fish from hiding cover. In the long-term, planting of riparian vegetation will increase shade, hiding cover, LW, and streambank stability. This will improve the survival of yearling and other juvenile salmonids by providing appropriate substrate for fry and an increase in cover from predators and high flows. Beneficial effects to fish also include enhanced fitness through improved conditions for forage species and improved reproductive success for adult salmonids as a result of increased deep water cover and holding areas. As plantings mature, width-to-depth ratios of disturbed channels and fine sediment delivery will decrease.

12. Streambank and channel stabilization. In this Opinion, the primary streambank stabilization method proposed is vegetated riprap with large woody debris. Other proposed methods, to be used alone or in combination, include a log or roughened rock toe, a partially spanning porous weir, woody plantings, herbaceous cover, deformable soil reinforcement, coir logs, bank reshaping and slope grading, floodplain flow spreaders, floodplain roughness, and engineered log jams. Damaged streambanks will be restored to a natural slope, pattern, and profile suitable for establishment of permanent woody vegetation, without changing the location of the bank toe. Rock and other hard structures within the functional floodplain reduce water quality by reducing or eliminating riparian vegetation that regulates the quantity and quality of runoff and, together with channel complexity, help to maintain and reduce stream temperatures. The benefits of using rock or other hard structures for this purpose are often speculative or minimal, at best, particularly in contrast to the multiple habitat benefits provided by other erosion control methods that do not require hardening of the stream bank or bed (Cramer et al. 2003; Cramer 2012).

The effects of stream bank restoration are likely to include construction effects discussed above, and reestablishment of native riparian forests or other appropriate native riparian plant communities, provide increased cover (LW, boulders, vegetation, and bank protection structures) and a long-term source of all sizes of instream wood, reduce fine sediment supply, increase shade, moderate microclimate effects, and provide more normative channel migration over time.

Upstream and downstream channel effects occur when bank and channel hardening and channel narrowing alter stream velocity. Downstream, loss of stream roughness and channel narrowing causes water velocity and erosion to increase. Upstream, channel narrowing reduces water velocity and leads to backwater effects during high flows that typically result in upstream deposition (Legasse et al. 2001). Then, when flows recede, erosion occurs around or through the new deposition. Thus, a hardened bank or channel creates chronically unstable conditions that increase bed and bank erosion upstream and downstream, and often affect either the subject structure or an unrelated structure in a way that applicants prefer to address by further hardening. This sets in motion another round of upstream and downstream channel effects that perpetuates and extends the extent of aquatic habitat damage.

Channel maintenance is another very serious source of upstream and downstream channel effects. Channel maintenance refers to the periodic (sometimes annual) dredging necessary to counteract natural deposition which occurs around structures where they impinge on the edge of a functional floodplain, particularly where a smaller tributary enters the floodplain and creates an alluvial fan. These areas tend to fill with alluvial material that will be dredged to prevent a road, culvert, or other structure from being overtopped during high flow events. This chronic source of bed removal is a major cause of channel instability and loss of spawning and rearing habitat for long distances upstream and downstream, and is a source of mechanical disturbance in bays, estuaries, and lower elevation mainstem reaches where sturgeon occur.

Ecological connectivity refers to the capacity of the landscape to support the movement of energy, water, sediment, organisms, and other material. Ecological connectivity is adversely affected by rock or other hard structures in the functional floodplain when bed material and aggrading channel processes cannot cycle throughout the reach, and when the upstream or downstream movements of organisms are restricted. The conservation of bull trout is intimately linked to the health of their underlying ecosystems. This, in turn, depends on more than just the ability of these fish to move upstream and downstream during different life history stages and under a wide variety of different stream conditions. Ecological health also requires ecological connectivity for a wide range of physical and biotic processes that are more difficult to quantify than fish passage, such as seasonally shifting channel patterns, the upstream flight and downstream drift of insects, and delivery of large wood from terrestrial sources to the stream, estuary and coastal ocean (Maser et al. 1988). Installation of rock or structures that require channel maintenance captures large wood, accelerates or delays fish movements, or otherwise inhibits the movement of energy and material also reduces ecological connectivity.

13. Maintenance, rehabilitation, and replacement of roads, culverts, and bridges. The effects of these projects include all of the preconstruction, construction, and site restoration effects described above. This includes actions necessary to complete geotechnical surveys, such

as access road construction, drill pad preparation, mobilization and set up, drilling and sampling operations, demobilization, boring abandonment, and access road and drill pad reclamation. Excavation, grading, and filling necessary to maintain, rehabilitate, or replace existing roads, culverts, and bridges, and to construct and maintain stormwater facilities are also included.

Stormwater runoff from the highway system, including roads, culverts, and bridges, delivers a wide variety of pollutants to aquatic ecosystems, such as nutrients, metals, petroleum-related compounds, sediment washed off the road surface, and agricultural chemicals used in highway maintenance (Buckler and Granato 1999; Colman et al. 2001; Driscoll et al. 1990; Kayhanian et al. 2003). These ubiquitous pollutants are a source of potent adverse effects to salmon and steelhead, even at ambient levels (Hecht et al. 2007; Johnson et al. 2007; Loge et al. 2006; Sandahl et al. 2007; Spromberg and Meador 2006), and are among the identified threats to sturgeon. Aquatic contaminants often travel long distances in solution or attached to suspended sediments, or gather in sediments until they are mobilized and transported by the next high flow (Alpers et al. 2000b; Alpers et al. 2000a; Anderson et al. 1996). These contaminants also accumulate in the prey and tissues of juvenile salmon where, depending on the level of exposure, they cause a variety of lethal and sublethal effects on salmon and steelhead, including disrupted behavior, reduced olfactory function, immune suppression, reduced growth, disrupted smoltification, hormone disruption, disrupted reproduction, cellular damage, and physical and developmental abnormalities (Fresh et al. 2005; Hecht et al. 2007; Lower Columbia River Estuary Partnership 2007). The proposed design criterion for stormwater management will treat stormwater flows associated with more than 95% of the annual average rainfall. Runoff from impervious surfaces within each project area being treated at or near the point at which rainfall occurs using low impact development, bioretention, filter subsoils, and other practices that have been identified as excellent treatments to reduce or eliminate contaminants for highway runoff (Barrett et al. 1993; Center for Watershed Protection and Maryland Department of the Environment 2000 (revised 2009); Herrera Environmental Consultants 2006; Hirschman et al. 2008; National Cooperative Highway Research Program 2006).¹⁹

Stormwater treatment practices, such as bioretention, bioslopes, infiltration ponds, and porous pavement, supplemented with appropriate soil amendments as needed,²⁰ are excellent treatments to reduce or eliminate contaminants from runoff (Barrett et al. 1993; Center for Watershed Protection and Maryland Department of the Environment 2000 (revised 2009); Hirschman et al. 2008; National Cooperative Highway Research Program 2006; Washington State Department of Ecology 2004; Washington State Department of Ecology 2012). Stormwater treatment may also include source control BMPs, which prevent pollution, or other adverse effects of stormwater, from occurring. Source control BMPs include methods as various as using mulches and covers on disturbed soil, putting roofs over outside storage areas, and berming areas to prevent stormwater run-on and pollutant runoff.

¹⁹ See also Memos from Ronan Igloria, HDR (Henningson, Durham, and Richardson, Inc.), to Jennifer Sellers and William Fletcher, Oregon Department of Transportation, dated December 28, 2007 (Stormwater Treatment Strategy Development – Water Quality Design Storm Performance Standard), February 28, 2008 (Stormwater Treatment Strategy Development – Water Quantity Design Storm Performance Standard - Final), and April 15, 2008 (Stormwater Treatment Strategy Development – BMP Selection Tool).

²⁰ See also Memos from Ronan Igloria, HDR (Henningson, Durham, and Richardson, Inc.), to Jennifer Sellers and William Fletcher, Oregon Department of Transportation (Igloira 2007; Igloira 2008; Igloria 2008).

Flow control BMPs typically control the volume rate, frequency, and flow duration of stormwater surface runoff. The need to provide flow control BMPs depends on whether a development site discharges to a stream system or wetland, either directly or indirectly. Stream channel erosion control can be accomplished by BMPs that detain runoff flows and also by those which physically stabilize eroding streambanks. Both types of measures may be necessary in urban watersheds. Construction of a detention pond is the most common means of meeting flow control requirements. Construction of an infiltration facility is the preferred option but is feasible only where more porous soils are available.

Although the Corps proposes that actions will capture, manage, and treat runoff up to the design storm level from most proposed projects, treatment will not eliminate and may not even significantly reduce all pollutants in the runoff currently produced at project sites. Thus, adverse effects of non-point source pollution will persist for the design life of the proposed action.

Roads, culverts, and bridges require routine maintenance to remain serviceable with a minimum of adverse effects to species and designated critical habitats. Most of these actions will be completed in accordance with the most recent version approved by USFWS of ODOT (2009) best management practices for routine road maintenance, unless those practices conflict with PDC in this Opinion.

Unlike routine road maintenance, structural failure of road, culvert, or bridge infrastructure causes extensive and long-lasting damage to aquatic habitats. Consequences of infrastructure failure include erosion and sedimentation, release of toxic materials or structural debris into the water, rerouting of flows into neighboring drainages that may be unable to adjust to the increase in peak flow, or onto unchanneled slopes. Structural failure may be caused by inadequate design, poor construction, damage accumulated from vehicles, inadequate maintenance, or extreme natural events, but most often is a result of flooding and improper or inadequate engineering and design, particularly at stream crossings but also where roads cross headwater swales and other areas of convergent groundwater. A typical failure occurs when culverts that are sized only to accommodate the flow of water, but not the additional sediment and wood typically transported during higher flows, becomes obstructed, thus causing water and debris to overflow. In more serious cases, diversion and concentration of overflow then leads to a “cascading failure,” a series of adverse events that end with loss of the structure or initiation of landslides and debris flows (Furniss et al. 1998; Gucinski et al. 2001).

Although flooding will always be a threat to this type of infrastructure, the Corps’ proposed action will minimize this danger by requiring road, culvert, and bridge designs that anticipate and accommodate the movement of water, sediment and debris during infrequent but major storms and reduce stormwater runoff. Reduced maintenance costs will be a significant ancillary benefit for applicants. Moreover, the proposed action will allow the Corps to authorize or carry out a “natural hazard response” when road, culvert, bridge, or utility line infrastructure fails, or is about to fail. This will allow a public transportation manager to act immediately, or before the next appropriate in-water work window, as necessary to repair or prevent infrastructure failure that poses an imminent threat to human life, property, or natural resources. Part of the response includes contacting NMFS as soon as possible to review PDC from this Opinion that are

applicable to the situation and determine whether additional steps may be taken to further minimize the effects of the initial response action on listed species or their critical habitat. Later, a report on the incident will provide an assessment of the effects to listed species and critical habitats and a plan to bring the response into conformance with all other applicable PDC in this Opinion.

14. Utility line stream crossings. Proposed utility line actions consist of stream crossings for pipes, pipelines, cables, and wires. Most direct and indirect effects of utility line actions are similar to the effects of general construction discussed above, and will follow the PDC for general construction as applicable. Aerial utility lines hung from an existing bridge are likely to add no additional effects to those of the bridge; drilled lines are likely to have a smaller subset of the construction effects discussed above, including drilling effects, or will express those effects to a lesser degree. However, trenched utility lines are likely to cause additional adverse effects related to erosion.

Excavation and subsequent filling of a trench in a streambank or dry channel is likely to make the area of the trench more or less resistant to erosion, depending on the substrate composition, the type of excavation, and the type of fill. If the trench area is less resistant to erosion, due to loosening of the substrate or through the use of fill with smaller substrate particles than were originally present, then high stream flows are likely to erode the disturbed substrate, thus mobilizing sediment or abruptly altering the bottom contours or bank stability of the stream. If the trench area is more resistant to erosion, through compaction of the substrate or through the use of fill with larger substrate particles than were originally present, then high stream flows may be less likely to erode the disturbed substrate than the remainder of the streambed or bank, possibly creating hydraulic control points and altering fluvial processes. Similarly, pipelines, cables, and materials used to armor them may create hydraulic control points (“jumps”) that degrade channel conditions and impede fish passage, if they remain at the same elevation after being exposed by streambed or bank erosion.

15. In- and Over-water Structures. An effect of overwater structures is the creation of a light/dark interface that allows ambush predators to remain in a darkened area (barely visible to prey) and watch for prey to swim by against a bright background (high visibility). Prey species moving around the structure are unable to see predators in the dark area under the structure and are more susceptible to predation. The same effect holds true for inwater structures that increase and create areas for predators to remain concealed from prey.

Predatory fish in many of the areas covered by this Opinion include northern pikeminnow, smallmouth bass, largemouth bass, and walleye. Predation on bull trout is reasonably certain to increase with the addition of structures. Juvenile fish abundance has also been found to be reduced under piers and overwater structures when compared to open water or areas with piles but no overwater structures (Able et al. 1998), likely due to limitations in prey abundance and increased predation under structures. Several studies have found smallmouth bass and northern pikeminnow predation on juvenile fishes to be significant. While these studies have centered on Chinook and steelhead, similar inferences can be made about the effects of predatory fish on bull trout where distribution of these fishes overlap:

Fritts and Pearsons (2004) estimated that smallmouth bass in the Yakima River consumed an average of roughly 200,000 juvenile Chinook salmon yearly. They primarily ate the smallest salmon available—that is, offspring of naturally spawning ocean-type Chinook salmon (subyearlings). They further indicated that smallmouth bass predation can adversely affect native salmonids where there is spatial overlap between smallmouth bass and small-sized salmonids.

Tabor et al. (1993) found that juvenile salmonids made up 59% by weight of smallmouth bass diets and 28.8% by weight of northern pikeminnow diets in the Columbia River near Richland, Washington. The juvenile salmon were mostly subyearling Chinook salmon. Predation rates were high during the spring and early summer, when their habitat overlapped.

Naughton et al. (2004) found that juvenile salmonids comprised less than 11% (by weight) of the diet of smallmouth bass in the Lower Granite Reservoir System. They postulate that variation in juvenile salmonid consumption by smallmouth bass is common within the basin and is probably related to differing biotic and abiotic conditions.

Poe et al. (1991) found that juvenile salmonids composed 67% of northern pikeminnow diets (by weight) and 14% of smallmouth bass diets in John Day Reservoir. They further found that subyearling Chinook salmon were selected by smallmouth bass when their two distributions overlapped.

Zimmerman and Ward (1999) found that predation of juvenile salmonids by northern pikeminnow in the Columbia River downstream from Bonneville Dam was consistently an order of magnitude greater than at sites in Columbia and Snake River impoundments.

Tabor et al. (2007), in examining salmonid predation by smallmouth and largemouth bass in the Lake Washington Basin found that overall rates of predation were low, but that during certain times of year up to 50% of the smallmouth bass diet was made up of salmonids (primarily subyearlings), particularly in the Lake Washington Ship Canal. They attribute this to the relatively small size of subyearlings and their use of nearshore habitats where overlap with bass is greatest.

Chapman (2007), in evaluating the effects of dock structures on subyearling Chinook salmon in Wells Dam Pool indicates that:

- Subyearling Chinook salmon less than 60mm in length use nearshore covered habitats extensively.
- Docks may be a surrogate for lack of overhead cover.
- Pikeminnow and smallmouth bass are two major predators that would be expected to use dock structures.
- The greatest potential for predation occurs in late April, May, and to a lesser extent, early June, when subyearlings are small and the water in littoral areas warms. Once they are larger they are less susceptible.
- Docks probably increase carrying capacity of Wells Dam Pool for smallmouth bass by providing structural cover and temporary access to prey.

- To avoid increases in mortality of subyearling summer/fall Chinook salmon, placement of docks in littoral zones of Wells Dam Pool should not be undertaken.

As identified in the 2010 Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (Lower Columbia Fish Recovery Board 2010)²¹, predation by native and introduced fish species is a limiting factor for recovery of bull trout. Evidence suggests that predation related mortality of juvenile salmonids during outmigration is substantial, thereby limiting survival and abundance of salmonids. Predation likely has always been a significant source of mortality but has been exacerbated by habitat changes. Current sources of predation on salmonids are substantial, however, how current predation levels compare to those experienced historically is unknown. Salmonids are an important food for large pikeminnow and millions of juvenile salmonids are estimated to fall prey each year. Significant numbers of salmon are lost to fish, bird, and marine mammal predators during migration through the mainstem Columbia River. Smallmouth bass (*Micropterus dolomieu*) also have been found to consume significant numbers of juvenile salmonids. Habitat alterations in the Lower Columbia River mainstem and estuary have increased the abundance of predators of juvenile salmonids.

The State of Washington's position paper (Dugger 2005) on shading effects recommends for anything wider than 3 feet that 60% of the total coverage be grated and that the grated areas not be used for storage. They do allow for some individual exceptions in waters greater than 20 feet in depth, velocity greater than 0.7 fps and at least 50 feet from the shore (Dugger 2005). NMFS believes that the incorporation of grating covering 60% of the surface area into all of the docks allows for more light penetration and diffuses the light/dark interface and will minimize the susceptibility of juvenile salmonids to piscivorous predation resulting from these types of projects.

Stuber et al. (1982), in their development of a habitat suitability index model for largemouth bass found that adults are most abundant in areas of low current velocity and velocities greater than 20 cm/sec (0.7 fps) were unsuitable. Placement of overwater structures in areas with velocities greater than 0.7 fps will minimize the susceptibility of juvenile salmonids to piscivorous predation resulting from these types of projects.

In addition, the presence of predators may force smaller prey fish species into less desirable habitats, disrupting foraging behavior, resulting in less growth (Dunsmoor et al. 1991).

Placement of structures in shallow water may also disrupt migration and cover habitat of smaller juvenile bull trout that use nearshore areas. Boat activity and the physical presence of the structures may result in juveniles delaying passage or forcing them into deeper water areas in an attempt to go around the structures.

Placement of structures close to the shore impacts the ability of juvenile salmonids to safely migrate past or to access other feeding and foraging habitat. It is conceivable that the nearshore area used by juveniles would be smaller on smaller stream systems. Therefore, placement of a

²¹ This plan and report from NMFS minimally referenced bull trout, with the exception that certain effects were analyzed both to bull trout and from bull trout on juvenile salmon and steelhead and predation effects. This reference has been incorporated due to the applicability of mortality due to predation.

floating structure at a minimum of 50 feet from the shoreline at OLW and MLLW would minimize the potential for disruption to migration and habitat utilization.

Shading from docks, piers, boat houses, moored boats, and marinas may also reduce juvenile bull trout prey organism abundance and the complexity of the habitat by reducing aquatic vegetation and phytoplankton abundance (Kahler et al. 2000). Placement of dock structures in areas devoid of aquatic vegetation would avoid impacts to food resources and refugia.

Placement of piles to support the structures will likely provide for some usage by cormorants and other piscivorous birds. Placement of anti-perching devices on the top of the pilings would preclude their use by any likely avian predators.

Residential structures and especially marinas are likely to have high levels of boating activity in their immediate vicinity, particularly next to floats. Specifically, floats may serve as a mooring area for boats or a staging platform for recreational boating activities. Boating activities may adversely affect bull trout and aquatic habitats directly through engine noise or prop movement, and the physical presence of a boat hull may disrupt or displace nearby fishes (Mueller 1980, Warrington 1999).

Mueller (1980), in studying boating effects on long-eared sunfish found that boating affected fish behavior. Depending on speed and proximity to the nests, boats caused spawners to abandon their nests for varying periods in order to find protective shelter. Type of craft (johnboat or canoe) had no noticeable difference in effect, but speed and distance were important. Slow-moving craft (paddled or motored at 1 m (3 feet)/second) passing near a spawner chased it from its nest more often than craft moving at faster speeds. In most predation cases, speed and distance of passing craft made a large difference. Slow-moving craft, whether paddled or motored near nests chased spawners away more frequently than faster-moving craft.

Graham and Cooke (2008) studied the effects of three boat noise disturbances (canoe paddling, trolling motor, and combustion engine (9.9 hp)) on the cardiac physiology of largemouth bass (*Micropterus salmoides*). They found that exposure to each of the treatments resulted in an increase in cardiac output in all fish, associated with a dramatic increase in heart rate and a slight decrease in stroke volume, with the most extreme response being to that of the combustion engine treatment. Recovery times were the least with canoe paddling (15 minutes) and the longest with the power engine (40 minutes). They postulate that this demonstrates that fish experienced sublethal physiological disturbances in response to the noise propagated from recreational boating activities.

To USFWS' knowledge, studies on bull trout response to these activities have not been conducted, but given these fishes' similar life history and biology it is reasonable that bull trout would also react in much the same manner. This is especially important at the mouths of tributaries where adult bull trout congregate/hold prior to further upstream migration. Precluding adult bull trout from reaching spawning habitat will result in pre-spawning mortality, thus reducing their abundance.

These boating impacts indirectly affect bull trout in many ways. Turbidity may injure or stress affected fishes (see above). The loss of aquatic macrophytes may expose bull trout to predation, decrease littoral productivity, or alter local species assemblages and trophic interactions. The continual loss of bankline results in requests for bank stabilization measures that further disrupt natural stream processes. Despite a general lack of data specifically for bull trout, pollution from boats may cause short-term injury, physiological stress, decreased reproductive success, cancer, or death for fishes. Further, pollution may also affect fishes by affecting likely prey species or aquatic vegetation.

Habitat degradation and loss adversely affect inshore and riverine ecosystems critical to living marine resources. The cumulative effects of small changes in many aquatic habitats may have a large systematic impact on watershed carrying capacity. Point and non-point discharges, waste dumps, eutrophication, acid rain, and other human impacts reduce this ability.

The proposed siting and dimension criteria for in water structures permitted under this program will not prevent usage by predators, but it will minimize the impacts described above. Grating in the floats will minimize the success of ambush predators. Placing structures further offshore will minimize disruption to migration and the success of predators. Anti-perching devices will alleviate potential bird predation. Increasing boater awareness through signage as to the impacts associated with boating will also help to minimize boating effects.

16. Dredging. Direct effects to fish are likely to include entrainment of fish (Dutta and Sookachoff 1975a, Boyd 1975, Armstrong et al. 1982, Tutty 1976) and mortality from exposure to suspended sediments (turbidity). The likely indirect effects of dredging include:

1. Behavioral changes (Sigler et al. 1984, Berg and Northcote 1985, Whitman et al. 1982, Gregory 1988) and sub-lethal impacts from exposure to increased turbidity (Sigler 1988, Sigler et al. 1984, Kirn et al. 1986, Emmett et al. 1988, Servizi 1988);
2. Mortality from predatory species that benefit from activities associated with dredged material disposal;
3. Mortality resulting from stranding as a result of vessel wakes;
4. Modifications to nearshore habitat resulting from erosion as a result of vessel wakes or dredging itself;
5. Loss of benthic food sources resulting from dredging and disposal of dredged material (Morton 1977); and
6. Cumulative effects of increased industrialization at port facilities along the river.

USFWS does not expect clamshell dredging to entrain bull trout considered in this Opinion. The action of the bucket passing through the water column should allow for bull trout to avoid it. However, hydraulic suction dredging may entrain juveniles. When fish come within the “zone of influence” of the cutter head, they may be drawn into the suction pipe (Dutta 1976, Dutta and Sookachoff 1975a). Dutta (1976) reported that salmon fry were entrained by suction dredging in the Fraser River and that suction dredging during juvenile migration should be controlled. Braun (1974a, 1974b), in testing mortality of entrained salmonids, found that 98.8% of entrained juveniles were killed. Dutta and Sookachoff (1975b) found that suction dredging operations “cause a partial destruction of the anadromous salmon fishery resource of the Fraser River.” Boyd (1975) noted that suction pipeline dredges operating in the Fraser River during fry

migration took substantial numbers of juveniles. As a result of these studies, the Canadian government issued dredging guidelines for the Fraser River to minimize the likelihood of entrainment (Boyd 1975). Further testing in 1980 by Arseneault (1981) resulted in entrainment of chum and pink salmon but in low numbers relative to the total of salmonids outmigrating (0.0001 to 0.0099%). Many of these effects and studies can also be applied to bull trout with respect to juvenile entrainment possibility.

The Corps conducted extensive sampling within the Columbia River in 1985-88 (Larson and Moehl 1990) and again in 1997 and 1998. In the 1985-88 study, no juvenile salmon were entrained and the 1997-98 study resulted in entrainment of only two juvenile salmon. McGraw and Armstrong's (1990) examination of fish entrainment rates in Grays Harbor from 1978 to 1989 resulted in only one juvenile salmon being entrained. Dredging was conducted outside peak migration times. Stickney (1973) also found no evidence of fish mortality while monitoring dredging activities along the Atlantic Intracoastal Waterway. These studies were on deep water areas associated with main channels. Few data are available on the extent of entrainment in shallow-water areas, such as those associated with the side channels proposed as part of maintenance dredging.

In areas of coarse sand, USFWS expects the turbidity generated from all types of dredging to be very small and confined to the area close to the draghead or bucket. Issues involving turbidity associated with flow lane disposal were addressed in the April 6, 1993 biological opinion with the Corps for navigation channel maintenance dredging (NMFS 1993). NMFS did not believe that mortality resulting from turbidity was an issue of concern during that consultation and the Service has no information that would change that belief for this Opinion regarding bull trout.

Dredging within the in-water work period and using best management practices (keeping the intake at or just below the surface of the material being extracted and raising it only for short periods to purge) is expected to minimize any potential impacts.

4.3 Effects of the Action to Bull Trout

The most intense adverse effects of the proposed action for bull trout result from in- or-near-water construction (i.e., stream crossing replacement projects, channel reconstruction/relocation, *etc.*). The physical and chemical changes in the environment associated with construction, especially decreased water quality (*e.g.*, increased total suspended solids and temperature, and decreased dissolved oxygen), are likely to affect a larger area than direct interactions between fish and construction personnel. As noted above, each individual project will be completed as proposed with full application of PDC for construction. Those measures will ensure that the Corps will:

1. not undertake restoration at sites occupied by spawning adult fish or where occupied redds are present;
2. defer construction until the time of year when the fewest fish are present; and
3. otherwise ensure that the adverse environmental consequences of construction are avoided or minimized.

Each action is likely to have the following effects on individual fish at the site and reach scale. The nature of these effects will be similar between projects because each project is based on a

similar set of underlying construction activities that are limited by the same design criteria and the individual bull trout core areas in the action area have relatively similar life history requirements and behaviors regardless of geographical location.

The intensity of the effects, in terms of changes in the condition of individual fish and the number of individuals affected, and severity of these effects will also vary somewhat between projects because of differences at each site in the scope of work area isolation and construction, the particular life history stages present, the baseline condition of each fish present, and factors responsible for those conditions. However, no project will have effects on fish that are beyond the full range of effects described here.

It is still possible that individual adult or embryonic bull trout will be adversely affected by the proposed action even though all in-water construction will occur during the in-water work period before spawning season occurs and after fry have emerged from gravel. Also, in some locations, adult bull trout may be present (either due to migration or residency) during part of the in-water work, and juveniles may still be emerging from the gravel. Therefore, cooperation between the USFWS and the action agencies, in cooperation with the State, will be needed to determine the best timing of projects on site-specific basis. The use of heavy equipment in-stream in spawning areas will likely disturb or compact spawning gravel. Upland erosion and sediment delivery will likely increase substrate embeddedness. These factors make it harder for fish to excavate redds, and decrease redd aeration (Cederholm et al. 1997). However, the degree of instream substrate compaction and upland soil disturbance likely to occur under most of these actions is so small that significant sedimentation of spawning gravel is unlikely. If, for some reason, an adult fish is migrating in an action area during any phase of construction, it is likely to be able to successfully avoid construction disturbances by moving laterally or stopping briefly during migration, although spawning itself could be delayed until construction was complete (Feist et al. 1996; Gregory 1988; Servizi and Martens 1991; Sigler 1988).

In general, direct effects are ephemeral (instantaneous to hours) or short-term (days to months), and indirect effects are long-term (years to decades, or the life of the project). Effects are described by life history stage in outline form below. Projects with a more significant construction aspect are likely to adversely affect more fish, and to take a longer time to recover, than projects with less construction.

In contrast to migratory adult and embryonic fish that will likely be absent during implementation of projects, resident adults, sub-adults and juvenile bull trout may be present at some portion of the restoration sites, particularly those located in SR habitat, and those located where bull trout exhibit the resident life form. At in- or near-water construction projects (i.e., stream crossing replacement projects, channel reconstruction/relocation, *etc.*), some direct effects of the proposed actions are likely to be caused by the isolation of in-water work areas, although other combined lethal and sublethal effects would be greater without the isolation. An effort will be made to capture all bull trout (all life stages) present within the work isolation area and to release them at a safe location, although some juveniles will likely evade capture and later die when the area is dewatered. Fish that are captured and transferred to holding tanks can experience trauma if care is not taken in the transfer process. Fish can also experience stress and injury from overcrowding in traps, if the traps are not emptied on a regular basis. The primary

contributing factors to stress and death from handling are: (1) water temperatures difference between the river and holding buckets; (2) dissolved oxygen conditions; (3) the amount of time that fish are held out of the water; and (4) physical trauma (from capture and handling). Stress from handling increases rapidly if water temperature exceeds 15°C (59°F), or if dissolved oxygen is below saturation. Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared on a regular basis. PDC related to the capture and release of fish during work area isolation will avoid most of these consequences, and ensure that most of the resulting stress is short-lived (Portz 2007).

Rapid changes and extremes in environmental conditions caused by construction are likely to cause a physiological stress response that will change the behavior of juvenile fish (Moberg 2000; Shreck 2000). For example, reduced input of particulate organic matter to streams, addition of fine sediment to channels, and mechanical disturbance of shallow-water habitats are likely to cause displacement from, or avoidance of, preferred rearing areas. Actions that affect stream channel widths are also likely to impair local movements of juvenile fish for hours, days, or longer. Migration will also likely be impaired. These adverse effects vary with the particular life stage, the duration and severity of the stressor, the frequency of stressful situations, the number and temporal separation between exposures, and the number of contemporaneous stressors experienced (Newcombe and Jensen 1996; Shreck 2000).

Juvenile fish compensate for, or adapt to, some of these disturbances so that they continue to perform necessary physiological and behavioral functions, although in a diminished capacity. However, fish that are subject to prolonged, combined, or repeated stress by the effects of the actions, combined with poor environmental baseline conditions, will likely suffer metabolic costs that are sufficient to impair their rearing, migrating, feeding, and sheltering behaviors and thereby increase the likelihood of injury or death. Because juvenile fish in the project areas are already subject to stress as a result of degraded watershed conditions, it is likely that a small number of those individuals will die due to increased competition, disease, and predation, and reduced ability to obtain food necessary for growth and maintenance (Moberg 2000; Newcombe and Jensen 1996; Sprague and Drury 1969).

In addition to the short-term adverse effects of construction on bull trout, each type of action will also have the following long-term effects to individual fish. Because each of the proposed RES will increase the amount of habitat available within the underlying stream or river, promote development of more natural riparian and stream channel conditions to improve aquatic functions, or both, the habitat available for fish will be larger, more productive, or both. This will allow more complete expression of essential biological behaviors related to reproduction, feeding, rearing, and migration. If habitat abundance or quality is a limiting factor for bull trout in streams, the long-term effects of access to larger or more productive habitat is likely to increase juvenile survival or adult reproductive success. However, individual response to habitat improvement will also depend on factors, such as the quality and quantity of newly available habitat, and the abundance and nature of the predators, competitors, and prey that reside there (NMFS 2013a). STU actions will have less long term effects due to limited long term impacts to the habitat abundance and quality, and IWOW may have neutral or negative effects solely due to the potential of creating more habitat for predators.

Instantaneous measures of population characteristics, such as population abundance, population spatial structure and population diversity, are the sum of individual characteristics within a particular area, while measures of population change, such as population growth rate, are measured as the productivity of individuals over the entire life cycle (McElhany et al. 2000). Thus, although the expected loss of a small number of individuals will have an immediate effect on population abundance at the local scale, the effect will not extend to measurable population change unless it reaches a scale that can be observed over an entire life cycle.

Because juvenile-to-adult survival rate for bull trout is thought to be quite low, the effects of a proposed action would have to occur to large proportions of juvenile fish in a single area or local population before those effects would be equivalent even to a single adult, and would have to kill many times more than that to affect the abundance or productivity of the entire local population over a full life cycle. Moreover, because the geographic area that will be affected by the proposed programmatic action is so large for bull trout, the small numbers of juvenile fish that are likely to be killed are spread out across dozens of local populations. The adverse effects of each proposed individual action will be too infrequent, short-term, and limited to kill more than a very small number of juvenile bull trout at a particular site or even across the range of a single local population, much less when that number is even partly distributed among all local populations within the action area. Thus, the proposed actions will simply kill too few fish, as a function of the size of the affected populations and the habitat carrying capacity after each action is completed, to meaningfully affect the primary attributes of abundance or population growth rate for any single local population of bull trout.

The remaining population attributes are within-population spatial structure, a characteristic that depends primarily on spawning group distribution and connectivity, and diversity, which is based on a combination of genetic and environmental factors (McElhany et al. 2000). Because the proposed actions are only likely to have short-term adverse effects to spawning sites, if any, and in the long-term will improve spawning habitat attributes, they are unlikely to adversely affect spawning group distributions or within-population spatial structure. Actions that restore fish passage will improve population spatial structure. Similarly, because the proposed action does not affect basic demographic processes through human selection, alter environmental processes by reducing environmental complexity, or otherwise limit a population's ability to respond to natural selection, the action will not adversely affect population diversity.

At the species level, biological effects are synonymous with those at the population level or, more likely, are the integrated demographic response of one or more subpopulations (McElhany et al. 2000). Because the likely adverse effects of any action funded or carried out under this Opinion will not adversely affect the overall population characteristics of bull trout, the proposed actions also will not have any a measurable effect on species-level abundance, productivity, or ability to recover bull trout across their ranges.

The effects of proposed action, as a whole, on bull trout considered in this Opinion will be the combined effects of all of the individual actions that are funded or carried out under this Opinion. Combining the effects of many actions does not change the nature of the effects caused by individual actions, but does require an analysis of the additive effects of multiple occurrences of the same type of effects at the individual fish, population, and species scales. If the adverse

effects of one action are added to the effects of one or more additional actions in the same place and time, individual fish will likely experience a more significant adverse effect than if only one action was present. This would occur when the action area for two or more recovery actions overlap, i.e., are placed within 100 to 300 feet of each other and are constructed at approximately the same time.

A discussion regarding the calculation and number of bull trout affected by the proposed action is examined in further detail in the Incidental Take Statement below (Section 7.0).

4.4 Scope of Effects to Bull Trout

The specific anticipated amount and effects of capture have been discussed for bull trout in the previous sections. The scope of effects from other actions previously consulted on can be described best by looking at the likely number of effects, and by using various metrics to understand those effects by general activity type.

Suspended sediment and contaminants:

Near and instream construction activities required for many activities will result in an increase in suspended sediment and possibly contaminants that will cause juvenile, sub-adult and adult fish to move away from the action area. Bull trout exposed to suspended sediment are likely to experience gill abrasion, decreased feeding, stress, or be unable to use the action area, depending on the severity of the suspended sediment release. On occasions some fish may die if sediment is too severe, or if they are unable to move away from the affected area. Bull trout exposed to petroleum-based contaminants, such as fuel, oil, and some hydraulic fluids, are likely to be killed or suffer acute and chronic sublethal effects. Acute sublethal effects could range from harassment to minor irritation of skin or membranes, chronic sublethal effects could cause gill damage, with resultant respiratory difficulties or illness which would affect growth, and make fish more prone to predation. Construction activities will also cause a minor increase in fine sediment levels in downstream substrates, temporarily reducing the value of that habitat for spawning rearing, and foraging.

The USFWS estimates that these projects could increase sedimentation up to 10% over background levels. The turbidity plume generated by construction activities is visible above background levels and will result in about a 10% increase in natural stream turbidity downstream from the project area source. A turbidity flux would likely be measureable downstream from a nonpoint discharge a proportionately shorter distance in small streams than large streams. Because of the wide variability of project types, locations and site-specific stream conditions it is impossible to accurately estimate the exact footprint that these projects will have. However, the effects of these projects must comply with EPA direction and State water quality standards, which were designed to insure reasonable protection for aquatic species. Therefore, the extent of measured effects for this category is as follows – a visible increase in suspended sediment (as estimated using turbidity measurements, as described in the ITS) up to 50 feet from the project area in streams that are 30 feet wide or less, up to 100 feet from the discharge point or nonpoint source of runoff for streams between 30 and 100 feet wide, and up to 200 feet from the discharge point or nonpoint source for streams greater than 100 feet wide.

While this increase in turbidity will adversely affect bull trout, it is likely that most fish will move away from this disturbance rather quickly if they have the ability to do so. This is particularly true of adult bull trout who exhibit extreme sensitivity to sedimentation.

Construction-related disturbance of streambank and channel areas; and vegetation treatment related disturbance of upland and wetland areas:

Some projects that do not require in-water or near-water construction will nonetheless injure or kill bull trout juveniles and adults. These effects will occur primarily due to increased delivery of fine sediments to streams due to activities in upland or wetland areas, or by road restoration projects. For example, prescribed burning will expose soils in upland areas, resulting in increased erosion and production of fine sediments that can be routed to streams, thus reducing productivity and survival or growth of juvenile fish. Other actions such as surveys and nutrient enhancement are likely to result in harassing fish sufficiently to flush them from areas with overhead cover and thus become more susceptible to predation. These types of impacts are expected to occur infrequently, but will nonetheless occur over large areas.

Invasive and non-native plant control:

Application of manual, mechanical, biological or chemical plant controls will result in short-term reduction of vegetative cover or soil disturbance and degradation of water quality which will cause injury to fish in the form of sublethal adverse physiological effects. This is particularly true for herbicide applications in riparian areas or in ditches that may deliver herbicides to streams occupied by bull trout. These sublethal effects, described in the effects analysis for this Opinion, will include increased respiration, reduced feeding success, and subtle behavioral changes that can result in predation. Direct measurement of herbicide transport using the most commonly accepted method of residue analysis (e.g., liquid chromatography–mass spectrometry, Pico et al. 2004), are burdensome and expensive for the type and scale of herbicide applications proposed. Thus, use of those measurements in to determine the extent of adverse effects is likely to outweigh any benefits of using herbicide as a simple and economical restoration tool, and act as an insurmountable disincentive to their use for plant control under this Opinion. Further, the use of simpler, indirect methods, such as olfactometric tests, do not correlate well with measured levels of the airborne pesticides, and may raise ethical questions (Brown et al. 2000) that cannot be resolved in consultation. Therefore, the USFWS has determined that the best available approach to manage the extent of adverse effects due to the proposed invasive plant control is to adhere to the limits defined in PDC 22G(d) that state application cannot exceed 10-acres above bankfull elevation and 2 acres below bankfull elevation, per 1.6-mile reach of a stream, per year.

4.5 Effects of the Action on Bull Trout Critical Habitat

Completion of each action is likely to have the following effects to the PBF or habitat features essential to the conservation of each species. These effects will vary somewhat in degree between individual actions because of differences in the scope of construction at each site, and in the current condition of PBF, the factors responsible for those conditions, and the differences in PBF between species. This assumption relies on all of the actions being based on the same set of underlying construction actions. In general, ephemeral effects are likely to last for hours or days, short-term effects are likely to last for weeks to months, and long-term effects are likely to last

for months, years or decades. Actions with more significant construction component are likely to adversely affect larger areas, and to take a longer time to recover, than actions based in restoration of a single habitat element. However, they are also likely to have correspondingly greater conservation benefits over time.

Because the area affected for each individual project is small, because the intensity and severity of the effects described is relatively low, and because their frequency in a given watershed is very low, any adverse effects to PBF conditions and conservation value of critical habitat at the site level or reach level are likely to quickly return to, and improve beyond, baseline critical habitat conditions in existence before the action. Moreover, projects completed under the restoration activity categories are also reasonably certain to lead to some degree of ecological recovery within each project area, including the establishment or restoration of environmental conditions associated with functional aquatic habitat and high conservation value. This is because each action is likely to partially or fully correct improper or inadequate engineering designs in ways that will help restore lost habitat, improve water quality, reduce upstream and downstream channel impacts, improve floodplain connectivity, and reduce the risk of structural failure. Improved fish passage through culverts and more functional floodplain connectivity, in particular, may have long-term beneficial effects.

As noted above, the indirect effects, or effectiveness, of habitat RES, in general, have not been well documented, in part because they often concentrate on instream habitat without addressing the processes that led to the loss of the habitat (Cederholm et al. 1997; Fox 1992; Simenstad and Thom 1996; Zedler 1996). Nonetheless, the careful, interagency process used by the Corps to develop the proposed program ensures that it is reasonably certain to lead to some degree of ecological recovery within each project area, including the establishment, restoration, or return to baseline of environmental conditions associated with functional habitat and high conservation value.

Summary of effects to bull trout critical habitat

Projects in any category type that require construction have the greatest potential to affect critical habitat. Most projects that alter a stream channel, or provide fish passage will adversely affect PBF 1, 2, 3, 6, 7 and 8 by contributing sediment to the system during construction and increasing cobble embeddedness during the short-term. Depending on the category and specific design of the project these effects could last from a few days or weeks to several months. Some long term effects could occur, possibly lasting years or decades where stream channels are realigned. While these PBF will be adversely affected for some period of time by these projects, all of the restoration proposed actions described in this Opinion will eventually contribute to the improvement of fish habitat (see discussions in section 4.0), with long-term benefits resulting from passage enhancement. Thus they will result in benefits over time to these PBF of critical habitat.

Instream projects will result in insignificant negative effects to PBF 1, 2, 3 and 6. These are ephemeral effects of low intensity and short duration.

Vegetation management activities will have adverse effects on PBF 1, 2, 3, 4, 6, 7 and 8. These effects are likely to be a combination of short-term (weeks to months) and long-term (one to 20

years depending on the individual project) effects that will contribute increased sediment to the system. These effects should diminish and eventually halt as native vegetation becomes reestablished. These projects will ultimately result in improved infiltration rates, reduced overland flows and sediment yields and a more natural hydrograph.

A more detailed description of how each project type will affect the individual PBF of bull trout critical habitat follows:

1. *Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.*

Channel Condition and Dynamics (floodplain connectivity) will be greatly affected by construction projects. Inwater or near-water construction will cause short-term adverse effects to stream channels at the site specific scale. Changes in flow resulting from many construction projects will also cause short-term adverse effects to the dynamics of the stream system. In most cases these effects will be short-term (weeks to months), but could be long-term, lasting years. Ultimately these projects are designed to improve conditions (passage, channel dynamics, correct problematic anthropogenic conditions), and therefore will benefit the ability of critical habitat to provide high quality water and connectivity. Because short-term impacts will reduce the ability of critical habitat to supply these functions for weeks, months, and in some cases long-term effects (stream realignment) lasting years could occur, these projects will adversely affect PBF 1.

Instream projects such as the placement of gravel, or LW may have slight negative effects to PBF 1 by contributing to turbidity and donation of some amounts sediment to the system, thus affecting water quality. Channels conditions will show some effects from many of these projects. These effects will be of low intensity, short duration (more likely hours than days), and are considered insignificant to PBF 1.

Vegetation management will have a neutral effect on this indicator. The other project types not requiring construction will have a neutral effect on this indicator of bull trout critical habitat. This category lacks any causal mechanism to affect any of this PBF.

Flow/Hydrology (change in peak/base flows) will be affected by construction projects. Flow will be interrupted, and redirected in some cases. Most of the adverse effects resulting from these types of projects would be short-term (weeks or months). However, larger projects such as stream realignment could have adverse effects on flow for many years before beneficial effects to the system are recognized. In general, construction projects described within this BO will adversely affect PBF 1.

Vegetation management projects will have short-term adverse effects on PBF 1 through this indicator. The use of herbicides to treat invasive plants could add chemicals to the system that may affect aquatic flora and thus aquatic fauna as well (see section 4.2). Any adverse effect to this PBF will be short-term and would be expected to lessen and then terminate once native vegetation becomes reestablished on the project sites. Restoration activities that improve conditions for streamside and upland vegetation will ultimately benefit the aquatic system in the long-term (1-20 years or more) through the reduction of sediment delivery over time, improved infiltration rates, and a more natural hydrograph over time.

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.*

Habitat Access (barriers) may be disrupted during implementation of some construction projects. In many cases this disruption may only be ephemeral, but in other cases short-term adverse effects will occur to PBF 2, with long-term benefits resulting from passage enhancement. Thus, they will result in benefits over time to PBF 2 eventually.

Instream projects such as the addition of LW, or the placement of gravel or boulders, will have a neutral effect on this indicator. Also, vegetation projects will have a neutral effect to this indicator as there is no causal mechanism for them to affect this indicator.

Water quality (Chemical contaminants/nutrients) will be adversely affected by instream and near stream construction projects. These projects will contribute sediment to the system and increase cobble embeddedness during the short-term. Depending on the category and specific design of the project these effects could last from a few days or weeks to several months (possibly years where stream channels are realigned). The presence of equipment instream or near lakeshore adds some degree of risk of contamination from lubricants, antifreeze, and hydraulic fluids. These risks are greatly reduced by the included PDCs (see 2G, 4G, 6G, 7G, 13G, 18G, and 20G) contained within this Opinion. While PBF 2 will be adversely affected for some period of time by these projects, all of the projects described in this BO will eventually contribute to the improvement of fish habitat.

Instream projects will have a slightly negative effect on water quality (ephemeral effects). The addition of LW, or placement of gravel or boulders may contribute minor amounts of sediment to the system. These effects should be of short duration and low intensity and are considered insignificant to this indicator.

Project activities that require vegetation treatments considered within this Opinion will adversely affect water quality in the short-term. The use of herbicides to treat invasive plants could add chemicals to the system that may affect aquatic flora and thus aquatic fauna as well (see section 4.2). Further, the removal of vegetation can change overland flows and infiltration rates. Increased run off from rainfall or snow melt will result in increased sediment delivery to the system. Most adverse effects to this PBF will be short-term and would be expected to lessen and then terminate once native vegetation becomes reestablished on the project sites. Activities that improve conditions for streamside and upland vegetation will ultimately benefit the aquatic system in the long-term (1-20 years, or more) through the reduction of sediment delivery over time, improved infiltration rates, and a more natural hydrograph over time.

Flow/Hydrology (change in peak/base flows) will be affected by construction projects. Flow will be interrupted, and redirected in some cases. Most of the adverse effects resulting from these types of projects would be short-term (weeks or months). However, larger projects such as stream realignment could have adverse effects on flow for many years before beneficial effects

to the system are recognized. In general, construction projects described within this Opinion will adversely affect PBF 2.

Project activities that require vegetation treatments will have short-term adverse effects on PBF 2 through this indicator. The use of herbicides to treat invasive plants could add chemicals to the system that may affect aquatic flora and thus aquatic fauna as well. Any adverse effect to this PBF will be short-term and would be expected to lessen and then terminate once native vegetation becomes reestablished on the project sites. Restoration activities that improve conditions for streamside and upland vegetation will ultimately benefit the aquatic system in the long-term (1-20 years) through the reduction of sediment delivery over time, improved infiltration rates, and a more natural hydrograph over time.

Instream projects such as the addition of LW, or the placement of gravel or boulders will have a neutral effect on this indicator.

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

Water Quality, Habitat Elements, Channel Condition and Dynamics, Habitat Access will be adversely affected by construction projects. These effects will limit the availability of prey species within critical habitat in the short-term. Increased sediment and reduced water quality will reduce the ability of critical habitat to provide foraging opportunities to bull trout through reduced visibility, and reduced presence of prey fish.

Instream projects may have a slightly negative effect on this indicator. These projects may increase, or disturb fine sediment at a small, localized scale. These effects are likely to be ephemeral, of short duration and of low intensity. Thus, these effects are considered insignificant to PBF 3 through these pathways.

Project activities that require vegetation treatments will adversely affect the ability of critical habitat to provide both aquatic and terrestrial prey species needed by bull trout during the short-term. Increased donations of sediment with increased turbidity may reduce both the availability of prey and the ability of bull trout to pursue such prey. Changes to streamside vegetation will result in some reduction of terrestrial macroinvertebrates available in bull trout critical habitat. This condition should ease over-time as native vegetation becomes reestablished on the affected sites. Because of these factors vegetation management projects will adversely affect PBF 3.

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

Habitat Elements (large wood, pool frequency and quality, large pools, off channel habitat, refugia) will not be negatively affected by construction projects when applied to PBF 4.

Instream projects such as additions of large wood, or placement of gravel or boulders would have entirely beneficial effects on these indicators. Project activities that require vegetation

treatments would generally have a neutral effect on these indicators as applied to PBF 4; however, they may well have a short-term (months) adverse effect on refugia. Therefore, they must be considered as an adverse effect on PBF 4 through this pathway.

Channel conditions and Dynamics (wetted width/maximum depth ratio, stream bank condition, floodplain connectivity) Construction projects will not have adverse effects to PBF 4 through this pathway. They will ultimately contribute to the ability of critical habitat to supply the elements of PBF 4.

Instream projects that provide additional LW, boulders and gravel will be entirely beneficial to this PBF as they will provide for an increased ability of critical habitat to provide the elements of PBF 4.

Project activities that require vegetation treatments will have a neutral effect on PBF 4 through this pathway.

- 5. *Water temperatures ranging from 36 °F to 59 °F (2 °C to 15 °C), 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.***

Water quality (Temperature) will not be affected by construction projects, or instream projects. These activities lack a causal mechanism to affect water temperature. Project activities that require vegetation treatments will have a slightly negative effect on this indicator. The removal of vegetation could allow increased solar radiation which could affect temperatures to some degree. These effects will be extremely localized and of low intensity, and are considered insignificant to PBF 5.

- 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.***

Water Quality (Sediment) will be adversely affected by construction projects. These projects will contribute sediment to the system and increase cobble embeddedness during the short-term. Depending on the category and specific design of the project these effects could last from a few days or weeks to several months (possibly years where stream channels are realigned).

Instream projects such as the placement of gravel or LW may have slight negative effects to PBF 1 by contributing to turbidity and donation of some amount of sediment to the system, thus affecting water quality. Channel conditions will show some effects from many of these projects. These effects will be of low intensity, short duration (more likely hours than days), and are considered insignificant to PBF 6.

Project activities that require vegetation treatments within this BO will adversely affect water quality in the short-term. The removal of vegetation can change overland flows and infiltration rates. Increased run-off from rainfall or snow melt will result in increased sediment delivery to the system. Most adverse effects to PBF 6 will be relatively short-term and would be expected to lessen and then terminate once native vegetation becomes reestablished on the project sites. However larger scale projects may increase sediment loads for long periods (up to five years). Restoration activities that improve conditions for streamside and upland vegetation will ultimately benefit the aquatic system in the long-term (1-20 years depending on the exact project) through the reduction of sediment delivery over time, improved infiltration rates, and a more natural hydrograph over time.

Habitat Elements (substrate embeddedness) will be adversely affected by instream or near-stream construction projects. The addition of sediment described above will result in some portion of substrate embeddedness. While it is expected that most of this would subside the year following the project when high flows would purge the system of most of the residual sediment on the substrate, these projects will still result in short-term adverse effects for most projects. Obviously in larger scale projects such as stream realignment these adverse conditions could persist longer, possibly up to years in time.

Instream projects such as the placement of gravel or LW may have slight negative effects to PBF 6 by contributing to turbidity and donation of some amounts sediment to the system thus affecting water quality. These effects will be of low intensity, short duration (more likely hours than days), and are considered insignificant to this indicator.

Project activities that require vegetation treatments will have an adverse effect on substrate embeddedness because they will result in increased sediment donations to the system short-term. If projects are located within bull trout SR habitat this could adversely affect the ability of critical habitat to provide high quality substrates needed for spawning. As mentioned above, most of these effects would not last more than one season but are considered an adverse effect on PBF 6.

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.

Flow/Hydrology (change in peak/base flows) will be adversely affected by construction projects. Flow will be interrupted, and redirected in some cases. Most of the adverse effects resulting from these types of projects would be short-term (weeks or months). However, larger projects such as stream realignment could have adverse effects on flow for many years before beneficial effects to the system are recognized. In general, construction projects described within this BO will adversely affect PBF 7 during the short-term, but will ultimately benefit critical habitat over the long-term (1-20 years) by aiding in the restoration of a more natural hydrograph.

Project activities that require vegetation treatments will have short-term adverse effects on PBF 7 through this indicator. The removal of vegetation can change overland flows and infiltration

rates. Increased run off from rainfall or snow melt will result in increased water delivery to the system. Any adverse effect to this PBF will be short-term and would be expected to lessen and then terminate once native vegetation becomes reestablished on the project sites. Restoration activities that improve conditions for streamside and upland vegetation will ultimately benefit the aquatic system in the long-term (1-20 years) through improved infiltration rates, and a more natural hydrograph over time.

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

Water quality (Chemical contaminants/nutrients) will be adversely affected by instream and near stream construction projects. These projects will contribute sediment to the system and increase cobble embeddedness during the short-term. Depending on the category and specific design of the project these effects could last from a few days or weeks to several months (possibly years where stream channels are realigned). The presence of equipment instream or near lakeshore adds some degree of risk of contamination from lubricants, antifreeze, and hydraulic fluids. These risks are greatly reduced by PDCs (see 6G and 7G) contained within this Opinion. While PBF 2 will be adversely affected for some period of time by these projects, all of the projects described in this Opinion will eventually contribute to the improvement of fish habitat.

Instream projects will have a slightly negative effect on water quality. The addition of LW or placement of gravel or boulders may contribute minor amounts of sediment to the system. These effects should be of short duration and low intensity and are considered insignificant to this indicator.

Project activities that require vegetation treatments considered within this BO will adversely affect water quality in the short-term. The use of herbicides to treat invasive plants could add chemicals to the system that may affect aquatic flora and thus aquatic fauna as well. Further, the removal of vegetation can change overland flows and infiltration rates. Increased run off from rainfall or snow melt will result in increased sediment delivery to the system. Any adverse effects to this PBF will be short-term and would be expected to lessen and then terminate once native vegetation becomes reestablished on the project sites. Restoration activities that improve conditions for streamside and upland vegetation will ultimately benefit the aquatic system in the long-term (1-20 years) through the reduction of sediment delivery over time, improved infiltration rates, and a more natural hydrograph over time.

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.*

Subpopulation Characteristics (Life History Diversity and Isolation, Persistence and Genetic Integrity) will be benefitted by construction projects that improve fish passage. Providing improved passage, or reconnecting isolated local populations where safe to do so (see PDC 14G and 2R) will improve genetic diversity.

Instream projects and project activities that require vegetation treatments would have a neutral effect on the indicator as they have no causal mechanism to affect PBF 9.

Effects to bull trout CHUs, RUs and critical habitat at the rangewide scale

While the proposed action will have adverse effects to bull trout critical habitat at the local, site-specific scale, these adverse effects will not be significant when evaluated at larger scales.

5.0 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 ESA.

The contribution of non-federal activities to the current condition of bull trout and bull trout critical habitats within the program-level action area was described in the Status of the Species and Critical Habitats and the Environmental Baseline sections, above. Among those activities were agriculture, forest management, mining, road construction, urbanization, water development, and river restoration. Those actions were driven by a combination of economic conditions that characterized traditional natural resource-based industries, general resource demands associated with settlement of local and regional population centers, and the efforts of social groups dedicated to the river restoration and use of natural amenities, such as cultural inspiration and recreational experiences.

Resource-based industries caused many long-lasting environmental changes that impacted bull trout and their critical habitats, such as state-wide loss or degradation of stream channel morphology, spawning substrates, instream roughness and cover, estuarine rearing habitats, wetlands, riparian areas, water quality (*e.g.*, temperature, sediment, dissolved oxygen, contaminants), fish passage, and habitat refugia. Those changes reduced the ability of populations of bull trout to sustain themselves in the natural environment by altering or interfering with their behavior in ways that reduced their survival throughout their life cycle. The environmental changes also reduced the quality and function of critical habitat PBF that are necessary for successful spawning, production of offspring, and migratory access necessary for adult fish to swim upstream to reach spawning areas, and have reduced the quality and quantity of rearing areas for juvenile fish. Without those features, the species cannot successfully spawn, produce offspring and survive. The declining level of resource-based industrial activity and rapidly rising industry standards for resource protection, however, are likely to reduce the intensity and severity of those impacts in the future.

The economic and environmental significance of natural resource-based economy is currently declining in absolute terms and relative to a newer economy based on mixed manufacturing and marketing with an emphasis on high technology (Brown 2011). Nonetheless, resource-based industries are likely to continue to have an influence on environmental conditions within the program-action area for the indefinite future. However, over time those industries have adopted

management practices that avoid or reduce many of their most harmful impacts. Likewise the Corps has adopted more protective standards, as is evidenced by the extensive conservation measures included with the proposed action, but which were unknown or in uncommon use until even a few years ago.

While natural resource extraction within northwest Federal lands may be declining, general resource demands are increasing with growth in the size and standard of living of the local and regional human population (Metro 2010; Metro 2011). Population growth is a good proxy for multiple, dispersed activities and provides the best estimate of general resource demands because as local human populations grow, so does the overall consumption of local and regional natural resources. Between 2000 and 2016, the population of Oregon grew from 3.4 to 4 million, an increase of approximately 15%. By 2020, the population of Oregon and Washington is projected to grow to 4.3 million (OOEA 2011). Most of the population centers in Oregon occur west of the Cascade Mountains. USFWS assumes that future private, state, and Federal actions will continue within the action areas, increasing as population rises.

The most common private activity likely to occur across the action areas addressed by this consultation is unmanaged recreation. Although the Corps is involved in managing recreational activities to some degree (i.e., campgrounds, trailheads, off-road-vehicle trails), a considerable amount of dispersed unmanaged recreation occurs. Expected impacts to bull trout from this type of recreation include minor releases of suspended sediment, impacts to water quality, short-term barriers to fish movement, and minor changes to habitat structures. Streambanks, riparian vegetation, and spawning redds can be disturbed wherever human use is concentrated.

Some recreational mining, primarily small-scale suction dredging occurs throughout the action area that has not until recently been subject to regulation. This mining causes releases of suspended sediment, disturbance of spawning gravels, minor riparian disturbance, and harassment of bull trout. The intensity of mining is somewhat dependent on the price of precious metals, but occurs at low levels in most areas.

Recreational fishing within the action area is expected to continue to be subject to ODFW regulations. The level of take of bull trout within the action area from angling is unknown, but is expected to remain at current levels. Unauthorized take of bull trout from fishing is a concern in some areas (J. Waldo pers. comm. 2003), but the USFWS doesn't believe that this will preclude recovery of the species.

When considered together, these cumulative effects are likely to have a small negative effect on bull trout population abundance, productivity, and some short-term negative effects on spatial structure (short-term blockages of fish passage). Similarly, the condition of critical habitat PBF will be slightly degraded by the cumulative effects.

5.1 Integration and Synthesis

The Integration and Synthesis section is the final step of the USFWS 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 4.0) and the cumulative effects (section 5.0) to

the status of the species (Section 2.0) and the environmental baseline (section 3.0) 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 critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitats (sections 2.2 and 2.3).

5.2 Species at the Population Scale

The scores of individual populations affected by the proposed program vary considerably in their biological status. Bull trout have declined due to numerous factors. The one factor for decline that all the aquatic species share is degradation of freshwater habitat (in addition to estuarine habitat for bull trout). Human development of the Pacific Northwest has caused significant negative changes to stream and estuary habitat across the range of these species. The environmental baseline varies across the program area, but habitat will generally be degraded at sites selected for RES, which makes them a candidate for project implementation.

The programmatic nature of the action prevents a precise analysis of each action that eventually will be funded or carried out under this Opinion, although each type of action will be carefully designed and constrained by comprehensive design criteria and conservation measures such that the proposed activities will cause only short-term, localized, and relatively minor effects. Also, actions are likely to be widely distributed within and across all RUs or affected basins (see Table 4), so adverse effects will not be concentrated in time or space within the range of any listed species. In the long-term, these actions will contribute to a lessening of many of the factors limiting the recovery of these species, particularly those factors related to fish passage, degraded floodplain connectivity, reduced aquatic habitat complexity, and riparian conditions, and improve the currently-degraded environmental baseline, particularly at the site scale. A very small number of individual fish, far too few to affect the abundance, productivity, distribution, or genetic diversity of any bull trout population, will be affected by the adverse effects of any single action permitted under the proposed action. Because characteristics at the population scale will not be affected, the likelihood of survival and recovery of the listed species will not be appreciably reduced by the proposed action.

As described in section 2.2, bull trout individuals use the action area for residency, migration, spawning and rearing portions of their life cycle; some bull trout migrate widely and rear in the action area, and some use portions of the action area as residents only occasionally migrating between streams to forage and spawning. USFWS identified many factors associated with the life cycle of bull trout that are limiting their recovery. These factors include, but are not limited to, elevated water temperatures, excessive sediment, reduced access to spawning and rearing areas, reductions in habitat complexity, instream wood, and channel stability; degraded floodplain structure and function, and reduced flow. Cumulative effects within the action area described in section 5.0 are likely to have a small negative effect on bull trout population abundance, productivity, and some short-term negative effects on spatial structure (short-term blockages of fish passage). Actions carried out under the proposed program will address and help to alleviate many of these limiting factors in the long run.

6.0 Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the direct and indirect effects of the proposed action, and anticipated cumulative effects, it is USFWS's biological opinion that the proposed action is not likely to jeopardize the continued existence of bull trout or result in the destruction or adverse modification of bull trout critical habitat. The Service reached this conclusion for the following reasons:

6.1 Bull Trout

- PDC incorporated into the PA will likely minimize direct and indirect effects to bull trout from project activities.
- In-water work windows, timing, and duration of projects will likely minimize direct and indirect effects to bull trout from project activities.
- Because the vast majority of bull trout spawning and early juvenile rearing habitat occurs in headwater streams on USFWS lands, and the permitted actions included under this programmatic generally occur outside these areas, we anticipate minimal effects to these types of sensitive habitats from the proposed action
- The amount of incidental take predicted to result from the proposed action is small and the spatial scope of that incidental take means the incidental take will not have a meaningful impact on reproduction, numbers or distribution of bull trout.

6.2 Bull trout Critical Habitat

- One of the key activity categories of the proposed action is restoration which is expected to benefit bull trout and bull trout critical habitat in the long term.
- The projects involved are too small, too far apart and too infrequent to adversely affect any one RU. Because of this the effects of these projects cannot rise to a level to adversely affect any RU, and thus cannot adversely modify critical habitat at the rangewide scale.
- The amount and extent of disturbed soil, increased sediment inputs to the streams, temporary reduction in rate of recovery of hardwood vegetation, and lack of shade are expected to occur in small, localized areas but may be measureable. These effects to critical habitat are also expected to be short in duration and temporary.
- The PDC and monitoring described in the proposed action and PDC are expected to minimize the extent and duration of habitat effects, such that it is unlikely that the function or conservation role of the critical habitat will be adversely affected in the long-term by the proposed activity.

7.0 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 attempt to engage in any such conduct. Harm is further defined by the USFWS 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. Harass is defined by the USFWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the Act, take that is incidental to and not intended as part of the agency action is not considered to be a prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

7.1 Amount or Extent of Take

Work necessary to construct and maintain the projects that will be authorized or carried out each year under this Opinion will take place adjacent to and within aquatic habitats that are reasonably certain to be occupied by individuals of one or more bull trout considered in this Opinion. As described below, each category of actions covered in this programmatic BO may cause incidental take of bull trout. All life history stages of fish (other than eggs) are anticipated to be adversely affected.

All life history stages of fish will be captured during work area isolation necessary to minimize construction-related disturbance of the proposed actions in this Opinion. In-stream disturbance that cannot be avoided by work area isolation will lead to short-term increases in suspended sediment, temperature, dissolved oxygen demand, or other contaminants, and an overall decrease in habitat function that harms adult and juvenile fish by denying them normal use of the action area for reproduction, rearing, feeding, or migration. Exclusion from preferred habitat areas causes increased energy use and an increased likelihood of predation, competition and disease that is reasonably likely to result in some level of injury and perhaps death of some individual fish.

Similarly, adult, sub-adult and juvenile fish may be harmed by construction-related disturbance of upland, riparian and in-stream areas for actions related to LW, boulder, and gravel placement; streambank restoration; reduction/relocation of recreation impacts; piling and other structure removal; road and trail erosion control and decommissioning; non-native invasive plant control; riparian vegetation treatment; riparian vegetative planting; physical and biological surveys; and related in-stream work. The effects of those actions will include additional short-term reductions in water quality, as described above, and will also harm adult and juvenile fish as described above. Herbicide applications will result in herbicide drift or transportation into streams that will harm listed species by chemically impairing normal fish behavioral patterns related to feeding, rearing, and migration.

Projects that require two or more years of work to complete may cause adverse effects that last proportionally longer, and effects related to runoff from the project site may be exacerbated by winter precipitation. These adverse effects may continue intermittently for weeks, months, or years until riparian vegetation and floodplain vegetation are restored and a new topographic equilibrium is reached. Incidental take that meets the terms and conditions of this incidental take statement will be exempt from the taking prohibition.

Calculation of numbers of Bull Trout

Because the USFWS has previously not consulted programmatically with the Corps on these actions, the number of potential projects is an estimate from previous single-action consultations. From past history, the Corps estimates that it will authorize or carry out up to 60 actions per year. The number of projects, scope, scales, and locations will change in each year; however, the USFWS will use this estimate to calculate take provisions in this Opinion, with the understanding that more projects may occur in certain years and less in others. In addition, it is unlikely that two or more projects would occur within 100 to 300 feet of each other. Further, the strong emphasis on use of proposed PDC to minimize the short-term adverse effects of these actions, the small size of individual action areas, and the design of actions that are likely to result in a long-term improvement in the function and conservation value of each action area will ensure that individual fish will not suffer greater adverse effects if two or more action areas do overlap. Moreover, the rapid onset of beneficial effects from a number of these actions is likely to improve the baseline for subsequent actions so that adverse effects are not likely to be additive at the population or watershed scale.

Fish Capture

While the majority of ESA-listed fish captured under these projects would be salmon and steelhead, some portions of these fish are likely to be bull trout. We have no data as to the exact proportion of bull trout to other salmonids within the action area, nor do we fully understand the exact relationships between bull trout and other salmonids that serve as much of their primary prey. Cohen (1977) describes a species ratio of 3:4, where given a situation where three prey species are present, four species of predators would likely also be present in a natural food web. The actual number of individual natural predators would be dependent of the abundance of prey individuals. The introduction of numerous non-native predators to the system has confounded this natural dynamic. This makes determining a ratio of bull trout to other prey salmonids extremely difficult. In previous programmatic consultations between USFWS and other action agencies there was no record of handling numbers for bull trout, and the USFWS has been unable to find capture, handling or mortality data that would be relevant across the action area which suggests what ratio of bull trout were captured in relation to the number of salmon or steelhead.

The USFWS assumes that 60% of those projects (*i.e.*, 36 actions per year) will require in-water work involving fish capture. To calculate the number of projects involving fish capture, we have used capture data from projects completed by USFWS and NOAA-Restoration Center from 2010 to 2012 under their respective opinions (USFWS 2013; NMFS 2013b), which included larger

projects such as dam removals and stream channel restoration, as a guide to estimate the number of fish we anticipate being captured and handled. USFWS and NOAA-Restoration Center had an average capture of approximately 132 ESA-listed salmon and steelhead per project, where isolation and dewatering was required.

In the absence of empirical data, and for programmatic assessments where there is uncertainty as to where projects will be implemented across the action area, the USFWS often relies on professional judgment to develop formulas that help predict the likelihood of a listed species occurrence and rate of occurrence within a project area. Given that bull trout are an apex predator and generally persist in much lower abundance than other sympatric salmonids such as salmon, steelhead and other species of trout, we believe bull trout would comprise a relatively low percentage of the overall catch of salmonids within a given project area. Through discussions between numerous fish biologists and assumptions made in other State-wide programmatic consultations, it is believed that the average ratio of bull trout to other salmonids across the action area would be quite low, probably somewhere between 3-4%. There will be wide variation by site-specific location. The majority of work anticipated under the proposed action will most likely occur during the months of July and August. In many systems water quality becomes limited during this period of time, and bull trout start to move upstream into SR habitat both to seek the cooler temperatures and in preparation for spawning in late summer/fall. Areas where resident bull trout populations exist may exhibit a ratio somewhere near 10% of the total salmonid population, or possibly higher in some cases. Therefore it is probable that this ratio in SR habitat will be increased above 10% during this time of year. In the converse, the ratio of bull trout to other salmonids is likely to drop in much of the FMO habitat during this time period to an extremely low ratio (<1%) because of its warmer temperatures and generally poorer water quality. During similar previous programmatic consultations, for the five-year period 2008-2012, other action agencies reported a total of seven bull trout mortalities. Because the ratio of bull trout to other salmonids varies considerably across their range, and to err on the side of caution, the USFWS estimates that a ratio of bull trout to salmon and steelhead of 5% exists on average across the action area. Therefore, based on an anticipated capture of 132 salmon and steelhead described previously the USFWS anticipates the average capture of 7 bull trout for projects where isolation and dewatering would be required.

Of the fish that the Corps capture and release, less than 2% are likely to be injured or killed, including by delayed mortality, and the remainder is likely to survive with no long-term adverse effects (NMFS 2013a). Of the bull trout to be captured and handled, 98% or more are expected to survive with no long-term effects. Thus, USFWS anticipates that up to 252 individual bull trout (*i.e.*, 60% of 60 projects/year = 36 projects * 7 bull trout/project) considered in the consultation will be captured, on average per year, and up to 6 individuals will be injured or killed, on average per year, (*i.e.*, 2% [injured or killed] of 252 = 6 whole fish (rounded up)) injured or killed as a result of fish capture necessary to isolate in-water construction areas. However, a mortality to five percent of the fish that are captured and released, with the remainder (95 percent) likely to survive with no long-term adverse effects has also been reported (McMichael et al. 1998; Cannon 2012). Therefore, to err on the side of caution, the more expansive estimate of 5% average annual lethal take (*i.e.*, 5% of 252) will be used here to allow for variations in fish health, environmental conditions and work conditions, which results in 13 whole fish.

As discussed previously, the value of adult bull trout to localized populations is far greater than that of juvenile fish. It takes large numbers of juveniles within any population to ultimately recruit one adult. The great majority of juvenile fish in any life stage do not survive to become adults. This is an important concept in gauging effects at the population scale.

NMFS (2013a) previously developed an estimation method to gauge the maximum effect that capture and release operations have on abundance of adult salmonids, with the understanding that a large majority of captured fish are juveniles. While not specifically developed for bull trout, in the absence of better data, the USFWS uses this same formula of: $A = n(pct)$, where:

A^{22} = number of adult equivalents “killed” each year

n = number of in-water projects likely to occur per year on average

$p = 7$, i.e., number of bull trout to be captured per project

$c = 0.05$, i.e., rate of injury or death caused by electrofishing during capture and release, primarily steelhead and coho salmon, based on data from Cannon (2008; 2012) and McMichael et al. (1998).

$t = 0.02$, i.e., an estimated average fry to adult survival ratio, see Smoker et al. (2004) and Scheuerell and Williams (2005). This is very conservative because many bull trout are likely to be captured as fry or juveniles, life history stages that have a survival rate to adulthood that is exponentially smaller than for adults.

The results of the application of this formula is displayed below:

- SLOPE BT: 36 projects x 7 bull trout x 5% x 2% = 0.252 adult equivalents

Thus, the effects of bull trout capture and handling on the abundance of juvenile or adult bull trout in any population is likely to be small, no more than 1 adult-equivalent (rounded up) per year (Table 6).

Thus, the effects of work-area isolation on the abundance of bull trout in any project activity category or population are likely to be small. Table 6 displays the expected take due to harm and capture of bull trout per year by project type. Table 7 describes the maximum take due to harm and capture allowed in any five-year period, which if exceeded in any project category would trigger reinitiation. Almost all of these fish are anticipated to be juveniles, but some number of adults could possibly be captured. For utility of operation the USFWS will not separate actual take numbers between juveniles, sub-adults and adults, but will assume that most (95-99%) of the capture would be juveniles. Adult equivalents (see Section 2.5.1) are included to show the likely effect on the bull trout population across the action area. These represent what effect the number of fish killed or injured (assuming these were all juveniles) would have on the adult population.

²² Equates to the number of immature fish needed in order to result in one surviving adult fish to display population effects (Smoker et al. 2004).

Table 6. Estimate of the amount of average capture, per year for projects authorized or carried out under SLOPES BT

Estimated Maximum Number of Projects (per year)	Estimated Maximum Number of Juvenile Bull Trout Captured (per year)	Estimated Maximum Number of Juvenile Bull Trout Injured or Killed (per year)	Estimated Maximum Number of Adult Bull Trout Equivalents "Killed" (per year)
36	252	7	0.252

If the number of bull trout captured or injury/mortality exceeds the figures listed in Table 7 in any five-year period, the Corps must reinitiate consultation.

Table 7. Estimate of the average take, per five-year period, for projects authorized or carried out under SLOPES BT

Type of take	Total for all project activities*
Fish captured	1260
Fish killed or injured	35
Adult equivalent fish killed	1.26
*for any 5-year period	

Harm due to habitat-related effects

Take caused by the habitat-related effects of this action cannot be accurately quantified as a number of fish because the distribution and abundance of fish that occur within an action area are affected by habitat quality, competition, predation, and the interaction of processes that influence genetic, population, and environmental characteristics. These biotic and environmental processes interact in ways that may be random or directional, and may operate across far broader temporal and spatial scales than are affected by projects that will be completed under the proposed program. Thus, the distribution and abundance of fish within the program action area cannot be attributed entirely to habitat conditions, nor can USFWS precisely predict the number of fish that are reasonably certain to be injured or killed if their habitat is modified or degraded by actions that will be completed under the proposed program. Additionally, there is no practical way to count the number of fish exposed to the adverse effects of the proposed action without causing additional stress and injury. In such circumstances, USFWS uses the causal link established between the activity and the likely changes in habitat conditions affecting the listed species to describe the extent of take as a numerical level of habitat disturbance.

Suspended sediment and contaminants

From previous discussion in Section 4.0 for projects involving near- and in-water construction, the measured extent of take due to suspended sediment and contaminants is best identified as the maximum extent of the turbidity plume generated by construction activities. The extent of take for this category is as follows – a visible increase in suspended sediment (as estimated using turbidity measurements, as described below) up to 50 feet from the project area in streams that are 30 feet wide or less, up to 100 feet from the discharge point or nonpoint source of runoff for

streams between 30 and 100 feet wide, or up to 200 feet from the discharge point or nonpoint source for streams greater than 100 feet wide.

Construction-related disturbance of streambank and channel areas

To measure those effects to bull trout as discussed previously (see Sections 4.0), the extent of adverse effects is best identified by the total length of stream reach that will be modified by construction each year. This approach has been used previously on NMFS and USFWS programmatic consultations that exhibit similar effects (USFWS 2013; NMFS 2013b). The USFWS will use an estimated number of 60 projects per year of which each may modify up to 300 linear feet of riparian and shallow-water habitat. Therefore, the extent of take based on this group of actions at 18,000 linear feet, or 3.4 linear stream miles, of in-channel based projects per year on average, should not exceed 90,000 feet or 17 linear river miles during any five-year period. This action area-wide take is allocated across all geographic locations covered by this Opinion.

Construction-and vegetation treatment related disturbance of upland, wetland and estuary areas

Some projects that do not require in-water or near-water construction will nonetheless injure or kill bull trout juveniles and adults. This take will occur primarily as harm caused by increased delivery of fine sediments to streams due to activities in upland or wetland areas, or by road restoration projects. For example, prescribed burning will temporarily expose soils in upland areas, resulting in increased erosion and production of fine sediments that can be routed to streams, thus reducing productivity and survival or growth of juvenile fish. These project activities should adhere to the turbidity requirements above, however, other actions such as surveys and site preparation activities are likely to result in take by harassing fish sufficiently to flush from areas with overhead cover and thus become more susceptible to predation. These types of impacts are expected to occur infrequently, but will nonetheless occur over large areas.

To calculate the number of acres of potential effects to upland and wetland areas, assuming each project may impact 300 feet of linear length, and assuming a 100-foot wide disturbance area (total calculated from the MHW), approximately 0.7 acres or a total of 42 acres (0.7 acres x 60 projects – used to calculate linear feet) may be affected by these types of activities. Thus, construction and vegetation treatment related disturbance of upland, wetland and estuary areas should not exceed the 17 linear river miles calculated above, or 210 acres in any five-year period. This action area-wide take is allocated across all geographic locations covered by this Opinion.

Invasive and non-native plant control.

Application of manual, mechanical, biological or chemical plant controls will result in short-term reduction of vegetative cover or soil disturbance and degradation of water quality which will cause injury to fish in the form of sublethal, adverse physiological effects. This is particularly true for herbicide applications in riparian areas or in ditches that may deliver herbicides to streams occupied by bull trout. These sublethal effects, described in the effects analysis for this Opinion, will include increased respiration, reduced feeding success, and subtle behavioral changes that can result in predation. Direct measurement of herbicide transport using the most commonly accepted method of residue analysis (e.g., liquid chromatography–mass spectrometry) (Pico et al. 2004) are burdensome and expensive for the type and scale of herbicide applications proposed. Thus, the burden of the use of those measurements in this take statement as an extent

of take indicator is likely to outweigh any benefits of using herbicide as a simple and economical restoration tool, and act as an insurmountable disincentive to their use for plant control under this Opinion. Further, the use of simpler, indirect methods, such as olfactometric tests, do not correlate well with measured levels of the airborne pesticides, and may raise ethical questions (Brown et al. 2000) that cannot be resolved in consultation. Therefore, the best available indicators for the extent of take due to the proposed invasive plant control is the extent of treated areas for the total area treated with herbicides within riparian areas, is to not exceed 10-acres above bankfull elevation and 2 acres below bankfull elevation, per 1.6-mile reach of a stream, per year, as described in PDC 22G. In addition, those activities involving invasive and non-native plant control should adhere to Northwest Forest Plan standards and/or PACFISH/INFISH (USDA and USDI 1995a; USDA and USDI 1995b) guidelines, if applicable depending on the geographic location of the project.

Summary of Incidental Take for bull trout

The amount and extent of authorized incidental take may differ by project activity type, scope, and/or location of each individual project; however, while the USFWS has attempted to determine maximum average impacts by year the take threshold for most of the indicators has been set at a five-year total rather than annually in order to allow more flexibility in application. This Opinion applies to the total 5-year accumulated limits as described in the sections above, except for the visible suspended sediment (turbidity) extent of take indicator and the invasive and non-native plant control, which do not vary by location. In summary, the best available indicators for the extent of take for these proposed actions for bull trout are as follows:

- Capture of bull trout during in-water work area isolation – the amount of take is: 1,260 bull trout per five-year period (injury/mortality of 35)
- Visible suspended sediment (turbidity) – the extent of take indicator for suspended sediments and contaminants is no more than a 10% increase in natural stream turbidity visible beyond the discharge point or nonpoint source of runoff.
- Streambank and channel alteration – the extent of take indicator construction-related disturbance of streambank and channel is no more than 90,000 linear stream feet, or 17 linear stream miles of streambank or channel alteration per five-year period.
- Upland vegetation disturbance – the extent of take indicators for construction-related disturbance of upland and wetland areas, or piling removal are no more than 17 linear stream miles or 210 acres of vegetation treatment per five-year period.
- Invasive and non-native plant control – no more than 10 acres above bankfull elevation and 2 acres below bankfull elevation, per 1.6-mile reach of a stream, per year or adhering to Northwest Forest Plan standards and/or PACFISH/INFISH (USDA and USDI 1995a; USDA and USDI 1995b) guidelines, if applicable depending on the geographic location of the project.

USFWS assumes that the proposed project activities will adhere to the average annual project numbers calculated above and has assigned take indicators for isolation/capture, near/instream construction, and harassment/harm to individuals. The Corps shall reinitiate consultation on the entirety of this consultation if they cover more fish captures and exceed mortality or injuries, stream miles, turbidity plume distance, road miles, or acres of vegetation treatment.

The proposed action addressed in this consultation includes projects that will replace or relocate an existing irrigation diversion structure, or modify an existing irrigation diversion structure so that it will meet NMFS's fish screen criteria. However, the proposed action does not include the issuance of any easement, permit, or right-of-way that would authorize construction of new diversion structures, or conveyance of water across Federal land by the USFWS. Those types of action require an individual consultation under section 7 of the ESA whenever they may affect bull trout or designated critical habitat. Moreover, any take that may be due to the use of an existing irrigation diversion structure to withdraw water, or to the use of a water system to convey water across Federal land, is not incidental to the proposed action, and is not exempted from the ESA's prohibition against take by the ITS of this document.

7.2 Effect of the Take

In the accompanying Opinion, USFWS determined that the level of incidental take summarized in Tables 6 and 7, and Section 7.1 is not likely to result in jeopardy to the listed species, and is not likely to result in adverse modification of the critical habitat of any listed species analyzed under the Opinion.

7.3 Reasonable and Prudent Measures and Terms and Conditions

"Reasonable and prudent measures" 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 following measures are necessary and appropriate to minimize the impact of incidental take of listed species from the proposed action.

The Action Agencies shall:

1. Minimize incidental take from administration of this Opinion by ensuring that the PDC proposed by the Corps are used in all actions funded or carried out under this Opinion.
2. Ensure completion of a comprehensive monitoring and reporting program regarding all actions funded or carried out by the Corps under this Opinion.

The measures described below are non-discretionary, and must be undertaken by the Corps or, if an applicant is involved, must become binding conditions of any funding provided to the applicant, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fail to require an applicant to adhere to the terms and conditions of the incidental take statement through funding conditions, the protective coverage of section 7(o)(2) may lapse. To monitor the impact of incidental take, the Corps must report the progress of the action and its impact on bull trout to USFWS as specified in the incidental take statement.

1. To implement reasonable and prudent measure #1 (minimize incidental take), the Corps shall ensure that:
 - a. Every action funded or carried out under this Opinion will be administered by the Corps consistent with the Program Administration sections 1 through 10.

- b. For each action involving construction, PDC 1G through 24G, as appropriate, will be added as conditions of funding.
 - c. For specific types of actions, the Corps will apply PDC 1R through 9R, 1S through 3S, and 1I through 8I, as appropriate.
- 2. To implement reasonable and prudent measure #2 (monitoring and reporting), the Corps shall ensure that:
 - a. Completion and recording of the following water quality observations to ensure that any increase in suspended sediment is not exceeding this limit:
 - i. Take a turbidity sample using an appropriately and regularly calibrated turbidimeter, or a visual turbidity observation, every 4 hours when work is being completed, or more often as necessary to ensure that the in-water work area is not contributing visible sediment to water, at a relatively undisturbed area approximately 100 feet upstream from the project area. Record the observation, location, and time before monitoring at the downstream point.
 - ii. Take a second visual observation, immediately after each upstream observation, approximately 50 feet downstream from the project area in streams that are 30 feet wide or less, 100 feet from the project area for streams between 30 and 100 feet wide, and 200 feet from the discharge point or nonpoint source for streams greater than 100 feet wide. Record the downstream observation, location, and time.
 - iii. Compare the upstream and downstream observations - If more turbidity or pollutants is/are observed downstream than upstream, the activity must be modified to reduce pollution. Continue to monitor every 4 hours until sediment releases cease to occur.
 - iv. If the exceedance continues after the second monitoring interval (after 8 hours), the activity must stop until the pollutant level returns to background.
 - v. If monitoring or inspections show that the pollution controls are ineffective, immediately mobilize work crews to repair, replace, or reinforce controls as necessary.
 - b. The following notifications and reports (Appendix A) are submitted to USFWS for each project to be completed under this Opinion. All notifications and reports are to be submitted electronically to USFWS at slopes@fws.gov.
 - i. Project notification form within 45-days before start of construction unless waived by the Service on a case-by-case basis.
 - ii. Project completion form within 60-days of end of construction.
 - iii. Fish salvage form within 60-days of work area isolation with fish capture.
 - c. The Corps' Regulatory and Civil Works Branches will each submit a monitoring report to the Service by February 15 each year that describes the Corps' efforts to carry out this Opinion. The report will include an assessment of overall program activity, a map showing the location and type of each action authorized and carried out under this Opinion, and any other data or analyses the Corps deems necessary or helpful to assess habitat trends as a result of actions authorized under this Opinion.
 - d. The Corps' Regulatory and Civil Works Branches will organize, facilitate, and attend an annual coordination meeting with the Service by March 31 each year to discuss the

- annual report and any actions that can improve conservation under this Opinion, or make the program more efficient or accountable.
- e. Failure to provide timely reporting may constitute a modification of SLOPES BT that has an effect to bull trout or critical habitat that was not considered in the Opinion and thus may require reinitiation of this consultation.

7.4 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA 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 that the Action Agencies require considerations for the biological needs of lamprey species for all permits requiring instream or near-stream projects. These biological considerations should be incorporated into project design, objectives, and best management practices for the protection and conservation of this species. The following information is largely excerpted from Best Management Practices to minimize adverse effect to Pacific Lamprey http://www.fws.gov/columbiariver/publications/BMP_Lamprey_2010.pdf (USFWS and USFS 2010) and Streif (2009). Additional information that will assist in the implementation of the following conservation recommendations can be found in those documents.

Consideration of Pacific lamprey is important for many reasons:

- They are a Tribal Trust species, because they have a high cultural significance to Native American tribes from California to Alaska and;
- They may have served as a primary food source for aquatic, mammal, and avian predators that also prey on ESA-listed salmonids and other recreational and commercially important fish species.
- Their abundance and distribution has significantly declined throughout its range over the past three decades, and efforts to reverse this decline are needed.

While Pacific lamprey are anadromous like salmon, their life history has some unique aspects that are typically not considered during implementation of instream activities, even when using design considerations and best management practices for salmonids. Adjustments to minimize adverse effects to Pacific lamprey should be made at the project design phase to accommodate lamprey passage, lamprey spawning periods, existence of nests, upstream and downstream movement, and avoid direct mortality to ammocoetes burrowed in the substrate.

For context, an abbreviated description of Pacific lamprey life history and habitat use in freshwater is provided as follows: As adults, Pacific lamprey return from the ocean to fresh water primarily during spring and summer months, primarily moving at night. They often spend about 1 year in freshwater habitat before spawning, usually holding under large substrate (e.g., large boulders, bedrock crevices) associated with low water velocities until the following spring, when they move to spawning areas. Adult lampreys spawn generally between March and July in

gravel bottom stream, usually at the upstream end of riffle habitat near suitable habitat for larvae (ammocoetes), and die after spawning (Beamish 1980).

After hatching, the ammocoetes drift downstream to areas of low stream velocity and burrow into depositional areas with sand or silt substrate, and filter feed on algae, diatoms, and detritus for 3 to 7 years. Ammocoetes can be difficult to detect since they range in size from about 2 to 150 mm; the smaller ones are easy to overlook. Ammocoetes will move downstream during flow events, mostly at night. Many age classes of ammocoetes will congregate together, often occurring in large clusters in depositional sites with fine sediments where habitats are optimal, making ammocoete populations particularly susceptible to activities that involve dredging/excavating, stranding and use of toxic chemicals. Metamorphosis of ammocoetes into the sub-adult form or “macrophthalmia” occurs generally from July through November but is variable depending on distance from salt water. Out-migration to the ocean occurs during or shortly after transformation (Beamish 1980). Out-migration generally peaks with rising stream and river flows in late winter or early spring (Kostow 2002).

Recommendations

1. Consult with local federal, state and tribal biologists to obtain information on known lamprey populations in the drainage and at affected area. Perform a site reconnaissance to identify locations of lamprey spawning and rearing habitat, and if possible, lamprey presence with nest surveys or methods outlined in Appendix B (Electrofishing Recommendations for Sampling Larval Pacific Lampreys). If local information is not attainable, assume lamprey presence/use based on anadromous salmonid distribution. Use this information to facilitate planning the project (Recommendations 2, 6, and 7) and influence work windows to avoid impacts to Pacific lamprey (Recommendation 3).
2. If lamprey use areas are within the basin and likely to be within the project area, use the following design considerations for any project that could reasonably be modified to improve conditions for lamprey habitat.
 - a. Habitat considerations for Pacific lamprey (all life stages).
 - i. Year-round flow and relatively stable flow conditions (sustained increase or decreases that take place over days and weeks) are essential to ammocoete rearing, juvenile emigration, adult holding, migration, and spawning.
 - ii. Habitat conditions that do not favor non-native fish species can reduce predation on juvenile lampreys.
 - iii. Water temperatures below 22 degrees C may decrease death or deformation of eggs or ammocoetes (Meeuwig et al. 2005) and possibly reduce predation and disease.
 - iv. Unimpeded passage for up- and downstream migrations, with suitable screens or barriers to undesirable habitats (Additional passage considerations are provided in Recommendations 6 and 7.)
 - b. Habitat considerations for Pacific lamprey (ammocoetes).
 - i. Depositional areas (alcoves, backwaters, pools, low velocity areas that recruit sands and silts provide ideal ammocoete rearing habitats. Ammocoetes often use silt and sand substrates but also use sand and small gravels.

- ii. Maintain channel stability (gradients) by preventing channel incision.
 - c. Habitat considerations for Pacific lamprey (adults).
 - i. Stream reaches with a variety of large cobble, boulder, and bedrock substrates may provide habitat for overwintering adults.
 - ii. Adults will often wedge themselves into natural or manmade crevices.
 - iii. Low gradient riffles and pool tailouts with substrate ranging in size from 27 to 88 mm with low embeddedness provide spawning habitats for lampreys.
- 3. Timing of instream activities: *In general, avoid working in stream or river channels from March 1 to July 1 in low to mid elevation reaches (<5,000 ft.). In high elevation reaches (>5,000 feet), avoid working in stream or river channels from March 1 to August 1. If either timeframe is incompatible with other objectives, survey affected area for nests and lamprey presence, and avoid disturbing them. Site-specific critical time periods should be developed at the local level in consultation with local federal, state and tribal biologists.*
 - a. The following is general guidance and information to help establish appropriate site-specific work windows:
 - i. Dependent on location within their distribution range, adult lampreys can be present at spawning areas and preparing to spawn from February to September. The peak period within the Columbia River basin is primarily from March 1 through July 1 in lower and mid elevation reaches;
 - ii. Nests present: March 1 through August 1 but time period is dependent on geographical location within the range of lamprey and elevation of spawning sites;
 - iii. Embryos hatch in approximately 19 days at 15° C (59° F);
 - iv. Emergence and settling into suitable habitat: April to August but time period is dependent on geographical location within the range of lamprey and elevation of spawning sites;
 - v. Ammocoetes are present year-round; there is no appropriate inwater work window for this life stage.
 - vi. Instream operating windows to avoid adverse effects to anadromous salmonids is most commonly from July 1 through August 15, which under most conditions would be sufficient to protect Pacific lamprey nests, eggs, and emerging larvae. Exceptions may include high elevation river and stream reaches (>5,000 ft.), where spawning would be expected to occur later in the spring, or if information obtained during the planning phase indicates different timing. If this is the case, surveys for nests should be initiated, and if found, defer instream work until August 1.
- 4. When temporarily dewatering an area associated with any instream channel work, or removing or disturbing substrate materials, consult with the U.S. Fish and Wildlife Service to determine which of the following conservation recommendations are appropriate:
 - a. Avoid activities in habitats where lampreys are known to exist.
 - b. If avoidance is not possible, survey, using methods outlined in Attachment A, to determine presence, preferably at the project planning stage and when the project is

- implemented, and adjust inwater work periods as appropriate for migrating or adult lamprey.
- c. If ammocoetes are found, several measures can be done alone or in tandem to minimize impacts, depending on site specifics:
- i. Dewater area slowly, over several days (particularly during hours of darkness) or at a minimum overnight, to encouraging ammocoetes to move out of areas of impact while maintaining a route of egress;
 - ii. Identify areas adjacent to ammocoete habitat outside of the disturbance area but within the channel and dig holes (e.g., few scoops with a backhoe, etc.) where ammocoetes may take refuge as dewatering occurs. Cover these 'refuge' holes to protect them from predators;
 - iii. Try an experimental technique -- there is some evidence to suggest that if straw bales (or similar structure such as bound evergreen trees with greenery intact) are placed in habitats where ammocoetes are present, they will move into these materials as dewatering occurs and can be safely removed the next day. If successful, document and provide this information to the U.S. Fish and Wildlife Service.
 - iv. Attempt salvage using methods outlined in Attachment A before dewatering, and move ammocoetes to a safe area, especially in areas without egress.
 - v. Sift through the removed substrate and salvage any ammocoetes within and return them to the stream away from the construction activity. If the upper foot of sediment (where ammocoetes are likely to be found) can be removed first, working upstream to downstream, and placed in an area for salvage, ammocoetes can be salvaged from that upper layer. The remaining, lower layers of sediments would presumably have few if any lamprey and those could be removed and placed upland. Salvage is the least preferred as many lamprey will be overlooked, due to their small size and the nature of the job, and many others will be crushed by the weight of the sediment during removal. Further, in areas of high ammocoete density and large amounts of fine sediment removal, such efforts would be very time-consuming.
5. When diverting water into irrigation canals and ditches removes water from the stream channel, several potential impacts to lamprey may occur:
- Reduced flows decrease the amount and quality of habitat available to Pacific lampreys;
 - Flows that are diverted quickly into canals and ditches may strand ammocoetes and migrating macrophthmia as occupied habitats are dewatered;
 - Flows that are diverted may result in desiccation of lamprey nests.
- a. Recommendations: For water diversions, implement the following recommendations as appropriate:
- i. Negotiate water savings and ditch consolidation wherever possible to provide more instream flow.
 - ii. Avoid reduction in streamflows of a magnitude that nests would be exposed and desiccated.

- iii. When diversion structures are opened for irrigation, request that they are opened slowly during the day to allow ammocoetes to escape to a watered area.
- iv. When shutting off a diversion, do so slowly, ideally starting at night and lasting for several days, so the lamprey can escape if they are between the headgate and any fish screen, or trapped behind the screen in the ditch. Start by cutting flow to 50% for the first 24 hours, and then to 75% over the next two days. Then, drop flow to 80-90% for a few days with the screen lifted (if applicable). This technique is also used for salmonids. The goal is to keep a continuously wetted channel between the diversion point and downstream wetted area in the ditch to facilitate movement out of the ditch.
- v. Salvage using methods outlined in Attachment A, or Recommendation 4.

6. Passage Projects: Design Considerations for Larval and Juvenile Lamprey.

Diverting water at diversion structures with screening may result in impingement of larval and juvenile lampreys (both ammocoetes and macrophthalmia) on screens installed to prevent juvenile salmonids from moving into ditches, canals, and hydropower turbines. In some instances, ammocoetes are too small for conventional screening to be effective, and can pass through screening materials. At unscreened facilities, all life stages (adult, larval and juvenile lamprey) can be diverted into areas that ultimately result in their death due to dewatering.

- Approach velocities greater than 0.40 ft./s for active screens or 0.20 ft./s for passive screens have been shown to make it difficult if not impossible for ammocoetes and macrophthalmia to avoid the structure (Dauble et al. 2006);
- Larger ammocoetes (those that cannot pass through) were found to become impinged on bar screens at hydroelectric facilities at velocities of 1.5 ft./s or higher (Moursund et al. 2001);
- In testing three types of screen materials, no lampreys became permanently stuck on 3/32 inch bar screen in front of turbines (Moursund et al. 2001).

a. Recommendations for Juvenile Passage:

- i. Screening installed that is consistent with criteria developed for salmonids will reduce impacts to adult lamprey and the larger juveniles/macrophthalmia life stages, and should be used at a minimum to protect salmonids and these larger life stages of lamprey.
- ii. Different screen types (materials, orientation and siting) may have different effects on lamprey. Little is known about what types of screens, water velocities, orientations of the screen and screen material are effective at reducing impacts to lampreys. Criteria developed for salmonids may or may not be appropriate for protecting lamprey, depending on the size of juveniles encountered at the project area. As criteria are developed for lamprey, step up replacement of fish screens at diversion structures known to entrain or cause mortality to lamprey with those that prevent entrainment of lamprey, in streams where lamprey are known to exist.
- iii. Use methods outlined in Attachment A to determine if lamprey are being entrained in an irrigation ditch.

7. **Passage Projects: Design Considerations for Adult Lamprey**
Diversion structures and dams (even those with fishways) may block adult lampreys migrating upstream, or result in death if lamprey are diverted into unscreened ditches and canals. In the last decade, there has been significant progress in determining appropriate measures to provide passage for adult Pacific lamprey: measures include modifications to fish ladders (Pacific Lamprey Technical Workgroup 2017), and lamprey-specific passage ramps (Zobott et al. 2015). Both of these documents provide specific guidance on fishway modifications and ramp construction for lampreys.
 - a. **Recommendations for Adult Passage:**
 - i. Screening, consistent with criteria developed for salmonids, will prevent adult lamprey from entering unsafe areas, and screens to this threshold, at a minimum, should be incorporated at all diversions.
 - ii. See *Practical guidelines for incorporating adult Pacific lamprey passage at fishways* (Pacific Lamprey Technical Workgroup 2017, available online at <https://www.fws.gov/pacificlamprey/mainpage.cfm>). for specific guidance on providing upstream passage within a) existing fishways and b) new fishway designs. Creating smooth surfaces and rounded corners with no 90 degree bends in high velocity areas, and using flat plates (e.g. steel, aluminum, polycarbonate) to provide attachment points for lamprey to passage over grating are some examples.
 - iii. Design and install lamprey passage systems at barriers (i.e. Moser et al. 2006, Zobott et al. 2015). These are relatively simple in design and provide alternate routes for adult lamprey passage where barriers to lamprey passage exist. These systems can be used as a stand-alone passage route for lamprey, or in combination with ladders, as needed to allow lamprey to bypass areas that are impassable/difficult for them.
 - iv. Replace hanging culverts using a bridge or stream simulation design.
 - v. Piling rocks at a culvert outlet in the water overflow or fitting outlet with attachment surface (e.g. flat plate) for temporary passage at hanging culverts.
 - vi. Use removable spillway weirs during peak movement periods.

Reporting

- a. In order for the Service to be kept informed of actions that minimize or avoid adverse effects or that benefit listed species or their habitats, the Service requests a copy of any relevant publications for conserving listed species and their habitats. Please send documents to:
State Supervisor
USFWS- Oregon Fish and Wildlife Office
2600 SE 98th Avenue, Suite 100
Portland, Oregon 97266
- b. In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations. Please provide notification in writing, or by email, to the following:

State Supervisor
USFWS- Oregon Fish and Wildlife Office
2600 SE 98th Avenue, Suite 100
Portland, Oregon 97266

8.0 REINITIATION OF CONSULTATION

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal action 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 are likely to be affected by the action.

If monitoring and reporting are not done in accordance with the description of the proposed action, the Corps need to reinitiate formal consultation in accordance with the requirements of 402.16(c). Failure to adequately monitor and report constitutes a change in the proposed action that may facilitate effects to listed species or critical habitat that were not considered in the BO. To reinitiate consultation, contact the Oregon State Office of the USFWS and refer to the Reference Number 01EOW00-2017-F-0370.

LITERATURE CITED

- Able KW, Manderson JP, Studholme AI. 1998. The distribution of shallow water juvenile fishes in an urban estuary: the effects of man-made structures in the Lower Hudson River. *Estuaries* 21: 731-44.
- ACA (Alberta Sustainable Resource Development and Alberta Conservation Association). 2009. Status of the bull trout (*Salvelinus confluentus*) in Alberta: Update 2009. Alberta Sustainable Resource Development. Wildlife Status Report No. 39 (Update 2009). Edmonton, Alberta.
- Alpers CN, Antweiler RC, Taylor HE, Dileanis PD, Domagalski JL (editors). 2000a. Volume 1: Methods and Data. *In: Metals transport in the Sacramento River, California, 1996-1997*, Water-Resources Investigations Report 99-4286. U.S. Geological Survey. Sacramento, California.
- Alpers CN, Antweiler RC, Taylor HE, Dileanis PD, Domagalski JL (editors). 2000b. Volume 2: Interpretation of metal loads. *In: Metals transport in the Sacramento River, California, 1996-1997*, Water-Resources Investigations Report 00-4002. U.S. Geological Survey. Sacramento, California.
- Anderson CW, Rinella FA, Rounds SA. 1996. Occurrence of selected trace elements and organic compounds and their relation to land use in the Willamette River Basin, Oregon, 1992–94. U.S. Geological Survey. Water-Resources Investigations Report 96-4234. Portland, Oregon.
- Ardren WR, DeHaan PW, Smith CT, Taylor EB, Leary R, Kozfkay CC, Godfrey L, Diggs M, Fredenberg W, Chan J, et al. 2011. Genetic structure, evolutionary history, and conservation units of bull trout in the coterminous United States. *Transactions of the American Fisheries Society* 140:506-525.
- AASHTO (American Association of State Highway and Transportation Officials). 2013. AASHTO LRFD Bridge Design Specifications, 2013 Interim Revisions. 6th edition. American Association of State Highway and Transportation Officials.
<http://www.aashtojournal.org/Pages/042613Publication.aspx>
- Abbott R, Bing-Sawyer, E. 2002. Assessment of pile driving impacts on the Sacramento blackfish (*Othodon microlepidotus*). Draft report prepared for Caltrans District 4. October 10.
- Armstrong DA, Stevens BG, Hoeman, JC. 1982. Distribution and abundance of Dungeness crab and Crangon shrimp, and dredged-related mortality of invertebrates and fish in Grays Harbor, Washington. Technical Report, School of Fisheries, University of Washington, Washington Department of Fisheries, and Seattle District Corps of Engineers. 349 p.
- Arseneault, JS. 1981. Memorandum to J.S. Mathers on the result of the 1980 dredge monitoring program. Fisheries and Oceans, Government of Canada.

- Baldwin DH, Sandahl JF, Labenia JS, Scholz NL. 2003. Sublethal effects of copper on coho salmon: Impacts on nonoverlapping receptor pathways in the peripheral olfactory nervous system. *Environmental Toxicology and Chemistry* 22:2266-2274.
- Baldwin DH, Spromberg JA, Collier TK, Scholz, NL. 2009. A fish of many scales: extrapolating sublethal pesticide exposures to the productivity of wild salmon populations. *Ecological Applications* 19(8):2004-2015.
- Baldwin DH, Tatara CP, Scholz NL. 2011. Copper-induced olfactory toxicity in salmon and steelhead: Extrapolation across species and rearing environments. *Aquatic Toxicology* 101:295-297.
- Barnard RJ, Johnson J, Brooks P, Bates KM, Heiner B, Klavas JP, Ponder DC, Smith PD, Powers PD. 2013. *Water Crossings Design Guidelines*. Washington Department of Fish and Wildlife. Olympia, Washington. <http://wdfw.wa.gov/publications/01501/>.
- Barrett ME, Zuber RD, Collins ER, Malina, JF, Charbeneau RJ, Ward GH (editors). 1993. *A review and evaluation of literature pertaining to the quantity and control of pollution from highway runoff and construction*. 2nd edition. Center for Research in Water Resources, Bureau of Engineering Research, University of Texas at Austin. Austin, Texas.
- Battin J, Wiley MW, Ruckelshaus MH, Palmer RN, Korb E, Bartz KK, Imaki H. 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 JS, Taylor EB, Devlin RH, Hagen J, McPhail JD. 1997. Evidence for natural hybridization between Dolly Varden (*Salvelinus malma*) and bull trout (*S. confluentus*) in a northcentral British Columbia watershed. *Canadian Journal of Fisheries and Aquatic Sciences* 54:421-429.
- Baxter CV. 2002. *Fish Movement and Assemblage Dynamics in a Pacific Northwest Riverscape*. Ph.D. Dissertation, Oregon State University, Corvallis, OR. 174 pp.
- Beamish RJ. 1980. Adult biology of the river lamprey (*Lampetra ayresi*) and the Pacific lamprey (*Lampetra tridentata*) from the Pacific coast of Canada. *Canadian Journal of Fisheries and Aquatic Sciences* 37: 1906-1923.
- Beauchamp DA, VanTassell JJ. 2001. Modeling seasonal trophic interactions of adfluvial bull trout in Lake Billy Chinook, Oregon. *Transactions of the American Fisheries Society* 130:204-16.
- Behnke RJ. 2002. *Trout and salmon of North America*. The Free Press, New York.
- Berg L, Northcote TG. 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.

- Beschta RL, Bilby RE, Brown GW, Holtby LB, Hofstra TD. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. Pages 191-232 in Salo ED, Cundy TW (eds). Streamside Management Forestry and Fisheries Interactions. Institute of Forest Resources, University of Washington, Seattle, Washington, Contribution No. 57.
- Bilby RE. 1984. Removal of woody debris may affect stream channel stability. *Journal of Forestry* 82:609-613.
- Bisson PA, Rieman BE, Luce C, Hessburg PF, Lee DC, Kershner JL, Reeves GH, Gresswell RE. 2003. Fire and aquatic ecosystems of the western USA: Current knowledge and key questions. *Forest Ecology and Management*. 178:213-229.
- BLM (U.S. Department of Interior Bureau of Land Management). 2005. Diflufenzopyr Ecological Risk Assessment, Final Report. USDI-Bureau of Land Management. ENSR Document Number 09090-020-650. Reno, Nevada.
- Boag TD. 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 CE. 1992. Notes on the nomenclature and distribution of the bull trout and the effects of human activity on the species. Pages 1-4 in Howell PF, Buchanan DV, eds. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.
- Bonneau JL, Scarnecchia DL. 1996. Distribution of juvenile bull trout in a thermal gradient of a plunge pool in Granite Creek, Idaho. *Transactions of the American Fisheries Society* 125:628-630.
- Boyd FC. 1975. Fraser River dredging guide. Tech. Rpt. Series No. PAC/T-75-2. Fisheries and Marine Service, Environment Canada.
- Braun F. 1974a. Monitoring the effects of hydraulic suction dredging on migrating fish in the Fraser River Phase I. Department of Public Works, Pacific Region, Canada.
- Braun F. 1974b. Monitoring the effects of hydraulic suction dredging on migrating fish in the Fraser River Phase II. Department of Public Works, Pacific Region, Canada.
- Brenkman SJ, Corbett SC. 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 PA, Brewin MK, Monita M. 1997. Distribution maps for bull trout in Alberta. Pages 206-216 in Mackay WC, Brewin MK, Monita M (eds). Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

Bricker OP. 1999. An overview of the factors involved in evaluation the geochemical effects of highway runoff on the environment. U.S. Geological Survey, and Federal Highway Administration. Open-File Report 98-630. Northborough, Massachusetts.

Brooks KM. 2000. Assessment of the environmental effects associated with wooden bridges treated with creosote, pentachlorophenol, or chromated copper arsenate wood. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin. (September 2000) <http://www.fpl.fs.fed.us/documnts/FPLRP/fplrp587.pdf>

Brooks KM. 2003. Literature review, computer model and assessment of the potential environmental risks associated with copper naphthenate treated wood products used in aquatic environments. A report prepared for Mr. Gerald E. Davis, Merichem Chemicals and Refinery Services, LLC, Tuscaloosa, Alabama (February 15, 2003).

Brooks KM. 2004. Environmental response to ACZA treated wood structures in a Pacific Northwest marine environment. A report prepared for J. H. Baxter and Company, San Mateo, California. 31 p. (January 20, 2004).

Brown KM (compiler and producer). 2011. Oregon Blue Book: 2011-2012. Oregon State Archives, Office of the Secretary of State of Oregon. Salem, Oregon. <http://bluebook.state.or.us/>.

Brown JN, Gooneratne SR, Chapman RB. 2000. Herbicide spray drift odor: Measurement and toxicological significance. Archives of Environmental Contamination and Toxicology 38:390-397.

Buchanan DV, Hanson ML, Hooton RM. 1997. Status of Oregon's bull trout, distribution, life history, limiting factors, management considerations, and status. Report to Bonneville Power Administration. Contract No. 1994BI34342, Project No. 199505400 (BPA Report DOE/BP-34342-5). Oregon Department of Fish and Wildlife, Portland, OR. 185pp.

Buchanan DM, Gregory SV. 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 1-8 in Mackay WC, Brewin MK, Monita M (eds). Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

Buckler DR, Granato GE. 1999. Assessing biological effects from highway-runoff constituents. U.S. Geological Survey, Open File Report 99-240. Northborough, Massachusetts. 45 p.

Burkey TV. 1989. Extinction in nature reserves: the effect of fragmentation and the importance of migration between reserve fragments. Oikos 55:75-81.

Burkey TV. 1995. Extinction rates in archipelagoes: Implications for populations in fragmented habitats. Conservation Biology 9: 527-541.

CDFG (California Department of Fish and Game). 2010. Part XII, Fish Passage Design and Implementation, Salmonid Habitat Restoration Manual. California Department of Fish and Game, Sacramento, California.

Cannon K. 2008. Email from Ken Cannon, Oregon Department of Transportation transmitting ODOT 2007 Fish Salvage Report. Personal Communication to Marc Liverman, National Marine Fisheries Service. July 29, 2008.

Cannon K. 2012. Email from Ken Cannon, Oregon Department of Transportation transmitting ODOT 2012 Fish Salvage Report. Personal Communication to Marc Liverman, National Marine Fisheries Service. February 4, 2012.

Carls MG, Meador JP. 2009. A perspective on the toxicity of petrogenic PAHs to developing fish embryos related to environmental chemistry. *Human and Ecological Risk Assessment: An International Journal* 15(6):1084-1098.

Carmona-Catot G, Moyle PB, Aparicio E, Crain PK, Thompson LC, García-Berthou E. 2010. Brook trout removal as a conservation tool to restore Eagle Lake rainbow trout. *North American Journal of Fisheries Management* 30:1315–1323.

Carpenter KD, Sobieszczyk S, Arnsberg AJ, Rinella FA. 2008. Pesticide Occurrence and Distribution in the Lower Clackamas River Basin, Oregon, 2000–2005. U.S. Geological Survey Scientific Investigations Report 2008-5027:98 p.

Cavender TM. 1978. Taxonomy and distribution of the bull trout, *Salvelinus confluentus* (Suckley), from the American northwest. *California Fish and Game* 64: 139-174.

Cederholm CJ, Dominguez LG, Bumstead TW. 1997. Rehabilitating stream channels and fish habitat using large woody debris. Pages 8-1 to 8-28. In: *Fish Habitat Rehabilitation Procedures. Watershed Restoration Technical Circular No. 9*. P.A. Slaney, and D. Zaldokas (editors). British Columbia Ministry of Environment, Lands and Parks. Vancouver, British Columbia.

Center for Watershed Protection, and Maryland Department of the Environment. 2000 (revised 2009). 2000 Maryland stormwater design manual: Volumes I and II. Maryland Department of the Environment. Baltimore, Maryland.

http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/MarylandStormwaterDesignManual/Pages/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.aspx.

ChadwickDB, Zirino A, Rivera-Duarte I, Katz CN, Blake AC. 2004. Modeling the mass balance and fate of copper in San Diego Bay. *Limnology and Oceanography* 49:355-366.

Chamberlain TW, Harr RD, Everest FH. 1991. Timber harvesting, silviculture and watershed processes. Pages 181-205 in Meehan WR (ed). *Influences of forest and rangeland management on salmonid fishes and their habitats*. American Fisheries Society Special Publication 19

- Chapman DW. 2007. Effects of docks in Wells Dam Pool on subyearling summer/fall Chinook salmon. Report to Douglas County Public Utility District. 18 p.
- Christopherson A, Wilson J. 2002. Technical Letter Report Regarding the San Francisco-Oakland Bay Bridge East Span Project Noise Energy Attenuation Mitigation. Peratrovich, Nottingham & Drage, Inc. Anchorage, Alaska. 27 p.
- Cohen JE. 1977. Ratios of prey to predators in community food webs. *Nature* 270: 165–167
- Collier TK, Meador JP, Johnson LL. 2002. Introduction: Fish tissue and sediment effects thresholds for polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and tributyltin. *Aquatic Conservation: Marine and Freshwater Ecosystems* 12:489-492.
- Colman JA, Rice KC, Willoughby TC. 2001. Methodology and significance of studies of atmospheric deposition in highway runoff. U.S.G. Survey, Open-File Report 01-259. Northborough, Massachusetts. 63 p.
- Combes S. 2003. "Protecting freshwater ecosystems in the face of global climate change." *in* Hansen LJ, Biringer JL, Hoffman JR (eds). *Buying Time: A user's manual for building resistance and resilience to climate change in natural systems*. Berlin, Germany: WWF.
- Costello AB, Down TE, Pollard SM, Pacas CJ, Taylor EB. 2003. The influence of history and contemporary stream hydrology on the evolution of genetic diversity within species: an examination of microsatellite DNA variation in bull trout, *Salvelinus confluentus* (Pisces: Salmonidae). *Evolution*. 57(2):328-344.
- Craig SD, Wissmar RC. 1993. Habitat conditions influencing a remnant bull trout spawning population, Gold Creek, Washington (draft report). Fisheries Research Institute, University of Washington. Seattle, Washington.
- Cramer ML (ed). 2012. Stream habitat restoration guidelines. Co-published by the Washington Departments of Fish and Wildlife, Natural Resources, Transportation and Ecology, Washington State Recreation and Conservation Office, Puget Sound Partnership, and the U.S. Fish and Wildlife Service. Olympia, Washington.
- Cramer MK, Bates K, Miller D, Boyd K, Fotherby L, Skidmore P, Hoitsma T, Heiner B, Buchanan K, Powers P, Birkeland G, Rotar M, White D. 2002. Integrated streambank protection guidelines. Washington Department of Fish and Wildlife, Habitat Technical Assistance. Olympia, Washington. <http://wdfw.wa.gov/publications/00046/wdfw00046.pdf>.
- Dambacher JM, Buktenica MW, Larson GL. 1992. Distribution, abundance, and habitat utilization of bull trout and brook trout in Sun Creek, Crater Lake National Park, Oregon. Proceedings of the Gearhart Mountain Bull Trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

- Darnell RM. 1976. Impacts of construction activities in wetlands of the United States. U.S. Environmental Protection Agency, Environmental Research Laboratory. Ecological Research Series, Report No. EPA-600/3-76-045. U.S. Environmental Protection Agency, Environmental Research Laboratory. Corvallis, Oregon.
- Dauble DD, Moursund RA, Bleich MD. 2006. Swimming behavior of juvenile Pacific lamprey, *Lampetra tridentata*. *Environmental Biology of Fishes* 75: 167-171.
- DeHaan P, Diggs M, VonBargen J. 2011. Genetic analysis of bull trout in the Saint Mary River System. U.S. Fish and Wildlife Service. Abernathy Fish Technology Center, Longview, Washington.
- DeVenzio H. Undated. Timber treatments: New preservatives and standards change the way people build and specify. *Bridge Builder Magazine*.
- DiTomaso JM, Kyser KB, Pitcairn MJ. 2006. Yellow starthistle management guide. California Invasive Plant Council. Berkley, California. Cal-IPC Publication 2006-03. 78 p. <http://www.cal-ipc.org>.
- Donald DB, Alger DJ. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. *Canadian Journal of Zoology/Revue Canadien de Zoologie* 71:238-247.
- Dosskey MG, Vidon P, Gurwick NP, Allan CJ, Duval TP, Lowrance R. 2010. The Role of Riparian Vegetation in Protecting and Improving Chemical Water Quality in Streams. *Journal of the American Water Resources Association*:1-18.
- Dugger CR. 2005. Position paper: Effects of shading from over-water structures on predation of juvenile salmonids. Washington Department of Fish and Wildlife Region 5, Vancouver, Washington. 12 p.
- Dunham JB, Rieman BE. 1999. Metapopulation structure of bull trout: Influences of physical, biotic, and geometrical landscape characteristics. *Ecological Applications* 9:642-655.
- Dunham JB, Rieman BE, Chandler G. 2003. Influences 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* 2003;23:894–904.
- Dunham JB, Baxter C, Fausch K, Fredenberg W, Kitano S, Koizumi E, Morita K, Nakamura T, Rieman B, Savvaitova K, et al. 2008. Evolution, ecology, and conservation of Dolly Varden, white-spotted char, and bull trout. *Fisheries* 33:537–550.
- Dunsmoor LK, Bennett DH, Chandler JA. 1991. Prey selectivity and growth of a planktivorous population of smallmouth bass in an Idaho reservoir. Pages 14-23 in Jackson DC (ed) .*The First International Smallmouth Bass Symposium*. Southern Division American Fisheries Society. Bethesda, Maryland.

Dutta LK. 1976. Dredging: Environmental effects and technology. Pages 301-319 In: Proceedings of WODCON VII. World Dredging Conference, San Pedro, California.

Dutta LK, Sookachoff P. 1975a. Assessing the impact of a 24" suction pipeline dredge on chum salmon fry in the Fraser River. Fish. And Marine Serv., Environment Canada, Technical Report Series No. PAC/T-75-26. 24 p.

Dutta LK, Sookachoff P. 1975b. A review of suction dredge monitoring in the lower Fraser River, 1971-1975. Fish. And Marine Serv., Environment Canada, Technical Report Series No. PAC/T-75-27. 100 p.

Driscoll ED, Shelley PE, Strecher EW. 1990. Pollutant loadings and impacts from highway runoff, Volume III: Analytical investigation and research report. Federal Highway Administration, Office of Engineering and Highway Operations Research and Development. FHWD-RD-88-008. McLean, Virginia.

Ebersole JL, Liss WJ, Frissell CA. 1997. Restoration of stream habitats in the Western United States: Restoration as reexpression of habitat capacity. *Environmental Management* 21(1):1-14.

Emmet RL, McCabe Jr. GT, Muir WD. 1988. Effects of the 1980 Mount St. Helens eruption on Columbia River estuarine fishes: implications for dredging on Northwest estuaries. Pages 74-91 in Simenstad CA (ed). Effects of dredging on anadromous Pacific coast fishes. Washington Sea Grant Program. Washington State University. Seattle, Washington.

Enger PS, Karlsen HE, Knudsen FR, Sand O. 1993. Detection and reaction of fish to infrasound. Fish behavior in relation to fishing operations. *ICES Marine Science Symposia* 196:108-112.

ESRI (Environmental Systems Research Institute). 2016. ArcGIS Desktop: Release 10.4. Redlands, CA: Environmental Systems Research Institute.

Feist BE, Anderson JJ, Miyamoto R. 1996. Potential impacts of pile driving on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon behavior and distribution. Fisheries Research Institute Report No. FRI-UW-9603:66 pp. School of Fisheries, University of Washington. Seattle.

FEMA (Federal Emergency Management Agency). 2009. Flood Insurance Manual. Federal Emergency Management Agency, Department of Homeland Security. Washington, D.C.

Fishbase. 2015.

<http://www.fishbase.org/Summary/SpeciesSummary.php?ID=2690&AT=bull+trout>. Accessed March, 2016.

Fox WW. 1992. Stemming the tide: Challenges for conserving the nation's coastal fish habitat. Pages 9-13 in Stroud RH (ed). Stemming the tide of coastal fish habitat loss. National Coalition for Marine Conservation, Inc. Savannah, Georgia.

FPL (Forest Products Laboratory). 2000. What's in that pressure-treated wood? U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin. <http://www.fpl.fs.fed.us/techlines.htm>

FPL (Forest Products Laboratory). 2001a. Coatings minimize leaching from treated wood. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin. (November, 2001) <http://www.fpl.fs.fed.us/techlines.htm>

FPL (Forest Products Laboratory). 2001b. Environmental impact of preservative-treated wood. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin. (December, 2001) <http://www.fpl.fs.fed.us/techlines.htm>

FPL (Forest Products Laboratory). 2003. Changes in pressure-treated wood for residential construction. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin. <http://www.fpl.fs.fed.us/techlines.htm>

Fraley JJ, Shepard BB. 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.

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

Freyer F, Healey MC. 2003. Fish community structure and environmental correlates in the highly altered southern Sacramento-San Joaquin Delta. Environmental Biology of Fishes 66:123-132.

Frissell CA. 1999. An ecosystem approach to habitat conservation for bull trout: groundwater and surface water protection. Open File Report Number 156-99. Flathead Lake Biological Station, University of Montana, Polson, MT, 46 pp.

Fritts AL, Pearsons TN. 2004. Smallmouth predation on hatchery and wild salmonids in the Yakima River, Washington. Transactions of the American Fisheries Society (133): 880-895.

Fuhrer K, Hutterli M, McConnell JR. 1996. Overview of recent field experiments for the study of the air-snow transfer of H₂O₂ and HCHO, in Chemical Exchange Between the Atmosphere and Polar Snow, 43, NATO ASI, pp. 307-318, Springer, 1996.

Furniss MJ, Roelofs TD, Yee CS. 1991. Road construction and maintenance. American Fisheries Society Special Publication 19:297-323.

Furniss MJ, Ledwith TS, Love MA, McFadin BC, Flanagan SA. 1998. Response of road-stream crossings to large flood events in Washington, Oregon, and Northern California. USDA Forest Service, Technology and Development Program. San Dimas Technology and Development Center. San Dimas, California.

Gergel SE, Dixon MD, Turner MG. 2002. Consequences of human-altered floods: Levees, floods, and floodplain forests along the Wisconsin River. *Ecological Applications* 12(6):1755-1770.

Gilbert CH. 1898. Fishes of the Klamath River Basin. *Bulletin of the U. S. Fish Commission for 1897*, Article 1. 1-13pp.

Gilliom RJ, Barbash GE, Crawford CG, Hamilton PA, Martin JD, Nakagaki N, Nowell LH, Scott JC, Stackelberg PE, Thelin GP, et al. 2006. Pesticides in the nation's streams and ground water, 1992-2001. U.S. Geological Survey Circular 1291:172 p.

Goetz FA. 1989. Biology of the bull trout, *Salvelinus confluentus*, literature review. U.S. Forest Service, Willamette National Forest, Eugene, Oregon.

Goetz FA. 1994. Distribution and juvenile ecology of bull trout (*Salvelinus confluentus*) in the Cascade Mountains. M.S. thesis. Oregon State University, Corvallis.

Goetz FA, Jeanes E, Beamer E. 2004. Bull trout in the nearshore. Preliminary draft. U.S. Army Corps of Engineers, Seattle, Washington, June, 2004, 396 pp.

Graham AL, Cooke S.J. 2008. The effects of noise disturbance from various recreational boating activities common to inland waters on the cardiac physiology of a freshwater fish, the largemouth bass (*Micropterus salmoides*). *Aquatic Conservation: Marine and Freshwater Ecosystems*.

Gray GA, Rondorf DW. 1986. Predation on juvenile salmonids in Columbia Basin reservoirs. Pages 178-185 in Hall GE, Van Den Avle MJ (eds). *Reservoir Fisheries Management Strategies for the 80's*. Southern Division American Fisheries Society, Bethesda, Maryland.

Gregory RS. 1988. Effects of turbidity on benthic foraging and predation risk in juvenile Chinook salmon. Pages 64-73. in Simenstad CA (ed). *Effects of dredging on anadromous Pacific coast fishes*. Washington Sea Grant Program, Washington State University. Seattle.

Gucinski H, Furniss MJ, Ziemer RR, Brookes MH. 2001. Forest roads: A synthesis of scientific information. USDA Forest Service, Pacific Northwest Research Station. General Technical Report PNW-GTR-509. Portland, Oregon. May. 103 p.
<http://www.fs.fed.us/pnw/pubs/gtr509.pdf>.

Haas GR, McPhail JD. 1991. Systematics and distributions of Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) in North America. *Canadian Journal of Fisheries and Aquatic Sciences* 48:2191-2211.

Haas GR, McPhail JD. 2001. The post-Wisconsin glacial biogeography of bull trout (*Salvelinus confluentus*): a multivariate morphometric approach for conservation biology and management. *Canadian Journal of Fisheries and Aquatic Sciences* 58:2189-2203.

- Hansen JA, Marr JC, Lipton J, Cacela D, Bergman HL. 1999a. Differences in neurobehavioral responses of Chinook salmon (*Onchorynchus tshawytscha*) and rainbow trout (*Onchorynchus mykiss*) exposed to copper and cobalt: Behavioral avoidance. *Environmental Toxicology and Chemistry* 18:1972-1978.
- Hansen JA, Rose JD, Jenkins RA, Gerow KG, Bergman HL. 1999b. Chinook salmon (*Onchorynchus tshawytscha*) and rainbow trout (*Onchorynchus mykiss*) exposed to copper and cobalt: Neurophysiological and histological effects on the olfactory system. *Environmental Toxicology and Chemistry* 18:1979-1991.
- Hara TJ, Law YM, MacDonald S. 1975. Effects of mercury and copper on the olfactory response in rainbow trout. *Journal of the Fisheries Research Board of Canada* 33:1568- 1573.
- Hard J. 1995. A quantitative genetic perspective on the conservation of intraspecific diversity. *American Fisheries Society Symposium* 17: 304-326.
- Hari RE, Livingstone DM, Siber R, Burkhardt-Holm P, Guttinger H. 2006. Consequences of climatic change for water temperature and brown trout populations in alpine rivers and streams. *Global Change Biology* 12:10–26.
- Hartill T, Jacobs S. 2007. Distribution and abundance of bull trout in the Sprague River (Upper Klamath Basin), 2006. Oregon Department of Fish and Wildlife. Corvallis, Oregon
- Healey MC, Prince A. 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.
- Hecht SA, Baldwin DH, Mebane CA, Hawkes T, Gross SJ, Scholz NL. 2007. An overview of sensory effects on juvenile salmonids exposed to dissolved copper: Applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. U.S. Department of Commerce, NOAA Fisheries, NOAA Technical Memorandum NMFS-NWFSC-83. 39 p.
- Heintz RA, Short JW, Rice SD. 1999. Sensitivity of fish embryos to weathered crude oil: Part II. Increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos incubating downstream from weathered Exxon Valdez crude oil. *Environmental Toxicology and Chemistry* 18:494-503.
- Henjum MG, Karr JR, Bottom DL, Perry DA, Bednarz JC, Wright SG, Beckwitt SA, Beckwitt E. 1994. Interim protection for late-successional forests, fisheries, and watersheds. National forests east of the Cascade Crest, Oregon, and Washington. A report to the Congress and President of the United States Eastside Forests Scientific Society Panel. American Fisheries Society, American Ornithologists Union Incorporated, The Ecological Society of America, Society for Conservation Biology, The Wildlife Society. The Wildlife Society Technical Review 94-2.
- Herrera Environmental Consultants, Inc. 2006. Technology Evaluation and Engineering Report: Ecology Embankment. Washington State Department of Transportation. Olympia, Washington.

<http://www.wsdot.wa.gov/NR/rdonlyres/3D73CD62-6F99-45DD-B004-D7B7B4796C2E/0/EcologyEmbankmentTEER.pdf>.

Hicken CE, Linbo TL, Baldwin DH, Willis ML, Myers MS, Holland L, Larsen M, Stekoll MS, Rice SD, Collier TK, Scholz NL, Incardona JP. 2011. Sublethal exposure to crude oil during embryonic development alters cardiac morphology and reduces aerobic capacity in adult fish. *Proceedings of the National Academy of Sciences* 108(17):7086-7090.

Hicks BJ, Hall JD, Bisson PA, Sedell JR. 1991. Responses of salmonid to habitat change. Pages 483-518 *in* Meehan WR (ed). *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats*. American Fisheries Society. Bethesda, Maryland.

Hingston JA, Collins CD, Murphy RJ, Lester JN. 2001. Leaching of chromated copper arsenate wood preservatives: A review. *Environmental Pollution* 111:53-66.

Hirschman D, Collins K, Schueler T. 2008. Technical Memorandum: The Runoff Reduction Method. Center for Watershed Protection. Ellicott City, Maryland. April 18.
<http://www.region9wv.com/Bay/Calculators/RRTechMemo.pdf>.

Hoelscher B, Bjornn TC. 1989. Habitat, density, and potential production of trout and char in Pend Oreille Lake tributaries. Project F-710R-10, Subproject III, Job No. 8. Idaho Department of Fish and Game, Boise, Idaho.

Howell PJ, Buchanan DV. 1992. *Proceedings of the Gearhart Mountain Bull Trout Workshop*. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Hudson JM, Koch R, Johnson J, Harris J, Koski ML, Galloway B, Williamson JD. 2015. Clackamas River Bull Trout Reintroduction Project, 2014 Annual Report. Oregon Department of Fish and Wildlife and U.S. Fish and Wildlife Service, 33 pp.

High B, Meyer K, Schill D, Mamer E. IDFG (Idaho Department of Fish and Game). 2008. Distribution, abundance, and population trends of bull trout in Idaho. *North American Journal of Fisheries Management* 28:1687-1701.

IDFG (Idaho Department of Fish and Game). 2014. Panhandle Region Annual Fisheries Report. 2013 Activities and Accomplishments. Issue 6, January 2014. Electronic newsletter.

Igloira R. 2007. Stormwater Treatment Strategy Development – Water Quality Design Storm Performance Standard. Personal Communication to Jennifer Sellers and William Fletcher, Oregon Department of Transportation. Memo from Igloira R, HDR (Henningson, Durham, and Richardson, Inc.). December 28, 2007.

Igloira R. 2008. Stormwater Treatment Strategy Development – Water Quantity Design Storm Performance Standard - Final. Personal Communication to Jennifer Sellers and William Fletcher, Oregon Department of Transportation. Memo from Igloira R, HDR (Henningson, Durham, and Richardson, Inc.). February 28, 2008.

Igloria R. 2008. Water Quantity Design Storm Performance Standard – Final Personal Communication to Jennifer Sellers and William Fletcher, Oregon Department of Transportation. Memo from Igloria R, HDR (Henningson, Durham, and Richardson, Inc.). April 15, 2008.

Incardona JP, Collier TK, Scholz NL. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. *Toxicology and Applied Pharmacology* 196:191-205.

Incardona JP, Carls MG, Teraoka H, Sloan CA, Collier TK, Scholz NL. 2005. Aryl hydrocarbon receptor-independent toxicity of weathered crude oil during fish development. *Environmental Health Perspectives* 113:1755-1762.

Incardona JP, Day HL, Collier TK, Scholz NL. 2006. Developmental toxicity of 4-ring polycyclic aromatic hydrocarbons in zebrafish is differentially dependent on AH receptor isoforms and hepatic cytochrome P450 1A metabolism. *Toxicology and Applied Pharmacology* 217:308-321.

IPCC (Intergovernmental Panel on Climate Change). 2007. Climate change 2007: the physical science basis. Available: www.ipcc.ch. (February 2007).

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

Johnson L. 2000. An analysis in support of sediment quality thresholds for polycyclic aromatic hydrocarbons (PAHs) to protect estuarine fish. White Paper from National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 29 p.

Johnson L, Sol SY, Ylitalo GM, Hom T, French B, Olson OP, Collier TK. 1999. Reproductive injury in English sole (*Pleuronectes vetulus*) from the Hylebos Waterway, Commencement Bay, Washington. *Journal of Aquatic Ecosystem Stress and Recovery*. 6:289-310.

Johnson LL, Collier TK, Stein JE. 2002. An analysis in support of sediment quality thresholds for polycyclic aromatic hydrocarbons (PAHs) to protect estuarine fish. *Aquatic Conservation: Marine and Freshwater Ecosystems* 12:517-538.

Johnson LL, Ylitalo GM, Arkoosh MR, Kagley AN, Stafford CL, Bolton JL, Buzitis J, Anulacion BJ, Collier TK. 2007. Contaminant exposure in outmigrant juvenile salmon from Pacific Northwest estuaries. *Environmental Monitoring and Assessment* 124:167-194.

Johnson LL, Anulacion B, Arkoosh M, Olson OP, Sloan C, Sol SY, Spromberg J, Teel DJ, Yanagida G, Ylitalo G. 2013. Persistent organic pollutants in juvenile Chinook salmon in the Columbia River Basin: Implications for stock recovery. *Transactions of the American Fisheries Society* 142:21-40.

Johnson VG, Peterson RE, Olsen KB. 2005. Heavy metal transport and behavior in the lower Columbia River, USA. *Environmental Monitoring and Assessment* 110:271-289.

Johnson KN, Franklin JF, Thomas JW, Gordon J. 1991. Alternatives for management of late successional forests of the Pacific Northwest. A report to the Agriculture and Merchant and Marine Fisheries Committees of the U.S. House of Representative. Scientific Panel on Late Successional Forest Ecosystems, Washington, D.C.

Jones JA, Swanson FJ, Wemple BC, Snyder KU. 2000. Effects of roads on hydrology, geomorphology, and disturbance patches in stream networks. *Conservation Biology* 14(1):76-85.

Julliard AK, Saucier D, Astic L. 1996. Time-course of apoptosis in the olfactory epithelium of rainbow trout exposed to a low copper level. *Tissue Cell* 28:367-377.

Kahler T, Grassley M, Beauchamp D. 2000. A summary of the effects of bulkheads, piers and other artificial structures and shorezone development on ESA-listed salmonids in lakes. Final Report to the City of Bellevue. The Watershed Company, Kirkland, Washington. 74 p.

Kayhanian M, Singh A, Suverkropp C, Borroum S. 2003. Impact of annual average daily traffic on highway runoff pollutant concentrations. *Journal of Environmental Engineering* 129:975-990.

Keevin TM. 1998. A review of natural resource agency recommendations for mitigating the impacts of underwater blasting. *Rev. Fish. Sci.* 6(4):281-313.

Keller EA, Macdonald A, Tally T, Merrit NJ. 1985. Effects of large organic debris on channel morphology and sediment storage in selected tributaries of Redwood Creek, Northwest California. Geomorphic processes and aquatic habitat in the Redwood Creek basin, Northwestern California. U.S. Geological Survey. Professional Paper 1454-P. P1-P29.
http://www.waterboards.ca.gov/water_issues/programs/tmdl/records/region_1/2003/ref962.pdf.

Kiely T, Donaldson D, Grube A. 2004. Pesticides industry sales and usage 2000 and 2001 market estimates. U.S. Environmental Protection Agency, Biological and Economic Analysis Division. http://www.epa.gov/opp00001/pestsales/01pestsales/market_estimates2001.pdf.

Kirn RA, Ledgerwood RD, Jensen AL. 1986. Diet of subyearling Chinook salmon (*Oncorhynchus tshawytscha*) in the Columbia River estuary and changes effected by the 1980 eruption of Mount St. Helens. *Northwest Science* 60:191-195.

Knudsen FR, Schreck CB, Knapp SM, Enger PS, Sand O. 1997. Infrasound produces flight and avoidance responses in Pacific juvenile salmonids. *Journal of Fish Biology*, 51:824-829.

Kostow K. 2002. Oregon Lamprey: Natural history, status and problem analysis. Oregon Department of Fish and Wildlife.

Lagasse PF, Schall JD, Richardson EV. (2001) *Stream stability at highway structures, 3rd edn.* US Department of Transportation, Report No. FHWA NHI 01-002, HEC-20, Federal Highway Administration, Arlington, VA.

Lagasse PF, Zevenbergen LW, Spitz WJ, Arneson LA. 2012. Stream Stability at Highway Structures, Fourth Edition. U.S. Department of Transportation, Federal Highway Administration, Office of Bridge Technology and National Highway Institute. Publication No. FHWA-HIF-12-004, Hydraulic Engineering Circular No. 20. Arlington, Virginia. April.
<http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hif12004.pdf>.

Larson KW, Moehl CE. 1990. Entrainment of Anadromous Fish by Hopper Dredge at the Mouth of the Columbia River in Simenstad CA, (ed). Effects of Dredging on Anadromous Pacific Coast Fishes. Washington Sea Grant program, University of Washington, Seattle. 160 p.

Lassettre NS, Harris RS. 2001. The geomorphic and ecological influence of large woody debris in streams and rivers. University of California-Berkeley. Department of Lands and Environmental Planning. Report. 68 p. http://frap.cdf.ca.gov/publications/lwd/lwd_paper.pdf.

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 [CONSERV. BIOL.] 7 856-865.

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 SA, Graham P. 1982. Flathead Lake fish food habits study. Environmental Protection Agency, through Steering Committee for the Flathead River Basin Environmental Impact Study. Contract R008224-01-4 to Montana Department of Fish, Wildlife, and Parks.

Lebow ST. 1996. Leaching of wood preservative components and their mobility in the environment—Summary of pertinent literature. . U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin. 36 p.
<http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr93.pdf>

Lebow ST, Tippie M. 2001. Guide for minimizing the effect of preservative-treated wood on sensitive environments. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin. 18 p. <http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr122.pdf>

Lebow ST. 2004. Alternatives to chromated copper arsenate (CCA) for residential construction. Pages 156-168 in Pre-Conference Proceedings, Environmental Impacts of Preservative-Treated Wood. Florida Center for Solid and Hazardous Waste Management, Gainesville, Florida.
<http://www.ccaresearch.org/Pre-Conference/#release>

Lebow ST, Cooper P, Lebow P. 2004. Variability in evaluating environmental effects of treated wood. Pages in Pre-Conference Proceedings, Environmental Impacts of Preservative-Treated Wood. Florida Center for Solid and Hazardous Waste Management, Gainesville, Florida.
<http://www.ccaresearch.org/Pre-Conference/#release>

Light J, Herger L, Robinson M. 1996. Upper Klamath basin bull trout conservation strategy, a conceptual framework for recovery. Part one. The Klamath Basin Bull Trout Working Group.

Loge F, Arkoosh MR, Ginn TR, Johnson LL, Collier TK. 2006. Impact of environmental stressors on the dynamics of disease transmission. *Environmental Science & Technology* 39(18):7329-7336.

Longmuir C, Lively T. 2001. Bubble curtain systems for use during marine pile driving. Report by Fraser River Pile & Dredge Ltd., New Westminster, British Columbia. 9 p.

Lower Columbia River Estuary Partnership. 2007. Lower Columbia River and estuary ecosystem monitoring: Water quality and salmon sampling report. Portland, Oregon.
http://www.estuarypartnership.org/sites/default/files/resource_files/WaterSalmonReport.pdf.

LCFRB (Lower Columbia Fish Recovery Board). 2010. Washington lower Columbia salmon recovery & fish and wildlife subbasin plan. May 28. Final. Lower Columbia Fish Recovery Board, Olympia, Washington. Available at:
http://www.lcfrb.gen.wa.us/Recovery%20Plans/June%202010%20RP/Vol%201/FINAL_Vol%20I%20Ch%201%20Intro%202010%20May.pdf

Madej MA. 2001. Erosion and sediment delivery following removal of forest roads. *Earth Surface Processes and Landforms* 26:175-190.

Magnuson JJ, Robertson DM, Benson BJ, Wynne RH, Livingstone DM, Arai T, Assel RA, Barry RG, Card V, Kuusisto, E, et al. 2000. Historical trends in lake and river ice cover in the Northern Hemisphere. *Science* 289, 1743.

Marcot BG, Allen CS, Morey S, Shively D, White R. 2012. An expert panel approach to assessing potential effects of bull trout reintroduction on federally listed salmonids in the Clackamas River, Oregon *North American Journal of Fisheries Management* 32:450-465.

Martinez PJ, Bigelow PE, Deleray MA, Fredenberg WA, Hansen BS, Horner NJ, Lehr SK, Schneidervin RW, Tolentino SA, Viola AE. 2009. Western lake trout woes. *Fisheries* 34:424-442.

Maser C, Tarrant RF, Trappe JM, Franklin JF (eds). 1988. From the forest to the sea: a story of fallen trees in General Technical Report, Pacific Northwest Experiment Station PNW-GTR-229. U.S. Department of Agriculture, Forest Service. Portland, Oregon.

MBTSG (Montana Bull Trout Scientific Group). 1995a. Upper Clark Fork River drainage bull trout status report (including Rock Creek). Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1995b. Bitterroot River drainage bull trout status report. Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1995c. Blackfoot River drainage bull trout status report. Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1995d. Flathead River drainage bull trout status report (including Flathead Lake, the North and Middle forks of the Flathead River and the Stillwater and Whitefish River). Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1995e. South Fork Flathead River drainage bull trout status report (upstream of Hungry Horse Dam). Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1996a. Swan River drainage bull trout status report (including Swan Lake). Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1996b. Lower Clark Fork River drainage bull trout status report (Cabinet Gorge Dam to Thompson Falls). Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1996c. Middle Clark Fork River drainage bull trout status report (from Thompson Falls to Milltown, including the lower Flathead River to Kerr Dam). Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1996d. Lower Kootenai River drainage bull trout status report (below Kootenai Falls). Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1996e. Middle Kootenai River drainage bull trout status report (between Kootenai Falls and Libby Dam). Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1996f. Upper Kootenai River drainage bull trout status report (including Lake Koocanusa, upstream of Libby Dam). Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

MBTSG (Montana Bull Trout Scientific Group). 1998. The relationship between land management activities and habitat requirements of bull trout. Prepared for Montana Bull Trout Restoration Team. Helena, Montana.

McCaffery M, Switalski TA, Eby L. 2007. Effects of Road Decommissioning on Stream Habitat Characteristics in the South Fork Flathead River, Montana. Transactions of the American Fisheries Society 136:553-561.

- McElhany P, Ruckelshaus MH, Ford MJ, Wainwright TC, Bjorkstedt EP. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-42. Seattle. 156 p.
- McGraw KA, Armstrong DA. 1990. Fish entrainment by dredges in Grays Harbor, Washington. Pages 113-131 in Simenstad, CA (ed). Effects of dredging on anadromous Pacific coast fishes. Washington Sea Grant. Seattle, Washington.
- McHenry M, Pess G, Abbe T, Coe H, Goldsmith J, Liermann M, McCoy R, Morley S, Peters R. 2007. The physical and biological effects of engineered logjams (ELJs) in the Elwha River, Washington. Salmon Recovery Funding Board and Interagency Committee for Outdoor Recreation. Report. April.
<http://www.fws.gov/wafwo/fisheries/Publications/Elwha%20ELJ%20Monitoring%20Final%20Report-final.pdf>.
- McIntosh BA, Sedell JR, Smith JE, Wissmar RC, Clarke SE, Reeves GH, Brown LA. 1994. Management history of eastside ecosystems: Changes in fish habitat over 50 Years, 1935 to 1992. General Technical Report PNW-GTR-321. USDA Forest Service, Pacific Northwest Research Station.
- McMichael GA, Fritts AL, Pearsons TN. 1998. Electrofishing injury to stream salmonids; injury assessment at the sample, reach, and stream scales. North American Journal of Fisheries Management 18:894-904.
- McPhail JD, Baxter JS. 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 No. 104. Vancouver, British Columbia, Canada.
- Meehan WR. 1991. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19.
- Meeuwig MH, Bayer JM, Seelye JG. 2005. Effects of temperature on survival and development of early life stage Pacific and western brook lampreys. Transactions of the American Fisheries Society 134: 19-27.
- Meeuwig MH, Guy CS, Kalinowski ST, Fredenberg WA. 2010. Landscape influences on genetic differentiation among bull trout populations in a stream-lake network. Mol Ecol 19: 3620–3633
- Meffe GK, Carroll CR. 1994. Principles of conservation biology. Sinauer Associates, Inc. Sunderland, Massachusetts.
- Merz JE, Chan OK. 2005. Effects of gravel augmentation on macroinvertebrate assemblages in a regulated California river. River Research Application 21:61-74.

- Metro. 2010. Urban Growth Report: 2009-2030, Employment and Residential. Metro. Portland, Oregon. January. <http://library.oregonmetro.gov/files/ugr.pdf>.
- Metro. 2011. Regional Framework Plan: 2011 Update. Metro. Portland, Oregon. http://library.oregonmetro.gov/files/rfp.00_cover.toc.intro_011311.pdf.
- Miller RR, Smith GR. 1981. Distribution and evolution of Chasmistes (Pisces: Catostomidae) in western North America. Occasional Papers of the Museum of Zoology, University of Michigan, Ann Arbor. Number 696. 46 pp.
- Minckley WL, Henrickson DA, Bond CE. 1986. Geography of western North American freshwater fishes: description and relationships to intracontinental tectonism. Pages 519-613 in Hocutt CH, Wiley EO (eds). The zoogeography of North American freshwater fishes. Wiley and Sons, New York.
- Moberg GP. 2000. Biological response to stress: Implications for animal welfare. Pages 1-21 in Moberg GP, Mench JA (eds). The biology of animal stress - basic principles and implications for animal welfare. CABI Publishing. Cambridge, Massachusetts.
- Mogen JT. 2013. Bull Trout Investigations in the St. Mary River Drainage, Montana 2010-2012 Summary Report. USFWS Northern Rockies Fish and Wildlife Conservation Office, Bozeman, Montana. 17 p.
- Mogen JT, Kaeding LR. 2005a. Identification and characterization of migratory and nonmigratory bull trout populations in the St. Mary River drainage, Montana. Transactions of the American Fisheries Society 134:841-852.
- Mogen JT, Kaeding LR. 2005b. Large-scale, seasonal movements of radiotagged, adult bull trout in the St. Mary River drainage, Montana and Alberta. Northwest Science 79(4):246-253.
- Morace JL. 2012. Reconnaissance of contaminants in selected wastewater-treatment-plant effluent and stormwater runoff entering the Columbia River, Columbia River Basin, Washington and Oregon, 2008–10. U.S. Geological Survey. Scientific Investigations Report 2012-5068. Reston, Virginia.
- Moore T. 2006. Distribution and abundance of bull trout and redband trout in Leonard and Deming Creeks, July and August, 2005. Oregon Department of Fish and Wildlife. Corvallis, Oregon.
- Moran DT, Rowley JC, Aiken GR, Jafek BW. 1992. Ultrastructural neurobiology of the olfactory mucosa of the brown trout, *Salmo trutta*. Microscopy Research and Technique 23:28-48.
- Morton JW. 1977. Ecological effects of dredging and dredge spoil disposal: a literature review. U.S. Fish and Wildlife Service Technical Paper No. 94. 33 p.

- Moser ML, Ogden DA, Cummings DL, Peery CA. 2006. Development and evaluation of a lamprey passage structure in the Bradford Island Auxiliary Water supply channel, Bonneville Dam, 2004. Prepared for the U.S. Army Corps of Engineers, Portland District. November 2006. 26 pp.
- Moursund RA, Mueller RP, Degerman TM, Dauble DD. 2001. Effects of Dam Passage on Juvenile Pacific Lamprey (*Lampetra tridentata*). Prepared by Battelle, Pacific Northwest Division, Richland, Washington for the U.S. Army Corps of Engineers, Portland, Oregon. January 2001. ~30 pp + appendices.
- Moyle PB, Israel JA. 2005. Untested assumptions: Effectiveness of screening diversions for conservation of fish populations. *Fisheries* 30(5):20-29.
- Mueller G. 1980. Effects of recreational river traffic on nest defense by longear sunfish. *Transactions of the American Fisheries Society* 109: 248-251.
- Murphy BR, Willis DW (eds). 1996. *Fisheries techniques*, 2nd edition. Bethesda, Maryland. 732 p.
- Murphy ML, Meehan WR. 1991. Stream ecosystems. Pages 17-46 in Meehan WR (ed). *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats*. American Fisheries Society. Bethesda, Maryland.
- Murphy ML. 1995. Forestry impacts on freshwater habitat of anadromous salmonids in the Pacific Northwest and Alaska -- requirements for protection and restoration. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Coastal Ocean Office. October. <http://www.cop.noaa.gov/pubs/das/das7.pdf>.
- Myrick CA, Barrow FT, Dunham JB, Gamett BL, Haas G, Peterson JT, Rieman B, Weber LA, Zale AV. 2002. Bull trout temperature thresholds. Peer review summary prepared for U.S. Fish and Wildlife Service.
- National Cooperative Highway Research Program. 2006. Evaluation of Best Management Practices for Highway Runoff Control. Transportation Research Board. NCHRP Report 565. Washington, D.C. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_565.pdf.
- Naughton GP, Bennett DH, Newman KB. 2004. Predation on juvenile salmonids by smallmouth bass in the Lower Granite Reservoir system, Snake River. *North American Journal of Fisheries Management*. 24:534-5444.
- Nehlsen W, Williams J, Lichatowich J. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. *Fisheries* 16(02):4-21.
- Newcombe CP, Jensen JO. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. *North American Journal of Fisheries Management* 16:693-727.

Newton JA, Pribyl S. 1994. Bull trout population summary: Lower Deschutes River subbasin. Oregon Department of Fish and Wildlife, The Dalles, Oregon. Oregon administrative rules, proposed amendments to OAR 340-41-685 and OAR 340-41-026. January 11, 1996.

NMFS (National Marine Fisheries Service). 1993. Biological Opinion for Columbia and Willamette Rivers Annual Operations and Maintenance Dredging. National Marine Fisheries Service, Portland, Oregon. December 22, 2013. (Refer to NMFS No: NWR-1993-178).

NMFS (National Marine Fisheries Service). 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. National Marine Fisheries Service. Portland, Oregon and Santa Rosa, California.
http://swr.nmfs.noaa.gov/sr/Electrofishing_Guidelines.pdf.

NMFS (National Marine Fisheries Service). 2008. Reinitiation of the Endangered Species Act Section 7 Formal Programmatic Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Fish Habitat Restoration Activities in Oregon and Washington, CY2007-CY2012 (June 27, 2008) (Refer to NMFS Nos.: FS: 2008/03505, BLM: 2008/03506, BIA: 2008/03507).

NMFS (National Marine Fisheries Service). 2010. Endangered Species Act Programmatic Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Conservation Recommendations for Vegetation treatments Using Herbicides on Bureau of Land Management (BLM) Lands Across Nine BLM Districts in Oregon (September 1, 2010) (Refer to NMFS No: 2009/05539).

NMFS (National Marine Fisheries Service). 2011a. Anadromous salmonid passage facility design. NMFS, Northwest Region, Portland, Oregon.
http://www.habitat.noaa.gov/pdf/salmon_passage_facility_design.pdf.

NMFS (National Marine Fisheries Service). 2011b. Endangered Species Act Section 7 Consultation biological opinion on the Environmental Protection Agency registration of pesticides 2,4-D, triclopyr BEE, diuron, linuron, captan, and chlorothalonil. Endangered Species Division of the Office of Protected Resources, National Marine Fisheries Service. Silver Spring, Maryland. <http://www.epa.gov/espp/litstatus/final-4th-biop.pdf>.

NMFS (National Marine Fisheries Service). 2011c. Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Reinitiation of the Payette National Forest Noxious Weed Management Program; Hells Canyon (17060101), Little Salmon River (17060210), Lower Salmon (17060209), South Fork Salmon (17060208), Middle Salmon-Chamberlain (17060207), Lower Middle Fork Salmon (17060206), and Upper Middle Fork Salmon (17060205) Subbasins; Idaho, Valley, Adams, and Custer Counties, Idaho (October 12, 2011) (Refer to NMFS No: 2011/03919). https://pcts.nmfs.noaa.gov/pls/pcts-pub/sxn7.pcts_upload.download?p_file=F8361/201103919_weeds_reinitiation_10-12-2011.pdf.

NMFS (National Marine Fisheries Service). 2012. Endangered Species Act Section 7 Formal Programmatic Opinion, Letter of Concurrence, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Revisions to Standard Local Operating Procedures for Endangered Species to Administer Actions Authorized or Carried Out by the U.S. Army Corps of Engineers in Oregon (SLOPES IV In-water Over-water Structures) (April 5, 2012) (Refer to NMFS No: 2011/05585).

NMFS (National Marine Fisheries Service). 2013a. Endangered Species Act Section 7 Formal Programmatic Opinion, Letter of Concurrence, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Revisions to Standard Local Operating Procedures for Endangered Species to Administer Stream Restoration and Fish Passage Improvement Actions Authorized or Carried Out by the U.S. Army Corps of Engineers in Oregon (SLOPES V Restoration). (March 19, 2013) (Refer to NMFS No: NWR-2013-9717).

NMFS (National Marine Fisheries Service). 2013b. Reinitiation of the Endangered Species Act Section 7 Formal Programmatic Conference and Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Aquatic Restoration Activities in the States of Oregon and Washington (ARBO II). Portland, OR.

NMFS (National Marine Fisheries Service). 2014. Reinitiation of the Endangered Species Act Section 7 Programmatic Conference and Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Revisions to Standard Local Operating Procedures for Endangered Species to Administer Maintenance or Improvement of Stormwater, Transportation or Utility Actions Authorized or Carried Out by the U.S. Army Corps of Engineers in Oregon (SLOPES for Stormwater, Transportation or Utilities) (March 14, 2014) (Refer to NMFS No: 2013-10411).

NOAA (National Ocean and Atmospheric Administration). 2003. Environmental and aesthetic impacts of small docks and piers – Workshop report: Developing a science-based decision support tool for small dock management, Phase 1: Status of the science. Kelty R, Bliven S (eds). NOAA Coastal Ocean Program Decision Analysis Series No.22.
<http://www.cop.noaa.gov/pubs/das.html>

NRC (Natural Resource Council). 2009. Urban Stormwater Management in the United States. National Academy Press, Washington, D.C. DOI: <https://doi.org/10.17226/12465>

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.

ODOT (Oregon Department of Transportation). 2009. Routine road maintenance: Water quality and habitat guide, best management practices. Oregon Department of Transportation. Salem, Oregon. http://www.oregon.gov/ODOT/HWY/OOM/docs/blue_book.pdf?ga=t.

- ODOT (Oregon Department of Transportation). 2011. ODOT Hydraulics Manual (2011 Version). Oregon Department of Transportation. ftp://ftp.odot.state.or.us/techserv/geo-environmental/Hydraulics/Hydraulics%20Manual/Table_of_Contents_rev_Nav.pdf.
- ODFW (Oregon Department of Fish and Wildlife). 2008. Oregon guidelines for timing of in-water work to protect fish and wildlife resources. Oregon Department of Fish and Wildlife. http://www.dfw.state.or.us/lands/inwater/Oregon_Guidelines_for_Timing_of_%20InWater_work2008.pdf.
- ODFW (Oregon Department of Fish and Wildlife). 2012. Klamath watershed fish district stock status report, September 2012. ODFW, Klamath Falls, Oregon.
- OOEA (Oregon Office of Economic Analysis). 2011. Oregon economic and revenue forecast. Appendix C: Population forecast by age and sex. <http://www.oregon.gov/DAS/OEA/docs/economic/appendixc.pdf>.
- Pacific Lamprey Technical Workgroup. 2017. Practical guidelines for incorporating adult Pacific lamprey passage at fishways. White Paper. 42 pp. + Appendix. Available online: <https://www.fws.gov/pacificlamprey/mainpage.cfm>
- Pico Y, Blasco C, Font G. 2004. Environmental and food applications of LC-tandem mass spectrometry in pesticide-residue analysis: An overview. *Mass Spectrometry Reviews* 23:45-85.
- Poe TP, Hansel HC, Vigg S, Palmer DE, Prendergast LA. 1991. Feeding of Predaceous Fishes on Out-Migrating Juvenile Salmonids in John Day Reservoir, Columbia River. *Transactions of the American Fisheries Society* 120:405-420.
- Poff NL, Hart DD. 2002. How dams vary and why it matters for the emerging science of dam removal. *BioScience* 52:659-668.
- Porter M, Nelitz M. 2009. A future outlook on the effects of climate change on bull trout (*Salvelinus confluentus*) habitats in the Cariboo-Chilcotin. Prepared by ESSA Technologies Ltd. for Fraser Salmon and Watersheds Program, B.C. Ministry of Environment, and Pacific Fisheries Resource Conservation Council.
- Portz DE. 2007. Fish-holding-associated stress in Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*) at South Delta fish salvage operations: Effects on plasma constituents, swimming performance, and predator avoidance. PHD Dissertation. University of California, Davis.
- Poston T. 2001. Treated wood issues associated with overwater structures in marine and freshwater environments. Olympia, Washington. Report. E. Washington Departments of Fish and Wildlife, and Transportation. April. <http://wdfw.wa.gov/publications/00053/wdfw00053.pdf>.
- Pratt, K. L. 1985. Pend Oreille trout and char life history study. Boise, ID: Idaho Department of Fish and Game. 105 p.

Pratt KL. 1992. A review of Bull trout life history. Pages 5-9 in Howell PJ, Buchanan DV (eds). Proceedings of the Gearhart Mountain Bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Pratt KL, Huston JE. 1993. Status of bull trout (*Salvelinus confluentus*) in Lake Pend Oreille and the lower Clark Fork River. Draft report. Prepared for the Washington Water Power Company, Spokane, Washington.

Quigley TM, Arbelbide SJ (eds). 1997. An assessment of ecosystem components in the Interior Columbia Basin and portions of the Klamath and Great Basins: volume III. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 4 vol.

Quinn TP. 2005. The behavior and ecology of Pacific salmon and trout. University of Washington Press, Seattle.

Ratliff DE, Howell PJ. 1992. The status of bull trout populations in Oregon. Pages 10-17 in Howell PJ, Buchanan DV (eds). Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis.

Redenbach Z, Taylor EB. 2002. Evidence for historical introgression along a contact zone between two species of char (Pisces: Salmonidae) in northwestern North America. *Evolution*, 56: 1021–1035. doi:10.1111/j.0014-3820.2002.tb01413.x

Reyff JA. 2003. Underwater sound levels associated with seismic retrofit construction of the Richmond-San Rafael Bridge. Document in support of Biological Assessment for the Richmond-San Rafael Bridge Seismic Safety Project. January, 31, 2003. 18 p.

Reyff JA, Donovan P. 2003. Benicia-Martinez Bridge Bubble Curtain Test - Underwater Sound Measurement Data. Memo to Caltrans dated January 31, 2003. 3 p.

Rich Jr. CF. 1996. Influence of abiotic and biotic factors on occurrence of resident bull trout in fragmented habitats, western Montana. M.S. Thesis, Montana State University, Bozeman, Montana.

Richardson EV, Davis SR. 2001. Evaluating Scour at Bridges, Fourth Edition. U.S. Department of Transportation, Federal Highway Administration, National Highway Institute. Publication No. FHWA NHI 01-001, Hydraulic Engineering Circular No. 18. Arlington, Virginia. May. <http://isddc.dot.gov/OLPFiles/FHWA/010590.pdf>.

Rieman BE, McIntyre JD. 1993. Demographic and habitat requirements for conservation of bull trout. U.S. Forest Service, Intermountain Research Station. General Technical Report INT-302.

Rieman BE, McIntyre JD. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. *Transactions of the American Fisheries Society* 124:285-296.

- Rieman BE, McIntyre JD. 1996. Spatial and temporal variability in bull trout redd counts. *North American Journal of Fisheries Management* 16:132-141.
- Rieman BE, Clayton J. 1997. Wildfire and native fish: Issues of forest health and conservation of sensitive species. *Fisheries* 22:6-14.
- Rieman BE, Lee DC, Thurow RF. 1997. Distribution, status and likely future trends of Bull trout within the Columbia River and Klamath River basins. *North American Journal of Fisheries Management* 17:1111-1125.
- Rieman BE, Dunham JB. 2000. Metapopulations and salmonids: a synthesis of life history patterns and empirical observations. *Ecology of Freshwater Fish* 9:51-64.
- Rieman BE, Allendorf FW. 2001. Effective population size and genetic conservation criteria for bull trout. *North American Journal of Fisheries Management* 21:756-764. American Fisheries Society, Bethesda, Maryland.
- Rieman BE, Isaak D, Adams S, Horan D, Nagel D, Luce C, Myers D. 2007. Anticipated Climate Warming Effects on Bull Trout Habitats and Populations Across the Interior Columbia River Basin. *Transactions of the American Fisheries Society*. 136:1552-1565.
- Rinella FA, Janet ML. 1998. Seasonal and spatial variability of nutrients and pesticides in streams of the Willamette Basin, Oregon, 1993–95. U.S. Geological Survey Water-Resources Investigations Report 97-4082-C:57 p.
- Ritter MA, Kainz JA, Porter GJ. 1996a. Field performance of timber bridges: 5. Little Salmon Creek stress-laminated deck bridge. U. S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin. Research Paper FPL-RP-547. 15 p.
<http://216.48.37.142/pubs/viewpub.jsp?index=5876>
- Ritter MA, Lee PD, Porter GJ. 1996b. Field performance of timber bridges: 6. Hoffman Run stress-laminated deck bridge. U. S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin. Research Paper FPL-RP-549. 16 p.
<http://216.48.37.142/pubs/viewpub.jsp?index=5877>
- Rogers PH, Cox M. 1988. Underwater sound as a biological stimulus. p. 131-149 in Atema J, Fay RR, Popper AN, Tavolga WN (eds). *Sensory biology of aquatic animals*. Springer-Verlag, New York.
- Rode M. 1990. Bull trout, *Salvelinus confluentus suckley*, in the McCloud River: status and recovery recommendations. Administrative Report Number 90-15. California Department of Fish and Game, Sacramento, California.
- Roni P, Quinn TP. 2001a. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. *Canadian Journal of Fisheries and Aquatic Science* 58:282-292.

Roni P, Quinn TP. 2001b. Effect of wood placement on movements of trout and juvenile coho salmon in natural and artificial stream channels. *Transactions of the American Fisheries Society* 130(4):675-685.

Roni P, Beechie TJ, Bilby RE, Leonetti FE, Pollock MM, Pess GR. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. *North American Journal of Fisheries Management* 22:1-20.

Roni P, Bennett T, Morely S, Pess GR, Hasnon K, Van Slyke D, Olmstead P. 2006. Rehabilitation of bedrock stream channels: The effects of boulder weir placement on aquatic habitat and biota. *River Research and Applications* 22:967-980.

Roper BB, Dose JJ, Williams JE. 1997. Stream restoration: Is fisheries biology enough? *Fisheries* 22(5):6-11.

Rosetta T. 2005. Technical basis for revising turbidity criteria (draft). Oregon Department of Environmental Quality, Water Quality Division. Portland, Oregon. October.

Rosgen DL. 1994. A classification of natural rivers. *Catena* 22:169-199.

Sand O, Enger PS, Karlsen HE, Knudsen F, Kvernstuen T. 2000. Avoidance responses to infrasound in downstream migrating European silver eels, *Anguilla anguilla*. *Environmental Biology of Fishes*, 57:327-336.

Sandahl JF, Baldwin DH, Jenkins JJ, Scholz NL. 2007. A sensory system at the interface between urban stormwater runoff and salmon survival. *Environmental Science & Technology* 41(8):2998-3004.

Saunders DA, Hobbs RJ, Margules CR. 1991. Biological consequences of ecosystem fragmentation: A review. *Conservation Biology* 5:18-32

Sargeant D, Newell E, Anderson P, Cook A. 2013. Surface Water Monitoring Program for Pesticides in Salmon-Bearing Streams, 2009-2011 Triennial Report, A Cooperative Study by the Washington State Departments of Ecology and Agriculture. Washington State Departments of Ecology and Agriculture. Olympia, Washington. February.

Scheuerell MD, Williams JG. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). *Fisheries Oceanography* 14:448-457.

Schill DJ. 1992. River and stream investigations. Job Performance Report, Project F-73-R-13. Idaho Department of Fish and Game, Boise, Idaho

Sedell JR, Everest FH. 1991. Historic changes in pool habitat for Columbia River Basin salmon under study for TES listing. Draft U.S. Department of Agriculture Report, Pacific Northwest Research Station, Corvallis, Oregon.

SERA (Syracuse Environmental Research Associates, Inc.). 1997. Use and assessment of marker dyes used with herbicides. Submitted to: Animal and Plant Health Inspection Service, U.S. Department of Agriculture. TR 96-21-07-03b. Syracuse Environmental Research Associates, Inc. Riverdale, Maryland.

SERA (Syracuse Environmental Research Associates, Inc.). 2001. Sethoxydim [Poast] - Human Health and Ecological Risk Assessment - Final Report. USDA, Forest Service, Forest Health Protection. SERA TR-01-43-01-01c. Riverdale, Maryland.
http://www.fs.fed.us/foresthealth/pesticide/pdfs/100202_sethoxydim_ra.PDF.

SERA (Syracuse Environmental Research Associates, Inc.). 2004a. Imazapic - Human Health and Ecological Risk Assessment – Final Report. USDA, Forest Service Forest Health Protection. SERA TR 04-43-17-04b. Arlington, Virginia.
http://www.fs.fed.us/foresthealth/pesticide/pdfs/122304_Imazapic.pdf.

SERA (Syracuse Environmental Research Associates, Inc.). 2004b. Chlorsulfuron - Human Health and Ecological Risk Assessment - Final Report. USDA, Forest Service Forest Health Protection. SERA TR 04-43-18-01c. Arlington, Virginia.
http://www.fs.fed.us/foresthealth/pesticide/pdfs/112104_chlorsulf.pdf.

SERA (Syracuse Environmental Research Associates, Inc.). 2004c. Dicamba - human health and ecological risk assessment – Final report. Submitted to: Forest Health Protection, USDA Forest Service. Arlington, Virginia.

SERA (Syracuse Environmental Research Associates, Inc.). 2004d. Sulfometuron Methyl - Human Health and Ecological Risk Assessment - Final Report. USDA, Forest Service, Forest Health Protection. SERA TR-03-43-17-02c. Arlington, Virginia.

SERA (Syracuse Environmental Research Associates, Inc.). 2007. Aminopyralid human health and ecological risk assessment – final report. Submitted to: USDA-Forest Service, Southern Region. Atlanta, Georgia. .
http://www.fs.fed.us/foresthealth/pesticide/pdfs/062807_Aminopyralid.pdf.

SERA (Syracuse Environmental Research Associates, Inc.). 2011a. Triclopyr - Human Health and Ecological Risk Assessment - Final Report. USDA, Forest Service, Forest Health Protection. SERA TR-052-25-03a. Atlanta, Georgia. <http://www.fs.fed.us/foresthealth/pesticide/pdfs/052-25-03aTriclopyr.pdf>.

SERA (Syracuse Environmental Research Associates, Inc.). 2011b. Glyphosate - Human Health and Ecological Risk Assessment - Final Report. USDA, Forest Service, Forest Health Protection. SERA TR-052-22-03b. Atlanta, Georgia.
http://www.fs.fed.us/foresthealth/pesticide/pdfs/Glyphosate_SERA_TR-052-22-03b.pdf.

SERA (Syracuse Environmental Research Associates, Inc.). 2011c. Imazapyr Human Health and Ecological Risk Assessment – final report. Submitted to: USDA-Forest Service, Southern Region. Syracuse Environmental Research Associates, Inc. Report. S.R. USDA/Forest Service. December. http://www.fs.fed.us/foresthealth/pesticide/pdfs/Imazapyr_TR-052-29-03a.pdf.

SERA (Syracuse Environmental Research Associates, Inc.). 2011d. Picloram - human health and ecological risk assessment – final report. Submitted to: USDA-Forest Service, Southern Region. Atlanta, Georgia. . http://www.fs.fed.us/foresthealth/pesticide/pdfs/Picloram_SERA_TR-052-27-03a.pdf.

Servizi JA. 1988. Sublethal effects of dredged sediments on juvenile salmon. Pages 57-63 *in* Simenstad CA (ed). Effects of dredging on anadromous Pacific coast fishes. Washington Sea Grant Program. Washington State University. Seattle, Washington.

Servizi JA, Martens DW. 1991. Effects of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon. Canadian Journal of Fisheries and Aquatic Sciences 49:1389-1395.

Sexauer HM, James PW. 1997. Microhabitat use by juvenile trout in four streams located in the eastern Cascades, Washington. Pages 361-370 *in* Mackay WC, Brewin MK, Monita M (eds). Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

Shively D, Allen C, Alsbury T, Bergamini B, Goehring B, Horning T, Strobel B. 2007. Clackamas River Bull Trout Reintroduction Feasibility Assessment: Sandy, Oregon, Mount Hood National Forest.

Shuter BJ, Meisner JD. 1992 Tools for assessing the impact of climate change on freshwater fish populations. GeoJournal 28:7-20.

Shreck CB. 2000. Accumulation and long-term effects of stress in fish. Pages 147-158 *in* Moberg GP, Mench JA (eds). The biology of animal stress - basic principles and implications for animal welfare. CABI Publishing. Cambridge, Massachusetts.

Sigler JW, Bjornn TC, Everest FH. 1984. Effects of Chronic Turbidity on Density and Growth of Steelheads and Coho Salmon. Transactions of the American Fisheries Society 113:142-150.

Sigler JW. 1988. Effects of chronic turbidity on anadromous salmonids: recent studies and assessment techniques perspective. Pages 26-37 *in* Simenstad CA (ed). Effects of Dredging on Anadromous Pacific Coast Fishes. Washington Sea Grant Program, Washington State University. Seattle.

Simenstad CA, Thom RM. 1996. Assessing functional equivalency of habitat and food web support in a restored Gog-Le-Hi-Te estuarine wetland. Ecological Applications 6:38-56.

- Simpson J, Wallace R. 1982. Fishes of Idaho. Moscow: The University Press of Idaho.
- Smillie GM, Ellerbroek D. 1991. Flood hazard evaluation for Divide and Wild creeks, Glacier National Park. Technical Report NPS/NRWRD/NRTR-91/02. Water Resources Division, National Park Service, Fort Collins, Colorado.
- Smoker WW, Wang IA, Gharrett AJ, Hard JJ. 2004. Embryo survival and smolt to adult survival in second-generation outbred coho salmon. *Journal of Fish Biology* 65 (Supplement A):254-262.
- Snyder DE. 2003. Electrofishing and its harmful effects on fish. Information and Technology Report USGS/BRD/ITR-2003-0002. U.S. Government Printing Office. Denver, Colorado. 149 p. <http://www.fort.usgs.gov/Products/Publications/21226/21226.pdf>.
- Spence BC, Lomnický GA, Hughes RM, Novitzki RP. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services, Inc. Corvallis, Oregon. Report. National Marine Fisheries Service, Portland, Oregon.
- Sprague JB, Drury DE. 1969. Avoidance reactions of salmonid fish to representative pollutants. Pages 169-179 in Jenkins SH (ed). *Advances in Water Pollution Research*. Proceedings of the Fourth International Conference, Prague. Pergamon Press, New York.
- Spromberg JA, Meador JP. 2006. Relating chronic toxicity responses to population-level effects: A comparison of population-level parameters for three salmon species as a function of low-level toxicity. *Ecological Modeling* 199:240-252.
- Spruell P, Rieman BE, Knudsen KL, Utter FM, Allendorf FW. 1999. Genetic population structure within streams: microsatellite analysis of Bull trout populations. *Ecology of Freshwater Fish* 8:114-121.
- Spruell P, Hemmingsen AR, Howell PJ, Kanda N, Allendorf FW. 2003. Conservation genetics of bull trout: Geographic distribution of variation at microsatellite loci. *Conservation Genetics* 4:17-29.
- Stehr CM, Brown DW, Hom T, Anulacion BF, Reichert WL, Collier TK. 2000. Exposure of juvenile Chinook and chum salmon to chemical contaminants in the Hylebos Waterway of Commencement Bay, Tacoma, Washington. *Journal of Aquatic Ecosystem Stress and Recovery* 7:215-227.
- Stehr CM, Linbo TL, Baldwin DH, Scholz NL, Incardona JP. 2009. Evaluating the effects of forestry herbicides on fish development using rapid phenotypic screens. *North American Journal of Fisheries Management* 29(4):975-984.
- Stenstrom MK, Kayhanian M. 2005. First flush phenomenon characterization. California Department of Transportation, Division of Environmental Analysis. CTSW-RT-05-73-02.6. Sacramento, California. August. http://149.136.20.66/hq/env/stormwater/pdf/CTSW-RT-05-073-02-6_First_Flush_Final_9-30-05.pdf.

Stewart DB, Mochnacz NJ, Sawatzky CD, Carmichael TJ, Reist JD. 2007. Fish life history and habitat use in the Northwest Territories: Bull trout (*Salvelinus confluentus*). Canadian Manuscript Report of Fisheries and Aquatic Sciences 2801. Department of Fisheries and Oceans, Winnipeg, MB, Canada, 2007, 54 pp.

Stickney RR. 1973. Effects of hydraulic dredging on estuarine animal studies. World Dredging Marine Construction, 34-37.

Stilwell DE, Musante CL. 2004. Effect of coatings on CCA leaching from treated wood in a soil environment. Pages 113 - 123 in Pre-Conference Proceedings, Environmental Impacts of Preservative-Treated Wood. Florida Center for Solid and Hazardous Waste Management, Gainesville, Florida. <http://www.ccaresearch.org/Pre-Conference/#release>

Stotz T, Colby J. 2001. January 2001 dive report for Mukilteo wingwall replacement project. Washington State Ferries Memorandum. 5 p. plus appendices.

Streif B. 2009. Considering Pacific Lamprey When Implementing Instream Activities. In Biology, Management, and Conservation of Lampreys in North America. Brown L, Chase S, Mesa M, Beamish R, Moyle P, eds. 321 pages. American Fisheries Society Symposium 73. Published by the American Fisheries Society. ISBN: 978-1-934874-13-4.

Stuber RJ, Gebhart G, Maughan OE. 1982. Habitat suitability index models: Largemouth bass. US Fish and Wildlife Service. FWS/OBS-82/10.16. 32 p.

Swanston DN. 1991. Natural processes. Pages 139-179 in Meehan WR (ed). Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society. Bethesda, Maryland.

Tabor RA, Shively RS, Poe TP. 1993. Predation on juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management. 13:831-838.

Tabor RA, Footen BA, Fresh KL, Celedonia MT, Mejia F, Lownad DL, Park L. 2007. Smallmouth bass and largemouth bass predation on juvenile Chinook salmon and other salmonids in the Lake Washington Basin. North American Journal of Fish Management. 27:1174-1188.

Taylor, B.E., S. Pollard, and D. Louie. 1999. Mitochondrial DNA variation in bull trout (*Salvelinus confluentus*) from northwestern North America: implications for zoogeography and conservation. Molecular Ecology 8:1155-1170.

Thomas G. 1992. Status of bull trout in Montana. Report prepared for Montana Department of Fish, Wildlife and Parks, Helena, Montana.

Trombulak SC, Frissell CA. 2000. Review of the ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 14(1):18-30.

Tutty BD. 1976. Assessment of techniques used to quantify salmon smolt entrainment by a hydraulic suction hopper dredge in the Fraser River estuary. Fisheries and Marine Service, Environment Canada. Technical Report, Series No. PAC/T-76-16.

USACE (U.S. Army Corps of Engineers) Northwest Division. 2009. Sediment Evaluation Framework for the Pacific Northwest. U.S. Corps of Engineers (Portland District, Seattle District, Walla Walla District and Northwest Division); U.S. Environmental Protection Agency, Region 10; Washington Department of Ecology, Washington Department of Natural Resources, Oregon Department of Environmental Quality, Idaho Department of Environmental Quality, National Marine Fisheries Service, U.S. Fish and Wildlife Service.

USDA (U.S. Department of Agriculture), USDI (U.S. Department of Interior). 1995a. Decision Notice/Decision Record for Interim Strategies for Managing Anadromous Fish-Producing Watersheds on Federal Lands in Eastern Oregon and Washington, Idaho and Portions of California (PACFISH).

USDA (U.S. Department of Agriculture), USDI (U.S. Department of Interior). 1995b. Decision of Notice and Finding of No Significant Impact for the Inland Native Fish Strategy: Interim Strategies for Managing Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana and Portions of Nevada (INFISH).

USEPA (U.S. Environmental Protection Agency). 1999. Diflufenzopyr, Pesticide Fact Sheet. U.S. Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances. Arlington, Virginia.

USEPA (U.S. Environmental Protection Agency). 2003. No effect determination for dicamba for Pacific anadromous salmonids. U.S. Environmental Protection Agency. Washington, D.C. March 27.

USEPA (U.S. Environmental Protection Agency). 2009. Risks of 2,4-D use to the Federally threatened California red-legged frog (*Rana aurora draytonii*) and Alameda whipsnake (*Masticophis lateralis euryxanthus*). Environmental Protection Agency, Environmental Fate and Effects Division, Office of Pesticide Programs. Washington, D.C.

USEPA (U.S. Environmental Protection Agency). 2011. Environmentally Acceptable Lubricants. United States Environmental Protection Agency, Office of Wastewater Management. Washington, DC 20460. Report no. 800-R-11-002.

USFS (U.S. Department of Agriculture Forest Service). 2006. 2,4-D human health and ecological risk assessment final report. Forest Health Protection, USDA-Forest Service. Arlington, Virginia.

USFS (U.S. Department of Agriculture Forest Service). 2008. Stream simulation: An ecological approach to providing passage for aquatic organisms at road crossings. Forest Service Stream-Simulation Working Group, National Technology and Development Program in partnership with U.S. Department of Transportation, Federal Highway Administration Coordinated Federal Lands Highway Technology Implementation Program.

USFS (U.S. Department of Agriculture Forest Service) Pacific Northwest Region, BLM (U.S. Department of Interior Bureau of Land Management Oregon State Office, BIA (U.S. Department of Interior Bureau of Indian Affairs). 2013. Biological Assessment for fish habitat restoration activities affecting ESA-Listed animal and plant species and their designated or proposed critical habitat and designated essential fish habitat under MSA found in Oregon, Washington and parts of California, Idaho and Nevada. January 28.

USFWS (U.S. Fish and Wildlife Service). 1998a Bull Trout Facts. Portland, OR

USFWS (U.S. Fish and Wildlife Service). 1998b. Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Klamath River and Columbia River District Population Segments of Bull Trout. Federal Register 63: 31647-31674.

USFWS (U.S. Fish and Wildlife Service). 1999a (Revised). A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation Watershed Scale (Matrix of Pathways and Indicators). Portland, OR. 52pp.

USFWS (U.S. Fish and Wildlife Service). 1999b. Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Conterminous United States. Federal Register 64: 58910-58933.

USFWS (U.S. Fish and Wildlife Service). 2002a. Bull trout (*Salvelinus confluentus*) draft recovery plan - Chapter 1: Introduction. U.S. Fish and Wildlife Service, Portland, Oregon, October, 2002, 137 pp.

USFWS (U.S. Fish and Wildlife Service). 2002b. Bull trout (*Salvelinus confluentus*) draft recovery plan - chapter 2 Klamath River. U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2004a. Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout (*Salvelinus confluentus*). U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2004b. Draft Recovery Plan for the Jarbidge Distinct Population Segment of Bull Trout (*Salvelinus confluentus*). U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2008a. Bull Trout: Five Year Review Summary and Evaluation. USDI Fish and Wildlife Service, Portland, Oregon. 55 pages.

USFWS (U.S. Fish and Wildlife Service). 2008b. Bull trout draft core area templates - complete core area by core area analysis. W. Fredenberg and J. Chan, *editors*. U. S. Fish and Wildlife Service. Portland, Oregon. 1,895 pages.

USFWS (U.S. Fish and Wildlife Service). 2010a. Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for Bull Trout in the Coterminus United States. Federal Register 75: 63898-64070.

USFWS (U.S. Fish and Wildlife Service). 2010b. Best management practices to minimize adverse effect to Pacific Lamprey.
http://www.fws.gov/columbiariver/publications/BMP_Lamprey_2010.pdf

USFWS (U.S. Fish and Wildlife Service). 2013. Programmatic Biological Opinion for Aquatic Restoration Activities in the States of Oregon, Washington and portions of California, Idaho and Nevada (ARBO II). 472 pages. Portland, Oregon. FWS reference: 01EOFW00-2013-F-0090.

USFWS (U.S. Fish and Wildlife Service). 2015. Recovery plan for the coterminous United States population of bull trout (*Salvelinus confluentus*). Portland, Oregon. xii + 179 pages.

USFWS (U.S. Fish and Wildlife Service). 2015a. Coastal Recovery Unit Implementation Plan for Bull Trout. Portland, Oregon. September 2015. 155 pages.

USFWS (U.S. Fish and Wildlife Service). 2015b. Klamath Recovery Unit Implementation Plan for Bull Trout. Portland, Oregon. September 2015. 35 pages.

USFWS (U.S. Fish and Wildlife Service). 2015c. Mid-Columbia Recovery Unit Implementation Plan for Bull Trout. Portland, Oregon. September 2015. 345 pages.

USFWS (U.S. Fish and Wildlife Service). 2015d. Columbia Headwaters Recovery Unit Implementation Plan for Bull Trout. Portland, Oregon. September 2015. 179 pages.

USFWS (U.S. Fish and Wildlife Service). 2015e. Upper Snake Recovery Unit Implementation Plan for Bull Trout. Portland, Oregon. September 2015. 113 pages.

USFWS (U.S. Fish and Wildlife Service). 2015f. St. Mary Recovery Unit Implementation Plan for Bull Trout. Portland, Oregon. September 2015. 30 pages.

USFWS (U.S. Fish and Wildlife Service), NMFS (and National Marine Fisheries Service). 1998. Endangered Species Consultation Handbook: Procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act.

USFWS (U.S. Fish and Wildlife Service), USFS (U. S. Forest Service). 2010. Best management practices to minimize adverse effects to Pacific lamprey (*Entosphenus tridentatus*). April 2010. 25 pp.

- Waldo J. 2003. Personal communication. Discussions between Wallowa-Whitman South Zone Fish Biologist Joel Waldo and Paul Bridges (USFWS) at the Powder River Bull Trout Recovery Group meeting in Baker City, OR, concerning harvest of bull trout by angling.
- Walters AW, Holzer DM, Faulkner JR, Warren CD, Murphy PD, McClure MM. 2012. Quantifying cumulative entrainment effects for Chinook salmon in a heavily irrigated watershed. *Transactions of the American Fisheries Society* 141(5):1180-1190.
- Warrington PD. 1999. Impacts of recreational boating on the aquatic environment. <http://www.nalms.org/bclss/impactsrecreationboat.htm>
- Watson G, Hillman TW. 1997. Factors affecting the distribution and abundance of bull trout: and investigation at hierarchical scales. *North American Journal of Fisheries Management* 17:237-252.
- Washington State Department of Ecology, Water Quality Program. 2004. Stormwater Management Manual for Eastern Washington. Publication Number 04-10-076. Olympia, WA. September. <https://fortress.wa.gov/ecy/publications/publications/0410076.pdf>.
- Washington State Department of Ecology, Water Quality Program. 2012. Stormwater Management Manual for Western Washington. Publication No. 12-10-030. August. <https://fortress.wa.gov/ecy/publications/publications/1210030.pdf>.
- WDFW (Washington Department of Fish and Wildlife). 1997. Grandy Creek trout hatchery biological assessment. FishPro Inc., and Beak Consultants.
- WDFW (Washington Department of Fish and Wildlife). 1998. Washington State Salmonid Stock Inventory: Bull Trout/Dolly Varden. Washington Department of Fish and Wildlife, Fish Management. 437 pp.
- Weis JS, Weis P, Proctor T. 1998. The extent of benthic impacts of CCA-treated wood structures in Atlantic Coast estuaries. *Archives of Environmental Contamination and Toxicology* 34:313-322.
- Weis JS, Weis P. 2004. Effects of CCA wood on non-target aquatic biota. Pages 32-44 in Pre-Conference Proceedings, Environmental Impacts of Preservative-Treated Wood. Florida Center for Solid and Hazardous Waste Management, Gainesville, Florida. <http://www.ccaresearch.org/Pre-Conference/#release>
- WSDT (Washington State Department of Transportation). 2010. Biological Assessment Preparation for Transportation Projects - Advanced Training Manual - Version 02-2011, Part 2 - Guidance on Specific BA Topics. Washington State Department of Transportation. Olympia, Washington.
- WDOE (Washington Department of Ecology). 2002. Evaluating criteria for the protection of freshwater aquatic life in Washington's surface water quality standards - dissolved oxygen: Draft

discussion paper and literature summary. Publication Number 00-10-071. Washington Department of Ecology, Olympia, WA, 90 pp.

Wentz DA, Bonn BA, Carpenter KD, Hinkle SR, Janet ML, Rinella FA, Uhrich MA, Waite IR, Laenen A, Bencala KE. 1998. Water Quality in the Willamette Basin, Oregon, 1991-95: U.S. Geological Survey Circular 1161 (updated June 25, 1998) <http://water.usgs.gov/pubs/circ1161>

Whiteley A, Spruell P, Allendorf FW. 2003. Population genetics of Boise Basin bull trout (*Salvelinus confluentus*). Final Report to Bruce Rieman, Rocky Mountain Research Station. University of Montana Wild Trout and Salmon Genetics Lab, Missoula, Montana.

Whitesel TA, Brostrom J, Cummings T, Delavergne J, Fredenberg W, Schaller H, Wilson P, Zydlewski G. 2004. Bull trout recovery planning: A review of the science associated with population structure and size. Science Team Report #2004-01, U.S. Fish and Wildlife Service, Portland, Oregon. 41 p.

Whitman RP, Quinn TP, Brannon EL. 1982. Influence of suspended volcanic ash on homing behavior of adult Chinook salmon. Transactions of the American Fisheries Society 113:142-150.

Williams DD, Feltmate BW. 1992. Aquatic Insects. CAB International. Wallingford, UK.

Winberg S, Bjerselius R, Baatrup K, Doving K. 1992. The effect of Cu(II) on the electro-olfactogram (EOG) of the Atlantic salmon (*Salmo salar* L.) in artificial freshwater of varying inorganic carbon concentrations. Ecotoxicology and Environmental Safety 24:167-178.

Wood TM. 2001. Herbicide use in the management of roadside vegetation, western Oregon, 1999-2000: Effects on the water quality of nearby streams. U.S. Geological Survey. Water-Resources Investigations Report 01-4065. Portland, Oregon.
http://or.water.usgs.gov/pubs_dir/Pdf/01-4065.pdf.

Würsig B, Greene Jr CR, Jefferson TA. 2000. Development of an air bubble curtain to reduce underwater noise from percussive piling. Marine Environmental Research 49: 19-93.

WWPI (Western Wood Preservers Institute). 1996. Best management practices for the use of treated wood in the aquatic environment (revised July 1996), at <http://www.wwpinstitute.org/>

Zedler JB. 1996. Ecological issues in wetland mitigation: An introduction to the forum. Ecological Applications 6(1):33-37.

Ziller JS. 1992. Distribution and relative abundance of bull trout in the Sprague River subbasin, Oregon. Pages 18-29 in Howell PJ, Buchanan DV (eds). Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Zimmerman MP, Ward DL. 1999. Index of predation on juvenile salmonids by northern pikeminnow in the Lower Columbia Basin, 1994-1996. Transactions of the American Fisheries Society. 128:995-1007.

Zobott H, Caudill CC, Keefer ML, Budwig R, Frick K, Moser M, Corbett S. 2015. Design Guidelines for Pacific Lamprey Passage Structures. Technical Report 2015-5-DRAFT. Prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon. 47 pp.

APPENDIX A: PROGRAMMATIC NOTIFICATION FORMS

SLOPES BT PROGRAMMATIC ACTION NOTIFICATION FORM

Submit this completed action notification form with the following information to USFWS at slopes@fws.gov. The SLOPES Bull Trout Programmatic e-mail box is to be used for **Incoming Only**.

USFWS Review and Approval. Any action that involves: (a) modification or variance of the action; (b) fish passage restoration, culvert replacement or retrofit; (c) fishway intended to attract, collect, exclude, guide, transport, or release bull trout including, but not limited to, a culvert retrofit, a pool-riffle structure, or a roughened chute; (d) blasting; (e) water control structure or dam removal; (f) earthwork at an EPA-designated Superfund Site, a state-designated clean-up area, or in the likely impact zone of a significant contaminant source, as identified by historical information or the Corps' best professional judgment; or (g) use of preservative or pesticide treated wood, must be individually reviewed and approved by USFWS as consistent with this Opinion before that action is authorized. USFWS will notify the Corps within 45 calendar days if the action is approved or disqualified. For actions that require USFWS approval, attach engineering designs and the results of a site assessment for contaminants to identify the type, quantity, and extent of any potential contamination.

Attach a copy of the erosion and pollution control plan, if required.

DATE OF REQUEST:		USFWS Tracking #:	
TYPE OF REQUEST:	☐ ACTION NOTIFICATION (NO APPROVAL)		
	☐ ACTION NOTIFICATION (APPROVAL REQUIRED)		
Statutory Authority:	☐ ESA ONLY		
Lead Action Agency:	Corps of Engineers		
Action Agency Contact:		Individual Corps Permit #:	NWP-
Applicant:		Individual DSL Permit #:	
Action Title:			
6th Field HUC & Name:			
Latitude & Longitude (including degrees, minutes, and seconds)			
Proposed Project:	Start Date:		End Date:
<u>Action Description:</u>			

Type of Action *Check all that apply:*Restoration

- ☐ 1R Boulder Placement
☐ 2R Fish Passage Restoration
☐ 3R Large Wood Restoration
☐ 4R Off- and Side-channel habitat restoration
☐ 5R Pile Removal
☐ 6R Set-back Existing Berms, Dikes, and Levees
☐ 7R Spawning Gravel Restoration
☐ 8R Streambank Restoration
☐ 9R Water Control Structure Removal
☐ 10R Wetlands Restoration

Stormwater, Transportation, Utilities

- ☐ 1S Streambank and channel stabilization
☐ 2S Road surface, culvert and bridge maintenance, rehabilitation and replacement
☐ 3S Stormwater facilities and utility line stream crossings

In-water Over-water

- ☐ 1I Install or expand navigation aid, buoy, dolphin, dock, or ramp
☐ 2I Maintain, rehabilitate, replace, or remove an existing in-water or over-water structure
☐ 3I Dredging to maintain vessel access
☐ 4I Dredging to maintain functionality

Actions Requiring Approval from USFWS:

- | | |
|---|---|
| ☐ Modification or variance of the action | ☐ Fish passage restoration |
| ☐ Fishway | ☐ Blasting |
| ☐ Water control structure/Dam removal | ☐ Earthwork at EPA-designated Superfund Site |
| ☐ Preservative/Pesticide treated wood | |

USFWS Species/Critical Habitat Present in Action Area:

Identify if the species and/or critical habitat is found in the action area:

- ☐ Bull Trout
 ☐ Bull Trout Critical Habitat

Terms and Conditions:

Check the Terms and Conditions from the biological opinion and PDC that will be included as conditions on the permit issued for this proposed action. Please attach the appropriate plan(s) for this proposed action

Construction PDC

- ☐ 1G Project Design
☐ 2G Site contamination assessment
☐ 3G Site layout and flagging
☐ 4G Staging, storage, and stockpile areas
☐ 5G Erosion control
☐ 6G Hazardous material spill prevention
☐ 7G Equipment, vehicles, and power tools
☐ 8G Drilling and Boring
☐ 9G Temporary access roads and paths
☐ 10G Dust abatement
☐ 11G Temporary stream crossings
☐ 12G Barge Use
☐ 13G Surface water withdrawal and construction discharge water
☐ 14G Fish passage
☐ 15G Fish screens
☐ 16G In-water work timing
☐ 17G Pile installation

- ☐ 18G Work area isolation
☐ 19G Fish capture
☐ 20G Site restoration
☐ 21G Revegetation
☐ 22G Invasive and non-native plant control
☐ 23G Actions that require compensatory mitigation
☐ 24G Cessation of work

Restoration PDC

- ☐ 1R LW and Boulder placement
☐ 2R Fish passage restoration
☐ 3R Off- or side-channel habitat restoration
☐ 4R Set-back existing berm
☐ 5R Pile Removal
☐ 6R Gravel Augmentation
☐ 7R Streambank Restoration
☐ 8R Water Control Structures
☐ 9R Road and Trail Erosion

STU PDC

- ☐ 1S Streambank and channel
☐ 2S Road maintenance
☐ 3S Utility line stream crossings
☐ 4R Set-back existing berm
☐ 5R Pile Removal

IWOW PDC

- ☐ 1I Boat ramps
☐ 2I Educational signs
☐ 3I Floatation material
☐ 4I New or replacement floats
☐ 5I Piscivorous birds
☐ 6I Relocation of existing structures in marina
☐ 7I Dredging to maintain vessel access
☐ 8I Dredging to maintain functionality

SLOPES BT PROGRAMMATIC SALVAGE REPORTING FORM

Within 60 days of completing a capture and release as part of an action completed under the SLOPES Bull Trout programmatic opinion: the applicant or, for Corps civil works actions, the Corps, must submit a complete a Salvage Reporting Form, or its equivalent, with the following information to USFWS at slopes@fws.gov.

Corps Permit #:

Corps Contact:

Action Title

Date of Fish Salvage Operation:

Supervisory Fish Biologist (name, address & telephone number):

Include With This Form:

1. A description of methods used to isolate the work area, remove fish, minimize adverse effects on fish, and evaluate their effectiveness.
2. A description of the stream conditions before and following placement and removal of barriers.
3. A description of the number of fish handled, condition at release, number injured, and number killed by species.

SLOPES BT PROGRAMMATIC ACTION COMPLETION FORM

Within 60 days of completing all work below ordinary high water (OHW) as part of an action completed under the SLOPES Bull Trout programmatic opinion, submit the completed action completion form with the following information to USFWS at slopes@fws.gov.

Corps Permit #:

Corps Contact:

Action Title

Start and End Dates for the completion of in-water work:

Start:

End:

Any Dates work ceased due to high flows:

Include With This Form:

1. Photos of habitat conditions before, during, and after action completion
2. Evidence of compliance with fish screen criteria for any pump used
3. A summary of the results of pollution and erosion control inspections, including any erosion control failure, contaminant release, and correction effort
4. Number, type, and diameter of any pilings removed or broken during removal
5. A description of any riparian area cleared within 150 feet of OHW
6. Linear feet of bank alteration
7. A description of site restoration
8. A completed Salvage Reporting Form from Appendix D for any action that requires fish salvage
9. As-Built drawings for any action involving riprap revetment, stormwater management facility, or bridge rehabilitation or replacement

APPENDIX B: Electrofishing Recommendations for Sampling Larval Pacific Lampreys

Electrofishing Recommendations for Sampling Larval Pacific Lampreys
(from: Moser et al. 2007; and G. Silver and C. Luzier, USFWS, personal communication)

1. Most surveys rely on a backpack or shore-based electrofishers in small streams, most effective in waters less than 0.8 m in depth.
2. Generally three types of electrofishers are suitable for ammocoete sampling:
 - a. AbP-2 “Wisconsin” electrofisher (ETS Electrofishing, Verona, WI);
 - b. Smith-Root LR-24 model electrofisher with lamprey settings; and
 - c. conventional electrofisher traditionally used for salmonids.
3. Electrofishers used for ammocoete sampling should be set with two wave forms, a lower frequency “tickle” wave form to coax ammocoetes out of the substrate and a higher frequency “stun” wave form to immobilize ammocoetes for netting.
4. Effective sampling involves this 2-stage method:
 - a. First stage: use 125V direct current with a 25 percent duty cycle applied at a slow rate of 3 pulses per second, to induce ammocoetes to emerge from the sediment.
 - b. Use a pattern of 3 slow pulses followed by a skipped pulse (burst pulse) helps ammocoetes to emerge.
 - c. Second stage: immediately after ammocoetes emerge, use a fast pulse setting of 30 pulses per second to immobilize and net them.

	Burst Slow Pulse Primary Wave Form	Standard Fast Pulse Secondary Wave Form
Voltage	125 v	125 v
Pulse Frequency	3 Hz	30 Hz
Duty Cycle	25%	25%
Burst Pulse Train	3:1	X

5. A conventional electrofisher can be used but the 2-stage settings/method described above should be used. Conventional electrofishing gear set for salmonid capture uses higher voltage and frequencies which potentially causes electronarcosis of buried ammocoetes, resulting failure to emerge and therefore a recording of false absence. Additionally, a conventional electrofisher has only one switch making the transition from slow (tickle) to fast (stun) pulse pattern more difficult as the switch needs to be released and pressed again. This technique can be learned with practice
6. Avoid exposing ammocoetes to extended periods of electrofishing as it has also been linked to electronarcosis.
7. Use dip nets to capture ammocoetes where they are readily visible. Where not visible, seines may be effective.
8. Capture efficiencies may vary according to site characteristics, electrofishing gear used and electrofishing techniques.
9. Within each reach, electrofishing should be conducted in a downstream to upstream direction (for the purpose of reducing turbidity/maintaining visibility) with one person operating the electrofisher and at least one person netting ammocoetes. Each reach should be thoroughly and slowly sampled, with more effort directed at suitable lamprey rearing habitat and less effort in areas with hard substrates or high water velocity.
10. Using the 2-stage method described above, the electrofisher should mainly be operated in the lower frequency output mode to irritate ammocoetes out of the substrate. When necessary, the higher frequency mode should be activated for capturing emergent ammocoetes.
11. Multiple electrofishing passes should be made to ensure a more complete removal of ammocoetes. A fifteen minute break between passes should be taken to reduce the chance of electronarcosis.