Appendix B: Biological Opinion

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Fish and Wildlife Office
Central Washington Field Office
215 Melody Lane, Suite 103
Wenatchee, WA 98801-8122

March 11, 2013

In Reply Refer To:
USFWS Reference: 13260-2008-F-0070 – R001

Cross Reference: 13260-2007-B-0013

Hydrologic Unit Code: 17-03-00-01-01 (Upper Yakima River)

Daniel M. Mathis, P.E.
Division Administrator
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Olympia, Washington 98501-1284

Dear Mr. Mathis,

This correspondence transmits the U.S. Fish and Wildlife Service's (Service) biological opinion for the design modification of the I-90 Snoqualmie Pass East Project which will replace the formerly proposed large snowshed with avalanche bridges. This design modification was offered by the contractor under the Cost Reduction Incentive Proposal process which encourages innovations in planning and performing work on transportation projects in Washington. The proposed avalanche bridges will be constructed from milepost 57.9 to milepost 58.4 within the area of the larger I-90 Snoqualmie Pass East project, located in Kittitas County, Washington. The Washington State Department of Transportation (WSDOT), acting on behalf of the Federal Highway Administration (FHWA), requested reinitiation of formal consultation because the design modification causes effects to the bull trout (*Salvelinus confluentus*) and designated critical habitat for bull trout not considered in the Service's original biological opinion for the I-90 Project, and because recent revision of critical habitat for the northern spotted owl (*Strix occidentalis caurina*) has resulted in exposure of critical habitat to new adverse effects.

On November 26, 2012, the Service received your letter requesting reinitiation of consultation (dated November 15, 2012) and the final Biological Assessment (BA) for the Project. Your BA and supplementary material about the proposed design modification provided during Interdisciplinary Team meetings contained the information the Service needed to evaluate

Project effects. These materials and a complete record for this consultation are on file in our Central Washington Field Office.

The attached biological opinion describes the effects of the Project on the Columbia River interim recovery unit of the bull trout and its designated critical habitat, as well as effects to revised critical habitat for the northern spotted owl in accordance with Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). We expect effects to other listed species and designated critical habitat from the proposed design modification to be the same as those consulted upon in our original biological opinion (Service Reference 13260-2008-F-0070) and informal consultation (Service Reference 13260-2008-I-0119).

Our analysis of Project effects in the attached biological opinion leads us to conclude that implementation of the proposed Project will not jeopardize the continued existence of the bull trout, nor will it destroy or adversely modify designated critical habitat for the bull trout or the northern spotted owl. The incidental take statement accompanying our biological opinion provides the FHWA with an exemption from the Section 9 prohibitions described in the Endangered Species Act, as well as mandatory "reasonable and prudent measures" and "terms and conditions" that are designed to minimize incidental take.

Thank you for helping to conserve listed species. The collaborative planning process used by the FHWA and the WSDOT for this Project is simultaneously improving transportation and conservation. The Service commends your dedication to successful implementation of the collaborative process, and looks forward to continued participation. If you have questions about this biological opinion or your responsibilities under the Endangered Species Act, please contact Karl Halupka of the Central Washington Field Office in Wenatchee at (509) 665-3508 x2001 or via e-mail at Karl_Halupka@FWS.gov.

Sincerely,

Jessica L Gonzales for

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BIOLOGICAL OPINION

for the

I-90 Snoqualmie Pass East Project
Reinitiation of Formal Consultation on
Phase 1C, Keechelus Lake Avalanche Bridges

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Hydrologic Unit Codes: 17-03-00-01-01 Upper Yakima River

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Issued by: Jessica L Gonzales for Date 11 Mar 2013

Ken S. Berg, Manager
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EXECUTIVE SUMMARY

This biological opinion presents the U.S. Fish and Wildlife Service's analysis of the effects of the I-90 Snoqualmie Pass East Project, Phase 1C Keechelus Lake Avalanche Bridges (Project), on bull trout, bull trout critical habitat, and revised critical habitat for the northern spotted owl. The biological opinion consists of three chapters. Chapter 1 is an introduction that provides background information, including consultation history, a brief description of the proposed Project, and a definition of the Project's action area. Chapter 2 covers the Project's effects on the bull trout and its designated critical habitat. This chapter includes an Incidental Take Statement that includes Reasonable and Prudent Measures to minimize incidental take resulting from the Project. Chapter 3 addresses Project effects on revised critical habitat for the northern spotted owl. This biological opinion is the outcome of a reinitiation of consultation regarding a design modification that would replace a large snowshed in the original design with avalanche bridges (Bridges).

The purpose of the proposed Bridges is to reduce risks associated with avalanches, rock fall, and landslides by removing and stabilizing loose material located upslope from the highway and by physically separating the highway from the hillside. The proposed Bridges are designed to be high enough to allow typical avalanches, rock, and debris to pass under the highway without impacting traffic.

The Federal Highway Administration (FHWA) is the lead federal agency, working in close cooperation with the Washington State Department of Transportation (WSDOT). FHWA and WSDOT have successfully employed a collaborative planning process for the Project. The Service has been engaged for over 13 years in this process, leading to an in-depth understanding of this Project.

The Service characterizes this Project as consisting of three elements, each consisting of multiple activities:

1. *Site Preparation*, including vegetation removal, rock excavation and blasting, and rock slope reinforcing.
2. *Bridge Construction*, including construction of retaining walls, bridge approaches, the foundations and superstructures of both bridges, demolition of the existing snowshed, work below the ordinary high water mark (OHWM) of Keechelus Lake (done in the dry during drawdown of the reservoir), and final grading and revegetation of the avalanche chutes and shoreline beneath the bridges.
3. *Operation and maintenance*, including drainage and stormwater treatment, application of de-icer and traction sand, as well as other rehabilitation and maintenance activities.

These Project elements are used throughout this biological opinion to describe and evaluate the likely consequences of the Project for the bull trout and its critical habitat, and revised critical habitat for the northern spotted owl. The Project incorporates all the conservation measures included in the original consultation on the I-90 Snoqualmie Pass East Project and adds new conservation measures to minimize potential effects on bull trout resulting from blasting near Keechelus Lake.

The baseline condition of bull trout in the Yakima Core Area and the Upper Yakima watershed is similar now to what it was at the time of the original consultation in 2008. Baseline conditions of populations and habitat indicators at both scales remain poor. Likewise, baseline conditions of the primary constituent elements of bull trout critical habitat in the Yakima critical habitat unit and the Upper Yakima watershed are poor.

Overall, we expect about six bull trout to experience adverse effects associated with site preparation activities during two construction seasons. These sub-lethal adverse effects due to exposure to blasting are unlikely to be sufficiently severe to reduce the survival and reproductive success of affected individuals. We expect additional bull trout to experience adverse contaminant exposures from operation and maintenance of the Bridges across 75 years, but the frequency and nature of these effects are highly uncertain. Within the context of all the factors that influence the dynamics of bull trout populations, we think the scope and severity of these effects will be too limited to result in changes in the reproduction, numbers, or distribution of the single local population affected.

We expect adverse effects to Primary Constituent Element 1 (hydrologic connectivity) and 8 (water quality and quantity) of revised bull trout critical habitat. The magnitude of potential effects of the Project on groundwater dynamics also is highly uncertain. Conversion of groundwater to surface flow could slightly increase water temperatures, and by reducing the volume of groundwater upwelling, could reduce the attractiveness of the action area to bull trout. Regarding PCE 8, we expect operations and maintenance will lead to occasional inputs of chemical contaminants from the roadway that will temporarily reduce the functionality of critical habitat. We expect these adverse effects to critical habitat to result primarily from delivery of dissolved heavy metals to Keechelus Lake, either in plow spray or untreated stormwater. We expect Project effects to both of these PCEs to reduce the functional capacity of critical habitat in Keechelus Lake to meet the conservation needs of bull trout. Design features and conservation measures included in this Project may contribute to improvements in some other PCEs relative to their functional capacity at the time of designation. At the scale of the Yakima critical habitat unit, our opinion is that the Project's localized adverse effects to critical habitat will have insignificant impacts on the overall functional capacity of the Yakima basin critical habitat unit.

Regarding revised critical habitat for the northern spotted owl, the Project will occur within the East Cascades North critical habitat unit and subunit ECN-4. The baseline condition of ECN-4 is moderate, reflecting a long history of intensive timber harvest, development of irrigation, transportation, and power transmission infrastructure, and residential and recreational development. Good forest growth conditions and protective forest management in portions of ECN-4 are contributing to recovery of critical habitat functionality within this subunit which is essential to spotted owl population connectivity in the Washington Cascades.

The proposed action would permanently remove 5.46 acres of dispersal habitat from subunit ECN-4. The action will remove the PCEs 1 (suitable forest types) and 4 (dispersal habitat) of designated critical habitat. The removal of a relatively small patch of dispersal habitat in a location where a steep slope and persistent traffic noise compromise the function of critical habitat will result in an insignificant decrease in critical habitat functionality at the scale of subunit ECN-4.

Cumulative effects include potential residential development on private lands and extensive recreational development across ownerships, with associated negative impacts to habitat quality. Concurrent forest restoration projects may accelerate development of large-old trees and improve aquatic habitat function and access. Ongoing maturation of previously logged forest in the area should improve forested habitat quality, hydrologic stability, and aquatic habitat complexity. Land acquisitions for habitat preservation are ongoing and likely to contribute to improving habitat quality. On balance, we expect that cumulative effects will likely have slightly negative impacts on bull trout, bull trout critical habitat, and revised critical habitat for the northern spotted owl.

In conclusion, considering the effects of the proposed Project, together with cumulative effects, we believe the status of the bull trout in the upper Yakima watershed and the Yakima Core Area are likely to be maintained with implementation of the Project. Over the long term, we expect the negative effects of the Project to be imperceptible at the larger scales of the interim recovery unit or coterminous range. Therefore, the proposed action is not likely to jeopardize the continued existence of the bull trout at the range-wide scale. Regarding bull trout critical habitat, Project effects may reduce the capacity of affected areas to support bull trout. These adverse effects, however, are unlikely to affect the functional capacity of the entire Yakima critical habitat unit to support the survival and recovery of bull trout. Our opinion is that overall Project effects are consistent with the conservation role of critical habitat range-wide to support viable core area populations. On that basis, implementation of the proposed Project is not likely to destroy or adversely modify bull trout critical habitat at the range-wide scale. Regarding revised spotted owl critical habitat, the relatively minor adverse effects of the Project on spotted owl critical habitat are unlikely to change the existing ability of critical habitat sub-unit ECN-4 to support its intended conservation role in the survival and recovery of the spotted owl. Small negative effects on dispersal habitat at the action area (sub-unit) scale are unlikely to influence functionality of critical habitat at the provincial (unit) or rangewide scales. Given that critical habitat will remain functional across scales from sub-unit to rangewide, and retain the current ability for PCEs to become functionally established, we conclude that the action, as proposed, will not destroy or adversely modify designated critical habitat for the spotted owl.

Chapter 1

Background

INTRODUCTION

This document represents the U. S. Fish and Wildlife Service's (Service) Biological Opinion (Opinion) based on our review of the proposed Phase 1C, Keechelus Lake Avalanche Bridges (Project) located in Kittitas County, and its effects on the bull trout (*Salvelinus confluentus*) and its designated critical habitat, as well as its effects on revised critical habitat for the northern spotted owl (*Strix occidentalis caurina*), in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). We received your November 15, 2012, request for formal consultation on November 26, 2012.

This Opinion is based on information provided in the final Biological Assessment, the draft Supplemental Environmental Impact Statement, presentations given at Interdisciplinary Team Meetings for the Project, conversations with Team members, unpublished reports, published literature, and other sources of information. A complete record of this consultation is on file at the Central Washington Field Office in Wenatchee, Washington.

The Phase 1C contractor, Guy F. Atkinson Construction, has proposed a major change to design of the I-90 Snoqualmie Pass East Project, replacing the formerly proposed large snowshed with avalanche bridges (Bridges). This new design modifies elements of the project to such an extent that the Washington State Department of Transportation (WSDOT) and the Federal Highway Administration (FHWA) determined that reinitiation of formal consultation was necessary because the construction of the Bridges will likely result in adverse effects to bull trout, bull trout critical habitat, and critical habitat for northern spotted owls.

The proposed action (Project) which is the subject of this Opinion includes construction as well as ongoing operations and maintenance of these Bridges. The expected design life of the Bridges is about 75 years and they would be used year-round, with the most frequent maintenance activities occurring during the winter (plowing snow, applying de-icers and traction sand). Consequently, the term of this Opinion is 75 years.

The Service's objectives for the following Opinion are (1) to determine whether the proposed Project is likely to "jeopardize the continued existence" of the bull trout, and (2) to determine if the proposed project will destroy or adversely modify designated critical habitat for the bull trout and northern spotted owl. The standards for determining jeopardy are described in Section 7(a)(2) of the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq.*) and further defined in 50 C.F.R. 402.14. Regarding critical habitat, this Biological Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the Act to complete our adverse modification analysis and determination.

Jeopardy Determination

The Service's jeopardy determination for the bull trout relies on four components of analysis. (1) The *Status of the Species* evaluates the species' range-wide condition, the factors responsible for that condition, and the species' survival and recovery needs. (2) The *Environmental Baseline* evaluates the condition of the species in the action area, the factors responsible for that condition,

and the role of the action area in the species' survival and recovery. (3) The *Effects of the Action* determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the species. Finally, (4) *Cumulative Effects* evaluates the effects of future, non-Federal activities in the action area on the bull trout.

In accordance with the implementing regulations for Section 7 of the Act and Service policy, the jeopardy determination is made by integrating these components. The integration begins with combining the effects of the proposed Federal action with the aggregated effects of everything that has led to the listed species' current status. This aggregation includes consideration of non-Federal activities in the action area that are likely to affect listed species in the future. The Service uses this assessment of aggregated 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 in the wild of the affected listed species.

To facilitate jeopardy analysis and recovery planning for wide-ranging species, the Service sometimes defines interim recovery units. Interim recovery units were defined in the final listing rule for the bull trout in November 1999 (64 FR 58910). We use these interim recovery units to guide consultation analyses and recovery efforts until a final recovery plan is developed. Pursuant to Service policy, when an action impairs or precludes the capacity of a recovery unit to provide both the survival and recovery functions assigned to it, that action may represent jeopardy to the species. When using this type of analysis, the biological opinion describes how the action affects not only the recovery unit's capability, but also the relationship of the recovery unit to both the survival and recovery of the listed species as a whole.

The jeopardy analysis for bull trout in this Opinion uses this approach. This analysis begins with a consideration of the role of the action area and the Yakima Core Area in the function of the Columbia River interim recovery unit. This functional assessment provides context for evaluating the effects of the proposed Federal action, combined with other relevant effects, on the survival and recovery of the bull trout within the coterminous United States.

Adverse Modification Determination

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

For the purpose of making the adverse modification determination, we evaluate the significance of effects of the proposed Federal action, along with any cumulative effects, on the functionality of bull trout critical habitat. We do this evaluation in the context of the rangewide condition of critical habitat and the role of the Action Area relative to the rangewide recovery function of critical habitat. Our objective is to determine if critical habitat rangewide would remain capable of serving its intended recovery function for the bull trout, or retain its current capacity for the PCEs to be functionally established in areas of currently unsuitable but capable habitat.

CONSULTATION HISTORY

The following chronology documents key points of the consultation process that culminated in the following Opinion for the bull trout, its critical habitat, and critical habitat for the northern spotted owl.

1. August 9, 2000. WSDOT convened an interdisciplinary team (IDT) to assist in planning the I-90 Snoqualmie Pass East project. This team's primary role was to provide recommendations to WSDOT and FHWA regarding the National Environmental Policy Act process, particularly development of alternatives and selection of a preferred alternative. The team was also charged with keeping WSDOT and FHWA apprised of the pertinent regulatory requirements of each of the member agencies. The Service was included as a voting member of this IDT, and we considered participation on this team the beginning of informal consultation for this Project. The Service continues to participate in the IDT to the present date and expects to continue into the future.
2. March 26, 2002. WSDOT convened the Mitigation Development Team (MDT) to deliver a comprehensive strategy for ecological connectivity and establish a framework for mitigating unavoidable impacts on regulated natural resources. The MDT was advisory to the IDT regarding the best available science, regulatory requirements, and methods to meet the ecosystem-based objectives of the Northwest Forest Plan (NWFP). In July 2006, the MDT Recommendation Package was completed.
3. January 14, 2008: The Service received a final biological assessment (BA) and an official request for formal and informal consultation on the I-90 Snoqualmie Pass East Project.
4. April 7, 2008. The National Marine Fisheries Service completed informal consultation on the Project.
5. April 29, 2008. The Service requested additional information from the FHWA in order to allow completion of formal consultation.
6. July 9, 2008. WSDOT provided the Service with a draft response to our information request. This supplemental information provides a sufficient basis for completing formal consultation.
7. July 21, 2008. FHWA provided the Service with their final response to our information request and requested formal consultation on project effects to marbled murrelet.
8. July 30, 2008. The Service acknowledged receipt of the additional information.
9. August 5, 2008. The Service completed informal consultation with a letter of concurrence for the grizzly bear, gray wolf, Canada lynx, and designated critical habitat for the northern spotted owl and the bull trout (Service Reference 13260-2008-I-0119).

10. September 3, 2008. The Service completed formal consultation for the Project with a biological opinion that analyzed effects to the bull trout, northern spotted owl, and marbled murrelet (Service Reference 13260-2008-F-0070).
11. July 2, 2009. WSDOT requested reinitiation of consultation regarding changes in Project design regarding Phase 1B of construction.
12. August 7, 2009. The Service completed reinitiation of informal consultation (Service Reference 13260-2009-I-0131).
13. July 26, 2010. WSDOT requested reinitiation of consultation regarding changes in Project design regarding Phase 1C of construction.
14. September 24, 2010. The Service completed reinitiation of informal consultation (Service Reference 13260-2010-I-0115).
15. October 18, 2010. The Service published a final rule in the Federal Register revising bull trout critical habitat that became effective on November 17, 2010. Revised critical habitat included additional portions of the Project area, especially Lake Keechelus.
16. April 11, 2011. The Service received from WSDOT a request for reinitiation of formal consultation to analyze Project effects on the revised designation of bull trout critical habitat.
17. April 20, 2011. The Service acknowledged receipt of the request from WSDOT for reinitiation of formal consultation and confirmed that our information needs had been met. The Service's letter also recognized that construction of the project would continue while reinitiation of formal consultation was underway. The Service explained how the combination of participating in the project's IDT and coordination with WSDOT staff had enabled the Service's analysis of project effects on revised critical habitat to conclude that the project would not result in adverse modification of designated critical habitat. Therefore, our biological opinion would not contain any reasonable and prudent alternatives, and the restrictions regarding commitment of resources during consultation found in Section 7(d) of the Act would not apply.
18. May to October 2011. Work on other Service priorities precluded completion of the requested reinitiation of formal consultation.
19. October 31, 2011. The Service participated in a meeting in which the contractor selected for construction of Phase 1C proposed to replace the large snowshed in the WSDOT design with avalanche bridges, using the Cost Reduction Incentive Proposal (CRIP) process which encourages innovations in planning and performing work on transportation projects in Washington. This development marked the inception of the Project subject to this reinitiation of consultation.
20. November 18, 2011. The Service shared with WSDOT, FHWA, and other participants in the IDT our comments about environmental risks and collaborative decision-making associated with the avalanche bridge proposal. Conversations (in person and via e-mail) about these and other issues raised by IDT members continued for several months.
21. December 2011. Refinement of project design (outside the area of the avalanche bridges) revealed that placement of fill below the ordinary high water mark of Keechelus Lake would be necessary to complete construction of eastbound lanes in the vicinity of Resort Creek. Placement of this fill would have the potential to result in adverse effects to bull trout exposed to this activity, as well as having adverse effects to designated critical habitat.

22. December 2011 to January 2012. In coordination with WSDOT, we decided to combine reinitiation of consultation on revised critical habitat with effects from fill placement at Resort Creek.
23. April 26, 2012. After reviewing and commenting on a draft biological assessment, the Service received from FHWA a request for reinitiation of consultation regarding project-wide effects on revised bull trout critical habitat. The biological assessment contained all the information needed by the Service to complete its analysis of effects to bull trout critical habitat from the revised project. This reinitiation of consultation is still pending. The Service expects to complete this consultation by May 2013.
24. June 21, 2012. The Service met with representatives from WSDOT and consultants to the Phase 1C contractor to discuss updated designs for the avalanche bridges and information needed for section 7 consultation on this modified design. This meetmg and subsequent communications led to identification of the highest risk aspects of the design modification and specific elements of the proposed modification that needed to be analyzed in the greatest detail in terms of potential effects to listed species and designated critical habitat.
25. October 2012. WSDOT and FHWA released a Draft Supplemental Environmental Impact Statement for the revised avalanche structures. The Service did not formally comment.
26. October 11, 2012. In coordination with WSDOT, the Service received a draft BA for the avalanche bridges from the environmental consultants to the Phase 1C contractor. After reviewing the draft and making comments, the Service notified WSDOT that, with comments addressed, the BA would contain the information necessary for the Service to complete reinitiation of consultation on the avalanche bridges.
27. November 2012. The Service discussed with WSDOT the relative urgency of completing reinitiation of consultation on bull trout critical habitat at the scale of the entire I-90 Snoqualmie Pass East project, versus reinitiation of consultation on the avalanche bridges. We decided to prioritize reinitiation of consultation on the avalanche bridges to enable the Phase 1C contractor to begin construction as soon as weather and snow conditions allowed in the Project area.
28. November 26, 2012. The Service received from WSDOT and FHWA a request for reinitiation of consultation and a final BA for the avalanche bridges.

Consultation on transportation projects proposed by FHWA and WSDOT occurs when planning and design are roughly 20 to 40 percent complete. As design and implementation proceed, the FHWA, WSDOT, and the Service have agreed to maintain open communication regarding the need to reinitiate consultation.

This Opinion covers all construction, mitigation, and operational activities described in the BA for the avalanche bridge Project. It does not cover geotechnical studies and ongoing maintenance activities. Consultation on these activities has been and continues to be conducted under regional programmatic consultations.

The Service commends FHWA and WSDOT for their extraordinary commitment to interagency collaboration on this Project. During this collaboration, we have participated on a variety of inter-disciplinary and technical committees, and we believe the natural resources we are charged

with conserving have benefited from the inclusive planning process FHWA and WSDOT have employed for this unique Project. Through this involvement we have gained a comprehensive understanding of both the benefits and impacts of the Project, which has been a great asset during the production of this Opinion. The Service looks forward to continued collaboration as Project implementation continues.

BIOLOGICAL OPINION

1 PROJECT DESCRIPTION

The project description provided here is an abbreviated summary. For a more detailed description of the proposed action, please refer to the Project BA.

Activities evaluated in this reinitiation are located on I-90 between milepost 57.9 and milepost 58.4 and are specific to the Bridges. The Bridges will be constructed for both eastbound and westbound lanes. The 1,200-foot-long Bridges will be constructed along the shoreline of Keechelus Lake, in the same general location and footprint as the proposed large snowshed.

The Bridge option would reduce risks associated with avalanches, rock fall, and landslides in this location by removing and stabilizing loose materials located upslope from the highway and by physically separating the highway from the hillside. The Bridges are designed to be high enough to allow typical avalanches, rock, and debris to pass under the highway without impacting traffic. A combination of elevating the road surface above the existing grade and excavating approximately 10 to 40 feet of material below the existing grade will provide a total clearance beneath the Bridges ranging between approximately 35 and 80 feet. This space will accommodate accumulations of snow from snow fall, plowing, and avalanches with adequate freeboard (remaining distance between the top of the accumulated snow and the Bridges) to protect motorists from additional avalanches, as they occur.

Although the bridge piers are designed to withstand potential impact forces from avalanches, the potential for the piers to be directly impacted by avalanches is reduced by locating them on raised benches between avalanche paths and building up fill material around the piers to form a series of chutes that would assist in directing sliding snow, rock, and debris between the piers and toward the Lake.

The Service characterizes this Project as consisting of three elements, each consisting of multiple activities:

1. *Site Preparation*, including vegetation removal, rock excavation and blasting, and rock slope reinforcing.
2. *Bridge Construction*, including construction of retaining walls, bridge approaches, the foundations and superstructures of both bridges, demolition of the existing snowshed, work below the ordinary high water mark (OHWM) of Keechelus Lake (done in-the-dry; i.e., above the surface elevation of the Lake during drawdown of the reservoir), and final grading and revegetation of the avalanche chutes and shoreline beneath the bridges.
3. *Operation and maintenance*, including drainage and stormwater treatment, application of de-icer and traction sand, as well as other rehabilitation and maintenance activities.

These Project elements are used throughout the remainder of this biological opinion to describe and evaluate the likely consequences of the Project for the bull trout and its critical habitat, and revised critical habitat for the northern spotted owl. Because the Service has already evaluated the likely impacts of the proposed large snowshed in the context of our original biological opinion on the entire I-90 Snoqualmie Pass East project, we focus the following Project

description on ways in which the avalanche bridges differ from the large snowshed. This pattern of emphasizing differences between the two designs will also be prominent in our analysis of Project effects.

Construction activities that are similar for both a large snowshed and the Bridges are:

- Shifts in traffic and construction staging,
- Rock slope excavation and reinforcing;
- Retaining wall construction for cuts, fills, and buttressing of unstable slopes; and
- Demolition of the existing snowshed.

Many of the construction methods used to build the bridges will be similar to construction methods for the snowshed, though they may differ in extent or timing.

1.1 Site Preparation

The Bridges are in roughly the same footprint as the large snowshed, therefore the amount of riparian vegetation removed along the shoreline of Keechelus Lake will be similar. The Bridges will require removal of additional vegetation on the hillside above I-90 due to larger rock cuts that are necessary to allow for the movement of snow and debris beneath the Bridges. The large snowshed would temporarily impact 2.32 acres of terrestrial habitat, while the design for the Bridges will temporarily impact 0.22 acre more habitat, for a total of 2.54 acres (Table 1.1). The larger snowshed would permanently impact 4.45 acres of terrestrial habitat, while the design for the Bridges will permanently impact an additional 3.26 acres of terrestrial habitat, for a total permanent impact of 7.71 acres (Table 1.2). Permanent terrestrial impacts involve conversion of vegetated areas to rock slopes, while temporary impacts are disturbance or removal of vegetation that will be replanted or allowed to recover to its original state.

Table 1.1
Changes to Temporary Impacts to Terrestrial Habitat (acres)

Habitat Type	Snowshed	Bridges[1]	Difference
Early Successional Forest	0.22	0.03	-0.19
Mid Successional Forest	0.13	0.11	-0.02
Mature Forest	1.38	1.78	0.40
Rock	0.59	0.62	0.03
Total	2.32	2.54	0.22

[1] *Includes impacts associated with the larger Snowshed which may have already occurred due to ongoing Phase 1C construction activities.*

Table 1.2
Changes to Permanent Impacts toTerrestrial Habitat (acres)

Habitat Type	Snowshed	Bridges[1]	Difference
Early Successional Forest	0.35	0.78	0.43
Mid Successional Forest	0.02	0.43	0.41
Mature Forest	1.97	4.25	2.28
Rock	2.11	2.25	0.14
Total	4.45	7.71	3.26

[1] *Includes impacts associated with the larger snowshed which may have already occurred due to ongoing Phase 1C construction activities.*

The temporary and permanent terrestrial habitat impact areas summarized above include areas of mature forest that will be cleared during site preparation. Note that construction of the Bridges will result in an additional 2.28 acres of impact to mature forest, for a total of 4.25 acres.

1.1.1 *Rock Excavation and Blasting*

The Bridges will require removal of more material due to a larger footprint for the sculpted avalanche chutes, both on the hillside and below the OHWM of Keechelus Lake (Table 1.3). More haul trips will be required for the movement of this additional material, but haul routes and storage locations will be the same as previously consulted upon. Unconsolidated material, such as loose rocks and fines, will be removed with mechanical methods such as excavators. Consolidated material, mostly bedrock, will be removed by scaling where possible, but by blasting where necessary. Blasting would be conducted higher in elevation with the Bridges than for the snowshed. Specifically, rock cuts on the slope above the Bridges will extend approximately 40 feet higher, based on preliminary grading plans.

Table 1.3
Material Removal Comparison (cubic yards)

	Snowshed	Bridges
Material Removal Total	122,100	218,000
Material Removed by Blasting above 2517	12,300	59,500
Material Removed by Blasting below 2517	0	8,900

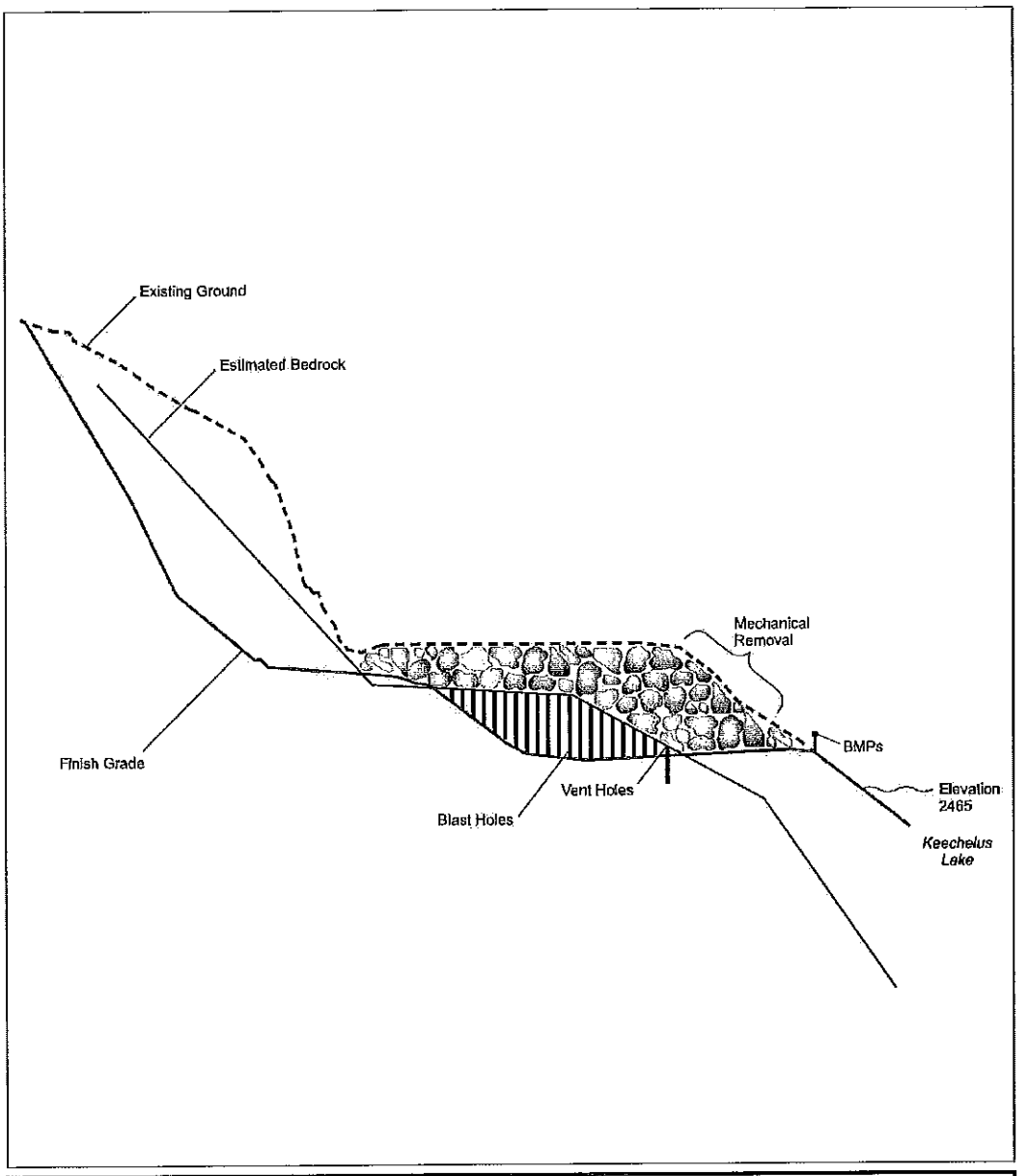
Controlled blasting as described in previous consultations will be used for the construction of the Bridges, both on the slope above I-90 and in the shoreline area of Keechelus Lake. Many factors influence the behavior of individual blast events, including substrate density, location of natural fissures and bedding planes, orientation of blast holes, size and type of explosive, hole size, timing, etc. Delay blasting techniques will be used to reduce ground vibration and air blast, reduce overbreakage and fly rock, and improve rock break up (IRMI 2008). Time delay detonation initiators are used to separate large blasts into a series of discrete smaller blasts, which reduces the overall effect of the blast. In addition, vent holes will be drilled into the rock

between the blast zone and the Lake to reduce the ground vibration transmitted to the Lake. These holes will be 2 to 4 inches in diameter, will be drilled from the roadway side without work occurring in the water, and will be backfilled with inert material after blasting is complete each season. All spoils generated from vent hole drilling will be hauled off and disposed of off-site, with no material being allowed to enter Keechelus Lake.

The Bridge proposal will require blasting closer to the shoreline area of Keechelus Lake and bull trout habitat than the large snowshed design due primarily to the excavation of additional areas for snow storage and avalanche passage below the Bridges. For the purposes of this assessment, any blasting that would be required below elevation 2,517 feet is considered shoreline blasting, and will be the focus of the effects analysis (2,517 above mean sea level is the full pool elevation for Keechelus Lake – the highest level the Lake can reach; the ordinary high water mark in Keechelus Lake is 2,510 feet). "Shoreline blasting" is the term we are using to distinguish blasting that will occur very near the Lake from blasting that will occur on rock slopes more distant from the Lake surface, where effects to bull trout are not expected to occur. Potential effects of rock slope blasting in this area were addressed in our previous consultation. However, the increased area of impact and potential increased duration of blasting will be discussed in more detail in this assessment. See Appendix A of the BA for more detailed information about blasting procedures.

In general, blasting associated with site preparation for the Bridges has the same timing, duration, and extent of effects as with the large snowshed. Approximately 59,500 cubic yards (cy) of bedrock will likely be removed by scaling and blasting above elevation 2,517 feet, and 8,900 cy will likely be removed by blasting below elevation 2,517 feet. Removal of material from the area beneath the Bridges will be accomplished by both mechanical removal of unconsolidated overburden and by blasting and subsequent mechanical removal of bedrock (Figure 1.1). The water elevation of 2,465 feet shown in the exhibit represents the average Keechelus Lake water elevation in mid-August recorded since 2004.

Figure 1.1 Conceptual blast diagram.



NOT TO SCALE	*Conceptual Blast Diagram*	
	I-90 CRIP *Keechelus Lake Avalanche Bridges*	DAVID EVANS AND ASSOCIATES INC.
	JACE0000-0008	
	October 2012	

WSDOT will require the contractor to adhere to the guidelines published in Wright and Hopky (1998) regarding setback distances and charge sizes to ensure sound pressure levels do not exceed a 100 kilopascal (kPa) threshold (Table 1.4). We chose to implement charge size and setback guidelines based on the 100 kPa threshold rather than the more protective peak particle velocity threshold of 13 millimeters per second for several reasons. First, the peak particle velocity threshold was developed for the protection of fish eggs in redds. No bull trout spawning occurs in Keechelus Lake near the proposed bridges. Second, evidence to evaluate the effectiveness of these guidelines is limited, but studies of free swimming salmonids (Bird and Robertson 1984) and eggs of lake trout (Faulkner et al. 2008) both found no increase in mortality associated with exposure to nearby blasting, even when measured peak particle velocities were more than double the 13 mm/s threshold recommended by Wright and Hopky (1998). These guidelines also do not accommodate consideration of conservation measures designed to minimize blast effects. Thus, we concluded that the threshold based on peak particle velocity was likely overprotective for the context of this Project. In addition, several minimization measures described below will be required to further reduce the potential for adverse blasting effects to bull trout.

Table 1.4
Setback Distance (ft) from Detonation of a Confined Explosive to Fish Habitat to Achieve 100 kPa Guideline Criteria

	Weight of Explosive Charge Per Delay (lbs) in Andesite Basalt						
Weight (lbs)	221	165	110	55	22	11	2
Distance from Water (feet)	155	134	109	77	49	34	15

Most bedrock blasting and rock removal closest to Keechelus Lake will occur near both the east and west ends of the proposed Bridges. Under the current Bridge design, assuming blasting will be required in consolidated bedrock only, then the closest distance that blasting might occur to Keechelus Lake is 69 feet, corresponding to a maximum charge size of 31 pounds per delay.

1.1.2 *Blasting-related Conservation Measures*
Section 4.1 of the original Biological Assessment from 2008 described a comprehensive list of avoidance and minimization measures and conservation measures that would be implemented with the I-90 Snoqualmie Pass East project. These measures also apply for the Bridges.

The following additional conservation measures (CM) will be implemented specific to the changed Project activities associated with construction of the Bridges. All measures listed here are related to blasting only and apply within the area located between highway design Stations LW 8350 + 00 and LW 8366+ 00 and between Keechelus Lake and a line represented by the median of the existing I-90 freeway. These measures do not apply to rock trim blasting on the slopes above I-90, work that was consulted on previously.

CM 1 – Blasting will only be conducted during daylight hours, when bull trout are most likely to be away from the shoreline areas of Keechelus Lake.

CM 2 – Blasting will only be conducted to remove consolidated bedrock material – loose or unconsolidated material will be removed by mechanical methods other than blasting.

CM 3 – Blasting will adhere to charge sizes and setback distances as shown in Table 1.4 above to minimize the potential for sound pressure levels to rise above 100 kilopascals.

CM 4 – Time-delay blasting will be used to minimize cumulative vibration effects.

CM 5 – Vent holes will be drilled in the consolidated bedrock between the blast area and Keechelus Lake to interrupt ground vibration prior to reaching Keechelus Lake. These vent holes will be filled after blasting is complete each season.

CM 6 – Heavy blast mats of sufficient size to cover the entire blast area will be used to ensure no fly rock enters the water of Keechelus Lake.

CM 7 – Blasting will be conducted after August 1 during each season where blasting will occur (currently estimated at two seasons).

1.2 **Bridge Construction**

Similar to the large snowshed, the proposed Bridges will not involve any work in the water of Keechelus Lake. Work will be conducted below the full pool and OHWM elevations of Keechelus Lake (2,517 feet and 2,510 feet above mean sea level, respectively), but this work will occur during the summer and early fall when the reservoir is drawn down. Replacing the shoreline retaining wall associated with the snowshed with constructed avalanche chutes beneath the Bridges will result in a net gain of 1.28 acres of new shoreline habitat below the OHWM elevation of Keechelus Lake, and 2.22 acres of new shoreline habitat below elevation 2,517 feet (Table 1.5). The replacement of a shoreline retaining wall in the large snowshed design with bridge piers and a more natural shoreline is a key difference between the designs.

The Bridges will be supported by 36 drilled shaft piers, seven less than the 43 drilled shafts for the larger snowshed. This difference will likely reduce time spent working on the lakebed and the amount of treatment needed for process water from drilling and pouring concrete into the drilled shafts. Blasting would not be used to install the bridge piers. Piers would be constructed using drilled shafts that are drilled when the Lake is drawn down. Construction of the Bridges would require more extensive temporary impacts below the OHWM of Keechelus Lake compared to the large snowshed (1.02 acre compared to 0.43 acre), primarily due to the excavation of the avalanche chutes (Table 1.5).

The proposed Bridges would be constructed using standard engineering designs and construction practices, reducing risk compared to the non-standard techniques and components required for the large snowshed. Relative to the large snowshed, traffic management during construction of the Bridges will be more straightforward.

Table 1.5
Temporary and Permanent Impacts to Aquatic Habitat

Impact	Impact Below OHWM (2,510 Feet)		Impact Below Full Pool (2,517 Feet)	
	Snowshed	**Bridges**	**Snowshed**	**Bridges**
Temporary Impact	0.43	1.02	0.57	1.43
Permanent Impact	0.40	0.05	0.67	0.08
New Shoreline Area Created	0	1.28	0	2.22

1.3 Operation and Maintenance

Ongoing maintenance of the Bridges would involve annual inspections, plowing, de-icing of the highway, applying traction sand, and clearing of snow and debris from the avalanche chutes and adjacent snow containment trench on an as-needed basis. The expected design life of the Bridges is about 75 years. Structural rehabilitation to extend the usable life of the Bridges may include deck rehabilitation, expansion joint replacement, and bridge column and grade beam repairs.

Compared to the large snowshed, the Bridges are likely to require some supplementary avalanche control (e.g., controlled releases using explosives) when conditions conducive to powder avalanches approach the severity of a 50-year return interval event. This will prevent conditions from worsening to the point that an ensuing avalanche could challenge the design criteria of the bridges, and will reduce potential risks to drivers from reductions in visibility from powder plumes accompanying avalanches that exceed the severity of a 50-year event.

1.3.1 *Stormwater Treatment*

WSDOT has committed to treating stormwater runoff for the equivalent of all new and existing impervious surfaces in the I-90 Snoqualmie Pass East project area. WSDOT committed to providing on-site treatment systems and off-site mitigation when on-site treatment is not possible because of physical constraints. This commitment meets the requirements of WSDOT's *Highway Runoff Manual* (HRM) (2011). In 2008, WSDOT conducted additional feasibility and design work for stormwater mitigation sites, and determined that in some areas, stormwater treatment would be physically impracticable because the highway is located between steep rock banks and Keechelus Lake, with limited space for stormwater treatment.

The Bridges will be built within this confined area where stormwater treatment options are limited. Some treatment is possible using linear, roadside best management practices (BMPs) such as media filter drains and bioinfiltration ponds, but not all road surfaces are treatable in this area. Portions of the highway in the design modification area that are untreatable due to site constraints will be compensated for by treating equivalently-sized areas at other sites within the overall I-90 Snoqualmie Pass East project limits. This approach to stormwater treatment has not changed since the issuance of the Biological Opinion.

The large snowshed design treated pavement runoff by collecting it in gutters and discharging through barrier scuppers to a media filter drain. Runoff that did not infiltrate through the media filter drain would either sheet flow to Keechelus Lake or discharge to ditches. The ditches either daylight to the lake or discharge to culverts draining to the lake. Untreated pavement drainage was to be conveyed in gutters to ditches or catch basin and pipe networks, ultimately discharging to the lakeside. Ditches were proposed along the toe of the steep hillside to collect hillside runoff and convey it through cross culverts to the Lake. Some of the cross culverts would also convey treated and untreated pavement runoff. The pavement inside the snowshed would not receive treatment; a catch basin and pipe network was proposed to collect runoff and discharge it to the Lake. A knife gate stormwater valve was proposed to control when these discharges would occur. Runoff from the hillside adjacent to the large snowshed was to be collected in a drainage gallery which functions as a large French drain. The gallery would discharge to multiple pipes running underneath the snowshed and daylight on the lakeside.

The proposed Bridges would provide enhanced treatment of the same pavement area as the snowshed design, plus the equivalent area of pavement as enclosed by the snowshed (Table 1.6). Flow control is not provided for the Bridges due to the proximity to Keechelus Lake, which is a flow-control-exempt waterbody per Table 3-5 of the 2011 WSDOT HRM.

Table 1.6
Stormwater Treatment Area Comparison (acres)

	Snowshed	Bridges
Treated Impervious Surface	5.11	8.21
Untreated Impervious Surface	2.69	2.57
Non-PGIS Structure	2.94	0
Total	**10.74**	**10.78**

The proposed Bridges will treat pavement runoff using two methods, both of which have been approved by the Washington Department of Ecology for use on the Project as providing appropriate levels of water quality treatment. The first method is similar to the system for the large snowshed, collecting runoff in gutters and discharging it through barrier scuppers to media filter drains. Runoff that does not infiltrate through a media filter drain would either sheet flow to Keechelus Lake or discharge to ditches. The ditches either daylight to the Lake or discharge to culverts draining to the lakeside. The second treatment method includes conveyance in gutters to catch basin and pipe networks discharging to bioinfiltration ponds. These stormwater management components were not present in the large snowshed system. Stormwater that does not infiltrate through the bioinfiltration ponds discharges to ditches which ultimately discharge through culverts to the lakeside. Untreated pavement drainage will be conveyed in gutters to ditches or catch basin and pipe networks ultimately discharging to the Lake. Ditches are proposed along the toe of the steep hillside to collect hillside runoff and convey it through cross culverts to the lakeside. Some of the cross culverts will also convey treated and untreated pavement runoff.

Pipes conveying runoff will most likely consist of plastic with a long design life (in excess of 75 years). These pipes will be buried at a sufficient depth to protect them from surface disturbance. These pipe systems will not generally be exposed to avalanches under the Bridges option because the bridges span the active avalanche paths and the pipes will be buried beneath the approaches to the Bridges. Maintenance of these systems will consist primarily of periodically cleaning the catch basins of sediment, similar to what is done by Maintenance Division staff elsewhere on the highway.

Though each proposed outfall location for the Bridges may convey stormwater from a different areal extent of pavement, there is only one proposed stormwater outfall for the Bridges that is in a different location than those proposed for the large snowshed. The new outfall conveys treated stormwater from the new bioinfiltration pond, discharges to Keechelus Lake, and is located adjacent to a proposed outfall for the large snowshed.

In an effort to reduce the amount of traction sand entering water bodies, the highway design will include grit chambers, which are modified catch basins with enlarged sumps (J. Turcott, pers. comm., May 14, 2012).

1.4 Construction Staging/Timeline

Major construction activities and timing are very similar for the larger snowshed and the Bridges. Construction of the Bridges will require five construction seasons (same as for the large snowshed as consulted upon), beginning in the summer of 2013 and ending in 2017.

In order to complete hillside rock excavation and stabilization, traffic must be shifted toward the Lake to create room for equipment and removal of material from the hillside. Traffic then will be shifted toward the hillside to provide access for construction of lakeside retaining walls and bridge foundation elements such as drilled shafts.

Additional traffic shifts would be required at the end of each construction season for winter shutdown. The winter configuration provides wider shoulders and lanes to allow for snow removal and greater safety through the construction zone. Construction activities will be shut down for winter, generally from October to April.

The eastbound (EB) bridge will be constructed first with initial substructure elements in 2013 and the remaining substructure in 2014. The existing snowshed will be demolished in 2014. After demolition of the existing snowshed, one winter season will pass with no avalanche protection over the existing roadway. During that year, we expect more aggressive avalanche control measures to occur, resulting in more closures and traffic slow-downs during the winter. Snow retention fences may be installed to reduce avalanche risk during the year no snowshed is present. Construction of bridge superstructure will begin in 2014 and be completed in 2015 along with the bridge approaches. After completion of the EB bridge at the end of the 2015 construction season, all traffic will be placed on the new bridge structure while the westbound (WB) bridge and approaches are constructed over the next two seasons. Traffic will shift to the final configuration at the end of the 2017 construction season.

The timing of construction adjacent to Keechelus Lake will be determined by water levels during each construction season. Different construction activities may occur at various times depending on how high or low the actual water level is at a given point in the construction season. For example, drilling for pier shafts may occur at various times between 2013 and 2015, but will typically occur in the late summer when water levels are lowest. Duration of drilling of each shaft is estimated to require four days. Similarly, final shaping of the avalanche chutes is likely to occur in the summer of 2016 or 2017, and will require approximately one month to complete.

1.5 **Definition of the Action Area**

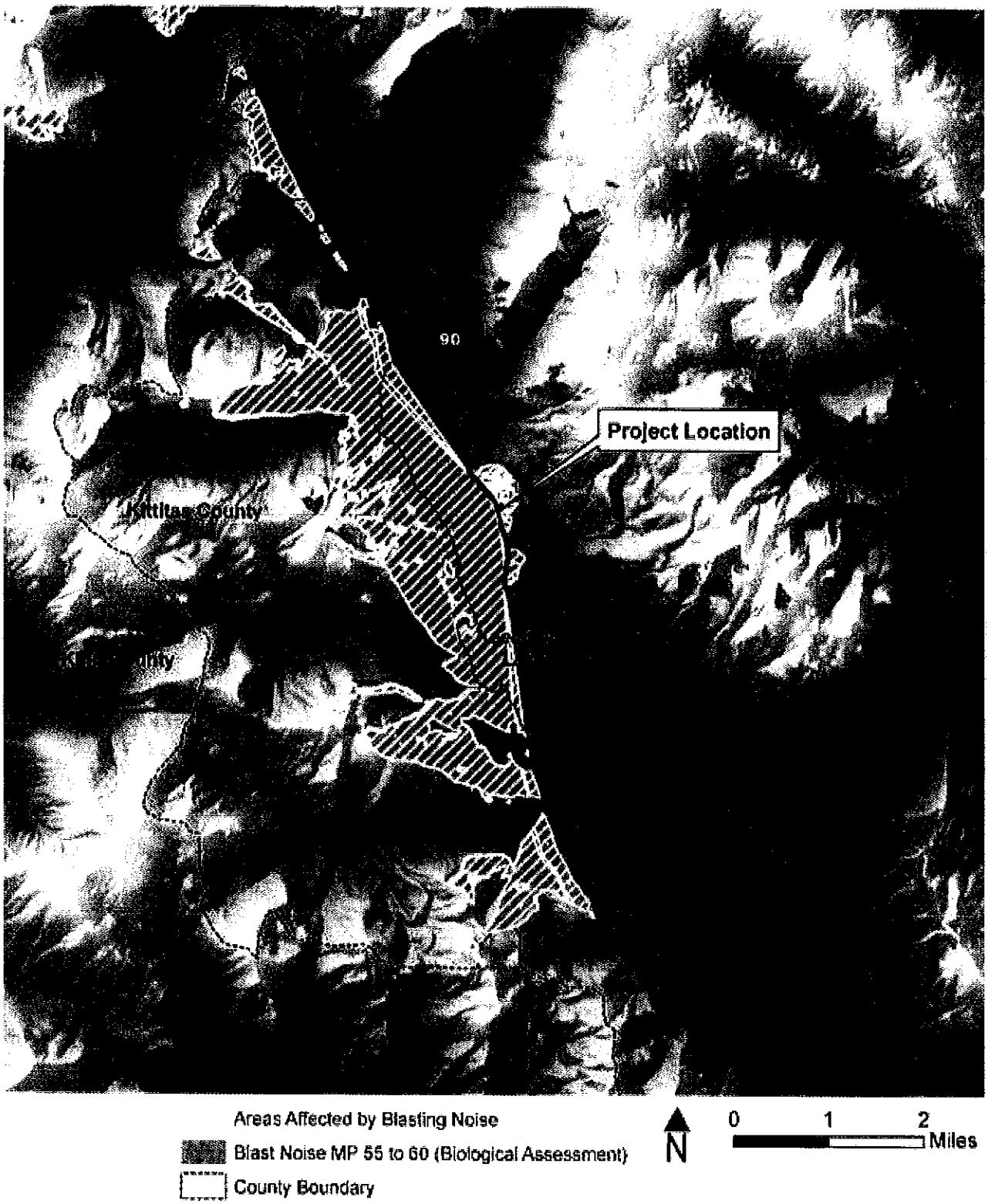
The action area is defined as all areas to be affected directly or indirectly by the Federal action, including interrelated and interdependent actions, and not merely the immediate area involved in the action (50 C.F.R. 402.02). In delineating the action area, we evaluated the farthest reaching physical, chemical, and biotic effects of the action on the environment. Subsequent analyses of the environmental baseline, effects of the action, cumulative effects, and levels of incidental take are based upon the action area as determined by the Service.

The action area for this reinitiation is based solely on the differences in activities and footprint for the Bridges relative to the originally proposed large snowshed. The Service adopted the following definitions of the terrestrial and aquatic components of the action area from the BA for the Project. The entire action area is within the Upper Yakima watershed.

1.5.1 *Terrestrial Zone of Impact*

Noise is expected to be the Project impact with the most far-reaching terrestrial environmental effects. The Bridges will use similar construction equipment to that described in the original consultation. The only potential difference in extent of terrestrial noise impacts is that rock excavation, which may include blasting, would be conducted higher in elevation with the Bridges than that for the snowshed. Specifically, rock cuts on the slope above the Bridges will extend approximately 40 feet higher, based on preliminary grading plans. Figure 1.2 displays the extent of noise from blasting in the original consultation compared with the current Project. Based on the results of this analysis, noise would not extend any farther than analyzed in the original consultation. The reason for this is that the existing topography is high enough to limit noise propagation to the extent shown in the original action area in 2008.

Figure 1.2
Extent of terrestrial action area



1.5.2 *Aquatic Zone of Impact*

Previous consultations were based on no in-water work occurring in Keechelus Lake, which is still the case with the Bridges. No pile driving or underwater blasting will occur. However, blasting of consolidated material will occur closer to Keechelus Lake for the excavation of the avalanche chutes, which has the potential to increase sound pressure levels in the Lake adjacent to construction.

In order to determine the extent of potential underwater impacts, the baseline or ambient noise level for Keechelus Lake needed to be determined. WSDOT (2010) guidance has identified underwater baseline noise levels at 135 dB_{rms} for deep freshwater lakes. This noise level is assumed as baseline for Keechelus Lake for this assessment. While this value is higher than some published values (e.g., Amoser and Ladich 2010), we believe that the relatively high level of human-derived noise and wind-derived noise at Keechelus Lake likely lead to a higher ambient noise level than occurs in deep freshwater lakes in more pristine settings. Therefore, we accept that ambient noise levels in Keechelus Lake may be similar to the value in the WSDOT guidance.

Blast charge size and setback distances will be used to ensure blasting in adjacent bedrock will not produce sound pressure levels above 100 kilopascals, or 194 dB_{peak} within the Lake. The rule- of-thumb to convert peak dB to rms dB is to subtract 15 dB. Therefore, maximum underwater sound pressure levels generated by blasting would be 179 dB_{rms}.

In addition to limiting charge sizes based on distance to water, vent holes will be drilled between the blast zone and Keechelus Lake. These vent holes will reduce sound pressure levels, functioning similar to bubble curtains which are used in water to introduce a change in media through which sound must travel. Because exact sound reduction levels are not known, this assessment will use the conservative unattenuated sound pressure level of 179 dB_{rms} as the maximum underwater sound pressure level entering Keechelus Lake near the blasting location. However, significant decreases in sound pressure levels are likely as a result of planned minimization measures.

Using the Practical Spreading Loss Model as recommended by USFWS and National Marine Fisheries Service, it is possible to calculate the approximate area within the Lake that would be subject to above ambient sound pressure levels. For underwater transmission loss of sound:

$$\mathbf{TL = 15Log(R_1/R_2)}$$

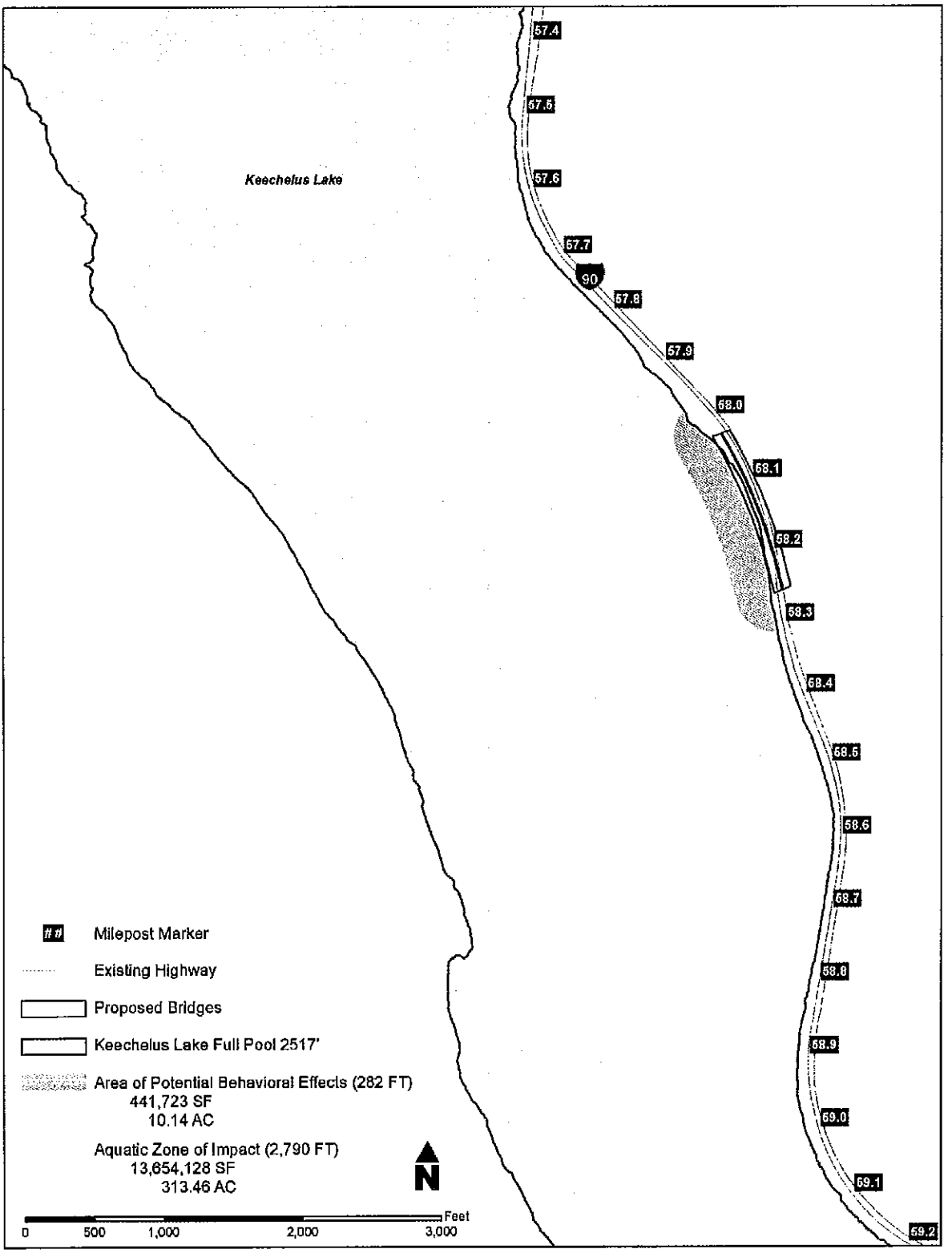
Where R1 is the distance where noise attenuates to a known threshold level, R2 is the range of the known noise level (for this assessment, estimated at 1 meter from shore), and TL is the amount of spreading loss (estimated noise level – threshold level). To solve for the attenuation distance, the equation becomes:

$$\mathbf{(10^{(TL/15)})(R2)}$$
$$\mathbf{(10^{((179-135)/15)}(1)}$$
$$\mathbf{851\ meters}$$

Therefore, elevated sound pressure levels that are generated by blasting near Keechelus Lake will attenuate to baseline levels approximately 851 meters (2,792 feet) from the shoreline (Figure 1.3).

When Keechelus Lake elevations increase in the season following work below the OHWM, there will likely be a turbid area caused by inundation of soil. The areal extent of this turbidity would likely remain in the immediate area, and could extend landward in the avalanche chutes from where this impact would occur with the large snowshed wall. This impact, as well as any impact associated with the maintenance and operation of the travel lanes during winter, will not extend beyond the distance identified above for sound attenuation.

Figure 1.3
Aquatic zone of impact



Chapter 2

Bull Trout (*Salvelinus confluentus*)

2.1 STATUS OF THE SPECIES FOR BULL TROUT

This section, along with Appendix 2A, provides information about the bull trout's life history, habitat preferences, geographic distribution, population trends, threats, and conservation needs. This includes description of the effects of past human activities and natural events that have led to the current status of the bull trout. This information provides the background for analyses in later sections of the biological opinion.

2.1.1 Listing Status and Distribution

The coterminous United States population of the bull trout (*Salvelinus confluentus*) was listed as threatened on November 1, 1999 (64 FR 58910). The current range of the threatened bull trout extends from the Klamath River Basin of south-central Oregon and the Jarbidge River in Nevada, north to various coastal rivers of Washington, to Puget Sound and east throughout major rivers within the Columbia River Basin to the St. Mary-Belly River, east of the Continental Divide in northwestern Montana (Cavender 1978, Bond 1992, Brewin and Brewin 1997, Leary and Allendorf 1997).

Throughout its range, the bull trout is threatened by the combined effects of habitat degradation, fragmentation and alterations associated with: dewatering, road construction and maintenance, mining, and grazing; the blockage of migratory corridors by dams or other diversion structures; poor water quality; incidental angler harvest; entrainment (a process by which aquatic organisms are pulled through a diversion or other device); and introduced non-native species (64 FR 58910).

The bull trout was initially listed as three separate Distinct Population Segments (DPSs)(63 FR 31647, 64 FR 17110). The preamble to the final listing rule for the United States coterminous population of the bull trout discusses the consolidation of these DPSs, plus two other distinct population segments, into one listed taxon, and the application of the jeopardy standard under section 7 of the Endangered Species Act relative to this species (64 FR 58930):

> Although this rule consolidates the five bull trout DPSs into one listed taxon, based on conformance with the DPS policy for purposes of consultation under section 7 of the Act, we intend to retain recognition of each DPS in light of available scientific information relating to their uniqueness and significance. Under this approach, these DPSs will be treated as interim recovery units with respect to application of the jeopardy standard until an approved recovery plan is developed. Formal establishment of bull trout recovery units will occur during the recovery planning process.

Thus, the Service's jeopardy analysis for the proposed Project is done at the scale of the Columbia River interim recovery unit.

On January 9, 2001, the Service proposed to list the Dolly Varden (*Salvelinus malma*) as a threatened species in Washington due to similarity of appearance (66 FR 1628). This proposed listing has not been finalized due to the need to complete higher priority listing actions.

2.1.2 Current Status and Conservation Needs

A summary of the current status and conservation needs of the bull trout within these interim recovery units is provided below. More comprehensive discussions of these topics are found in the Service's draft recovery plan for the bull trout (USFWS 2002a; 2004a, b), the Service's Science Team Document (Whitesel et al. 2004), the Proposed and Final rules designating revised critical habitat, including supporting documentation (USFWS 2010a, 2010b), the Rock Creek Mine Biological Opinion (USFWS 2006), and the 5-year review (USFWS 2008).

The habitat conservation needs of the bull trout are generally expressed as the "four Cs": cold, clean, complex, and connected habitat. Cold stream temperatures, clean water quality that is relatively free of sediment and contaminants, complex channel characteristics (including abundant large wood and undercut banks), and large patches of such habitat that are well connected by unobstructed migratory pathways are all needed to promote conservation of bull trout at multiple scales ranging from the coterminous United States to local populations. The recovery planning process for the bull trout has also identified the following conservation needs for the bull trout: (1) maintain and restore multiple, interconnected populations in diverse habitats across the range of each interim recovery unit; (2) preserve the diversity of life-history strategies; (3) maintain genetic and phenotypic diversity across the range of each interim recovery unit; and (4) establish a positive population trend (USFWS 2002a; 2004a, b).

Central to the survival and recovery of the bull trout is the maintenance of viable core areas (USFWS 2002a, 2004a, b). A core area is defined as a geographic area occupied by one or more local bull trout populations that overlap in their use of rearing, foraging, migratory, and overwintering habitat, and in some cases, in their use of spawning habitat. Each of the interim recovery units consists of one or more core areas. About 114 core areas are recognized across the coterminous United States range of the bull trout (USFWS 2002a; 2004a, b).

As noted above, in recognition of available scientific information relating to their uniqueness and significance, five segments of the coterminous United States population of the bull trout are considered essential to the survival and recovery of this species and are identified as interim recovery units: (1) Jarbidge River; (2) Klamath River; (3) Columbia River; (4) Coastal-Puget Sound; and (5) St. Mary-Belly River. Each of these segments is necessary to maintain the bull trout's distribution, as well as its genetic and phenotypic diversity, all of which are important to preserve the species' resilience to changing environmental conditions.

2.1.3 Jarbidge River

This interim recovery unit currently contains a single core area with six local populations. Less than 500 resident and migratory adult bull trout, representing about 50 to 125 spawners, are estimated to occur within the core area. The current condition of the bull trout in this interim recovery unit is attributed to the effects of livestock grazing, roads, angler harvest, timber harvest, and the introduction of non-native fishes (USFWS 2004a). The draft bull trout recovery plan identifies the following conservation needs for this unit: maintain the current distribution of the bull trout within the core area; maintain stable or increasing trends in abundance of both resident and migratory bull trout in the core area; restore and maintain suitable habitat conditions for all life history stages and forms; and conserve genetic diversity and increase natural opportunities for genetic exchange between resident and migratory forms of the bull trout. An

estimated 270 to 1,000 spawning fish per year are needed to provide for the persistence and viability of the core area and to support both resident and migratory adult bull trout (USFWS 2004a).

2.1.4 Klamath River

This interim recovery unit currently contains three core areas and 12 local populations. The current abundance, distribution, and range of the bull trout in the Klamath River Basin are greatly reduced from historical levels due to habitat loss and degradation caused by reduced water quality, timber harvest, livestock grazing, water diversions, roads, and the introduction of non-native fishes (USFWS 2002a). Bull trout populations in this unit face a high risk of extirpation (USFWS 2002a). The draft bull trout recovery plan (USFWS 2002a) identifies the following conservation needs for this unit: maintain the current distribution of the bull trout and restore distribution in previously occupied areas; maintain stable or increasing trends in bull trout abundance; restore and maintain suitable habitat conditions for all life history stages and strategies; conserve genetic diversity and provide the opportunity for genetic exchange among appropriate core area populations. Eight to 15 new local populations and an increase in population size from about 3,250 adults currently to 8,250 adults are needed to provide for the persistence and viability of the three core areas (USFWS 2002a).

2.1.5 Columbia River

The Columbia River Unit occupies all or parts of Washington, Oregon, Idaho and Montana, and contains about 100 discrete or semi-discrete core areas (USFWS 2008) and roughly 500 local populations. The condition of the bull trout within these core areas varies from poor to good, but generally all have been subject to the combined effects of habitat degradation, fragmentation, and alteration associated with one or more of the following activities: dewatering; road construction and maintenance; mining, and grazing; the blockage of migratory corridors by dams or other diversion structures; poor water quality; incidental and intentional angler harvest; entrainment into diversion channels; introduced non-native species; and the decline or elimination of salmon populations which provided an important prey base and other essential aquatic ecosystem functions. The draft bull trout recovery plan identifies the following conservation needs for this unit: maintain or expand the current distribution of the bull trout within core areas; maintain stable or increasing trends in bull trout abundance; maintain/restore suitable habitat conditions for all bull trout life history stages and strategies; and conserve genetic diversity and provide opportunities for genetic exchange (USFWS 2002a).

The size and diversity of the Columbia River interim recovery unit make it difficult to determine its current status and the potential unit-wide ramifications of implementing individual projects. The degree to which demographic performance of core areas is correlated across the vast geography encompassed by this Unit is unknown. Given the large number of factors and threats that influence bull trout populations, it is reasonable to expect different core areas across the Unit to experience different arrays of factors that yield a shifting mosaic of stable, increasing, and declining demographic performance. This variation in demographic performance obscures the Unit's actual level of resilience.

The Service compiled information about core area resilience for its 5-year review of bull trout status, but did not aggregate this information into assessments at the unit-wide scale (USFWS

2005). The core area risk assessment indicates that 76 percent of the core areas in the Columbia River interim recovery unit, (including the Yakima core area, in which the proposed Project will occur) are in the two highest-risk categories. This risk profile suggests that unit-wide resilience to further habitat degradation may be limited. Population trends for most core areas in the unit are unknown. Distribution of bull trout at the core area scale has not changed since the coterminous listing in 1999, but distribution changes at the scale of local populations have not been comprehensively evaluated. Furthermore, genetic information necessary for identifying core areas that are distinctive elements of intra-unit diversity is being developed, but is not currently available. Overall, the high number of and variability among core areas, difficulty of assessing aggregate risk, lack of key biological information, and the lack of a final Recovery Plan to inform 7(a)(2) analysis all contribute to uncertainty about the current status of the Unit and the potential Unit-wide consequences of localized project effects.

2.1.6 Coastal-Puget Sound

Bull trout in the Coastal-Puget Sound interim recovery unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous life history form is unique to this unit. This interim recovery unit currently contains 14 core areas and 67 local populations (USFWS 2004b). Bull trout are distributed throughout most of the large rivers and associated tributary systems within this unit. With limited exceptions, bull trout continue to be present in nearly all major watersheds where they likely occurred historically within this unit. Generally, bull trout distribution has contracted and abundance has declined especially in the southeastern part of the unit. The current condition of the bull trout in this interim recovery unit is attributed to the adverse effects of dams, forest management practices (e.g., timber harvest and associated road building activities), agricultural practices (e.g., diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation), livestock grazing, roads, mining, urbanization, angler harvest, and the introduction of non-native species. The draft bull trout recovery plan (USFWS 2004b) identifies the following conservation needs for this unit: maintain or expand the current distribution of bull trout within existing core areas; increase bull trout abundance to about 16,500 adults across all core areas; and maintain or increase connectivity between local populations within each core area.

2.1.7 St. Mary-Belly River

This interim recovery unit currently contains six core areas and nine local populations (USFWS 2002a). Currently, the bull trout is widely distributed in the St. Mary River drainage and occurs in nearly all of the waters that it inhabited historically. Bull trout are found in only a 1.2-mile reach of the North Fork Belly River within the United States. Redd count surveys of the North Fork Belly River documented an increase from 27 redds in 1995 to 119 redds in 1999. This increase was attributed primarily to protection from angler harvest (USFWS 2002a). The current condition of the bull trout in this interim recovery unit is primarily attributed to the effects of dams, water diversions, roads, mining, and the introduction of non-native fishes (USFWS 2002a). The draft bull trout recovery plan (USFWS 2002a) identifies the following conservation needs for this unit: maintain the current distribution of the bull trout and restore distribution in previously occupied areas; maintain stable or increasing trends in bull trout abundance; restore and maintain suitable habitat conditions for all life history stages and forms; conserve genetic diversity and provide the opportunity for genetic exchange; and establish good working relations

with Canadian interests because local bull trout populations in this unit are comprised mostly of migratory fish, whose habitat is mostly in Canada.

2.1.8 Life History and Population Dynamics

Like other salmonids from western North America, the bull trout is a well-studied fish species. Detailed reviews of available information about the diverse life-history strategies exhibited by bull trout and the resulting variability in population dynamics are available in the Service's draft bull trout recovery plan and in the background information for the 5-year status review of the bull trout. A summary of this information is presented in Appendix 2A.

2.1.9 Consulted-on Effects

Projects subject to Section 7 consultation under the Act have occurred throughout the range of bull trout. Singly or in aggregate, these projects could affect the species' status. In order to assess the effects of previous actions/projects on bull trout, we incorporate by reference the Service's Biological Opinion for the Rock Creek Mine in Montana prepared by our Region 6 office (USFWS 2006). In the Status of the Species section of that BO, the Service reviewed 137 BOs produced by the Service from the time of listing in June 1998 until August 2003. The Service analyzed 24 different activity types (e.g., grazing, road maintenance, habitat restoration, timber sales, hydropower, etc.). Twenty BOs involved multiple projects, including restorative actions for bull trout.

The geographic scale of projects analyzed in these 137 BOs varied from individual actions (e.g., construction of a bridge or pipeline) within one basin, to multiple-project actions, occurring across several basins. Some large-scale projects affected more than one interim recovery unit. In summary, 124 BOs (91 percent) applied to activities affecting bull trout in the Columbia River population, 12 BOs (9 percent) applied to activities affecting bull trout in the Coastal-Puget Sound population, 7 BOs (5 percent) applied to activities affecting bull trout in the Klamath River population, and 1 BO (less than 1 percent) applied to activities affecting the Jarbidge and St. Mary Belly populations.

Our aggregate analysis of BOs was also stepped-down from the interim recovery unit scale to the core area scale (USFWS 2006). For example, the Rock Creek Mine Biological Opinion included an evaluation of the Clark Fork River basin from the time of listing until August 2003. Of 37 actions that occurred in this river basin during this period, the majority (35) involved habitat disturbance with unquantifiable effects, 16 actions were ongoing, and 21 actions had been completed and effects were no longer occurring. Similarly, the number of actions, type of actions, and a brief description of the action was provided for each river basin where bull trout may have been adversely affected (USFWS 2006).

For each action, the causes of adverse effects were identified, as were the anticipated consequences for spawning streams and/or migratory corridors, if possible (in most cases, these consequences were known). Actions whose effects were "unquantifiable" numbered 55 in migratory corridors and 55 in spawning streams. The Service also attempted to define the duration of anticipated effects (e.g., "short-term effects" varied from hours to several months). Projects likely to result in long-term benefits also were identified.

At the time of preparation of the Rock Creek Mine Biological Opinion, all other BOs within the range of bull trout reached a "no-jeopardy" determination. After reviewing previous BOs, the Service concluded that the continued long-term survival and existence of the bull trout had not been appreciably reduced range-wide (USFWS 2006). The Service's assessment of BOs from the time of listing until August 2003 (137 BOs), confirmed that no actions that had undergone Section 7 consultation during this period, considered either singly or cumulatively, would appreciably reduce the likelihood of survival and recovery of the bull trout or result in the loss of any (sub) populations (USFWS 2006).

Between August 2003 and July 2006, the Service issued 198 additional BOs that included analyses of effects on bull trout (USFWS 2006). These BOs also reached "no-jeopardy" determinations, and the Service concluded that the continued long-term survival and existence of the species had not been appreciably reduced range-wide due to these actions (USFWS 2006).

All BOs issued after July 2006 also reached "no-jeopardy" determinations. Since July 2006, a review of the data in our national Tracking and Integrated Logging System (TAILS) reveal this trend has held true to date; no jeopardy opinions have been issued for the bull trout. Also, the Service has developed the Consulted-on Effects Database (COED), an internal online electronic data collection, storage and retrieval system for bull trout. This database provides a powerful tool for assessing the rangewide status of bull trout. The COED system is currently being populated with data regarding project effects and associated incidental take from past Federal consultations.

2.2 ENVIRONMENTAL BASELINE FOR BULL TROUT

Regulations implementing the Act (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of State and private actions which are contemporaneous with the consultation in progress. This section analyzes the current condition of the bull trout in the action area, the factors responsible for that condition, and the intended role of the action area in the conservation of the Columbia River interim recovery unit.

Characterizing the environmental baseline for highly mobile species requires a multi-scale analysis that evaluates the condition of all areas used by the affected population. The population of bull trout found in the action area of a project often inhabits a much larger area through the course of its life cycle. For example, bull trout often migrate over 100 kilometers (km) between spawning and overwintering habitat. For bull trout, the Service primarily considers two different spatial scales: (1) the watershed or specific reaches in a watershed affected by the proposed project, and (2) the "core area" scale, which typically incorporates multiple watersheds occupied by separate, but potentially interacting, local populations of bull trout. The watershed or reach scale is used to characterize habitat conditions in the vicinity of the proposed action.

The condition of habitat at both scales is evaluated in terms of seven broad classes of habitat features (pathways), each of which has a related set of specific metrics (indicators) that are rated

based on their functional condition. Baseline conditions for each indicator are described on a relative scale of functionality ("functioning appropriately," "functioning at risk" or "not properly functioning"). This analytical framework is referred to as the Matrix of Pathways and Indicators (MPI) (USFWS 1999). In a similar fashion, the condition of bull trout metapopulations at the core area scale is evaluated in terms of "subpopulation" indicators in the Matrix of Pathways and Indicators (USFWS 1999). The Service uses these hierarchical scales to structure its evaluation of baseline condition as well as its subsequent analysis of project effects and jeopardy.

The action area is part of the Yakima River core area for the bull trout. The Draft Bull Trout Recovery Plan (USFWS 2002b) included all local populations in the Yakima Basin in a single core area. However, based on migratory blockages that limit opportunities for downstream migration and preclude upstream migration under current conditions, the core area is composed of several reproductively isolated population groups. For context, we first discuss the baseline condition of the bull trout within the Yakima core area, followed by a discussion of baseline conditions in the Upper Yakima watershed. Baseline conditions at both of these scales have not changed appreciably since our original consultation on the I-90 Snoqualmie Pass East project in 2008.

2.2.1 **Environmental Baseline for the Yakima River Basin and Core Area**

The Yakima River Basin is located in south central Washington. It consists of two primary sub-basins; the Yakima River sub-basin to the north and the Naches River sub-basin to the south. Combined, these two sub-basins drain an area of about 6,155 square miles (15,900 square kilometers). Along the western portion of the Basin, the glaciated peaks of the Cascade Mountains exceed 8,000 feet. East and south from the Cascade crest, the elevation decreases to the broad valleys and the lowlands of the Columbia Plateau. The lowest elevation in the Basin is 340 feet at the confluence of the Yakima and Columbia Rivers at Richland. Precipitation is highly variable across the Basin, ranging from approximately over 140 inches per year near the crest of the Cascades, to 7 inches per year near the Columbia confluence. Total runoff from the basin averages approximately 3.4 million acre-feet per year, ranging from a low of 1.5 to a high of 5.6 million acre-feet (YBFWPB 2004).

Natural hydrology of the area was historically driven by heavy snowfall from November through March resulting in peak flows derived from snowmelt from May to July. Late fall and winter rain-on-snow events also produced high flows. Historically, the hydrologic cycle in this Basin was characterized by extensive and complex exchange of water between the surface, hyporheic (shallow groundwater made up of downwelling surface water) and groundwater zones. Under pre-1850s conditions, vast alluvial flood plains were connected to complex webs of braids and channels. These large hydrological buffers spread and diminished peak flows, promoting infiltration of cold water into the underlying gravels. Side channels and sloughs provided a large area of edge habitat and a variety of thermal and velocity regimes. For salmonids, these side channel complexes increased productivity, carrying capacity, and life history diversity by providing suitable habitat for all freshwater life stages in close physical proximity (YBFWPB 2004).

Current hydrology in the Yakima core area is controlled by the Bureau of Reclamation's Yakima Basin Project, and these controlled flows deviate significantly from the natural flow regime.

There are five major storage reservoirs in the basin; Keechelus, Kachess, and Cle Elum in the Yakima sub-basin, and Bumping and Rimrock in the Naches sub-basin. None of the dams forming these reservoirs provide upstream fish passage. Total storage capacity of all reservoirs is approximately 1.07 million acre feet; total diversions average over 2.5 million acre feet. Several minor storage dams and many diversion dams are present in the Basin. The construction and operation of this irrigation system has significantly altered the natural seasonal hydrograph of all downstream reaches of the mainstem and some tributaries.

Private ownership totals over 1.2 million acres of the nearly 4 million acres in the Yakima Basin. The single largest landowner is the U.S Government with 1.5 million acres, or 38 percent of the land area. Most of the federal land is within the Okanogan and Wenatchee National Forest. Other large federal land holdings include the U.S. Army Yakima Training Center, a portion of the Department of Energy Hanford Nuclear Reservation, and Bureau of Land Management lands. Other public ownership (state, county, and local governments) total over 400,000 acres. The entire Yakima Basin lies within areas either ceded to the United States by the Yakama Nation or areas reserved for the use of the Yakama Nation. The Yakama Reservation occupies about 40 percent of Yakima County and about 15 percent of the basin (YBFWPB 2004).
Land use above the confluence of the Naches and Yakima rivers is dominated by timber production, grazing, and recreation. The area below the confluence is dominated by intensive irrigated agriculture. Ahtanum Creek is the only major tributary below this confluence known currently to support spawning bull trout. Migratory bull trout have been located as far downstream in the mainstem of the Yakima as Benton City, and are known to use the Mainstem Columbia River as for foraging, migration, and overwintering.

At the time of listing, the Service considered a bull trout "sub-population" to be "a reproductively isolated group of bull trout that spawns within a particular area of a river system." During the recovery planning process, the Service discontinued use of the term "sub-population" in favor of the term "local population" which we define similarly as "a group of bull trout that spawn within a particular stream or portion of a stream system;" a local population is considered to be the smallest group of fish that is known to represent an interacting reproductive unit. Resident and migratory (both fluvial and adfluvial) bull trout are found throughout the Yakima Core Area. Bull trout in the Yakima Core Area are currently distributed in 16 local populations:

1. Mainstem Upper Yakima River (Keechelus Dam to Easton Reach for spawning, with some migration/overwintering in lower Yakima)
2. Ahtanum Creek (North, South, and Middle Forks)
3. American River (Union and Kettle creeks)
4. Bumping River
5. Deep Creek (Bumping Lake)
6. Rattlesnake Creek
7. Crow Creek
8. North Fork Tieton River (Rimrock Lake)
9. South Fork Tieton River (Rimrock Lake)
10. Indian Creek (Rimrock Lake)
11. Teanaway River and tributaries (North Fork Teanaway)
12. Box Canyon Creek (Kachess Lake)
13. Upper Kachess River - including Mineral Creek (Kachess Lake)

14. Gold Creek (Keechelus Lake)
15. Cle Elum River (including Cooper River and Cooper Lake)
16. Waptus River and Waptus Lake

Taneum Creek, in the upper Yakima River, is a location where bull trout reintroduction is expected, potentially creating the seventeenth local population in the core area (see the draft Bull Trout Recovery Plan for more detailed information).

2.2.1.1 *Conservation Role of the Yakima Core Area*

The Yakima core area may play a central role in the conservation of the Columbia River interim recovery unit of the bull trout. Not all of the information necessary to definitively determine the appropriate conservation role of this core area is available, but a reasonable working hypothesis can be deduced from what is known. Geographically, this core area is the largest in the Columbia River interim recovery unit in Washington State, and among the largest in the entire unit. Simply by virtue of its large size, the Yakima core area plays an important role in maintaining the spatial distribution of bull trout within the unit.

Not only is the Yakima core area large in size, it is also located at a major intersection in the Columbia basin, where the upper Columbia and Snake River evolutionary groups meet (see Spruell et al. 2003). The Yakima core area may be part of a "mixing zone" between these areas in terms of demographic and genetic exchange (USFS 2004, p. 6; Ardren at al 2011, p. 520-521). This raises the likelihood that the Yakima core area may have a distinctive genetic background, containing elements from both of these adjacent lineages. If the Yakima core area proves to be a repository of rare alleles or unusual combinations of loci from different lineages, this core area could be essential for maintaining genetic diversity within the unit.

From a demographic perspective, the Yakima River was historically among the most productive sub-basins for anadromous salmon in the Columbia basin. Before 1850, an estimated 500,000 to 900,000 salmon and steelhead returned annually to the Yakima basin (YSF&WPB 2004). Since that time, sockeye, summer Chinook, and coho salmon have been extirpated, coho have been reintroduced, and in the last 10 years, the largest total runs including all species have been less than 30,000 fish (YSF&WPB 2004). No estimates of historic bull trout abundance are available, but high productivity of anadromous salmon and the presence of several natural lakes that could support adfluvial life-history strategies suggest that migratory bull trout populations historically were also large and prolific. The Yakima core area had the biological potential to serve as a source population exporting migratory emigrants to smaller and less stable core areas in both the upper Columbia and Snake River basins. Movements of this scale are within the range of migration distances documented by recent telemetry studies (e.g., BioAnalysts 2004). Providing gene flow between the major evolutionary lineages and demographic support to less productive core areas in the vicinity may have been the historic roles of the Yakima core area in the unit. This hypothesized reference condition could suggest the appropriate conservation objective for the Yakima core area in the recovery of the Columbia River interim recovery unit.

If these hypothesized roles of the Yakima core area are correct, extirpation or functional extirpation of bull trout from this core area could have negative consequences for the distribution, numbers, and reproduction of the Columbia River interim recovery unit. A large gap would be present at a central location in the unit. This gap would exceed the distance that

bull trout typically move during migration. Natural recolonization of the Yakima core area would require exceptional movements by fish from surrounding core areas, making management intervention (reintroduction) the only option for restoring bull trout to the Yakima with a reasonable likelihood of success in the foreseeable future. If native Yakima bull trout have unique genotypes, extirpation would reduce genetic diversity. If native Yakima bull trout are also locally adapted, reintroduced fish may not be as productive as the native population, or achieving successful reintroduction may be challenging. Genetic exchange between the upper Columbia and Snake lineages would be curtailed, and would only occur through management intervention, such as translocating spawners. Core areas within migratory distance of the Yakima that may historically have benefited from demographic support from this population would now be more isolated and deprived of demographic and genetic inputs, likely diminishing the probability of persistence of these core areas. All of these outcomes are contrary to the recovery goals and objectives in the Service's draft recovery plan.

The current status of a bull trout at the core-area scale can be summarized based on the seven Pathways in the MPI: 1) population characteristics, 2) water quality, 3) habitat access or connectivity, 4) habitat elements, 5) channel condition and dynamics, 6) flow/hydrology, and 7) watershed condition. Each of these pathways is described specifically for the Yakima core area in the following sub-sections. We conclude our summary assessment of baseline conditions by reviewing both positive and negative factors affecting the quality and quantity of bull trout habitat in the Yakima core area, and by listing the most potent threats to the persistence of bull trout in the core area.

2.2.1.2 *Population characteristics*

Historically, bull trout occurred throughout the Yakima River basin. Although a large number of bull trout local populations are still widely scattered across the basin, currently they are fragmented into isolated local units. Among the 16 local populations, most are isolated above impassible dams with limited, one-way, downstream export of individuals, or they are connected to only one or two other local populations. Survival rates of bull trout passing downstream through these dams are unknown, but high rates of mortality have been documented for other species. Historic patterns of seasonal migration, as well as demographic and genetic exchange among local populations, have been severely curtailed by barriers resulting from human activities during the last century.

The Yakima Core Area includes long sections of FMO habitat in the mainstem Yakima River, including connections to the Columbia River. Historic conditions provided access to many large wetland and lake habitat features that bull trout could choose to use as FMO habitat. Historically, bull trout could have migrated upstream or downstream from these lakes to spawning habitat. Currently, passage barriers, including five major BOR irrigation reservoirs, limit access to both spawning and FMO habitat.

2.2.1.2.1 *Number and Distribution of Local Populations*. Because of anthropogenic changes and the lack of migratory connectivity between most local populations in the Yakima Basin, the approximately 16 existing local populations currently function as, at most, nine reproductively isolated populations.

In the Tieton drainage above the Tieton Dam, local populations of bull trout are found in the South Fork Tieton River (including Bear Creek), North Fork Tieton River, and Indian Creek. These local populations most likely originated from native fluvial bull trout in the Tieton River. Construction of the Tieton Dam in 1925 forced bull trout in these local populations to adopt an adfluvial life-history pattern. In the South Fork, juvenile bull trout have been observed in several tributaries including Short and Dirty, Grey, Spruce, and Corral Creeks. In the North Fork, information about the bull trout local population is very limited. Catch records for Clear Lake on the North Fork Tieton documented bull trout presence in the 1950's. In 1993, U.S. Forest Service staff reported capturing one 75 to 100 millimeter (3 to 4 inch) bull trout from a minnow trap in Clear Lake. In addition, biologists from Central Washington University observed an adult bull trout in the upper North Fork Tieton River in 1996. Interagency surveys located both adult migratory bull trout and one redd in the North Fork Tieton River in 2004 and over 37 redds in 2007.

Below the Tieton Dam, bull trout also have been found in the Tieton River. Whether these bull trout represent a self-sustaining local population or are primarily fish that passed through the dam and cannot return upstream is unclear. These fish emigrate to other local populations (e.g., Rattlesnake Creek, American River) to spawn and have been shown to migrate into other areas (Mizell and Anderson 2006; WDFW 2008).

Within the Naches system, other bull trout local populations have been identified in Rattlesnake Creek (including Little Wildcat Creek), American River (including Union and Kettle creeks), and in the Little Naches River in Crow Creek. Bull trout greater than 500 mm (20 inches) in length have been observed spawning in the American River (WDFW 1998), indicating these are migratory individuals.

In the Bumping River, adfluvial bull trout spawn in Deep Creek and rear and mature in Bumping Lake. The local population in Deep Creek probably originated from a native adfluvial life-history form that used the natural lake which was enlarged by dam construction in 1910. Construction of the dam enlarged the natural lake and forced any fluvial bull trout to adopt an adfluvial life history. While Deep Creek is the only identified local population above Bumping Lake, the U.S. Forest Service reported a single redd with three bull trout in the upper Bumping River in 1994. A bull trout redd was seen in the Bumping River during a U.S. Forest Service snorkel survey in September 2003 and juveniles were seen in another snorkel survey in September 2002. Bull trout also have been found in the Bumping River (below Bumping Lake). Like the bull trout found below Rimrock Lake, the life history and likely spawning locations of these individuals is unknown.

Shifting to the Yakima River sub-basin, the Teanaway River is the first major tributary above the confluence with the Naches River that supports bull trout. The bull trout local population in the Teanaway River is found primarily in the North Fork Teanaway River and in DeRoux Creek. Bull trout in the North Fork Teanaway River are likely a mix of both small resident forms and larger fluvial forms. Adult and juvenile sized bull trout have also been observed in Jungle and Jack Creeks. Although habitat appears to be suitable for bull trout in the West and Middle Forks of the Teanaway River, no bull trout have been found in these streams. Limited spawning has

been detected in past surveys, and the last time a redd was observed was in 2009, when only a single redd was detected. Subsequent surveys have not found any redds (Table 2.1).

In the Kachess River, bull trout local populations above Kachess Dam probably originated from a native adfluvial life-history form, which was present in the existing lake before the construction of the dam in 1905. Local populations identified by the Middle Columbia Bull Trout Recovery Team in this area include Box Canyon Creek and the upper Kachess River. However, some spawning may occur in Mineral Creek when adequate flows are available.

Similar to Kachess Lake, bull trout in Keechelus Lake most likely originated from a native adfluvial life-history form which was present before the construction of the dam and irrigation reservoir in 1914 (which modified the natural lake). Spawning by this local population currently occurs only in Gold Creek. Anecdotal reports indicate that bull trout may have been present in Rocky Run Creek in the early 1980's. Surveys following the protocol to detect bull trout developed by the Western Division of the American Fisheries Society, in cooperation with the Service were conducted in 2001 (Jones and Stokes 2002a). No bull trout were detected. In 2005, a bull trout was located in Cold Creek, below the barrier culvert. Recent monitoring efforts have also found juvenile bull trout in Coal Creek (P. James, Central Washington University, personal communication).

The Middle Columbia Bull Trout Recovery Team has identified two local populations above Cle Elum Dam; one using Cle Elum mainstem and its tributaries and the other associated with Waptus Lake and River system. These populations may be separated due to distance and geologic landform and/or thermal barriers. A waterfall located on the lower Waptus River between Waptus and Cle Elum lakes may act as a barrier to bull trout migration between the two systems. Additional surveys are needed to determine if additional local populations exist in the Waptus River system. Similar to other areas within the Yakima Core Area, these bull trout most likely originated from a native adfluvial life-history form which was present before the construction of Cle Elum dam in 1931. Construction of the Cle Elum Dam enlarged the natural lake and forced any fluvial bull trout present to adopt an adfluvial life-history pattern. Catch records collected from anglers indicate that bull trout were present in Waptus Lake in the 1940s and early 1950s. Washington Department of Fish and Wildlife (WDFW) biologists confirmed the continued presence of bull trout in Waptus Lake by capturing a single juvenile fish in a gill net in 1996 and a large adult bull trout in 1997.

Radio-telemetry studies conducted outside the Yakima Core Area have shown that bull trout tagged in the mainstem Columbia River move long distances into tributaries to spawn. Thus, it is possible that the bull trout in the Yakima Core Area could migrate to both the lower portion of the Yakima River and the Columbia River, especially to use these areas as overwintering habitat. Telemetry studies in the Yakima basin have found bull trout tagged in the Tieton River, Naches River, and Bumping River overwintering in sections of the mainstem lower/middle Naches and in the Yakima River mainstem down to Ahtanum Creek (Mizell and Anderson 2006). Evidence of bull trout use of the lower Yakima River mainstem is more anecdotal. One bull trout was caught by a WDFW biologist doing surveys near Toppenish in 2003. Another bull trout was tagged with a telemetry transmitter at Rosa Dam, just upstream of the Naches River confluence in 2004. Bull trout have also been observed in the mainstem Columbia River both upstream and

downstream of the Priest Rapids Dam and sub-adults have been observed within the fish ladders at both Wanapum and Priest Rapids Dam (USFWS 2007). The Yakima River core area is the most likely source of these individuals.

A recent restoration planning effort for the Yakima Basin described bull trout metapopulation dynamics as they apply to this Basin (YBTAP 2012, pg. 31-32), which we summarize here. The concept that regional populations of a species may persist in variable environments as collections of local populations interacting through dispersal (Hanski and Simberloff 1997) has been widely accepted by biologists and managers. Salmonids, including bull trout, appear to have a metapopulation structure because spawning and rearing habitats are usually spatially discrete. Also dispersal patterns, local environmental variability and disturbance regimes often create a patch dynamic described by metapopulation models (Rieman and McIntyre 1993; Rieman and McIntyre 1995; Dunham and Rieman 1999).

However, the results of genetic studies suggest that strong natal site fidelity in bull trout limits dispersal between local populations. Strong population structure is shown in almost all genetic studies of bull trout local populations, including the Yakima Basin (Spruell et al. 1999; Costello et al. 2003; Small and Martinez 2011). In the short-term, low levels of exchange of individuals among populations may limit source-sink" metapopulation dynamics or successful recolonization after extirpation events. Over many decades or centuries, however, dispersal rates are likely high enough to re-establish extirpated populations or provide an important influx of genes (Rieman and Dunham 2000). But successful dispersal, even over a long timeframe, requires populations large enough to support some degree of straying.

In the Yakima Basin, large populations are few and isolated above dams. In the Naches River subbasin, the three strongest local populations (South Fork Tieton River, Indian and Deep creeks) exist above two storage dams (Tieton and Bumping). If fish passage were restored at either of these dams, it would be reasonable to assume that metapopulation dynamics and recolonization potential would be strengthened, as would individual population resilience. In the upper Yakima River basin, however, the remaining bull trout populations have poor abundance trends (Gold and Box Canyon creeks and Kachess River), and several populations are clinging to existence (Cle Elum, Waptus, and Teanaway rivers). Given current conditions, even with restored fish passage at the upper basin storage dams, there may not be enough individual bull trout to ensure dispersal and recolonization without significant improvements in the size of the local populations.

2.2.1.2.2 *Adult Abundance.* Abundance of bull trout in the Yakima Core Area has been tracked primarily through redd surveys conducted on index reaches in spawning areas. Redd surveys are commonly used as an index of local abundance, with the accuracy of this index dependent on rigorous standardization of survey procedures (Dunham et al. 2001). Comparable data from redd surveys for most of the local populations in the Yakima core area are only available between 1999 and 2012. During this period, redd counts have been variable. The number of redds in the Yakima Core Area ranges from a high of 795 in 2009 to 457 in 2005 (Table 2.1). Since 1999, the annual average number of redds in the Yakima Core area is 610 redds. Fisheries biologists familiar with the Yakima core area think that the number of redds in the Yakima core area is low relative to the amount of habitat available. For this summary, we do not expand the redd count

index to estimate number of adult bull trout; instead we make comparisons based on the index. Since our original biological opinion for the I-90 Snoqualmie Pass East project in 2008, redd counts have consistently exceeded the long term mean by 100 to more than 150 redds (Table 2.1).

At the time of listing, bull trout populations were considered at risk of extirpation from naturally occurring events if they were (1) unlikely to be reestablished by individuals from another sub-population (i.e., they are functionally or geographically isolated from other sub-populations), (2) limited to a single spawning area (i.e., spatially restricted), and either (3) characterized by low individual or spawner numbers or (4) primarily of a single life-history form (63 FR 31649). All local populations of bull trout in the Yakima Basin meet one or more of the four factors listed above that increases risk of extirpation. At the time of listing, only the Rimrock Lake sub-population (i.e., Indian Creek and South Fork Tieton River local populations) of bull trout was considered stable; the remaining sub-populations within the Basin were classified as depressed and declining (63 FR 31647). The population status for the Naches River bull trout sub-population was classified as unknown. With the exceptions of Rimrock Lake and the Naches River, the remaining sub-populations were considered to be at risk of extirpation. All local population in the Yakima Core Area, including the two largest populations in the basin (South Fork of the Tieton River and Indian Creek), have effective population sizes which are small enough to categorize as being at high risk of deleterious genetic effects associated with small populations over the medium and long-term. Redd counts are so low for Ahtanum Creek, and for all bull trout populations in the upper Yakima arm (especially the Teanaway and Cle Elum local populations), that they are at high risk of extirpation in the short-term or may already be extirpated. See Appendix 2A for more information about small population effects.

Table 2.1. Redd counts for bull trout populations in the Yakima Basin, 1999–2012.

	Year														
Location	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Avg
Keechelus to Easton		2	1		1			3	1				0		**1**
Ahtanum Creek															
N.F. Ahtanum Cr.	7	11	20	17	12	8	6	7	8	1	3	0	1	2	**7**
M.F. Ahtanum Cr.	0	10	1	6	8	11	5	6	5	3	9	15	11	8	**7**
S.F. Ahtanum Cr.		5	14	13	7	5	3	4	5	3	6	2	4	2	**6**
Naches River															
Rattlesnake Cr.	44	45	57	69	54	32	15	40	13	37	36	64	42	42	**42**
American R.	30	44	36	27	30	40	35	55	31	22	39	47	40	54	**38**
Crow Cr.	19	26	6	9	9	6	4	8	8	2	5	9	7	9	**9**
Rimrock Lake (isolated by dam)															
S.F. Tieton R.	161	144	158	141	178	178	205	189	152	266	259	194	234	226	**192**
Indian Cr.	205	226	117	100	101	50	91	106	58	130	200	144	147	174	**132**
N.F. Tieton (above Clear Lk)						1		1	37	28	15	18	11	17	**16**
Bumping Lake (isolated by dam)															
Deep Cr.	107	147	51	120	57	97	73	95	130	145	178	199	192	169	**126**
Bumping River		0				0			0	0	2	0	0	0	**0**
Yakima River															
N.F. Teanaway R.							2	1	0	0	1	0	0	0	**1**
Kachess Lake (isolated by dam)															
Box Canyon	17	10	14	15	8	19	8	8	2	8	21	30	31	9	**14**
Kachess River		15	14	0	16	8	3	0	22	2	2	15	33	8	**11**
Keechelus Lake (isolated by dam)															
Gold Cr	40	19	15	31	9	20	7	8	6	40	29	23	7	7	**19**
Cle Elum & Waptus watershed (isolated by dam)	0	0	0	0			0	0	0	0	0				**0**
Grand Total Redds	630	702	503	548	489	475	457	528	477	687	795	760	760	727	**610**

2.2.1.2.3 *Population Growth and Survival (productivity).* Because estimates of total population size are rarely available, the productivity or population growth rate for bull trout is usually estimated from temporal trends in indices of abundance at a particular life stage, such as redd counts being used to estimate adult abundance. The direction and magnitude of a trend in the index can be used as a surrogate for the growth rate of the entire population. For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time.

Thirteen years of consistent data have been collected in the same stream reaches among all local populations in the Yakima Core Area. This relatively short time-series in combination with high interannual variation makes detection of trends in productivity difficult. Overall, the population trend for the Yakima Core area since 1999 is unstable, possibly reflecting uncorrelated temporal variation among the isolated local populations.

Fisheries management in the Yakima core area has also had detrimental effects on bull trout. Heavy sport angling pressures occur in parts of the Yakima core area due to a combination of rainbow trout stocking, high catch limits, fishing regulations that allow the use of bait, and easy public access to the mainstem and tributaries. Because bull trout are aggressive feeders and highly susceptible to sport fishing, incidental catch of bull trout and associated injury and mortality has probably reduced survivorship of adult fish. In addition, poaching has been documented or suspected in Gold Creek, Box Canyon Creek, Deep Creek, South Fork Tieton River, and Indian Creek. Several non-native fish species have been introduced to the Basin, and some continue to be stocked to support sport fisheries. Introduced species include brook trout, brown trout, lake trout, bass, catfish, bluegill, sunfish, and crappie. All these have likely adversely affected bull trout populations through a combination of hybridization, competition, and predation.

In general, a positive relationship exists between heterozygosity and productivity of fish populations (e.g., Allendorf and Leary 1986). Genetic analyses that have been conducted on bull trout in the Yakima core area yielded divergent results regarding heterozygosity, with one study finding low levels of expected heterozygosity (Reiss 2003) and the others finding generally high levels (Hawkins and Van Bargen 2006, Small et al. 2009). These differences may reflect different methods and scales of analysis. Given the small size of several local populations and corresponding high potential for levels of inbreeding that reduce heterozygosity, it is likely that inbreeding is contributing to some reductions in productivity in small, isolated, local populations, such as those in the upper Yakima sub-basin.

A potentially positive aspect of reservoir development in the Yakima core area is an increase in the area of lake habitat available for foraging and overwinter residence for bull trout. Stocking of some prey species in these lakes, such as kokanee, may have contributed to foraging opportunities for adult bull trout using these lakes. However, construction of impassable dams and other development in the Yakima basin contributed to the extirpation of native sockeye and coho salmon populations and declines of other anadromous salmon runs to remnant levels (YBTAP 2012). It is unclear if stocking of kokanee and other species replaces the prey base formerly provided by juvenile anadromous salmonids and the marine-derived nutrients they contributed to the basin.

2.2.1.2.4 *Summary of Population Characteristics*. Historically, the bull trout occurred throughout the Yakima River Basin. Now populations are fragmented and isolated, and most are located above impassable dams, and therefore do not have access to most of their historic habitat. Lack of bull trout detections in some local populations suggests that extirpation may be imminent or may already have occurred. The conservation status assessment conducted as part of the bull trout 5-year review found that the Yakima core area is at "High Risk"; meaning that extremely limited and/or rapidly declining numbers, range, and/or habitat, is making the bull trout in this core area highly vulnerable to extirpation (USFWS 2008, pgs. 29-30).

2.2.1.3 *Habitat Characteristics*

At the core area scale, we describe baseline conditions using the Pathway categories in the MPI. This approach provides what we consider to be an appropriate level of detail for characterizing habitat conditions used by the metapopulation of bull trout in and near the action area.

2.2.1.3.1 *Water Quality*. Throughout the irrigation season, the lower Yakima River (downstream from Granger, RM 82) receives large volumes of warm, sediment- and pollutant-laden water from irrigation effluents (Johnson et al. 1986). Diminished stream flows in the Lower Yakima and Naches rivers during the irrigation season, combined with high air temperatures, degraded riparian vegetation, and development on floodplains, all contribute to extended river reaches with water temperatures that exceed the physiological tolerances of native salmonids (Yakima Basin Fish and Wildlife Recovery Board [YBFWRB] 2006). These conditions are well tolerated by native and non-native predatory fish and serve to increase their foraging efficiency. Additionally, poor water quality conditions in the Lower Yakima River can lead to increased mortality rates in native anadromous smolts and bull trout from water-borne pathogens. High water temperatures persist in the lower Yakima River throughout the irrigation season (YBFWRB 2006).

Water quality conditions throughout the Yakima subbasin are severely impaired along many reaches of the Yakima River and its tributaries largely because of flow regulation, irrigated agriculture, and general floodplain development (YBFWRB 2006). The Washington State Department of Ecology (WDOE) has placed 67 watercourse segments throughout the Yakima Basin on the most recent 303(d) list (2012) of threatened and impaired waterbodies (WDOE 2012). Primary impairments leading to these listings included increased temperatures, high agricultural pollutant concentrations (e.g., 4,4'-DDE, DDT, dieldrin, 4,4'-DDD, chlorpyrifos, endosulfan, and PCB), dissolved oxygen deficits, and a host of other water quality constituents (e.g., arsenic, mercury, silver, fecal coliform, pH, ammonia, chlorine, turbidity, and phosphorous) that are generally detrimental to fish health and persistence (Johnson et al. 1986).

Bull trout require cold stream temperatures for successful spawning. Throughout the Yakima Basin, over 45 streams have been listed on the 303(d) list of impaired waterbodies due to elevated temperatures. These waterbodies include most of the streams inhabited by local populations of bull trout. Craig (1997) found that streams in the Yakima River basin with more than 20 redds had a 7-day summer mean temperature below 12 °C, and no single day with a temperature > 14.8 °C.

Accelerated sedimentation impairs the growth, health and survival of salmonids (Newcombe and Jensen 1996, Suttle et al. 2004). Approximately 90 percent of the turbidity and suspended sediment in the Yakima River mainstem below Easton Dam are human-produced, and therefore remediable (Creech and Joy 2002). Operation and maintenance activities of the Bureau of Reclamation's Yakima Project have altered the timing, volume, and magnitude of sediment movement in the river through modification of the magnitude and timing of river flows. Irrigation drain maintenance, including dredging and flushing, has also contributed sediment and associated pollutants to the Yakima River system. Based on data collected during the 1995 irrigation season, Joy and Patterson (1997) found that Moxee Drain contributed 35 tons per day of sediment to the lower Yakima River in the latter part of the irrigation season. For comparison, the Naches River (largely unregulated above the Tieton River confluence) contributed only 27 tons per day during this same period, even though average discharge in the river was 14 times greater than in the drain. Also during this same period, other gauged drains (Spring, Snipes, Sulphur, and Granger creeks) produced an average contribution of 116 tons of sediment per day to the lower Yakima River.

Significant total suspended sediment reductions have been realized since the 1997 assessment as a result of a water quality improvement program implemented by the Roza and Sunnyside Divisions. The sediment input from the Granger and Sulphur Creek drains has been reduced by more than 95 percent (Stanford et al. 2002). This progress is encouraging, but other drains and tributaries continue to contribute large amounts of agriculturally-derived fine sediments to the Yakima River and its tributaries. Although not included on the published Washington State 303(d) list for 1998, Creech and Joy (2002) found that the mainstem Yakima River between Lake Easton and Cle Elum, and from Ellensburg to the Naches River exceeded the state water standards for turbidity. Both of these reaches also contained high levels of suspended sediments (Creech and Joy 2002).

In addition to the direct negative effects of accelerated sedimentation, both turbidity and sediments provide a surface that can absorb or adsorb pollutants. In Yakima basin streams, most of the pesticide t-DDT (total DDT; i.e. the sum of DDT, DDE, and DDD concentrations) is transported by suspended sediment (Joy and Patterson 1997, Creech and Joy 2002). Joy (2002) determined that turbidity and suspended sediments persist for sufficient duration to cause harm to salmonids in the upper Yakima River mainstem.

Sedimentation can also contribute to reductions in invertebrate abundance and diversity, which reduces prey availability for bull trout. The lower Yakima contained noticeably lower numbers of mayflies, caddisflies, and stoneflies than the upper Yakima and no stonefly larvae were found in the mainstem Yakima River (Cuffney et al. 1997 in Snyder and Stanford 2001).

Ebbert and Embrey (2001) found a total of 25 pesticide compounds at 34 sites (including both surface and groundwater) across the Yakima basin, with the highest pesticide detection frequencies and concentrations occurring during the irrigation season. Within the basin, several studies have documented pesticide levels that exceed Environmental Protection Agency or WDFW guidelines to protect wildlife populations from chronic carcinogenic risk, and other investigations have documented the presence of physical abnormalities on fish collected from agricultural drains and the lower Yakima River (Johnson et al. 1986, Cuffney et al. 1997, Morace

et al. 1999). Morace et al. (1999) found that the biological impacts of agriculture were manifested by a decrease in the abundance and diversity of native species of fish and invertebrates and a shift in algal communities to high abundances of species indicative of eutrophic conditions. There was also an increase in the abundance and number of non-native fish species that are largely tolerant of nutrient-rich conditions (Morace et al. 1999). Mainstem Yakima River locations downstream from the City of Yakima exhibited the severe impairment of fish communities that is typically associated with high levels of pesticides in fish tissues (Morace et al. 1999). Endosulfan (an organochlorine pesticide), chlorpyrifos and malathion (organophosphate pesticides), dieldrin (a cyclodiene insecticide), Atrazine (a restricted-use herbicide), and acrolein (an herbicide) are all known to have harmful effects to fish, and all of these have been detected in Yakima basin waterbodies at levels exceeding 303(d) criteria.

High concentrations of DDT (and its degradates DDE and DDD) have been detected in fish from the Basin; these concentrations are the highest reported in the United States (Rinella et al. 1992; 1993; USGS 2002). Reported levels of *t*-DDT (total DDT) have ranged from undetectable to over 3000 *u*g/kg in fish tissue from the Yakima River (Johnson et al. 1988). The national standard for fish tissue is 1000 *u*g/kg (USGS 2002). Effects of these contaminants on fish include abnormal behavior (leading to increased predation), increased egg and fry mortality, possible carcinogenic effects, and teratogenic impacts (Extoxnet 1996, Centers for Disease Control 2002). DDT (primarily in the form of *p,p'*-DDE) has been reported throughout the Yakima River (WDOE 2012, Ebbert and Embrey 2001). Overall, DDE was detected in over 50 percent of the samples tested. The concentrations reported ranged from a minimum of six times the EPA chronic-toxicity guideline to as much as nine times the permitted levels (Ebbert and Embrey 2001).

DDT, DDE, and DDD are released back into the water column every time a pulse of water is sent through the system because these compounds are stored in or attached to sediments. Such pulses are typical due to operations of the storage reservoirs in the Basin. Because: (1) bull trout may be present in the lower Yakima at any time; (2) the lower Yakima River is used as a migration/dispersal corridor and for foraging and over wintering by bull trout; and (3) female fish likely contain developing eggs at the time of migration through the lower Yakima River, we conclude that it is reasonably certain that negative impacts from these chemicals to both adult and larval bull trout have, and continue to, occur from BOR Project activities.

Manipulations of the flow regime in the Basin also indirectly affect dissolved oxygen (DO) concentrations. Many waterbodies in the Basin are on the 303(d) list for low DO. Because salmonids are known to avoid areas with low DO and the lower Yakima River is a migration/dispersal corridor for bull trout, low DO levels likely trigger some degree of avoidance behavior in bull trout that attempt to migrate upstream through these reaches. This influences the distribution, reproduction, numbers, and (in the long-term) decreases the likelihood of persistence of affected bull trout populations.

Contaminants, other than pesticides, also have negative impacts on bull trout. Effects of selenium on fish include gross embryo deformities, growth inhibition, depressed immune response, mass wasting, changes in blood parameters and tissue structure, edema, reduced activity and feeding, reduced survival, and mortality (Hamilton and Wiedemeyer 1990). Much

of the upper sub-basins (Cle Elum, Upper Naches, Teanaway, and Tieton) contain naturally occurring selenium, with dairy farms that use selenium-supplemented feed and mining operations adding to the total load (Fuhrer et al. 1987). Higher levels of cadmium, mercury, as well as selenium were found in fish tissues from the lower mainstem of the Yakima River than from the upper sub-basins. There is a statewide fish consumption advisory for children and women and childbearing age due to mercury accumulation in fishes.

In addition to the presence of chemical contaminants, other aspects of water chemistry such as pH are degraded in the Yakima Basin. Eleven percent of the 856 pH measurements from 143 sites sampled in the Basin during the 1986 to 1991 water years did not meet State water quality criteria (WDOE 1998, 2002). Ninety-seven percent of these sites had pH values greater than 8.5, outside of the range normally experienced by the aquatic community (6.5-8.5) (WDOE 1998). Values outside of the normal range for aquatic life may seriously depress the food base for bull trout. Elevated pH may also delay pesticide decomposition, alter nutrient uptake, and synergistically interact with pesticide and heavy metals to weaken and kill salmonids (Kentucky Water Watch 2004, McKie and Johnson 2004).

Reductions in riparian areas in much of the Basin (up to 50 percent in some areas) have reduced the ability of these areas to filter excess nutrients running off of adjacent agricultural and residential areas. Excessive nitrogen (in the forms of ammonia-N) levels have been reported for Crystal Creek, Selah Ditch, upper mainstem Yakima River, Granger Drain, and lower mainstem Yakima River (WDOE 2012).

2.2.1.3.2 *Habitat Access or Connectivity*. Connectivity among patches of suitable habitat is another essential conservation need of bull trout. Passage impediments, however, challenge native salmonids across the Yakima subbasin. Access to upstream tributary habitats can be blocked by constructed barriers such as road or pipeline crossings and diversion dams, or by depleted stream flow below diversions (YBFWRB 2006). At some diversions with fish ladders (Roza, Sunnyside, and Prosser dams), seasonal operations at can hinder adult upstream movement during critical migration periods, or completely block access when upstream storage is predicted to be insufficient (Easton Dam). Furthermore, hydropower wasteways such as Roza Power Plant Wasteway, and irrigation drainage features such as Sulphur Creek Wasteway, and Moxee and Granger Drains, which are connected to the Yakima River and its tributaries, discharge false attraction flows that can entrain or confuse migrating fish. Exposure to adverse water quality constituents for fish entrained into these watercourses might significantly decrease their chances of spawning successfully later.

Population genetic studies indicate little gene flow among most local populations of bull trout in the Yakima core area. The genetic structure of twelve spawning populations of bull trout within the Yakima core area has been examined in two studies; one using six polymorphic microsatellite loci (Reiss 2003) and a second using sixteen loci (Hawkins and Van Bargen 2006, Small et al. 2009). Both studies found high variability among populations (e.g., FST = 0.217; Reiss 2003), except among fluvial populations that are not separated by migration barriers. In addition, one population from Rimrock reservoir had similar gene frequencies, possibly reflecting historical connectivity with the fluvial populations (Reiss 2003). In the two reservoirs that contained more than one population, the local population in each spawning stream was

genetically distinct. Several approaches to phylogenetic analyses all suggested that local populations in Ahtanum Creek and the North Fork Teanaway Rivers are highly differentiated from other populations in the Yakima subbasin, suggesting these populations may be composed largely of resident individuals (Small et al. 2009, pg. 10). Likewise, in the Naches subbasin, bull trout from Deep Creek, isolated above Bumping Dam, are highly distinct from the other local populations in the subbasin (Small et al. 2009, pgs. 10 – 11).

Telemetry studies of fluvial and resident bull trout also have provided insights about connectivity among populations, population movement patterns, habitat preferences, and over-wintering areas (Mizell and Anderson 2006). The main populations of the Naches River [Tieton (Clear Creek, Indian Creek, S.F. Tieton), Rattlesnake Creek, Bumping River, Crow Creek, American River, Kettle Creek and Union Creek] exhibit nearly identical over wintering behavior in the mainstem Naches River, but timing varies significantly among populations (Mizell and Anderson 2006). Over wintering occurs in several deep pools where the populations intermingle over the winter months, then separate-out for spawning. Across local populations, spawning site fidelity was found to be at or near 100%, supporting the results of genetic analyses. The Ahtanum population was found to be isolated or semi-isolated from the remainder of the Yakima Basin, and the populations in each of the three forks of the Ahtanum are very nearly isolated from each other (Mizell and Anderson 2006). Bull trout in the Naches River move upwards in the main stem Naches in the early summer, before temperatures in the lower river rise sufficiently to be an impediment to migration (Mizell and Anderson 2006). Habitat choices seem to be driven more by velocity than by riparian cover, with tagged bull trout choosing water velocities where cover was provided by surface obfuscation and where prey was readily available (Mizell and Anderson 2006).

Telemetry studies in the upper Columbia River core areas have found some individual bull trout moving between core areas. Whether these migratory individuals spawned successfully and contributed to gene flow among core areas is unknown. Telemetry studies in the Yakima core area have not yet found a similar pattern of inter-core area movement.

An assessment of bull trout population genetic structure at the scale of the entire Columbia Basin indicated some apparent relationships among populations in the Yakima River, Upper Columbia River, and the Snake River (P. Spruell, pers. comm. 2004). Some populations in the Yakima River also were found to have unique genetic characteristic (Y. Reiss, pers. comm. 2004). Additional information about the potential for gene flow between the Yakima Core area and other core areas in the vicinity is needed.

Passage barriers within the Yakima Core Area have fragmented the bull trout metapopulation and limited migration to high quality spawning, foraging, and overwintering habitat. Of the 16 identified local populations, 12 are either completely or partially isolated. Across the core area, low numbers of migratory bull trout accompanied by lack of passage, limits the potential for genetic exchange and the reestablishment of local populations if local extirpation occurs. Fragmentation of the metapopulation is among the most potent threats to the persistence of the Yakima core area.

2.2.1.3.3 *Habitat Elements*. Large woody debris (LWD) is an integral component of productive aquatic habitat. In the Yakima core area, BOR Project operations and maintenance have impaired the recruitment of LWD in a number of ways. First and most obvious, headwater source areas are removed from the river continuum by storage dam embankments on the Yakima, Kachess, Cle Elum, Tieton, and Bumping Rivers. Further down the system, diversion structures impede the transport of LWD. Secondly, flow regulation and water withdrawals have contributed to impaired floodplain function along alluvial reaches of the river (Snyder and Stanford 2001). Cottonwoods (*Populus* spp.) are the primary species along the alluvial floodplain reaches of the Basin. Their growth and survival are vitally important to the aquatic ecosystem. Very little recruitment to cottonwood stands in the alluvial floodplain reaches of the Yakima and Naches Rivers is occurring primarily as a result of the highly modified annual flow regime of the Basin (Braatne and Jamieson 2001). This, coupled with floodplain disconnection and development, has decreased LWD supply and recruitment. A modeling effort to assess LWD recruitment rated less than half of the riparian areas in the Basin as having good potential (USFS 1996). The reduction in LWD recruitment has altered the structure and function of stream channels in the Basin. Importantly, habitat heterogeneity has been lost and the habitat complexity necessary to support healthy bull trout populations is lacking.

Pools are another important element in the habitat mosaic that allows for the full expression of all life history forms of bull trout (63 FR 31647). They provide important holding and resting areas for adult bull trout (Hoelscher and Bjornn 1989, Pratt 1992), as well as cover and winter refugia for fry and juveniles (63 FR 31647). In the Basin, large numbers of fluvial adult bull trout have often been observed holding in pools prior to spawning (James 2002; Mizell and Anderson 2006).

No comprehensive assessment of pool frequency and quality exists for streams in the Yakima River Basin. McIntosh et al. (1994) compared pool frequency in 80 km (48 mi) of tributaries in the Basin (Taneum Creek, Little Naches River, Rattlesnake Creek, and the American River) from data collected in the 1930s and 1940s, with that collected in 1990-1992. He found that pool frequency had increased in both managed and unmanaged areas. However, none of the surveyed areas were affected by flow regulation and the increases were attributed to a recovery from intensive sheep and cattle grazing that had occurred in the 1880s and early 1900s (McIntosh et al 1994). None of the streams surveyed by the U.S. Forest Service in the upper Yakima watersheds met expected levels of pool frequencies (USFS 1996).

Because the lower Yakima River has been heavily and negatively impacted by sediment deposition from agricultural drains, it is reasonable to assume that pool frequency and quality in the lower river has been significantly diminished. Given that the sources of LWD (a key element in pool formation) have been reduced by Project structures and operations, it is also reasonable to assume that pool frequency and quality have been impaired throughout the Project-affected portions of the Basin.

Off-channel habitat is another important habitat element providing rearing areas and refugia from high flows and predation. Flood control, road building, and bank stabilization projects as well as flow manipulation have isolated, reduced, or eliminated many off-channel habitats throughout

the Yakima Basin (YSF&WPB 2004). Much of what remains is unsuitable due to elevated temperatures or poor water quality (YSF&WPB 2004).

2.2.1.3.4 *Channel Condition and Dynamics*. The width/depth ratios for regulated rivers are generally considered to be highly altered (decreased) from the natural condition because of flood plain development, placement of dikes and revetments, flow regulation, and disruptions of the sediment budget (Leopold et al. 1964, Dunne and Leopold 1978, Alabyan and Chalov 1998). All of these activities have occurred in the Yakima Basin. This situation is further exacerbated by the lack of LWD. Thus, it is reasonable to assume that the width/depth ratio in many reaches of the Yakima River system has decreased, resulting in stream channels that are narrower and incised with increased water velocities. These conditions reduce habitat quality, particularly for salmonids in their early life stages. Several reaches of the Yakima River have been identified where these effects are particularly severe, including those near the cities of Yakima and Ellensburg, and the upper river from the Easton Diversion Dam to the Teanaway River confluence (NPPC 2001).

Throughout the upper Yakima River Basin, relatively recent glacial activity filled valleys with large amounts of gravels, cobbles, and boulders. Vast alluvial floodplains developed, connected via a complex web of braided channels. This geologic template produced a series of alluvial groundwater basins separated by bedrock control points (e.g., Selah and Union Gaps) and canyons (e.g., Yakima Canyon) (Kinnison and Sceva 1963). Alluvial floodplains of this type were also found in varying magnitudes on numerous tributaries to the mainstem of the Yakima River (e.g., the Cle Elum, Teanaway, and Naches Rivers) and share the same composition and hydrologic function. Where alluvial floodplain habitats were once extensive throughout the Yakima River Basin, only a few remnant reaches now remain along the Yakima and Naches rivers (Snyder and Stanford 2001).

Historically, the hydrologic cycle of the Basin was characterized by extensive exchange between surface waters and the shallow alluvial groundwater aquifers (Kinnison and Sceva 1963). Spring runoff (and other high flow events) spread across the floodplain, distributing cold water into side channels that percolated into and recharged the alluvial aquifer. Alluvial aquifers served as hydrologic buffers that returned water to the Yakima River as baseflow later in the season after the cessation of snowmelt runoff. When coupled with an intact floodplain ecosystem, the lower Yakima River was a much different environment than what is observed today. Through annual flow manipulation, the BOR Project has significantly altered the natural hydrologic system within the Yakima River Basin by: (1) significantly reducing the extent of alluvial flood plain habitats and the role of alluvial aquifers in maintaining cold water in streams; (2) altering the runoff regime; and (3) disrupting the longitudinal, vertical, and horizontal connectivity of affected river systems within the Basin.

Many factors have led to the disconnection of alluvial flood plain reaches and the loss of off-channel habitat in the Basin, including: (1) revetments that isolate side-channel habitat; (2) de-watering associated with agricultural practices; (3) chemical and thermal pollution; and (4) extensive gravel mining that has severed extensive groundwater connectivity (Collins 1995; Stanford et al. 2002). Channelization has had significant negative impact to the extent of floodplain connectivity that remains (YSF&WPB 2004).

Significant flood plain encroachment also has occurred in the Basin. On average, 66 percent of five alluvial reaches evaluated have been physically disconnected (Eitemiller et al. 2000). In the upper Yakima Basin, an average of 60 percent of the floodplain has been lost and from 57 to 85 percent of the floodplain in the lower Yakima River has been lost (Snyder and Stanford 2001). These encroachments have eliminated or isolated large areas of side channels and sloughs.

What little functional flood plain that remains has been, and continues to be, affected by BOR Project operations. River operations for irrigation and flood control alter the natural hydrograph by impounding high flow events. A common effect of these operations is a sharp reduction in the frequency with which high flow events recharge the alluvial flood plain aquifer. Truncation of flood peaks by capture in reservoirs also reduces the duration, magnitude, and spatial extent of flood plain inundation. This not only alters the quantity, quality, and timing of groundwater discharge to the river but also diminishes the availability, extent, and temporal duration of off-channel habitats. These changes in the pattern of floodplain inundation also have the undesirable effect of encouraging further commercial and residential development on the flood plain. Flood plain disconnection combined with flow regulation (i.e., the inversion and truncation of the natural hydrograph) have dramatically reduced river flood plain interactions. The result has been a loss of horizontal and vertical connectivity, diminished habitat heterogeneity through the loss of off-channel habitat, and a general loss of ecosystem function.

Due to the detrimental impacts of past and present land use practices and the significant changes in the magnitude and duration of flow regimes, stream bank conditions throughout the Basin are also generally in a degraded condition (Stanford et al. 2002). Mining, logging, grazing, and road building activities have caused stream bank erosion, fine sediment delivery, and loss of riparian function. Accelerated stream bank erosion and fine sediment deposition have been documented in the upper Yakima River watershed (Cole, Gold, Little, and Big Creeks), the upper Cle Elum River watershed, and the South Fork Tieton River watershed (USFS 1998a, b, and 1999 a, b). Degraded stream banks and elevated fine sediment levels have also been reported in the Little Naches drainage (Dawson 1999). Streambank complexity has been greatly reduced in the Tieton and Naches River watersheds (YSF&WPB 2004).

2.2.1.3.5 *Flow/Hydrology*. The Yakima, Cle Elum, Tieton, Bumping, and Naches rivers are manipulated to maximize winter reservoir storage and summer irrigation deliveries according to the seasonal needs of irrigators (YBFWRB 2006). These operations result in streamflows across the subbasin that are mostly out of phase with the life history requirements of native salmonids. Reservoir operations combined with diversions across the Yakima Basin have inverted and truncated the natural pattern of streamflow so that river systems are now spatially and temporally discordant with their surrounding watersheds. The biota of these systems has also suffered because flow regulation patterns are less than optimal for native salmonids (Fast et al. 1991) and floodplain riparian species (Braatne and Jamieson 2001). Summer and fall drawdown of Lake Kachess, Lake Keechelus, and Rimrock Lake (Tieton Reservoir) obstructs or prevent access to tributaries by adult bull trout on spawning migrations and strands juvenile bull trout (YBFWRB 2006).

Below the storage reservoirs, habitat degradation associated with flow regulation has likely adversely impacted bull trout. Several features of the regulated hydrographs for various river reaches in the basin are highly unnatural. With the exception of the upper Naches River (above the Tieton River confluence), the magnitude of flows resulting from rain-on-snow events and snow-melt runoff has been significantly reduced by water storage in reservoirs. In contrast, the magnitude of flows during the peak of the irrigation season from July through mid-September is greatly elevated in some areas of the Basin, particularly in the upper Yakima River arm. However, during this same time period, the lower Yakima River below the Sunnyside Diversion Dam experiences lower than natural flows due to water withdrawals for irrigation.

Flow regulation during this late summer/early fall period may be most problematic for bull trout in the Basin. This is due primarily to the operational procedure known as "flip-flop". The purpose of the "flip-flop" operation is to encourage spring Chinook salmon to spawn at relatively low flows so that less water is required during the winter to keep the redds covered. This water operation also reduces impacts on irrigation water supply during the next season. In early September the annual "flip-flop" operation in the Yakima Basin involves reducing flows in the upper arm of the Yakima River and increasing flows in the Naches River with increased water releases from Rimrock Reservoir.

The extreme flow modification in the Keechelus Dam to Easton Diversion Dam reach, beginning in late June and extending through September, likely has had an adverse effect on bull trout survival and reproduction. From 1981 through 2002, regulated flows have averaged 682, 918, and 440 cfs for the months of July, August, and September, respectively (source: BOR, Yakima Field Office, Hydromet database). These flows are 3.7, 9.3, and 4.7 times the average estimated unregulated discharge for those months, respectively. From 1997 through 2002, the average daily flow in September (a month when bull trout would be staging to spawn or possibly spawning) declined considerably to 83 cfs, very close to the flow which would occur under unregulated conditions (93 cfs). This was done to accommodate the increasing numbers of spring Chinook spawning in the reach. However, average daily flows during July and August strayed further from natural unregulated flows in these years with an average daily discharge of 992 cfs in July (809 cfs over the average daily estimated unregulated flow of 183 cfs from 1981-2001) and 977 cfs in August (878 cfs over the average daily estimated unregulated flow of 99 cfs from 1981-2001).

For many years, flows in this reach were arbitrarily reduced following the irrigation season. As recently as 1992 this reach experienced periods when no water was released from Keechelus Dam at all. Although this condition has not occurred since 1995, flows in January and March averaged just 15 cfs daily. Since 1999, winter conditions have improved considerably. The winter minimum flow is set by the BOR Field Office manager after an appropriate flow recommendation has been made based on a field survey. Since spawning flows have been provided in the neighborhood of 80-100 cfs, winter minimum flows have generally been kept at 70 cfs or higher.

When flip-flop occurs in early September, this release pattern is switched and late season irrigation demands are met primarily from Rimrock Reservoir on the Naches River side for about 40 days. The effect of this operation is the complete inversion of the flow regimes on both sides

of the basin. The high flows in the upper Yakima River which have been maintained since July are reduced to levels very close to those which would occur under unregulated conditions. On the Cle Elum River, the change is most profound as flows drop an order of magnitude in the fall. In the Tieton River, the effect is the opposite as flows increase four to five times over the level at which they were held much of the summer. At the end of the irrigation season, usually around October 20, the Project shifts emphasis to water storage and flows in the Tieton River are often reduced below 20 cfs. Flows are usually reduced on the Yakima River side of the basin as well, sometimes by as much as 50 percent, but they must remain adequate to protect spring Chinook redds. On both sides of the basin, these unstable and abnormal flow patterns have likely had a negative impact on fluvial bull trout. Successful spawning under these conditions is unlikely in the upper Yakima, Cle Elum and Tieton Rivers. Habitat stability for other life stages of bull trout and for other taxa in the aquatic community, including prey species, may also be seriously compromised under these operating conditions. Effects of these flow modifications on various habitat pathways have been described above.

Water withdrawals from streams by irrigation diversions within the basin contribute to low flow conditions in some streams (i.e., Manastash, Taneum, Naneum, Ahtanum, and Cowiche Creeks and the Tieton River), and seasonal dewatering of others. Seven mainstem irrigation diversion dams (Easton, Town Ditch, Wapato, Sunnyside, Prosser, Yakima Tieton Irrigation District, and Horn Rapids) have contributed to altered flow regimes within the basin (Snyder and Stanford 2001). Low flows can inhibit bull trout spawning migrations and result in the stranding of juvenile bull trout in Ahtanum and Rattlesnake Creeks and Teanaway River (E. Anderson, WDFW, 2002, pers. comm.).

2.2.1.3.6 *Watershed Condition*. Forest practices, agriculture, urbanization, flow regulation, along with diking and streambank protection have simplified stream channels, damaged riparian habitat, and impaired the ability of streams to interact with their floodplains and aquifers across the Yakima subbasin (YBFWRB 2006). Gravel resources have been mined up to the river's edge, urban development has encroached into the river corridor, and floodplain and riparian habitat has become tracts of agricultural land (YBFWRB 2006).

Bull trout are less likely to use streams for spawning and rearing in areas with high road density, and are typically absent at mean road densities above 1.1 kilometer per square kilometer (1.7 miles per square mile) (Quigley and Arbelbide 1997). The extensive road network throughout the Yakima core area has generally reduced habitat quality. In particular, the Teanaway and Little Naches drainages have high road densities and corresponding reductions in habitat suitability.

Before 1905, riparian corridors and habitat were estimated to have covered 2 percent of the land area in the Yakima Basin; that area has decreased to 0.5 percent currently (Quigley and Arbelbide 1997). Healthy riparian areas contribute to the amount of LWD in streams, to channel dynamics, to nutrient loads and, therefore, to community structure, and to lower water temperature; these factors can have far-reaching effects both upstream and downstream (Bolton and Shellberg 2001). Loss of these functions is typically associated with reduced productivity of fish populations.

The Upper Yakima River, Upper Naches River, Ahtanum Creek, Teanaway River, and Taneum Creek watersheds all have long histories of forest management. For example, in the Upper Yakima, twenty-six percent of the watershed is an early seral (i.e., seedling/sapling) stage primarily as a result of timber harvest (USFS 1999b). The watershed has many roads constructed for timber harvest purposes, with a road density of 2.6 kilometers per square kilometer (4.1 miles per square mile) (USFS 1999b). Detrimental impacts from timber management can include the removal of LWD, and the reduction in riparian vegetation which results in water temperature increases, accelerated erosion, and de-stabilization of stream channels.

Past forest management has led to changes in natural disturbance regimes. Past and ongoing fire suppression, increased tree densities and forest fuel continuity, and residential development along the wildland-urban interface, are among the factors that can lead to larger and more severe wildfires. Uncharacteristically severe wildfires can lead to levels of increased mass wasting, increased sediment delivery to streams, reduced stream shade that increases water temperature, and other effects to the aquatic environment that exceed the natural range of variation and physiologic tolerance levels of bull trout. Wildfire can improve aquatic habitats and benefit fish populations in natural situations of well-connected habitats and mixed-severity fire. However, isolated populations with limited access to suitable habitat, like those in the Yakima core area, can be extirpated by exposure to severe wildfire or other extreme disturbance events.

During the summer of 2012, the Table Mountain Fire (42,312 ac) and Yakima Complex Fires (2,300 ac) burned within the Yakima core area. The Table Mountain Fire occurred in the Swauk Creek drainage and had large areas of high-severity fire at higher elevations. Bull trout currently are not present in this watershed. The Yakima Complex consisted of many smaller fires, the largest of which was the Wild Rose Fire, which occurred in the Tieton River drainage and burned about 500 acres. A fluvial population of bull trout is present in the Tieton River near the burned area. Analysis of the effects of both these fires on aquatic habitats is pending.

The Ahtanum, Teanaway, and Tieton watersheds within the Basin also have a long history of cattle and sheep grazing dating back to the 1800's (NPPC 2001). Improperly managed livestock grazing can degrade bull trout habitat by removing riparian vegetation, which destabilizes streambanks, widens stream channels, promotes incised channels, lowers water tables, reduces pool frequency, increases soil erosion, and alters water quality (Howell and Buchanan 1992, Mullan et al. 1992, Overton et al. 1993). These effects can reduce overhead cover, increase summer water temperatures, and increase sediment in spawning and rearing habitats. Recently, illegal grazing has resulted in take of bull trout in the Tieton River and Ahtanum Creek areas due to cattle trampling bull trout redds (Jeff Krupka, USFWS, 2003, pers. comm.) .

The expansion of agriculture and the associated use of pesticides and herbicides in the Basin have resulted in the degradation of water quality within streams and rivers that are adjacent to, and downstream of, agricultural fields. Currently, 188,259 hectares (465,000 acres) are under irrigation in the Basin. The Yakima River Basin ranks fifth nationally in total agricultural production (USBR 1999). In addition to degraded water quality, bull trout habitat within the Basin has been adversely affected by irrigation diversions and water withdrawals (Snyder and Stanford 2001).

Historically, hard rock and placer mining occurred at several sites within the Basin. These mining operations dredged, diked, and confined stream channels and leached toxic heavy metals such as mercury into the stream channels. Although no large mines have been constructed recently, there is a limited amount of small-scale suction dredging and hard rock mining still occurring in several watersheds including the Little Naches, and Cle Elum (Dawson 1999, USFS 1999a). Suction dredge mining may alter the substrate composition and benthic insect community composition where in-channel mining activity occurs (Harvey and Lisle 1998). Studies indicate that such changes have occurred (Standford et al. 2002) but mining has not been specifically identified as a root cause. In the upper Kachess River, a third-order tributary to Kachess Lake, tailings left from copper mining activities around the turn of the century have washed down during rainstorms (Meyer 2002). Now, because of the massive quantities of alluvial material that have been deposited, these tailings cause the frequent dewatering of the upper Kachess River in the summer and fall. The Swauk Creek drainage has been impacted by extensive hard rock and placer mining for gold, but bull trout have only been rarely found near the mouth of this creek.

Gravel mining has also affected bull trout in the Yakima Basin. The Gold Creek gravel pit has lowered sub-surface water levels to an unknown degree and likely has contributed to the frequent de-watering of Gold Creek. The Selah Pit, a gravel mining operation near the city of Yakima, is the largest gravel pit in the State of Washington and covers over 93 hectares (230 acres).

Specific areas within the Yakima River Basin have grown in popularity as a preferred area for home sites. As the human population increased, more impacts to riparian areas and water quality have also increased (NPPC 2001). Damage includes increases in nutrient loading from septic systems and chemical applications, alterations to channel morphology, and effects from road construction. Areas where flood plain development is proceeding most rapidly are Lower Little Creek and the Naches River (E. Anderson, WDFW, 2001, pers. comm.).

2.2.1.3.7 *Summary of Habitat Conditions*. The Service has developed a methodology for risk assessment of bull trout core areas for use in section 7 consultation (USFWS 2006, 2007). This method integrates the condition of all MPI habitat pathways and indicators and includes consideration of the presence of brook trout as an indicator of ecological and genetic threats (see Rieman et al. 2006). Applying this approach to the Yakima core area we find that habitat conditions for spawning and rearing areas for all local populations are at high risk (i.e., not properly functioning) for the pathways of habitat access, channel condition, flow/hydrology, and brook trout presence and are at moderate risk (i.e., functioning at risk) for the pathways of water quality and habitat elements. This is generally due to blocked migratory corridors, loss of complex river habitat, altered channel and watershed conditions, and extreme hydrologic patterns. The condition of feeding, migratory, and overwintering habitat in the Yakima Core Area is at high risk (i.e., not properly functioning) for bull trout because of poor water quality, lack of adequate habitat complexity, poor channel complexity, degraded instream flow or hydrology, highly disturbed watershed conditions, and the widespread presence of brook trout.

2.2.1.4 *Other Factors Affecting the Bull Trout's Environment in the Yakima Core Area*
Restoration programs which include riparian restoration, restoration of fish passage at barriers,

and habitat improvement projects are occurring in the Yakima Core Area. Local watershed groups have coordinated to complete stream habitat work along the mainstem Yakima River and its tributaries and are working with the U.S. Forest Service to complete culvert repairs. Most large culverts on the national forest land have been replaced with open bottom arches or bridges to facilitate fish passage. The Plum Creek Timber Company Cascades Habitat Conservation Plan (HCP) was developed on lands in the upper Yakima Basin. The HCP has provisions for timber harvesting and other land management Best Management Practices that benefit aquatic habitats and bull trout. Grazing problems in Ahtanum Creek on Washington Department of Natural Resources lands and Ahtanum Irrigation District lands have been reduced with the placement of a fence along riparian areas adjacent to most of the spawning habitat. Grazing problems on National Forest lands in the South Fork Tieton have been reduced with changes to grazing allotment management plans that reduce cow access to spawning areas and reduce impacts to riparian areas. The Forest Practices HCP (FPHCP) is expected to have a significant beneficial effect on access and connectivity through accelerated identification and remediation of fish-passage barriers on private forest lands. Improved access and connectivity across FPHCP lands is expected to benefit migrations as well as allow re-occupancy of locations where extirpation has occurred.

Implementation of research and restoration projects under ESA Section 10(a)(1)(A) permits have resulted in direct effects to bull trout due to capture and handling and indirect mortality (BOR, WDFW, EPA, Central Washington University, Yakama Nation, and USFWS fisheries studies). Although projects associated with the restoration programs may result in long-term benefits for bull trout and their habitat, all entities listed above holding permits engaged in research activities that resulted in take of bull trout. ESA Section 6 Habitat Acquisition funds have been used to acquire and protect from development multiple private parcels with riparian frontage, totaling over 8,000 acres in the Upper Yakima and Tieton watersheds. These efforts complemented efforts by the Cascades Conservation Partnership which purchased over 37,000 acres of private lands and transferred them to public ownership, mostly in the Upper Yakima, Taneum, and Teanaway watersheds.

Many non-Federal actions have occurred in the Yakima Core Area since the listing of bull trout. Activities such as emergency flood control, development, and infrastructure maintenance are conducted on a regular basis and affect riparian and instream habitat. Recent land-use changes from agriculture to urban development along the riparian areas may also be affect bull trout and bull trout habitat. County permits have likely increased for construction of homes in floodplain and riparian areas. The aggregate effects of all these activities on bull trout populations and the quantity and quality of bull trout habitat are uncertain. Despite large restoration efforts, available information about bull trout population performance suggests overall conditions in the core area are stable.

2.2.1.5 *Threats to the Bull Trout in the Yakima Core Area*

The Yakima Bull Trout Action Plan (YBTAP, 2012) provided a current, threat-based assessment of habitat and population conditions in the Yakima Basin. This assessment characterized threats consistent with the Service's draft Bull Trout Recovery Plan, and developed threats analyses by life stage for each local population in the Basin. The aim of these threats analyses was to

identify specific monitoring and restoration actions that would most benefit bull trout populations. Across the Basin, the following threats were analyzed in the YBTAP:

- **Agriculture:** Impacts associated with agricultural operation (excluding livestock grazing) on lands adjacent to bull trout bearing waters (includes riparian degradation, sedimentation, impaired water quality, and harassment of bull trout). Irrigation return flows often are warm and contain increased levels of sediment, nutrients, and contaminants. Specific areas impacted include: Yakima River Mainstem Lower Rattlesnake Creek; Big Creek; Lower Taneum Creek; Teanaway River; and Ahtanum Creek.
- **Altered flow:** Impacts associated with flow regimes that are significantly altered in terms of magnitude, timing, and duration through water storage operations and/or water withdrawal. Water withdrawals reduce instream flow (sometimes dewatering stream reaches), and increase water temperatures.
- **Angling:** Impacts associated with angling, legal and illegal. The combination of hatchery-stocked rainbow trout, large catch limits, use of bait, and easy public access has resulted in high angling pressures that may result in angling-related injury and mortality. In addition, poaching has been identified as a serious concern in Gold Creek, Box Canyon Creek, Deep Creek, South Fork Tieton River, and Indian Creek.
- **Development:** Impacts associated with residential development (urban, rural, or Forest Service cabins) along bull trout bearing waters (includes riparian degradation, erosion and sedimentation, channel disturbance, chemical contamination, and harassment of bull trout). Human population in the basin is projected to increase about 45 percent by 2020 (YSF&WPB 2004).
- **Dewatering:** A dewatering of stream reaches that restricts fish habitat access, quantity, and quality and can also result in stranding. Dewatering associated with irrigation withdrawal, reservoir management, etc. is categorized as altered flows or passage barriers. Bull trout may experience high risk of predation and physiologic stress when they pass through the drawdown zones of reservoirs, where accessing spawning streams entails passing a gauntlet of predators surrounding a shallow stream with no cover. Aggradation of stream deltas and reservoir drawdown zones can also lead to passage problems which are currently addressed by ad hoc or emergency solutions that have limited effectiveness.
- **Entrainment:** Inadvertent passage of fish through the unscreened outlet works of storage dams or irrigations diversions, resulting in physical trauma, isolation from upstream habitats, and/or entrainment into irrigation systems.
- **Forest management:** Negative impacts on stream condition including hydrology, sediment load, riparian health, and water temperature that result from current and/or past forest management practices (includes impacts from forest roads). Persistent fire suppression in dry forests has increased risk of uncharacteristically severe wildfire. Forest management has degraded habitat conditions and habitat access in the upper Yakima River, Cle Elum River, Taneum River, Ahtanum Creek, Teanaway River, Naches River, and the Tieton River.
- **Grazing:** Impacts associated with livestock grazing on lands adjacent to bull trout bearing waters (includes riparian degradation, sedimentation, impaired water quality, and harassment of bull trout). Livestock practices have particularly degraded bull trout habitat in Ahtanum Creek, Teanaway River, and the Tieton River.

- **Introduced species:** Presence and potential impacts (e.g., introgression, competition, predation, and disease transmission) associated with the introduction of lake, brook, or brown trout.
- **Limited extent of habitat:** Habitat quantity (i.e., stream distance accessible) that has been altered in streams whose lower reaches were inundated by reservoir construction.
- **Low abundance:** A demographic threat resulting from a low population census size as estimated from annual redd counts. Populations receiving a significant threat level under this threat are believed to be at an elevated risk of extirpation.
- **Mining:** Negative impacts on stream health resulting from mining operations (oil, natural gas, coal, precious metals, and gravel). Mining has impacted water quality and channel complexity.
- **Passage barriers:** Artificial barriers to fish passage, including storage dams, diversion dams, recreational dams constructed by the public, culverts, and passage problems associated with irrigation reservoir depletion that preclude passage into spawning tributaries (i.e., dewatering at the mouth of a stream on a reservoir bed). Fragmentation of habitat may be contributing to loss of genetic diversity.
- **Prey base:** Impacts that have negatively affected the availability of food (fish and macroinvertebrates).
- **Recreation:** Impacts associated with recreational use of lands adjacent to bull trout bearing waters (includes riparian degradation, erosion and sedimentation, channel disturbance, and harassment of bull trout). Does not include impacts of associated forest roads or angling pressures on bull trout.
- **Transportation networks:** Impacts associated with major roads or highways (paved) or rail lines.

Water Quality, which was included as a separate threat in the USFWS 2008 status review, was not viewed in this document as a stand-alone threat but is the effect of other threats such as forest management or agriculture.

The YBTAP threats analysis corresponds with our preceding description of the environmental baseline in the Yakima core area to indicate threats to bull trout persistence are numerous and varied. Agricultural activities and altered flow associated with ongoing operations of the Bureau of Reclamation's Yakima Basin Project, and urban and rural development with rapid human population growth, are among the most pervasive challenges to the integrity of aquatic habitats and bull trout populations. Details about the mechanisms underlying these threats and their severity are available in the YBTAP (2012). Additional information about threats is also available in the Draft Bull Trout Recovery Plan and accompanying documents (USFWS 2002a) the Yakima Subbasin Plan (YSF&WPB 2004), and the Service's 5-year review (USFWS 2008).

The variety and severity of this assemblage of threats makes the persistence of bull trout in the Yakima core area questionable (USFWS 2008, pg. 30). This pattern of threats closely resembles those associated with extirpation of bull trout populations (Rieman and McIntyre 1993) as well as extirpation of populations of anadromous salmon and other native fishes of the Pacific Northwest (Frissell 1993). Restoring connectivity among habitats and local populations, aggressive floodplain habitat restoration, and return of flow regimes to more natural patterns would all contribute toward increasing the likelihood that bull trout in the Yakima core area

might persist and eventually contribute to the recovery of the Columbia River interim recovery unit.

2.2.2 Environmental Baseline in the Upper Yakima River Watershed and Action Area

The action area is located within the upper Yakima watershed, in the headwaters of the Yakima sub-basin. The upper Yakima watershed analysis (USFS 1997) provided an overview of the watershed and is incorporated by reference. Elevations in the upper Yakima watershed range from 8,000 feet in the headwaters along the Cascade crest, to 1,800 feet at the confluence with the Teanaway River. The total area of the watershed is about 133,000 acres. In 1996, the watershed had about 51,000 acres of private land (39 percent), and the remainder was managed by the U.S. Forest Service, under several NWFP land allocations (Snoqualmie Pass Adaptive Management Area (SPAMA) – 45,400 acres – 34 percent, Alpine Lakes Wilderness – 14,400 acres – 11 percent, and LSR – 13,200 acres – 10 percent). Due to land transfers described below, the proportions in SPAMA and LSR have increased since 1996, while private ownership has decreased.

Average annual precipitation ranges from about 100 inches in the headwaters to 35 inches at the Teanaway River confluence. Snow is the predominant form of precipitation, falling mostly from October to March. Mature forested habitat covers about 40 percent of the watershed, and most of this forest is in the western hemlock/Pacific silver fir series; i.e., it is moist to mesic with a fire regime characterized by infrequent, stand-replacement fires.

The upper Yakima watershed has experienced extensive timber harvest, particularly in the last 60 years. Harvest has been most intensive on intermingled private forest lands, resulting in highly fragmented forested habitats and high road densities (4.1 miles per square mile). Twenty-six percent of the watershed is in an early seral stage (seedling/sapling) primarily due to past timber harvest (USFS 1999b). In addition to timber harvest, other features that contribute to forest fragmentation in the watershed are the Keechelus and Kachess reservoirs, Lake Easton, railroad lines, electric transmission lines, I-90, and recreational facilities, including four ski areas, two developed campgrounds, many dispersed camping areas, and a growing network of trails that are used for summer and winter recreation (USDA 1997b). Changes in ownership and management direction in the upper watershed associated with the NWFP are likely contributing to a trend of reducing fragmentation due to road decommissioning and other restoration activities.

Lake Keechelus was impounded in 1917 to increase the water supply for irrigation in the lower Yakima Valley. The impoundment is an enlargement of a natural lake and, at full capacity, has a spillway elevation of 767 m (2,516 feet) above sea level, an area of 10.5 km^2 (4 mi^2), and a maximum depth of 108 m (354 ft) (Dion et al. 1976; Goodwin and Westley 1967). About 6.3 percent of the total volume is active storage. No fish passage facilities were constructed for the anadromous or migratory salmonids that used the upper Yakima River for spawning, rearing or adult habitat before the dam was constructed. Management of Lake Keechelus as a water supply reservoir reduces the quality of the lake's riparian and littoral zones. Because the lake level fluctuates by up to 60 vertical feet each year, riparian trees at the lake's edge only provide shading and other riparian functions for a short period during each year when the lake is full (Jones and Stokes 2002b). Fluctuations in water elevation prevent much of the shoreline from developing forested vegetation communities, and little vegetation grows in the seasonally

inundated areas. Fluctuations in the surface elevation of the lake also impede passage of fish from the lake into several tributary streams and limit development of the benthic invertebrate community in the seasonally inundated area (Jones and Stokes 2002b).

The fish community in Lake Keechelus has been dramatically altered by extirpations of native species and introductions of exotic species. Natural populations of spring chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *O. kisutch*, sockeye salmon, *O. nerka*, and steelhead trout, *O. mykiss*, have been extirpated from this lentic system (Tuck 1995). Today the main game fish is kokanee salmon (landlocked *O. nerka*), but limited numbers of rainbow trout, *O. mykiss*, cutthroat trout and brook trout, *Salvelinus fontinalis*, are also caught. The burbot, *Lota lota*, a large, piscivorous, freshwater cod, competes with bull trout as the top-level predator within the lake (S. Craig, pers. comm.). State fishing regulations do not permit harvest of bull trout from Lake Keechelus, but some injury and mortality from hooking is likely.

The brook trout is the exotic species with the greatest potential to have adverse effects on bull trout. Brook trout hybridize with bull trout and compete for habitat and prey (e.g., Rieman et al. 2006). Surveys in the Project area found brook trout in most of the fish-bearing streams (Jones and Stokes 2002a).

The current I-90 facility further fragments aquatic and riparian habitats and imposes known or possible passage barriers on several creeks throughout the Project area (Table 2.2) (Jones and Stokes 2002a and b).

Since completing consultation on the entire I-90 Snoqualmie Pass East Project in 2008, the most substantive changes to baseline conditions have resulted from implementation of the I-90 Project, implementation of the Forest Service's Roaring Thin Project, decommissioning of Plum Creek Roads, and revision of the Master Development Plan for the Snoqualmie Pass Ski Area. The effects of these projects on bull trout local populations and habitat will be described in the following sub-sections.

In the early spring of 2008, a large avalanche occurred that covered about ¼ mile of Gold Creek downstream of spawning habitat with large wood and rock debris, earth, snow, and ice (YBTAP 2012). When the Service completed its original biological opinion we did not know if this avalanche debris might block access to spawning areas. Subsequent redd surveys have located redds above the avalanche zone, and rearing juveniles are using the area affected by the avalanche (YBTAP 2012).

Table 2.2. Aquatic habitat fragmentation associated with I-90 (from Jones and Stokes 2002a).

Stream	Project Phase	Fragmentation effects
Coal Creek	1	Partial or complete culvert barriers; channel constriction; lack of riparian vegetation near highway and maintenance facility
Gold Creek	1	Lack of riparian vegetation
Rocky Run	1	New bridges have improved access, but remnant concrete slab in the channel may still impede passage.
Wolfe Creek	1	New bridges have improved passage
Resort Creek	1	Culvert barrier, except at high Keechelus pool; possible barrier at old I-90 roadbed.
Townsend Creek	1	Culvert barrier, except at high Keechelus pool; possible barrier at old I-90 roadbed.
Price Creek	2	Culvert barrier (very long culvert with shallow flow)
Noble Creek	2	Culvert barrier due to outlet, slope, and length.
Bonnie Creek	2	Impounded by fill barrier and dissipates into wetland at I-90.
Cedar Creek	2	Culvert barrier at I-90 and downstream.
Telephone Creek	2	Culvert barrier
Hudson Creek	2	Culvert barrier
Kachess River	2	Channel constriction at I-90 bridges; lack of riparian vegetation.

2.2.2.1 *Characteristics of Bull Trout Populations in the Watershed and Action Area*
Keechelus Dam effectively separates the historically continuous watershed of the Upper Yakima River into two discrete segments; above the dam, and below the dam. Lack of fish passage at the dam isolates upstream fish, preventing them from participating in the larger metapopulation in the lower watershed. Genetic analysis of bull trout from the isolated Lake Keechelus population and other populations throughout the Yakima basin suggests that gene flow historically occurred among populations across the Tieton, Naches, and Yakima watersheds (Reiss 2003). Bull trout in the Gold Creek local population most likely originated from a native adfluvial life history form that was present before the construction of the dam and irrigation reservoir (WDFW 1998). Bull trout populations in the Kachess and Keechelus watersheds also are genetically relatively similar within the Basin (Reiss 2003), suggesting genetic exchange occurred between the populations in these two sub-watershed before construction of barrier dams. In the nearly 100

years since the dams cut-off exchange of individuals between these populations, however, some divergence has occurred, and the Gold Creek population is now genetically distinct from all other populations in the Yakima Basin (Small et al. 2009).

Little information is available about bull trout use of lake and reservoir habitats, and the Service is not aware of any detailed information about bull trout use of Keechelus Lake. We expect that bull trout from the Gold Creek local population use Keechelus Lake as foraging, migratory, and overwintering habitat (YBTAP 2012, pg. 138). Studies of bull trout in Chester Morse Reservoir and Flathead Lake found diverse patterns of habitat usage, including use of both deep water and littoral habitats (Connor et al. 1997). Food items found in bull trout stomachs appeared to come from all areas of the lake (Connor et al. 1997). Most foraging apparently occurs at night; during daylight hours most bull trout apparently rested near the bottom of Chester Morse Lake (Connor et al. 1997).

Gold Creek provides the only known spawning habitat for bull trout in the upper Yakima watershed. Gold Creek drains a watershed with an area of about 35 km^2 (13.5 mi^2). The upper Gold Creek Basin is located in the Alpine Lakes Wilderness Area, but the lower portion is highly degraded by Keechelus Reservoir inundation, past timber harvest practices, gravel excavations for I-90 construction in the 1970s, and residential development on private lands. Gravel for I-90 was excavated from the flood plain of Gold Creek, resulting in the creation of several ponds or small lakes. Gold Creek Pond, 0.7 km above the present-day interstate bridges, is the largest of the excavations (9.1 ha) and has a maximum depth of 18 m and a base-flow of 0.13 m^3/sec^{-1} in late fall (Wissmar and Craig 1997). A fish barrier falls is located approximately 11.4 river km upstream from the I-90 bridges, but a bedrock cascade at 8.5 km may impede spawning migration (Craig 1997).

Hydrology in Gold Creek has been affected by a variety of factors including flooded borrow-pits, channel aggradation, loss of large woody debris, personal-use wells, and private gravel-mining operations. All these factors are thought to contribute to de-watering a 3.3 km (2 mi) section of Gold Creek above the pond when discharge is less than 0.13 m^3/sec^{-1} (Craig 1997; Meyer 2002). This period of low flow and dewatering from August through October coincides with bull trout migration and spawning (Craig 1997). Bull trout mortalities have been found along this stretch when surface flow in Gold Creek was eliminated (S. Craig, USFWS, pers. comm., 2002). Dewatering of the main channel of Gold Creek occurred in several years between 1993 and 1998 (Wissmar and Craig 2004) and in several years between 2000 and 2003 (Walt Larrick, BOR, pers. comm.. 2004). Dewatering of the channel isolates upstream migrants from the spawning areas, and also strands fish, which can result in direct mortality and reduced spawning. For example, Wissmar and Craig (1998) estimated that 63 percent (1993) and 24 percent (1994) of the adult bull trout died in Gold Creek. Mortality presumably occurred as the fish swam downstream after spawning and before these fish reached the reservoir (USFS 2007).

The Washington Department of Fish and Wildlife has been conducting redd surveys in Gold Creek since 1984. The data show wide variation in the number of redds present. Survey tallies range from 2 in 1984 and 1985 to 51 in 1996. The recent average (1999 to 2012, see Table 2.1) was 19 and the median was 16 redds, underscoring the precarious status of the population. The adfluvial population of bull trout in Keechelus Lake is rated as "critical" by the Washington

Department of Fish and Wildlife due to the low number of spawning adults and because they spawn only in Gold Creek (WDFW 1998). Dependence on just one spawning reach makes this population very vulnerable to habitat degradation and stochastic events. Demographic and empirical models indicate that isolated populations with less than 100 spawning adults may be prone to extinction (Rieman and McIntyre 1993; Dunham and Rieman 1999).

The highest densities of redds in Gold Creek are normally found in a spring-fed channel at 6.6 km (4 mi) and in the immediate vicinity of the ephemeral Silver Creek located at 7.3 km (4.5 mi; Wissmar and Craig 1998). In a survey of 14 streams in the Upper Yakima Basin, Gold and Box Canyon Creeks (the latter is a tributary to Kachess Lake) had the lowest densities of bull trout redds (Craig 1997). Gold Creek was one of two creeks where peak spawning activity occurred in October and this may be attributed to the higher daily water temperatures (> 9 ^{o}C) during September. The population of bull trout in Gold Creek was the last of the surveyed populations to complete spawning. Gold Creek redds were predicted to have hatched in late April, with an estimated incubation time of about 200 days (Craig 1997). Emergence was estimated to occur in May (S. Craig, USFWS, pers. comm. 2002).

Spawning occurs from early September to mid-October for the Gold Creek local population. It is suspected that migrating bull trout spawners may enter the creek in July or earlier, however, migration timing is likely affected by channel dewatering patterns and water temperature during this time. A portion of the Gold Creek channel above the Lake goes dry in most years during the summer, effectively cutting off fish passage until flows are reestablished by fall precipitation. Bull trout may hold in Lake Keechelus and attempt their spawning migration when Gold Creek flows increase due to increased flows resulting from these rain events (USFS 2007).

Since 2008, the I-90 Project has replaced the small highway bridges that constricted the channel of Gold Creek with long bridges and removed the highway fill that prevented Gold Creek from interacting with its floodplain in the delta where the Creek enters Keechelus Lake. The extensive construction, demolition, and excavation necessary to complete that work have nearly been completed. Some highway fill and rip rap still need to be removed which will allow final grading and installation of habitat complexity structures to occur. To date, all work has been completed with a remarkably high level of compliance with regulatory requirements. Nonetheless, bull trout have been exposed to increased noise, activity, and sediment inputs that the Service expected would result in a low level of incidental take. Since construction began, redd counts have declined to low levels (Table 2.1; 7 redds detected in 2011 and 2012). Because declines and fluctuations in redd counts of a similar magnitude have occurred in the past, we do not know if or how much highway construction activities contributed to recent declines. We also do not know if avalanche debris is impeding access to spawning areas or if bull trout might be spawning in the avalanche area where debris could reduce the detectability of redds. The recent low counts suggest that the population may be passing through another bottleneck that further reduces genetic diversity and increases future susceptibility to extirpation.

The small bridge on Forest Road 4832, however, is still in place and continues to constrain the Creek. The berm of fill on which Road 4832 is located also prevents floodplain interactions. Consequently, access to Gold Creek has been improved, but not restored. Hydrologic factors contributing to dewatering in lower Gold Creek are the subject of ongoing investigation. The

USFS has proposed a restoration approach for this area in their Upper Yakima Restoration Project, and planning for this project is ongoing. Extensive planting of native species has occurred around the Gold Creek Ponds, but the Service does not expect this activity to have any substantive effects on the hydrology of Gold Creek.

Cold Creek is another tributary to Lake Keechelus that is considered to be bull trout habitat. A perched culvert under the John Wayne Trail formerly prevented bull trout passage from Keechelus Lake into Cold Creek. In 2005, the Bureau of Reclamation began work on a rock structure to facilitate migration between the lake and the stream. During construction, a sub-adult bull trout was trapped at the outlet of the culvert, and released into the stream above the work area. Flooding in November of 2006 destroyed the upstream passage structure. A new bridge over Cold Creek installed as part of the Roaring Thin Project should facilitate passage of bull trout. Cold Creek provides high quality spawning habitat for resident fish, including bull trout, and is recognized as an important stream for the future recovery of bull trout in the Upper Yakima watershed.

Anecdotal reports indicate that bull trout may have been present in Rocky Run Creek in the early 1980's. Surveys following the protocol to detect bull trout developed by the Western Division of the American Fisheries Society, in cooperation with the Service were conducted in 2001 (Jones and Stokes 2002a). No bull trout were detected.

Very little information is available about the fluvial bull trout population that exists below Keechelus Dam. Redd surveys done in the upper Yakima River Basin did not include the reach immediately downstream of Keechelus dam until fall, 2000. That season biologists found two redds and four tending adults below the dam. In fall, 2001, one redd and one tending adult were found and one adult bull trout mortality was discovered. The surveying biologists concluded that the habitat and water conditions in this reach were suitable for bull trout (J. Thomas, USFWS, pers. comm., 2001). Since that time 3 redds were found in 2006 and 1 in 2007. The limited available information all suggests this population is very small. This population may consist of individuals from the Gold Creek population that have passed through the outlet works of Keechelus Dam. Individuals entrained through Kachess Dam may also be present.

In 2010, the Bureau of Reclamation conducted a study of fish entrainment through the outlet of Keechelus Lake. Screw trapping in the channel below the outlet works of the dam was conducted from mid-May through August (YBTAP 2012). This sampling captured 526 fish of at least 11 species, but no bull trout were collected (USBR 2010). These results suggest bull trout entrainment through Keechelus Dam may be relatively infrequent.

Currently, all bull trout population indicators are considered to be "not properly functioning" for both of the Gold Creek and Yakima River populations. This evaluation is the result of redd surveys detecting either a low average number of redds (Gold Creek, mean = 19; Table 2.1 above) or few or no redds (upper Yakima fluvial). Available data suggest that both bull trout populations are perilously small. No information is available about the status of resident bull trout. Widespread presence of brook trout raises the possibility of ecological competition and introgressive hybridization.

The conservation roles of these local populations are to maintain the spatial distribution of bull trout in the Yakima core area, and eventually to provide demographic support to other local populations. The upper Yakima watershed has adequate headwaters habitat to support a resilient local population of bull trout. The current depressed state of the population belies this potential. Restoration of passage at Keechelus dam, floodplain restoration in Gold Creek, improved access to Lake Keechelus tributaries, and restoration of a more natural flow regime below the Keechelus dam may allow these local populations to fulfill these conservation roles in the future.

2.2.2.2 *Habitat Conditions in the Watershed*

Since completing our original Opinion for the I-90 Project, no new projects have prompted a comprehensive re-evaluation of habitat conditions at the watershed scale. Some changes to baseline conditions have resulted from implementation of the initial phases of the I-90 Project, the Roaring Thin Restoration Project (USFS 2007), ongoing decommissioning of Plum Creek roads, and implementation of the revised Master Development Plan for the Snoqualmie Pass Ski Area.

As described above, implementation of the I-90 Project has largely occurred as anticipated in our original Opinion. Project implementation has resulted in improved habitat access for bull trout to Gold Creek, Rocky Run Creek, and Wolf Creek, all due to installation of larger bridges in the highway. Construction activities have led to some increased sedimentation, but monitoring results suggest that except for a few short-term exceedances that were quickly remedied, sedimentation has been within expected levels. Implementation of the I-90 Project to date has provided opportunities for improvement in the "off-channel habitat," "floodplain connectivity," and "riparian reserve" habitat indicators, but these potential improvements will not be fully realized until subsequent phases of construction or interrelated actions are completed. Therefore, at this time, our opinion is that this project has not resulted in changes to baseline conditions sufficient to warrant changing the functional rating of any habitat indicators.

Similarly, implementation to date of the Roaring Thin Restoration Project, while beneficial to several habitat indicators is not sufficient to change the function of any habitat indicators at the watershed scale. This project has resulted in improved access to Cold Creek via replacement of a ford with a large bridge, pre-commercial thinning of about 1,600 acres to accelerate the development of old forest structure, decommissioning of about 10 miles of full-bench roads, and restoration of the shoreline of Lost Lake. Implementation of these project elements will result in both short-term negative and long-term beneficial effects to multiple habitat indicators.

Implementation of the revised Master Development Plan for the Snoqualmie Pass Ski Area will permanently remove about 10 acres of forested habitat. However, the Plan also requires transferring about 320 acres to the USFS for management consistent with the Snoqualmie Pass Adaptive Management Area Plan, which emphasizes development of old forest structure. Again, this project resulted in both negative and beneficial effects to habitat indicators, but the scope of these effects will not change watershed scale function of any indicators.

At the scale of the entire upper Yakima watershed, no habitat indicators are considered to be "functioning appropriately". Most indicators are "not properly functioning," especially those associated with the watershed condition pathway (Table 2.3). Likewise, many of the habitat

indicators considered essential to habitat suitability for bull trout (temperature, habitat access, large woody debris, pool frequency and quality, and peak and base flow) all are "not properly functioning." A number of streams in the watershed are on the 303(d) list for exceeding temperature levels, including Gold, Big and Cabin creeks, and Lake Keechelus. Past logging and road building in riparian habitat may be contributing to high summer stream temperatures (USFS 1999b). Fine sediment in spawning habitat areas exceeds 15 percent by volume in Cole, Gold, Little and Big creeks (USFS 1999b). The upper reaches of the watershed within the Alpine Lakes Wilderness are in nearly pristine condition, but in the lower watershed, intensive timber management on both publicly and privately owned lands, dispersed recreation, and roads have degraded habitat conditions.

For the fluvial bull trout population below Keechelus Dam, the Yakima River and side channels provide considerable high quality rearing habitat (Jones and Stokes 2002b). However, barriers to passage, high summer temperatures, and an unnatural flow regime all detract from habitat access and quality (Jones and Stokes 2002b). Barriers to passage include the Keechelus and Kachess Dams and a regulated barrier at the Easton Diversion Dam, as well as tributary barriers in the I-90 Snoqualmie Pass East project area (Table 2.3). Together, these barriers to passage have isolated local populations from one another and severely limited the area of suitable habitat available to the fluvial population in the upper Yakima River. Summer temperatures in the river often exceed optimal levels for bull trout spawning and rearing. Flow from Lake Keechelus is managed to store spring runoff and provide flow during summer for downstream irrigation. As a result, flow in the Yakima River is unnaturally low during spring and unnaturally high during summer. These unnatural patterns may limit usable habitat area as well as the abundance of invertebrate prey in the river (Jones and Stokes 2002b).

Table 2.3 Upper Yakima Watershed, Summary of Habitat Indicator Baseline Conditions

	Baseline Condition	
Habitat Indicators	**Gold Creek (Phase 1)**	**Yakima Fluvial (Phase 2)**
Temperature	NPF	NPF
Sediment	FAR	FAR
Chemical contamination and nutrients	FAR	FAR
Physical barriers or habitat access	NPF	NPF
Embeddedness	FAR	FAR
Large Wood	NPF	NPF
Pool frequency and quality	NPF	NPF
Large pools	FAR	FAR
Off-channel habitat	FAR	FAR
Refugia	NPF	NPF
Width:depth ratio	FAR	FAR
Streambank condition	FAR	FAR
Floodplain connectivity	FAR	FAR
Peak and base flow	NPF	NPF
Drainage network	FAR	FAR
Road density and location	NPF	NPF
Riparian reserves	NPF	NPF
Disturbance History	NPF	NPF
Disturbance regime	NPF	NPF

FAR = functioning at risk
NPF = not properly functioning

This profile of baseline habitat conditions indicates the bull trout populations present are challenged by both limited habitat quantity and quality. The poor status of local populations reflects the large number of non-functional habitat components in the watershed.

2.2.3 Factors Affecting the Environment for Bull Trout in the Action Area

Since 1999, the factor probably having the largest impact on the upper Yakima watershed is large-scale changes in land ownership. In this watershed alone, the U.S. Forest Service has acquired more than 40 square miles (> 25,600 acres) of land, and Washington State, the Yakama Nation, the Service, and conservation organizations have protected both uplands and additional riparian areas along the Yakima River and its tributaries. The Service's expectation is that habitat conditions in the watershed will improve as a result of these land transfers and conservation acquisitions, and the scale of these activities is sufficiently large that it may eventually shift the watershed baseline to higher functional levels for some MPI metrics. If fish passage can be successfully implemented at Keechelus Dam, and a more normative flow regime

implemented in the Yakima River below the dam, these measures could complement ongoing protection and restoration efforts and move the watershed substantially toward proper function.

The main recent activities in the portion of the watershed under U.S. Forest Service management are timber management, recreation, and transfer of land ownership from private to public, with subsequent restoration activities. On private lands, residential and agricultural development continues at a rapid pace. In particular, efforts to prevent lateral migration of the Gold Creek channel along the lower reaches have diminished habitat quality (YBTAP 2012.). Several projects in the watershed with the potential to affect both bull trout and aquatic habitats have been the subjects of prior consultations. Among these, the Bureau of Reclamation's Keechelus Safety of Dams Project may have had the most profound effects on aquatic habitat. This project had both direct negative effects and perpetuated the isolation of the Gold Creek population of bull trout.

The Keechelus Safety of Dams Project, implemented by the U.S. Bureau of Reclamation (BOR) corrected safety deficiencies in the dam through major reconstruction. The BOR project degraded the condition of 10 indicators in the MPI and did not move any indicator in a beneficial direction. The most substantive adverse effects included; (1) drawdown of the Lake creating a physical or thermal barrier to fish passage near the mouth of Gold Creek, (2) construction activities introducing excess sediment and degrading both water quality and rearing habitat quality, (3) loss of forest and wetland area, and (4) new road construction decreasing floodplain connectivity and increasing the drainage network (USDI 2001). Proposed mitigation actions may have partially alleviated some of these adverse effects.

Rates of timber harvest on federal land have been low for about the last 15 years. Most of the projects with a timber harvest component that have occurred on federal lands in the watershed also included restoration components such as road decommissioning, closure of dispersed recreation sites, and thinning prescriptions intended to accelerate the development of large trees (e.g., Roaring, Hudson, Lodge, and WhitMar projects). Most of these projects were implemented away from streams and had negligible effects on aquatic habitats. Overall, the Service estimates that less than 2,500 acres of federally managed forest lands have had vegetation management treatments in the watershed since 1994, representing less than 2 percent of federal ownership, and less than 1 percent of the total watershed area.

Rates of timber harvest on private land in the watershed are unknown. Forestry activities on State and private lands in Washington State are covered under the Forest Practices Habitat Conservation Plan. The term of the Plan is 50 years, and over this period effects to bull trout are expected to include short term adverse effects to stream temperatures, large woody debris, and sediment, and long term beneficial effects on habitat access. Analysis of the effects of this Plan led to the identification of bull trout core areas that were at increased risk of exposure to adverse effects, primarily due to the high proportion of private timberlands in these core areas. The upper Yakima watershed is among the core areas at high overall risk (high exposure, risk to habitat, and population risk). However, conversion of private timber lands to residential development may be a more potent threat to aquatic habitat conditions in the watershed than continued timber management. Past escalation of real-estate prices in the area has led to development of residential communities on private lands across the watershed. We could not

develop a reasonable estimate of the number of commercial forest acres recently converted to residential development.

Recreational use of the Yakima watershed is extensive, including a full range of motorized and non-motorized activities. Developed and dispersed camping and accompanying trail use are the dominant activities in the lower and mid-elevations of the watershed (USFS 1997). In winter, snowmobiling, cross-country skiing and snowshoeing dominate. Estimates suggest rates of use increase about 5 percent annually, and use of dispersed and developed camp sites is at or above capacity during the summer (USFS 1997). Among recreation activities, dispersed camping may be having the greatest impact on aquatic resources, especially degradation of riparian area function and floodplain connectivity.

Natural disturbances, particularly wildland fire, have had relatively minor effects on the upper Yakima watershed in recent years. Noteworthy effects to aquatic habitats from windthrow and insect or disease outbreaks also have not occurred. As described above, in the winter of 2008 – 2009, a large avalanche occurred in upper Gold Creek that crossed the stream channel, depositing considerable amounts of large wood and other debris. Based on subsequent redd survey results, this event did not block passage to upstream spawning locations.

Considering the balance of positive and negative effects of recent and ongoing activities in the upper Yakima watershed, the Service's opinion is that the net condition of the watershed remains "not properly functioning" or poor, with a slightly positive trend in terms of habitat suitability for bull trout.

2.2.4 **Likelihood of Bull Trout Presence in the Action Area**

Bull trout historically were found throughout the upper Yakima watershed. The Gold Creek local population which is likely to be affected by the Project is now restricted in their distribution and believed to be very small. Information presented above in sub-section 3.2.1 described the size, migration timing, spawning distribution, and use of Keechelus Lake as FMO habitat by the Gold Creek local population. This information indicates a high likelihood that bull trout from this local population will be present in the action area during the construction season and will be exposed to operation and maintenance activities over the long term.

The Service expects that all life stages of bull trout typically will be present at low densities (Jones and Stokes 2002b). Higher densities can occur at special habitat features, even in watersheds like the upper Yakima where populations are depressed. The deep pools between the existing highway bridges and the Road 4832 bridge may attract and retain migrating bull trout, especially if upstream dewatering occurs early and prevents passage. Tributary mouths near to Gold Creek, such as Rocky Run and Wolfe creeks, may also support higher densities of rearing juvenile bull trout. Spawning and rearing areas in upper Gold Creek may experience the highest bull trout densities during spawning. In contrast, the density of bull trout in Keechelus Lake is likely always low, reaching its lowest levels from July to October when adults are spawning in Gold Creek, and its highest levels during the winter and spring when adults and sub-adults overwinter in the Lake.

2.2.5 Global Climate Change

Global climate change has the potential to affect the baseline condition of bull trout habitat at all scales from the coterminous U.S. to the sub-watershed and action area. Available evidence also indicates climate change effects are reasonably certain to continue into the foreseeable future. Consequently, climate change could be addressed under multiple headings in this Opinion (e.g., rangewide status of the species, environmental baseline, and cumulative effects). Rather than scatter our discussion of this important topic throughout the Opinion, we consolidate in this section our consideration of how climate change may alter baseline conditions across scales.

Climate change is one of the most significant ongoing effects to baseline conditions for bull trout and their associated aquatic habitat throughout the state of Washington. Climate change, and the related warming of global climate, has been well-documented in the scientific literature (Bates et al. 2008; ISAB 2007). Evidence includes increases in average air and ocean temperatures, widespread melting of snow and glaciers, and rising sea level. Given the increasing certainty that climate change is occurring and is accelerating (Bates et al. 2008; Battin et al. 2007), we can no longer assume that climate conditions in the future will resemble those in the past.

Climate change has the potential to profoundly alter the aquatic habitat through both direct and indirect effects (Bisson et al. 2003). Direct effects are evident in alterations of water yield, peak flows, and stream temperature. Some climate models predict 10 to 25 percent reductions in late spring, summer, and early fall runoff amounts in coming decades. Indirect effects, such as increased vulnerability to catastrophic wildfires, occur as climate change alters the structure and distribution of forest and aquatic systems. Observations of the direct and indirect effects of global climate change include changes in species ranges and a wide array of environmental trends (ISAB 2007; Hari et al. 2006; Rieman et al. 2007). In the northern hemisphere, ice-cover durations over lakes and rivers have decreased by almost 20 days since the mid-1800s (WWF 2003). For cold-water associated salmonids in mountainous regions, where upper distribution is often limited by impassable barriers, an upward thermal shift in suitable habitat can result in a reduction in size of suitable habitat patches and loss of connectivity among patches, which in turn can lead to a population decline (Hari et al. 2006; Rieman et al. 2007).

Climate change is already affecting the frequency and magnitude of fires, especially in the warmer, drier regions of the west. To further complicate our understanding of these effects, the forest that naturally occurred in a particular region may or may not be the forest that will be responding to the fire regimes of an altered climate (Bisson et al. 2003). 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).

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 snow pack diminishes, stream flow timing will change, and peak flows will likely increase in volume. Higher ambient air temperatures will

likely cause water temperatures to rise (ISAB 2007). Data from long-term stream monitoring stations in western Washington indicate a marked increasing trend in temperatures in most major rivers over the past 25 years (WDOE 2007).

There is still a great deal of uncertainty associated with predictions of timing, location, and magnitude of temperatures changes. It is also likely that the intensity of effects will vary by region (ISAB 2007). Research indicates that temperatures in many areas will continue to increase due to the effects of global climate change. According to model predictions, average temperatures in Washington State are likely to increase between 1.7 °C and 2.9 °C (3.1 °F and 5.3 °F) by 2040 (Casola et al. 2005).

Bull trout rely on cold water throughout their various life stages and increasing air temperatures likely will cause a reduction in 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 char species. Groundwater temperature can also be 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 (Rieman et al. 2007). Increases in air temperature are likely to be reflected in increases in both surface and groundwater temperatures.

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-related warming of lakes will likely lead to longer periods of thermal stratification, forcing coldwater fish such as bull trout to be restricted to the bottom layers for greater periods of time. Deeper thermoclines resulting from climate change may further reduce the area of suitable temperatures in the deeper depths of lakes and intensify competition for food (WWF 2003).

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 will cause 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). The increased magnitude of winter peak flows in high elevation areas is likely to affect spawning and incubation habitat for bull trout and Pacific salmon. Although lower elevation rivers are not expected to experience as severe an impact from alterations in stream hydrology, they are generally not cold enough for bull trout spawning, incubation, and juvenile rearing.

As climate change progresses and stream temperatures warm, thermal refugia will be critical to ensure the persistence of bull trout and other species dependent on cold water. Thermal refugia are important for providing bull trout with patches of suitable habitat while allowing them to migrate through, or to make foraging forays into, areas with above optimal temperatures. Juvenile rearing may also occur in waters that are at or above optimal temperature, but these rearing areas are usually in close proximity to colder tributaries or other areas of cold water refugia (USEPA 2003).

Climate change is and will be an important factor affecting bull trout distribution and population dynamics. As distribution contracts, patch size decreases and connectivity is truncated; populations that are currently connected may become thermally isolated, which could accelerate the rate of local extinction beyond that resulting from changes in stream temperature alone (Rieman et al. 2007). In areas with already degraded water temperatures or where bull trout are at the southern edge of their range, they may already be at risk of impacts from current as well as future climate change. As these trends continue, the conservation role of bull trout populations in headwaters habitats may become more significant. Long-term persistence of bull trout may only be possible in headwater areas that provide suitable habitat refugia.

2.3 STATUS OF BULL TROUT CRITICAL HABITAT

Critical habitat is defined in section 3(5)(A) of the Act as "the specific area within the geographic area occupied by the species on which are found those physical or biological features essential to the conservation of the species, and that may require special management considerations or protection, and specific areas outside the geographical area occupied by a species at the time it is listed, upon determination that such areas are essential for the conservation of the species." The Act defines conservation as the procedures necessary to bring about the eventual recovery and delisting of a listed species.

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat within 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the Act and the August 6, 2004, Ninth Circuit Court of Appeals decision in Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service (No. 03-35279) to complete the following analysis with respect to critical habitat.

2.3.1 Legal Status and History of Bull Trout Critical Habitat

The Service published a final critical habitat designation for the coterminous United States population of the bull trout on October 18, 2010 (70 FR 63898), replacing the previous final critical habitat designation published in 2005; the 2010 final rule became effective on November 17, 2010. A document providing the biological rationale for inclusion of each critical habitat unit (CHU) in the designation 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 U.S. range, as listed on November 1, 1999 (50 FR 63898), which includes a total of five interim recovery units (previously known as distinct population segments; the Jarbidge River, Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River) [1]. Rangewide, the Service designated critical habitat in five states in a combination of reservoirs/lakes and streams/shoreline (Table 2.4). Designated bull trout critical habitat is of two primary use types: 1) spawning and rearing (SR), and 2) foraging, migration, and overwintering (FMO).

[1] The Service's 1999 coterminous listing rule identified five interim recovery units (50 CFR Part 17, pg. 58910) and our five year review recommended re-evaluation of these units based on new information (USFWS 2008, pg. 9). Our subsequent critical habitat designation described six draft recovery units (75FR63927). Until the bull trout draft recovery plan is finalized, the five interim recovery units will be used for purposes of section 7 jeopardy analyses. The adverse modification analysis in this biological opinion does not rely on recovery units, relying instead on the newly listed critical habitat units and subunits.

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 2010 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. Unoccupied areas included in the revised designationwere 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.

Table 2.4. Stream/shoreline distance and reservoir/lake area designated as bull trout critical habitat by state.

State	Stream/Shoreline Miles	Stream/Shoreline Kilometers	Reservoir /Lake Acres	Reservoir/ Lake Hectares
Idaho	8,771.6	14,116.5	170,217.5	68,884.9
Montana	3,056.5	4,918.9	221,470.7	89,626.4
Nevada	71.8	115.6	-	-
Oregon	2,835.9	4,563.9	30,255.5	12,244.0
Oregon/Idaho	107.7	173.3	-	-
Washington	3,793.3	6,104.8	66,308.1	26,834.0
Washington (marine)	753.8	1,213.2	-	-
Washington/Idaho	37.2	59.9	-	-
Washington/Oregon	301.3	484.8	-	-
Total	19,729.0	31,750.8	488,251.7	197,589.2

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 (one bank) of the waterbody is designated, 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.

The 2010 final rule excluded some critical habitat segments based on a careful balancing of the benefits of inclusion versus the benefits of exclusion. Critical habitat does not include: (1) waters adjacent to non-Federal lands covered by legally operative incidental take permits for habitat conservation plans (HCPs) issued under section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (Act), in which bull trout is a covered species on or before the publication of this final rule; (2) waters within or adjacent to Tribal lands subject to certain commitments to conserve bull trout or a conservation program that provides aquatic resource protection and restoration through collaborative efforts, and where the Tribes indicated that inclusion would impair their relationship with the Service; or (3) waters where impacts to national security have been identified (75 FR 63898). Excluded areas are approximately 10 percent of the stream/shoreline miles and 4 percent of the lakes and reservoir acreage of designated critical habitat. Each excluded area is identified in the relevant Critical Habitat Unit (CHU) text, as identified in paragraphs (e)(8) through (e)(41) of the final rule (see Tables 2.5 and 2.6 for the list of excluded areas). The exclusion of waterbodies from designated critical habitat does not negate or diminish their importance for bull trout conservation. Because exclusions reflect the often complex pattern of land ownership, designated critical habitat is often fragmented and interspersed with excluded stream segments.

Table 2.5. Stream/shoreline distance excluded from bull trout critical habitat based on tribal ownership or other plan.

Ownership and/or Plan	Kilometers	Miles
Lewis River Hydro Conservation Easements	7.0	4.3
DOD – Dabob Bay Naval	23.9	14.8
HCP – Cedar River (City of Seattle)	25.8	16.0
HCP – Washington Forest Practices Lands	1,608.30	999.4
HCP – Green Diamond (Simpson)	104.2	64.7
HCP – Plum Creek Central Cascades (WA)	15.8	9.8
HCP – Plum Creek Native Fish (MT)	181.6	112.8
HCP–Stimson	7.7	4.8
HCP – WDNR Lands	230.9	149.5
Tribal – Blackfeet	82.1	51.0
Tribal – Hoh	4.0	2.5
Tribal – Jamestown S'Klallam	2.0	1.2
Tribal – Lower Elwha	4.6	2.8
Tribal – Lummi	56.7	35.3
Tribal – Muckleshoot	9.3	5.8
Tribal – Nooksack	8.3	5.1
Tribal – Puyallup	33.0	20.5
Tribal – Quileute	4.0	2.5
Tribal – Quinault	153.7	95.5
Tribal – Skokomish	26.2	16.3
Tribal – Stillaguamish	1.8	1.1
Tribal – Swinomish	45.2	28.1
Tribal – Tulalip	27.8	17.3
Tribal – Umatilla	62.6	38.9
Tribal – Warm Springs	260.5	161.9
Tribal – Yakama	107.9	67.1
Total	3,094.9	1,923.1

Table 2.6. Lake/Reservoir area excluded from bull trout critical habitat based on tribal ownership or other plan.

Ownership and/or Plan	Hectares	Acres
HCP – Cedar River (City of Seattle)	796.5	1,968.2
HCP – Washington Forest Practices Lands	5,689.1	14,058.1
HCP – Plum Creek Native Fish	32.2	79.7
Tribal – Blackfeet	886.1	2,189.5
Tribal – Warm Springs	445.3	1,100.4
Total	7,849.3	19,395.8

2.3.2 **Primary Constituent Elements (PCEs) for Bull Trout Critical Habitat**

Within designated critical habitat areas, the PCEs for bull trout critical habitat are those physical and biological features 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 the bull trout and the characteristics of the habitat necessary to sustain its essential life-history functions, we have determined that the following PCEs are essential for the conservation of bull trout.

1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.
2. Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.
5. Water temperatures ranging from 2 °C to 15 °C (36 °F to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
6. In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
7. A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
9. Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Only PCEs 2, 3, 4, 5, and 8 apply to marine nearshore waters identified as critical habitat. Lakes and reservoirs within the CHUs can contain most of the physical or biological features necessary to support bull trout, with the exception of those associated with PCEs 1 and 6. Additionally, PCE 6 does not apply to FMO habitat designated as critical habitat. Although PCE 9 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.

The Service evaluates activities that cause adverse effects to critical habitat to determine if they are likely to "destroy or adversely modify" critical habitat to an extent that it no longer serves the intended conservation role for the species nor retains the function of those PCEs that relate to the ability of the area to support the species. Activities that may destroy or adversely modify critical habitat are those that alter the PCEs to such an extent that the conservation value of critical habitat is appreciably reduced (75 FR 63898; USFWS 2004d, Vol. 1. pp. 140-193, Vol. 2. pp. 69-114).

2.3.3 Conservation Role and Description of Bull Trout Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (75 FR 63898). Core areas reflect the metapopulation structure of bull trout and approximate relatively discrete units for the purposes of recovery planning and risk analyses. Critical habitat units 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. The Service designated 32 CHUs and 78 associated subunits within the geographical area occupied by bull trout under the 2010 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.

Consistent with the general conservation role of bull trout critical habitat, the primary function of individual CHUs and subunits is to maintain and support core areas. These core areas, in turn, have multiple functions and characteristics, which include: (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 and, in part, provide habitat conditions that encourage movement of migratory fish (MBTSG 1998, pp. 48-49; Rieman and McIntyre 1993, pp. 22-23); (3) cover an area 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) represent the full 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).

To determine what should be designated as critical habitat for bull trout, the Service identified specific areas that contain the physical and biological features essential to bull trout conservation, considering distribution, abundance, trend, and connectivity needs. The objective was to ensure the areas designated as critical habitat would effectively serve the following recovery goals:

- Conserve opportunity for diverse life-history expression
- Conserve opportunity for genetic diversity
- Ensure bull trout are distributed across representative habitats
- Ensure sufficient connectivity among populations
- Ensure sufficient habitat to support population viability (e.g. abundance, trends)

- Consider threats to the species
- Ensure sufficient redundancy to conserve population units

The Bull Trout Final Critical Habitat Justification document (USFWS 2010c) provides the rationale for the designation of areas to meet the conservation needs of bull trout, including the uniqueness of some CHUs. For example, the Olympic Peninsula and Puget Sound CHUs are the only CHUs that support amphidromous[2] bull trout and are unique to the Coastal-Puget Sound population segment. These two CHUs contain marine nearshore and freshwater habitats, outside of core areas, that are used by bull trout that seasonally migrate from one or more core areas. These habitats contain physical and biological features that are critical to adult and subadult foraging, overwintering, and migration, and are essential for the conservation of this unique life history.

2.3.3.1 *Activities that May Affect PCEs*

The final rule (75 FR 63898) states, "A variety of ongoing or proposed activities that disturb or remove primary constituent elements may adversely affect, though not necessarily 'adversely modify' bull trout critical habitat as that term is used in section 7 consultations." Actions that may adversely affect critical habitat could occur within the waterbody and/or on lands adjacent to or upstream of waterbodies designated as critical habitat. Activities that have been identified as directly and/or indirectly affecting bull trout critical habitat PCEs include but are not limited to the following: mining, agriculture, grazing, water use, flood control, bank stabilization and other instream construction work, recreation, transportation development, road maintenance, timber harvest, dams, and introductions of nonnative invasive species. These activities may affect bull trout critical habitat by altering water chemistry, creating instream barriers (both permanent and temporary), increasing water temperature, reducing the food base, and precluding natural stream and hydrologic functions.

2.3.4 **Current Critical Habitat Condition Rangewide**

The condition of bull trout critical habitat varies from good to poor across its range. There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded PCEs, the following are particularly significant and have resulted in a legacy of degraded habitat conditions:

(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

[2] Amphidromous species leave the marine environment and return seasonally to fresh water as subadults, sometimes for several years, before returning to spawn (Brenkman and Corbett, 2005, p. 1075).

compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993, p. 857; Rieman et al. 2006, pp. 73-76);

(4) In the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and

(5) Degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

Since the revised critical habitat designation became effective on November 17, 2010, few projects and natural events have occurred that have affected the condition of critical habitat. Thus at the rangewide scale, the current baseline condition of critical habitat is fundamentally similar to what it was at the time of designation. No Section 7 consultations on projects have concluded that adverse modification of critical habitat was likely, and no large natural events have changed the baseline condition of any units. Likewise, the ongoing effects of climate change are modifying the condition of critical habitat, but the short period of time since designation suggests that climate-related changes are likely negligible.

2.4 ENVIRONMENTAL BASELINE OF BULL TROUT CRITICAL HABITAT

The action area is part of the Yakima River Basin critical habitat unit (Unit 11), as designated by the Service's October 18, 2010, final rule (75 FR 63898). This CHU does not contain any subunits because it supports a single core area. For context, we first provide a general characterization of the overall status of the entire critical habitat unit. We follow this with a more specific description of baseline conditions in the upper Yakima watershed where the Project is located. The Environmental Baseline for bull trout was described in Section 3 above using the Matrix of Pathways and Indicators as a framework for organizing our presentation. Here, we describe the current condition of bull trout critical habitat in the Yakima Basin CHU using the Primary Constituent Elements as the organizing framework. The correspondence between indicators in the MPI and the PCEs of critical habitat is presented in Appendix 2B.

2.4.1 **Environmental Baseline for the Yakima Basin CHU**

The Yakima River CHU is located on the eastern slopes of the Cascade Range in south-central Washington. It encompasses the entire Yakima River basin located between the Klickitat and Wenatchee Basins. The Yakima Basin CHU includes the mainstem Yakima River and its tributaries from its confluence with the Columbia River upstream to its headwaters at the crest of the Cascade Range. The Yakima Basin drains generally southeast into the Columbia River near the town of Richland, Washington.

The Yakima River basin is one of the largest basins in the state of Washington. The basin occupies most of Yakima and Kittitas Counties, about half of Benton County, and a small portion of Klickitat County. A total of 1,177.2 km (731.5 mi) of stream habitat and 6,285.2 ha (15,531.0 ac) of lake and reservoir surface area in this CHU are designated as critical habitat.

Across the Yakima CHU, habitat conditions show a similar pattern; lower reaches of the mainstem Yakima and its tributaries are fairly degraded, likely influenced by the high degree of development, roads, forestry, agriculture, irrigation diversions, grazing, mining, and other infrastructure. Many lower reaches also have 303(d) listed impairments of water quality, with temperature and instream flow being fairly common. In contrast, the upper reaches are generally

of higher quality and have less anthropogenic impacts, although there is substantial variation across the CHU. Although this pattern is typical, there is substantial variation among watersheds within the unit.

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

Historically, the hydrologic cycle of the Basin was characterized by extensive exchange between surface waters and the shallow alluvial groundwater aquifers (Kinnison and Sceva 1963). Spring runoff (and other high flow events) spread across the floodplain, distributing cold water into side channels that percolated into and recharged the alluvial aquifer. Alluvial aquifers served as hydrologic buffers that returned water to the Yakima River as baseflow later in the season after the cessation of snowmelt runoff. Current hydrology in the Yakima core area is controlled by the Bureau of Reclamation's Yakima Basin Project, and these controlled flows deviate significantly from the natural flow regime.

Through annual flow manipulation, the BOR Project has significantly altered the natural hydrologic system within the Yakima River Basin by: (1) significantly reducing the extent of alluvial flood plain habitats and the role of alluvial aquifers in maintaining cold water in streams; (2) altering the runoff regime; and (3) disrupting the longitudinal, vertical, and horizontal connectivity of affected river systems within the Basin. Significant flood plain encroachment also has occurred in the Basin. On average, 66 percent of five alluvial reaches evaluated have been physically disconnected (Eitemiller et al. 2000). In the upper Yakima Basin, an average of 60 percent of the floodplain has been lost and from 57 to 85 percent of the floodplain in the lower Yakima River has been lost (Snyder and Stanford 2001). These encroachments have eliminated or isolated large areas of side channels and sloughs.

What little functional flood plain that remains has been, and continues to be, affected by BOR Project operations. River operations for irrigation and flood control alter the natural hydrograph by impounding high flow events. A common effect of these operations is a sharp reduction in the frequency with which high flow events recharge the alluvial flood plain aquifer. Truncation of flood peaks by capture in reservoirs also reduces the duration, magnitude, and spatial extent of flood plain inundation. This not only alters the quantity, quality, and timing of groundwater discharge to the river but also diminishes the availability, extent, and temporal duration of off-channel habitats. These changes in the pattern of floodplain inundation also have the undesirable effect of encouraging further commercial and residential development on the flood plain. Flood plain disconnection combined with flow regulation (i.e., the inversion and truncation of the natural hydrograph) have dramatically reduced river flood plain interactions. The result has been a loss of horizontal and vertical connectivity, diminished habitat heterogeneity through the loss of off-channel habitat, and a general loss of ecosystem function. Because these alterations are concentrated in the lower watershed, this PCE illustrates the general pattern described above of degraded conditions in the lower watershed and good conditions in the upper reaches of tributaries. Considering the scale of the entire subunit, we believe the baseline condition of this PCE is "functioning at risk."

2.4.1.2 *PCE 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.*

There are five major storage reservoirs in the basin; Keechelus, Kachess, and Cle Elum in the Yakima sub-basin, and Bumping and Rimrock in the Naches sub-basin. None of the dams forming these reservoirs provide upstream fish passage. Of the 16 identified local populations, 12 are either completely or partially isolated. These passage barriers have fragmented the bull trout metapopulation and limited migration to high quality spawning, foraging, and overwintering habitat.

Water withdrawals from streams by irrigation diversions within the basin contribute to low flow conditions in some streams (i.e., Manastash, Taneum, Naneum, Ahtanum, and Cowiche Creeks and the Tieton River), and seasonal dewatering of others. Seven mainstem irrigation diversion dams (Easton, Town Ditch, Wapato, Sunnyside, Prosser, Yakima Tieton Irrigation District, and Horn Rapids) have contributed to altered flow regimes within the basin (Snyder and Stanford 2001). Low flows can inhibit bull trout spawning migrations and result in the stranding of juvenile bull trout in Ahtanum and Rattlesnake Creeks and Teanaway River (E. Anderson, WDFW, 2002, pers. comm.).

The combination of anthropogenic barriers to migration and the common occurrence of barriers due to dewatering in the mainstem and tributaries lead us to consider the overall condition of this PCE to be "functioning at unacceptable risk."

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

We have no direct information regarding this PCE, but may infer its functionality through evaluating the general condition of riparian areas, water quality/quantity, and overall habitat complexity. The condition of riparian areas and habitat complexity generally improves in the upper portions of the watershed, as the influences of development, agricultures uses, and other human management decreases. The exception may be commercial forestry, which can have locally significant effects on habitat condition and generally occurs in the mid- to upper-elevation areas in the CHU.

In most watersheds, roads parallel waterways and degrade riparian function, as well as channel dynamics and habitat complexity. Forest road location and density significantly degrade riparian conditions in some watersheds, likely to a degree that influences the food base for bull trout.

The diminished abundance of anadromous salmon is probably the most serious and persistent effect on bull trout food availability in the Yakima CHU. This factor, in combination with the effects of roads, leads us to consider this PCE as "functioning at risk."

2.4.1.4 *PCE 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.

Similar to PCE 3, the functionality of PCE 4 generally improves as you move up the watershed and development and land management pressures decrease. In lower portions of the Yakima CHU, many of the features or outcomes associated with development and land management (e.g., roads, residential development, agriculture, and livestock grazing) contribute to loss of wetlands and riparian areas and impair habitat complexity in aquatic environments. Roads and development impinge on stream channels, and riprap and levees designed to protect property and reduce flooding simplify habitats and alter hydrologic function, especially when large woody debris is removed or reduced in size or distribution. This in turn can alter sediment deposition patterns, large woody debris transport, and pool development. A variety of restoration activities have occurred in recent years, including reconnection of off-channel habitats, improved road maintenance, culvert replacement, road relocation, and installation of large woody debris. High variability among watersheds regarding the condition of this PCE makes it especially challenging to specify a synthetic rating for the entire CHU. Because bull trout require complexity in both FMO (lower watershed) and SR (upper watershed) habitats, we consider this PCE to be "functioning at risk," overall.

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

Throughout the Yakima Basin, over 45 streams have been listed on the 303(d) list of impaired waterbodies due to elevated temperatures. These waterbodies include most of the streams inhabited by local populations of bull trout.

Craig (1997) found that streams in the Yakima River basin with more than 20 redds had a 7-day summer mean temperature below 12 °C, and no single day with a temperature > 14.8 °C, while monitoring from the Lower Yakima and Naches rivers have shown extended river reaches with water temperatures that exceed the physiological tolerances of native salmonids (Yakima Basin Fish and Wildlife Recovery Board [YBFWRB] 2005). These data illustrate the general pattern described above of degraded conditions in the lower watershed and good conditions in the upper reaches of tributaries. Considering the scale of the entire unit, we believe the baseline condition of this PCE is "functioning at risk."

2.4.1.6 *PCE 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.*

The overall condition of substrate in spawning and rearing areas is generally good, because these areas are predominantly located in areas subject to little development or management pressures. Conditions among tributaries in the unit are, however, highly variable, and are influenced by the specific hydrologic, geologic, and other processes occurring in different watersheds. Bull trout rearing in many portions of this unit occurs in areas where extensive bank armoring and other changes associated with residential development have occurred. Substrate characteristics in these areas have likely been modified in ways that reduce survival. Considering both transient changes in substrate characteristics due to natural disturbance, and more chronic changes associated with development, we believe the overall condition of PCE 6 is "functioning at risk" in this CHU.

2.4.1.7 *PCE 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.*

The Yakima, Cle Elum, Tieton, Bumping, and Naches rivers are manipulated to maximize winter reservoir storage and summer irrigation deliveries according to the seasonal needs of irrigators (YBFWRB 2005). These operations result in streamflows that are mostly out of phase with the life history requirements of native salmonids. Reservoir operations combined with diversions across the Yakima Basin have inverted and truncated the natural pattern of streamflow so that river systems are now spatially and temporally discordant with their surrounding watersheds. Water withdrawals from streams by irrigation diversions within the basin contribute to low flow conditions in some streams (i.e., Manastash, Taneum, Naneum, Ahtanum, and Cowiche Creeks and the Tieton River), and seasonal dewatering of others. Seven mainstem irrigation diversion dams (Easton, Town Ditch, Wapato, Sunnyside, Prosser, Yakima Tieton Irrigation District, and Horn Rapids) have contributed to altered flow regimes within the basin (Snyder and Stanford 2001). Overall the condition of this PCE is "functioning at unacceptable risk," due primarily to hydrograph manipulations by storage reservoir operations and reductions in base flows.

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

The condition of this PCE is variable across the CHU. In spawning areas, water quality and quantity is generally good. In rearing areas, conditions are variable, with some degradation in both water quality (primarily due to increased sedimentation) and quantity. In FMO habitat in the lower portions of the CHU, numerous reaches are 303d listed for impairments due to pollutants. As described above, water withdrawals have also reduced water quantity sufficient to warrant 303d listing for low in-stream flow. Overall, PCE 8 is "functioning at risk" based on our qualitative integration of variable conditions across the entire CHU.

2.4.1.9 *PCE 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.*

A variety of non-native fish have been stocked throughout the CHU in the past for a variety of purposes including increased recreational angling opportunities. While this no longer occurs in connected waterways, several species of non-native fish are present throughout the CHU and likely have negative effects to bull trout including competition, hybridization, and predation. Brook trout are widely distributed in the unit. While we know that negative interactions are occurring with non-native fish species, we cannot quantify the magnitude of this effect. Given this uncertainty, we assume this PCE to be "functioning at risk" at the scale of the CHU.

Integrating across PCEs, the overall condition of the Yakima CHU is "functioning at risk," with considerable variability within and between watersheds. Spawning and rearing areas are generally in more functional condition than FMO habitat.

2.4.2 Environmental Baseline of Critical Habitat in the Upper Yakima Watershed and the Action Area

At this smaller scale, we can provide a more specific assessment of PCE function because we are describing conditions at a certain location rather than trying to characterize typical conditions across a broad geographic area that is highly variable. To streamline our description of baseline conditions at the watershed and action area scale, we use a "crosswalk" (Appendix 2B), which shows the relationship between the PCEs of critical habitat and the MPI habitat indicators. Many of the physical, chemical, and biological features of the PCEs of critical habitat correspond to MPI habitat indicators.

As described in section 1.5 above, the Action Area for this Project is located entirely in the Upper Yakima watershed, and includes areas of Keechelus Lake and surrounding uplands that will be affected by Project-related noise. The outer boundary of the action area within Keechelus Lake is defined by the propagation and attenuation of sound waves from blasting.

The conservation role of bull trout critical habitat in the action area is to provide lacustrine FMO habitat functions. Critical habitat in Gold Creek, which is outside the action area but is within the Upper Yakima watershed, provides both foraging, migratory, and overwintering habitat, as well as spawning and rearing habitat.

Using the terminology of the MPI, we consider most of the PCEs in the Upper Yakima watershed and the action area to be "functioning at risk," with the remainder "not properly functioning " (Table 2.7). For those PCEs that are "functioning at risk," all included some indicators that were "not properly functioning," suggesting that overall critical habitat functionality in the watershed and action area leans decidedly toward the low end of the functionality spectrum. As described in the Environmental Baseline sections above, resilience of critical habitat in the Upper Yakima watershed to further impacts is likely quite low.

Table 2.7. Baseline Condition of Critical Habitat in the Upper Yakima Watershed and the Action Area

PCE	Properly Functioning	Functioning at Risk	Not Properly Functioning
PCE 1 - Springs, Seeps, Groundwater		X	
PCE 2 - Migratory Corridors			X
PCE 3 - Abundant Food Base		X	
PCE 4 - Complex Habitats		X	
PCE 5 - Temperature			X
PCE 6 – Substrate		X	
PCE 7 - Hydrograph			X
PCE 8 -Water Quality/ Quantity			X
PCE 9 - Nonnative Species		X	

5.3.1 *Factors Affecting Critical Habitat in the Action Area*
Many of the same factors described in the Environmental Baseline, section 3.2 above, likely affect the condition and functionality of critical habitat in the action area in a similar manner. Critical habitat in the Upper Yakima watershed is likely only marginally providing for the conservation needs of the bull trout local population in this watershed.

2.5 EFFECTS OF THE ACTION ON BULL TROUT AND BULL TROUT CRITICAL HABITAT

The Service's section 7 regulations define "effects of the action" as "the direct and indirect effects of an action on the species together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline" (50 C.F.R. 402.02). "Indirect effects" are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur.

As we described in the Environmental Baseline section above, the MPI provides the framework the Service uses to assess potential Project effects (USFWS 1999). This format, adapted from the 1996 National Marine Fisheries Service format of a similar name, includes a decision matrix with pathways and indicators (MPI) designed to describe a baseline of population and habitat conditions and effects of the proposed action on these conditions. Baseline conditions are described on a relative scale of functionality for each indicator. We then evaluate project effects on each indicator in the context of the environmental baseline in the action area. We consider proximity, distribution, timing (duration, frequency), type, intensity, and severity of effects in order to evaluate the degree of effect resulting from project implementation (USDI and USDC 1998, pp. 4-22 to 4-24). The Service typically expresses degree of effect in terms of impacts to individual fish and fish populations and deviations of habitat indicators in the MPI from their baseline condition. This entire process is described in the *Analytical Process for Developing Biological Assessments for Federal Actions Affecting Fish within the Northwest Forest Plan Area* (USDA et al. 2004), a document produced through interagency cooperation between the

Service, the National Marine Fisheries Service, the Bureau of Land Management, and the USFS. This analytical process is the framework for our assessment of the proposed action.

In an effort to streamline our analysis of Project effects, we consider simultaneously effects on the bull trout, as well as effects on designated critical habitat for the bull trout. We do this in the context of the MPI by first considering direct effects on bull trout population indicators, and second, by considering effects on habitat indicators. We then rely on the Crosswalk (Appendix 2B) to translate Project effects on indicators into a summary of effects on PCEs of designated critical habitat for the bull trout.

To begin our analysis of effects, we typically deconstruct projects into separate elements that trigger different impact mechanisms. We have characterized this Project as having three elements (see Project Description above and the BA for details). For ease of reference, we use the following labels for the three primary Project elements:

1. Site Preparation, rock excavation and blasting.
2. Bridge Construction, including work below the ordinary high water mark.
3. Operations and Maintenance, including drainage and stormwater treatment.

We used these Project elements to structure our analyses of direct effects to bull trout and indirect effects to habitat conditions, including effects to designated critical habitat.

The following premises underlie our approach to describing and analyzing Project effects:

1. Project elements trigger various impact mechanisms that directly kill (lethal effect), injure, or modify the behavior of bull trout, or result in changes in habitat condition that cause indirect injury (sub-lethal effects). Sub-lethal effects can vary from transient but significant disruptions of feeding behavior that temporarily reduce physiologic condition to physical injuries that reduce longevity and reproductive success.
2. All adverse effects can be integrated and expressed in the common currency of changes in the numbers, distribution and reproduction of bull trout.
3. Individual bull trout from local populations in the Wenatchee core area may be affected by the Project. Bull trout from other core areas may possibly be exposed to Project effects, but we believe that the likelihood of this is sufficiently low to be considered discountable.

Based on these premises, our effect analysis consists of two major components:

1. Evaluate the potential for direct injury or mortality of individual bull trout, and
2. Evaluate the potential for effects on habitat indicators to result in indirect adverse effects.

We integrate both components to determine their combined influence on the numbers, distribution and reproduction of bull trout populations exposed to effects of the action. Evaluating effects at the individual level relative to components 1 and 2 requires several sub-steps:

a. Determine which project elements and impact mechanisms are likely to result in adverse effects,
b. Identify the life stages most likely exposed to those effects.
c. Estimate the number of individuals in these life stages that will be exposed to project effects based on the intersection between the timing of element effects and the

seasonal timing of habitat use by different life stages. This typically involves estimating the total number of individuals present in the vicinity at the time project activities begin and the number of individuals likely to pass through the affected area during the anticipated period of effects and,

d. Estimate the relative severity of effects resulting from exposure.

Determining the Project elements likely to result in adverse effects can be accomplished by qualitatively evaluating the potential effects of each element on bull trout individuals and habitat indicators (Table 2.8). Although Table 2.8 resembles the "checklist" in the Matrix of Pathways and Indicators, we are not referring here to watershed-scale effects on indicators. Rather, we simply borrow the familiar MPI format to structure our qualitative ratings of the effects of Project elements on bull trout individuals and habitat at the action area scale. Identifying life stages likely to be exposed can usually be based on relatively good information about spatial and temporal patterns of habitat use. Estimating numbers of individuals exposed and the relative severity of effects requires many assumptions. The most basic assumption is that average conditions in the past can be used as an index of conditions during Project implementation. Numerous additional assumptions about population size, age structure, migration timing, reproductive rate and other features contribute to high levels of uncertainty surrounding these estimates. The Service attempts to be as transparent as possible about these sources of uncertainty.

Table 2.8. Relative effects of Project elements on bull trout and habitat indicators.

Direct effects and Indirect impact mechanisms (habitat indicators)	Project Elements		
	Site Preparation	Bridge Construction	Operations & Maintenance
Direct injury (turbidity or contaminant exposure)	-	Same as snowshed	- - - (contaminants)
Direct disturbance	- - - (blasting)	-	-
Temperature	-	+	+
Sediment/turbidity/ substrate embeddedness	-	Same as snowshed	- - / +
Chemical contaminants and Nutrients	-	-	- - - (contaminants)
Physical barriers	No effect	+	+
Large Wood	-	No effect	+
Pool frequency and quality	NA	NA	NA
Large pools	NA	NA	NA
Off-channel habitat	NA	NA	NA
Refugia	No effect	No effect	No effect
Width:depth ratio	NA	NA	NA
Streambank condition	- -	- -	- / +
Floodplain connectivity	No effect	- / +	+
Peak and base flow	-	-	- / +
Drainage network	-	-	-
Road density and location	-	-	-
Riparian reserves	-	-	+
Disturbance History	-	-	-
Disturbance regime	-	-	- / +

Minus signs indicate level of negative impact. One minus sign indicates a negative impact that is insignificant or discountable. Two minus signs indicates a negative impact that has the potential to cause an adverse effect to a listed species that can be reliably avoided by proper implementation of conservation measures. Three minus signs indicate a high likelihood of causing an adverse effect in all or a proportion of individuals exposed to this impact. "No effect" means bull trout are unlikely to be directly or indirectly affected by this project element because there are no impact mechanisms that link project elements to an indicator. Plus signs denote beneficial effects.

2.5.1 **Direct Effects**

All Project elements carry a reasonable likelihood of resulting in direct injury or mortality of bull trout (Table 2.8). The Service believes there are three impact mechanisms that could lead to direct injury or mortality of bull trout: (1) physical injury resulting from exposure to sound pressure waves associated with bedrock blasting near Keechelus Lake, (2) gill abrasion, physiologic stress, and behavioral changes associated with bull trout exposure to turbidity plumes following inundation or runoff from areas disturbed during construction, and (3) physiologic and behavioral changes associated with exposure to toxic contaminants in untreated plow spray and untreated stormwater. Minimization measures and conservation measures included in the Project should be effective at minimizing injury and mortality from these mechanisms. However, despite these measures, injury and mortality will likely occur and what follows is the Service's attempt to estimate the magnitude of these effects by Project element.

For Site Preparation, we did not evaluate the potential effects of nearshore blasting in our original biological opinion. The location and seasonal timing of proposed blasting activities suggests that adult and sub-adult life stages of bull trout are most likely to be exposed. We expect that few, if any, rearing juveniles are likely to be exposed to this Project element based on the assumptions that juveniles predominantly rear in tributaries near spawning areas, which are several miles from the action area, and that juveniles typically do not emigrate to the Lake in large numbers unless they are physically displaced from upstream rearing areas in Gold Creek by extremely high flow events (Downs et al. 2006). Thus, we expect all exposed bull trout to be at least sub-adult size (about 150 mm or 6 inches).

For Bridge Construction, we expect this Project element to result in turbidity plumes that could cause adverse direct effects. We expect these plumes to be similar in size and duration to those associated with construction of the large snowshed, which we evaluated in our 2008 biological opinion. We considered the potential for the expected 0.5 to 0.85 acre increase in the area of disturbance under the Bridges to result in increased turbidity that could increase adverse effects to bull trout. Our opinion is that in the bedrock and boulder dominated area where the Bridges will be constructed, that the increased size of the disturbed area is unlikely to produce turbidity plumes when inundated post construction that differ substantially from those expected to result from snowshed construction. The increase in disturbed area associated with the Bridges warranted re-analysis of potential turbidity effects in this reinitiation of consultation, because it probably will produce more turbidity. However, our opinion is that the increase in turbidity will be small and the effect pathway and number of bull trout exposed is likely to be the same, resulting in the same estimated amount of incidental take from the Bridges as from the large snowshed. Therefore, we do not consider Bridge construction to result in substantially new or different effects relative to our original consultation. Because we do not expect any substantive differences in direct effects due to sediment exposure than we analyzed previously, we will not repeat that analysis here (please see pages 61 to 72 of our 2008 biological opinion).

For Operations and Maintenance, our opinion is that the Bridges will have a higher likelihood of producing harmful exposures to contaminants than the large snowshed. Operations and maintenance activities during late fall, winter, and early spring (roughly December 1 to April 1) are more likely to result in occasional harmful exposures because during this period plow spray

can deliver contaminants directly to the Lake and snow and ice build-up will reduce or negate the functionality of stormwater treatment facilities.

2.5.1.1 *Disturbance due to Blasting Exposure*
The detonation of explosives in or near water produces post-detonation compressive shock waves characterized by a rapid rise to a high peak pressure followed by a rapid decay to below ambient hydrostatic pressure. The latter pressure deficit causes most impacts on fish (Wright and Hopky 1998, pg. 3). The primary site of damage in finfish is the swimbladder, the gas-filled organ that permits fish to maintain neutral buoyancy. The kidney, liver, spleen, and sinus venous also may rupture and hemorrhage. Limited studies show that an overpressure in excess of 100 kPa will result in these effects (Wright and Hopky 1998, pg. 3). The degree of damage is related to type of explosive, size and pattern of the charge(s), method of detonation, distance from the point of detonation, water depth, and species, size and life stage of fish. Sub-lethal effects, such as disturbance-induced changes in behavior of fish, have been observed on several occasions as a result of noise produced by explosives (Wright and Hopky 1998, pg. 3). The effects may be intensified in the presence of ice and in areas of hard substrate (Wright 1982).

Current guidance from the Service and the National Marine Fisheries Service uses 150 dB_{rms} as the lower threshold measure of sound energy that has the potential to result in adverse behavioral effects. Sound pressure levels in excess of 150 dB_{rms} are expected to cause temporary behavioral changes, including elicitation of a startle response, disruption of feeding, or avoidance of an area. These levels are not expected to cause direct permanent injury, but may result in adverse sub-lethal effects to individual fish. The currently accepted noise thresholds for physical injury to salmonids are 206 dB_{peak} and 187 dB cumulative sound energy level for salmonids weighing greater than or equal to 2 grams. We do not expect blasting will elevate sound pressure levels within Keechelus Lake to the identified threshold for physical injury.

The same rationale and model described in the Action Area section above can be used to define a zone of potential for adverse behavioral effects within Keechelus Lake. A sound pressure level of 194 dB_{peak} (179 dB_{rms}) will attenuate to below the 150 dB_{rms} threshold for potential behavioral effects within 86 meters (282 feet) of the shoreline of Keechelus Lake at the blasting site. These effect-zone calculations do not incorporate the pressure reduction likely to result from use of minimization measures. The minimization measures as described in this document and actual water levels during construction will further minimize this potential effect to bull trout. However, any adult or sub-adult bull trout that would be within the effect zone in Keechelus Lake during blasting and within the area identified above could potentially be exposed to a change in behavior or avoidance of the area.

The conservation measures included in the Project include measures designed to reduce sound pressure levels that reach the Lake (minimization measures) and measures that take advantage of life cycle timing and behavior of bull trout to reduce the potential for exposure (avoidance measures). The minimization measures include use of time-delay blasting and use of vent holes or line drilling. These are known to be effective measures at reducing sound levels, but specific details regarding their implementation can influence their effectiveness. For example, Wright and Hopky (1998, pg. 9) recommend a time delay of 25 milliseconds in order to minimize the potential for serial charge detonations to amplify pressure levels. Similarly, the size and

distribution of vent holes can appreciably influence the degree to which this approach reduces blast-induced ground vibrations (Park et al 2009, pg. 465 - 468). Rather than assume a particular form of implementation of these measures and estimating potential impacts to bull trout accordingly, we conduct our analysis of blasting effects using the conservative approach described in the BA in which no reductions in sound pressure are ascribed to the minimization measures (attenuation is by distance only).

We incorporate consideration of the effectiveness of most avoidance measures in our effects analysis. However, we have no basis for estimating the degree to which blasting may be deferred seasonally to allow drawdown of Keechelus Lake to increase the distance to the water, so the beneficial effects of this avoidance measure are not factored into our analysis (we assume blasting commences when charge sizes and setback distances consistent with Table 1.4 (Wright and Hopky 1998) can be implemented).

Under these criteria, the zone of behavioral impact in Keechelus Lake covers roughly 10 acres. The total area of Keechelus Lake varies considerably based on surface elevation, but at ordinary high water that area is about 2,400 ac. Using this total surface area, the 10 acre zone of behavioral impact represents less than 1 percent of the total Lake area.

In our original biological opinion we assumed that the number of adult and sub-sdult bull trout exposed to sediment was proportional to the area of the Lake affected by sediment plumes (pg. 63). We estimated adult abundance in the Lake during the construction season to be about 50 individuals and the population of sub-adults to be about 250 individuals, for a total of 300 bull trout in both life stages. If we again assume that exposure of bull trout is proportional to the area of the Lake impacted, then we would expect that less than 3 bull trout (1 adult and 2 sub-adults) could be exposed to blasting in each construction season when blasting occurs (2 seasons expected)(Table 2.9 below). This estimate is based on using best-professional judgment to integrate multiple sources of uncertainty including:

- Seasonal duration of blasting.
- Diel and seasonal movement patterns of bull trout.
- Propensity of bull trout to either avoid or be attracted to the blast area (i.e., stunned or disoriented prey could be an attractant).

Given high uncertainty, we consider the proportional area approach to exposure estimation to be a reasonable approximation. We assume that all bull trout exposed to blasting noise will experience adverse behavioral effects.

2.5.1.2 *Contaminant Exposure*

We acknowledge that FHWA and WSDOT have committed to using the best available approaches to managing stormwater in the I-90 Snoqualmie Pass East project area, including the constrained area in the vicinity of the avalanche Bridges. In an effort to find new or alternative ways to minimize anticipated adverse effects resulting from bull trout exposure to stormwater contaminated with metals such as copper and zinc, the Service carefully reviewed the proposed design of the Bridges and information about the performance of different stormwater treatment BMPs, especially in regard to metal removal (e.g., Davis et al. 2003; Geosyntec and Wright Water Engineers 2012; Hossain et al. 2005; Huang 2012; Sun and Davis 2007; Li and Davis 2009, Maurer 2009; Vijayaraghavan et al. 2010). The outcome of this effort is that we are

convinced that the proposed design incorporates the features that will produce a highly effective treatment system within the constraints imposed by space limitations and other functional objectives of the Bridge design. Further reduction of potential exposures would require more than minor changes to the proposed design, which we do not feel are warranted, given our expectations about the frequency and severity of potential effects resulting from exposures. We also note that the current highway does not include any designed stormwater treatment. Both the Bridges and the snowshed will result in significant improvements in water quality relative to baseline conditions, reducing loading of metals and other contaminants by 50 percent or more despite highway expansion (Water Resources Technical Update 2012, pg. 9).

Under common or typical conditions, we expect that enhanced stormwater treatment of an equivalent area of pavement that would have been covered by the snowshed, using approved treatment methods, will provide appropriate treatment. Likewise, under typical winter conditions we expect levels of contaminants in plow spray and treated stormwater to be relatively low, and when diluted in Keechelus Lake, benign to exposed bull trout. We do not expect harmful exposures to contaminants to result from de-icer or traction sand applications. Some research exists to indicate that an increase in de-icer components in receiving waters would not be detectable (WSDOT 2002b). Chloride and magnesium concentrations likely to be released into aquatic environments as a result of the use of de-icer compounds in the I-90 project area should be well below levels harmful to aquatic organisms (OTAK 2007). In general, we do not expect harmful exposures to occur when stormwater treatment facilities are fully operational.
We expect contaminant levels in treated stormwater to be too low to cause adverse effects to exposed bull trout, and that there will be very little difference in levels of contaminant delivery between the large snowshed and the Bridges when stormwater treatment facilities are fully operational.

The Bridges, however, will increase the amount of highway surface that requires winter maintenance by nearly 3 acres compared to the large snowshed. During the winter, contaminants from vehicle traffic will likely mix with snow and ice on the road surface. Subsequent plowing operations on the bridges and resulting plow spray will then deposit this mixture, untreated, directly into Keechelus Lake. During winter operations, icing also will likely reduce effectiveness of stormwater treatment facilities. Under these particular conditions, we expect adverse effects to bull trout due to exposure to roadway contaminants to occur infrequently.

The Service anticipates that harmful pulses of contaminants could be delivered to the Lake occasionally after extended periods of contaminant accumulation on the roadway and when stormwater treatment facilities have diminished function due to icing. The Service estimated that harmful exposures would be infrequent events because they require the simultaneous occurrence of:

- An extended period of contaminant accumulation on the roadway,
- Icing of stormwater treatment facilities sufficient to reduce or negate their effectiveness,
- Heavy snow or rain following the period of accumulation that leads to delivery of untreated stormwater or plow spray directly to Keechelus Lake,
- Water surface elevation of Keechelus Lake high enough to inundate the area near the Bridges,

- Concentrations of dissolved copper and zinc in this plow spray or untreated runoff high enough to temporarily raise concentrations in Keechelus Lake below the bridges to harmful levels, and
- Exposure of bull trout under this suite of conditions.

Nonetheless, the 75-year design life of the bridges also contributes to our opinion that all of these conditions are reasonably certain to co-occur, resulting in exposure of bull trout to harmful levels of contaminants. Though undoubtedly infrequent, we consider these exposures to be reasonably certain to occur because:

- Records of weather conditions indicate that periods with a relatively low probability of precipitation normally occur from mid-January to early February, and often persist for 2 weeks or more (data for Stampede Pass Station 458009, for the period 1 January 1944 to 30 September 2012, accessed at http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa8009). These periods are often followed by relatively heavy precipitation events.
- Icing of stormwater treatment facilities will occur during winter nearly every year.
- Keechelus Lake water surface elevations over 2,500 feet have occurred during this winter period in six years (roughly 18 percent of years) since 1980 (data for Keechelus dam accessed at http://www.usbr.gov/pn-bin/yak/arc3.pl?station=KEE).

We do not, however, have information necessary to estimate concentrations of metals in untreated stormwater at this location, or resulting concentrations in Keechelus Lake.

As described in our original analysis of the entire I-90 Snoqualmie Pass East Project, we expect that bull trout in Keechelus Lake are likely to be exposed to occasional pulses of contaminated plow spray or untreated stormwater that contain concentrations of dissolved metals or hydrocarbons high enough to result in adverse behavioral or physiologic effects. The effects described here represent a small incremental increase in these effects associated with replacing the large snowshed with avalanche bridges.

Rain on snow events after extended cold and relatively dry weather in winter could provide a high risk context for accumulation of contaminants on the roadway followed by their rapid delivery to the Lake in untreated stormwater. Typical roadway contaminants such as zinc and copper have been found predominantly in dissolved form (rather than particulate bound) in pulses of roadway runoff after periods of accumulation (Sansalone and Buchberger 1997). Salmonids show adverse effects to slight increases in concentrations of metals above background levels, especially for zinc (Sprague 1968) and copper (Hecht et al. 2007). Currently proposed stormwater treatment BMPs for the Project are likely only to reduce dissolved copper to concentrations near 5 μg/L (Wright Water Engineers and Geosyntec Consultants 2011), which is greater than the level at which juvenile salmonids have shown negative effects in laboratory studies (Sandahl et al 2007). Expected average annual loadings of metals for the snowshed and Bridges are similar, but the Bridges are expected to increase dissolved copper loading by about 2.5 percent and dissolved zinc loading by about 2.2 percent (Water Resources Technical Update 2012, pg. 9). These estimates of loadings do not express ranges of variation and are not readily converted to concentrations associated with individual runoff events. Consequently, we interpret these loading changes simply as indicating the proposed Project carries a slightly increased risk of exposure to harmful contaminant levels. Bull trout appear to be less sensitive to acute copper and zinc exposures than other salmonids, but low hardness of water in Keechelus Lake increases

the potential for adverse effects from metal exposures (Hansen et al. 2002 a,b). The relative severity of effects resulting from these exposures is difficult to estimate given uncertainties, but behavioral avoidance of contaminated areas may be the most likely outcome (Hansen et al. 1999). Putting all these pieces together, our opinion is that high sensitivity of salmonids to increased concentrations of metals, combined with expected small increases in loadings, suggest that occasional exposures to adverse concentrations of metals or hydrocarbons are reasonably certain to occur over the life of the proposed Project.

Given uncertainty from several sources, our rationale for expecting adverse effects due to contaminant exposure is largely qualitative rather than quantitative. These sources of uncertainty also preclude us from estimating the number and life stages of bull trout likely to be exposed to contaminants and the likely consequences of that exposure. Sources of uncertainty include the future likelihood of occurrence of weather conditions conducive to contaminant accumulation and delivery, contaminant concentrations and speed of dilution to non-toxic levels, as well as factors associated with the density and distribution of bull trout in the Lake.

We expect exposure events to be infrequent, and that low numbers of bull trout could be exposed to harmful concentrations of contaminants for sufficient time to result in adverse effects. We estimate that the area of the Lake in which adverse contaminant exposures might occur is roughly about 5 acres, considering the length of the proposed Bridges, the lateral extent of plow spray, and that diffusion and mixing will slightly expand the area affected by contaminants. We consider infrequent behavioral avoidance of about 5 acres of nearshore habitat in Keechelus Lake to represent the adverse effect associated with the proposed design modification. In this situation with several sources of uncertainty, monitoring could play an important role in developing a better understanding of potential adverse effects to bull trout from contaminant exposures.

2.5.1.3 *Summary of Direct Effects to Bull Trout*

In comparison to impacts from the large snowshed, we expect new direct effects to bull trout to emanate from blasting and exposure to roadway contaminants. We expect sub-adult and adult life stages to be exposed to these new effects, and that these effects will be sub-lethal (Table 2.9). We also expect that exposure of the same individuals to more than one of these sub-lethal effects will still result in sub-lethal consequences due to the anticipated relatively low severity of these effects. The time frames of effects from these mechanisms differ greatly. Blasting effects will be concentrated in up to two construction seasons (spring to fall) of blasting during site preparation early in the construction sequence. In contrast, contaminant exposure could occur anytime during the 75-year design life of the Bridges, and we expect harmful exposures to occur primarily during the winter.

Table 2.9. Summary of direct adverse effects* from the Bridges stratified by impact mechanism, life stage, and severity of effect.

Exposure Context			Severity of Estimated Effect		
Impact Mechanisms	Llife stage	Estimated number exposed	Exposed but not adversely affected	Sub-lethal effects	Lethal effects
Exposure to blasting noise	Adults	2	0	2	0
	Sub-adults	4	0	4	0
Exposure to contaminants	Adults	Behavioral avoidance of about 5 acres of nearshore habitat			
	Sub-adults				
Totals:		6	0	6	0

* Exposure to elevated suspended sediment is not included here because we expect these effects from Bridge construction to be the same as previously estimated for snowshed construction in our original biological opinion.

2.5.2 Effects to Habitat Indicators

The following sub-sections address indirect effects to bull trout from Project implementation. We discuss both negative and beneficial Project effects to habitat indicators in the MPI due to the Project elements. In general, we expect that site preparation will not result in effects to habitat indicators that are sufficiently severe to cause adverse effects to bull trout exposed to changed conditions. The rocky nature of the Keechelus Lake shoreline in the action area, combined with our expectation that BMPs will be effectively deployed during construction, provide the basis for this determination. Bridge construction and subsequent inundation of the disturbed work area will result in a temporary adverse effect to the sediment/embeddedness composite indicator (Table 2.8). This temporary adverse effect to habitat, however, as described under section 2.5.1 above regarding direct effects, will be similar to the adverse effects on this indicator associated with construction of the large snowshed, so this effect does not represent a new adverse effect associated with Bridge construction. Operations and maintenance of the Bridges will have adverse effects on the chemical contaminants indicator, and this does represent a new effect relative to the large snowshed. Overall, the only habitat indicators likely to experience sufficient degradation at the site scale to result in adverse effects to bull trout exposed to these changed habitat conditions are "sediment/embeddedness," and "chemical contaminants and nutrients" (Table 2.8). Multiple indicators will experience beneficial effects (Table 2.8).

As indicated in Table 2.8, we believe the elements of the proposed Project have no mechanisms by which they can affect the "refugia" indicator. Furthermore, several MPI indicators pertinent to channel conditions are not applicable to this Project located along the shoreline of Keechelus Lake ("pool frequency and quality," "large pools," "off-channel habitat," and "width to depth ratio"). We will not discuss any of these indicators further in our analysis of this Project's effects.

2.5.2.1 *Temperature*

This indicator is currently "not properly functioning" and our expectation is that the proposed Project will have negligible negative effects on temperature during site preparation, primarily due to removal of a small amount of riparian vegetation along the lakeshore. Bridge construction and operation may have a slight positive effect on temperatures relative to the large snowshed by improving hydrologic connections between the hillside and the Lake and by shading a small

portion of the Lake surface during some seasons when water levels in the Lake are high. These slight beneficial effects are unlikely to result in much change in bull trout use of habitat near the bridge.

2.5.2.2 *Sediment/Embeddedness*

The sediment and embeddedness indicators are "functioning at risk" in the Upper Yakima watershed. Theses habitat indicator are intended to focus on substrate conditions in spawning and rearing habitat, respectively, both of which are located primarily in Gold Creek and will not be affected by the proposed Project. In the context of this Project on the shoreline of Keechelus Lake in FMO habitat, we considered the potential for elements of the proposed Project to result in levels of increased sedimentation that could change the nature of substrate in the Lake sufficiently to alter patterns of habitat use (primarily foraging) by sub-adult and adult bull trout. Construction of the Bridges will require more extensive temporary impacts below the OHWM of Keechelus Lake compared to the snowshed (1.02 acres compared to 0.45 acre), primarily due to excavation of the avalanche chutes. Because excavation of the engineered avalanche chutes will occur when the Lake is drawn down and the work area is dry, temporary sedimentation impacts will be limited to releases produced following the first contact of the excavated area with precipitation or wave action following removal of sediment control BMPs. Most of the substrate in this location will consist of large rock, which should minimize these temporary turbidity impacts. Our opinion is that efficient use of best management practices is likely to limit sediment mobilization to the Lake during site preparation and bridge construction. Increased sedimentation from these elements is unlikely to be of sufficient volume to substantively change habitat quality by reducing abundance or productivity of prey species or substantially reducing access to interstitial spaces. As described above, however, individual bull trout exposed to post inundation turbidity plumes that occur post construction may experience temporary adverse effects.

In contrast to the proposed large snowshed, the Bridges have an increased likelihood of delivering increased sediment levels during ongoing operations and maintenance. These sediment inputs will have both beneficial and negative effects depending on their source. Beneficial effects are likely to accrue from avalanche debris reaching the lakebed. Sediment from this source is likely to consist of a variety of grain sizes from silt to boulders and will likely be accompanied by large woody debris. This complex mix of materials is likely to improve substrate complexity and corresponding habitat quality for both bull trout and their prey. In contrast, the bridges will result in chronic inputs of traction sand during winter operations. These inputs will likely exceed traction sand inputs associated with the large snowshed. Adherence to winter maintenance plans that limit application of traction sand as well as installation of grit chambers on the Bridges should prevent the delivery of sand to the degree that it degrades habitat quality sufficiently to result in adverse effects to bull trout that are exposed to those changed habitat conditions. The steep slope of the lakebed near the Bridges and periodic scouring of the lakebed from avalanches should also help to reduce the accumulation of traction sand in the vicinity. Avalanche debris, however, will likely include some coarse-grained substrate material that would have low levels of embeddedness soon after its deposition in the Lake. These inputs could sufficiently improve embeddedness levels that bull trout and their prey could temporarily increase use of habitat near the bridges.

2.5.2.3 *Chemical Contaminants and Nutrients*
The baseline condition of this indicator is "functioning at risk." Although site preparation and bridge construction have the potential to lead to harmful releases of contaminants to the lakebed, past experience suggests that proper deployment of conservation measures, BMPs, and risk minimization measures, combined with robust construction oversight and monitoring, will reduce this risk to discountable levels.

In contrast, ongoing operation of the bridges will likely lead to contaminant inputs that could result in adverse effects to exposed individuals. The Bridges will increase the amount of highway surface that requires winter maintenance by nearly 3 acres compared to the large snowshed. Water quality impacts from operations would be due primarily to mixing of contaminants with snow and ice on the road surface. Subsequent plowing operations on the Bridges and resulting plow spray will then deposit this mixture, untreated, directly into Keechelus Lake during winter operations. Effectiveness of stormwater treatment BMPs is also likely to be reduced by icing during winter operations. In the section above that described direct effects, we estimated that contaminant inputs could occasionally reduce bull trout use of about 5 acres of nearshore habitat in Keechelus Lake.

2.5.2.4 *Physical Barriers/Habitat Access*
The baseline condition of this indicator is "not properly functioning." The Project does not occur in an area with any tributary streams, and therefore will not affect habitat access in this regard. Excavation of the engineered avalanche chutes will, however, create a 1.28-acre increase in shoreline habitat below OHWM, and a 2.22-acre increase in shoreline habitat below full-pool elevation. This additional habitat area within the Lake will beneficially affect bull trout by providing additional foraging and daily movement opportunities for any fish that may use the nearshore areas whenever water levels in the reservoir are high. Complexity of this habitat may be enhanced by avalanche debris, potentially allowing this habitat to have disproportionately high levels of use by all life stages of bull trout found in Keechelus Lake.

2.5.2.5 *Large Woody Debris*
The current condition of this indicator in the upper Yakima watershed is "not properly functioning." There will be no difference in riparian vegetation removal between the snowshed and the Bridges, indicating no difference in potential wood recruitment from trees on the shoreline of the Lake. Upland differences in vegetation clearing are present, however, between the large snowshed and the Bridges. Approximately 2.2 acres of additional upland terrestrial habitat will be removed for the construction of the Bridges. Most of this habitat is mature forest. Removal of this habitat represents a negative effect on potential wood recruitment associated with the Bridges, but this negative effect needs to be considered in the context of fundamental design differences between the Snowshed and Bridge alternatives. A potential beneficial effect of the Bridges is increased delivery of large woody debris to Keechelus Lake from avalanches. Compared to the snowshed, which would have caught most woody debris falling down the slope, the Bridges will allow woody debris carried by avalanches to be transported to the shoreline. This woody debris could improve shoreline habitat complexity for bull trout foraging along the shoreline, providing cover for both bull trout and their prey. The durability of this habitat enhancement will depend on the degree to which boulders and other coarse material in the avalanche debris functions as ballast to hold the large woody debris in place when reservoir

operations lead to inundation of the debris field. Some woody material will be removed by rising lake levels and moved down-lake toward Keechelus Dam where it may be removed if it interferes with reservoir operations. Vegetation in the avalanche chutes is currently dominated by shrubs, which limits the availability of large woody debris for delivery to the Lake. Growth and maturation of trees on the slopes above the bridges will also likely lead to more stable snow conditions and contribute to reduced rates of avalanche occurrence in the future. Large avalanche events, however, will occasionally deliver some of these larger trees to the Lake. Over the life of the Project, we expect the Bridges to provide a net benefit compared to the large snowshed for this habitat indicator.

2.5.2.6 *Streambank Condition*

This indicator is currently considered to be "functioning at risk" in the upper Yakima watershed. Because no permanent or intermittent streams are in the Project area, we discuss Project effects to this indicator in terms of shoreline condition in Keechelus Lake. Both the Bridges and large snowshed designs included roughly equal amounts of work below the OHWM that will result in negative effects on shoreline condition during site preparation and construction (Table 6). The key difference between the designs is that most of these impacts to shoreline condition were permanent with the Snowshed, but will be temporary with the Bridges. The large snowshed design included a long retaining wall (> 1,000 feet) that would serve as the shoreline for the Lake at higher surface elevations of the reservoir. The Bridges replace most of this shoreline wall with a shoreline consisting of native material. This more natural shoreline will consist mostly of large boulders or bedrock, with relatively little vegetation present. Nonetheless, this more natural shoreline will provide more habitat complexity for bull trout and their prey than the retaining wall. The proposed shape of this shoreline, a series of small bays between peninsulas of fill protecting the Bridge piers, also will increase shoreline length and shelter these areas from wave action. These complex, shaded, and sheltered shoreline habitats will likely have their biggest beneficial effect on bull trout by enhancing foraging opportunities. Unfortunately, this attractive habitat would be located where untreated stormwater and plow spray during winter could occasionally expose bull trout to contaminants.

2.5.2.7 *Floodplain Connectivity*

The upper Yakima watershed is "functioning at risk" for this indicator. Again, because no permanent or intermittent streams are in the Project area, we discuss Project effects to this indicator in terms of connectivity between Keechelus Lake and adjacent uplands. Restoration of ecological connectivity is one element of "purpose and need" for the overall I-90 Snoqualmie Pass East Project. Comparing the large snowshed to the Bridges in terms of connectivity restoration suggests that the Bridges provide a substantive benefit. The Bridges will allow natural processes, including groundwater flow as well as avalanches and associated debris, to move in relatively uninterrupted paths from the uplands to the Lake. As described above, this process continuity will likely enhance habitat complexity and productivity, improving aquatic habitat conditions for bull trout in the Lake.

2.5.2.8 *Peak and Base Flows*

The baseline condition of this indicator in the upper Yakima watershed is "not properly functioning." We expect overall Project effects from all elements to be relatively minor for this habitat indicator. The Bridges will be installed in an area of steep terrain with shallow rocky

overburden on top of bedrock. Site preparation and construction will likely increase the pace of runoff reaching the Lake, but our expectation is that the increase will not be significant relative to the rate of natural runoff in this situation. During periods of the year when stormwater treatment facilities are operational, these facilities should further minimize differences in rate of infiltration and resulting changes in flows. We do not expect water withdrawals for construction to be large enough to result in any detectable differences in flow.

2.5.2.9 *Drainage Network*
The baseline condition of this indicator in the upper Yakima watershed is "functioning at risk." Construction of short access roads and haul routes during construction may temporarily increase the drainage network, but we expect that proper installation of BMPs will successfully limit erosion and sedimentation. We also expect that final grading and revegetation will minimize Project effects on the local drainage network to insignificant levels.

2.5.2.10 *Road Density and Location*
The baseline condition of this indicator in the upper Yakima watershed is "not properly functioning." As described above for the "drainage network" indicator, we expect the construction of access roads and haul routes will have a minor, temporarily negative effect on this indicator. The short total length of these road segments on the site will have little impact on the functional condition of this indicator at the watershed scale. The permanent effect of this Project will be adding two lanes of traffic along the lakeshore, with most of this new roadway suspended on Bridges over the Lake's surface. This increase in roadway is a local negative effect, but is not of sufficient extent to result in adverse effects to bull trout or to influence this indicator at the watershed scale.

2.5.2.11 *Riparian Reserves*
Riparian reserves are generally "not properly functioning" in the upper Yakima watershed. We expect impacts of the Project on this indicator to be negative and relatively minor. Impacts will be confined to the narrow strip of riparian vegetation adjacent to Keechelus Lake, and there will be essentially no difference between impacts associated with the large snowshed and the Bridges. The expected minor impacts will be permanent, but will be limited to about 1,000 lineal feet on the north shore of the Lake where effects from loss of shading will be negligible and overcompensated by shading provided by the bridges. Avalanche-related inputs of large woody debris will likely replace this riparian function. Overall, these impacts will likely result in insignificant impacts to bull trout exposed to them.

2.5.2.12 *Disturbance History*
The baseline condition of this indicator is "not properly functioning" in the upper Yakima watershed. Site preparation for the Bridges will require about 2.2 acres more clearing of currently forested habitat than would have occurred with the long snowshed. At the watershed scale, this is a relatively minor impact that will have insignificant effects on bull trout in Keechelus Lake.

2.5.2.13 *Disturbance Regime*
In the Upper Yakima watershed, the baseline condition of this indicator is "not properly functioning." Substitution of the Bridges for the large snowshed could lead to a higher

frequency of artificial avalanche triggering in extreme snow years to avoid extreme avalanches that might approach the design specifications of the Bridges. Given that this preemptory triggering is only likely to happen when conditions exceed 50-year return interval events, this effect on disturbance regime will be infrequent and limited in scope. A beneficial effect of the Bridges on this indicator is that they will allow avalanches to run out to their natural terminus in the Lake, allowing a more natural disturbance process compared to the snowshed. The low frequency and limited extent of Project effects on this indicator are likely to result in insignificant effects to bull trout.

2.5.3 **Responses of Bull Trout to Habitat Effects**

This section integrates across habitat effects and predicts how these effects are likely to influence the numbers, distribution, and reproduction of the local bull trout populations affected. This integration is largely qualitative.

Potentially adverse Project effects to habitat indicators will likely be limited to brief increases in sedimentation post-construction and occasional increases in contaminant inputs over the long term. As described above, we expected increases in disturbed lakebed area to result in small changes in sedimentation effects from the Bridges which will be indistinguishable from the effects analyzed in our original biological opinion. Therefore, we will not elaborate on sedimentation effects here. Contaminant effects are likely to affect a small area of Keechelus Lake immediately surrounding the bridges (estimated at about 5 acres). This area is less than 0.5 percent of the total area of Keechelus Lake. Delivery of sufficient contaminants to result in adverse effects to exposed bull trout will occur infrequently, when conditions conducive to contaminant accumulation on the roadway and icing of stormwater treatment facilities are followed by moderate to heavy snowfall or rain, and when Lake levels are high enough for direct delivery of stormwater or plow spray to the Lake surface. This combination of a small area affected and infrequent occurrence of conditions that could lead to adverse effects suggests that, although effects to the contaminant habitat indicator will occasionally be adverse, these effects are likely to result in only slight changes in the dynamics of the local population of bull trout affected.

These infrequent contaminant delivery events will occur in the context of pronounced improvement in overall contaminant loadings resulting from stormwater treatment improvements throughout the I-90 Snoqualmie Pass East Project area and from offsite stormwater mitigation. These changes in baseline conditions of this indicator are likely to result in measureable improvements in bull trout population abundance and reproductive success.

The proposed Project will also have beneficial effects on several habitat indicators including "physical barriers," "streambank condition," "floodplain connectivity," "riparian reserves," and "disturbance regime." We expect that the magnitude of these beneficial effects will balance if not outweigh the minor negative effects the Project will have on other habitat indicators (see Table 2.8). Consequently, we expect the Project to have an overall neutral to slightly beneficial effect on habitat conditions relative to the large snowshed. Thus, we expect bull trout population size and productivity to remain stable or increase slightly in response to Project effects on habitat conditions.

2.5.4 **Integration of Direct Effects and Indirect Habitat Effects**

We expect all adverse effects from the Project to impact the Gold Creek local population of bull trout in the Yakima Core Area. Overall, we expect about 6 bull trout to experience adverse effects associated with site preparation activities during two construction seasons (Table 2.10). These sub-lethal adverse effects due to exposure to blasting are unlikely to be sufficiently severe to reduce the survival and reproductive success of affected individuals. We also expect adverse effects from exposure to elevated turbidity, but these effects are similar to those we analyzed for the large snowshed. Therefore, these turbidity-related effects do not represent an increment in adverse effects associated with the Bridges. Direct effects from site preparation and construction should therefore have a neutral effect on the Gold Creek local population of bull trout.

We expect adverse contaminant exposures from operation and maintenance of the Bridges across 75 years to result in behavioral avoidance of about 5 acres of nearshore habitat in Keechelus Lake (Table 2.10).

Individual bull trout could experience more than one sub-lethal impact (e.g., due to exposure to both blasting and contaminants). The Service's opinion is that the severity of expected sub-lethal impacts is low enough that if multiple impacts to single individuals occurred they would still be sub-lethal.

Over the 75-year design life of the Project, we expect the Project to have a neutral or slightly beneficial effect on habitat conditions. The combination of neutral direct effects and neutral or slightly beneficial habitat effects, suggests the Project is likely to result in no appreciable change in population performance of the Gold Creek local population of bull trout.

Table 2.10: Summary of adverse direct effects to bull trout by type of effect.

	Direct Effect Type and Severity				
	Contaminants		Blasting		
Life Stage	Lethal	Sub-lethal	Lethal	Sub-lethal	**Total**
Adult	-	Behavioral	-	2	2
Sub-adult	-	avoidance of	-	4	4
Total	-	about 5 acres	-	6	6

2.5.5 **Effects to Bull Trout Critical Habitat**

Our analysis of Project effects on designated critical habitat is based on our description of Project effects on habitat indicators presented above.

As described in the BA and in our analysis of effects on habitat indicators above, the Project is most likely to have effects on PCEs 1, 3, 4, 7 and 8 of bull trout critical habitat. We discuss potential Project effects on each PCE separately, below, including some PCEs that we consider unlikely to be affected by the Project.

PCE 1 is focused on hydrologic connectivity and thermal refugia. Site preparation and bridge construction are likely to have the greatest impact on this PCE. Blasting and excavation could intercept or otherwise change groundwater flow paths, but it is unlikely that these changes would substantially reduce groundwater flow into Keechelus Lake. A more likely outcome is that some groundwater would be converted to surface flow, and the point of entry of groundwater into the Lake could shift. Bridge construction, especially installation of piers could affect subsurface water flow paths and quantities, create turbid groundwater, and potentially elevate groundwater pH. We expect most of these effects to be temporary, occurring during four seasons of pier installation. Only shifts in flow paths, including minor effects on the spatial distribution of groundwater delivery and quantity of flow, would persist for the long term. The magnitude of potential effects of the Project on groundwater dynamics is highly uncertain. The large volume of excavated material and high number of shafts to be drilled in the Project area suggest that adverse effects could occur to this PCE primarily due to conversion of groundwater to surface water. This conversion could slightly increase water temperatures, and by reducing the volume of groundwater upwelling, could reduce the attractiveness of the area to bull trout. Effects to this PCE from Bridge installation are likely to be slightly greater than for the snowshed due to more blasting and excavation. Fewer piers will lead to fewer effects from construction, but our opinion is that the negative effects of excavation, especially conversion of groundwater to surface flow, will have more negative consequences for habitat functionality than effects due to pier installation.

PCE 3 is about the food base for bull trout. Disturbance from blasting near the shoreline may temporarily displace bull trout prey that could be in the area during blasting. Blasting only during daylight hours when bull trout are not likely foraging in the shoreline areas of the Lake should minimize blasting effects on foraging opportunities. It is also conceivable that bull trout, as opportunistic predators, could take advantage of prey fish that are injured or disoriented by exposure to blasting. Disturbance of the lakebed during construction and resulting compaction and increased sedimentation could also reduce invertebrate prey beyond the effects of reservoir operations. However, our opinion is that the extent and severity of these potential effects on food base would result in insignificant changes in habitat functionality for bull trout. Operations and maintenance could have effects on food base due to contaminant inputs (negative effects) and increased habitat complexity due to increased floodplain connectivity and inputs of avalanche debris, including large wood. Because we expect contaminant inputs to be occasional or episodic rather than chronic, our opinion is that the negative effects of contaminants on the food base in Lake Keechelus will be insignificant over the long term. Beneficial effects of the Project on habitat complexity are likely to be more continuous and may result in more substantive increases in prey availability.

PCE 4 is concerned with habitat complexity. Site preparation and construction activities, are likely to result in transient reductions in habitat complexity. Baseline conditions of the shoreline in the Project area are degraded and do not currently provide much habitat complexity. Given this simplified baseline condition, our opinion is that Project-related negative effects will result in insignificant changes in habitat functionality. In contrast, operations and maintenance of the Bridges is likely to result in increased complexity over the long term, resulting in a substantial beneficial effect, as we described above. In particular, inputs of avalanche debris, including

large wood and substrate material in a variety of sizes, should increase habitat suitability for both bull trout and their prey.

PCE 7 is about a natural hydrograph. The natural hydrograph of Keechelus Lake has been severely compromised by reservoir operations. Within the context of reservoir operations, minor changes in groundwater discharges associated with site preparation and bridge construction will have insignificant effects on the existing, altered hydrograph. During operations and maintenance, stormwater treatment and discharges have the potential to slightly increase peak flows and diminish base flows by conveying runoff from impervious surfaces to the Lake. When stormwater treatment facilities are fully operational, these effects are likely to be mostly beneficial. Stormwater infiltration ponds should slow the onset of peak flows and reduce their magnitudes. Infiltrated stormwater may contribute slightly to improved base flow inputs to the Lake. When stormwater treatment facilities are not operational due to icing or during storm events that overwhelm their design capacity, the Project will result in higher peak flows. This accentuation of peak flows, however, is likely to be insignificant relative to the snowshed, and insignificant regarding the hydrologic suitability of Keechelus Lake as bull trout FMO habitat.

PCE 8 is about water quality and quantity. As described above, we expect site preparation and bridge construction to have insignificant effects on water quality, largely due to effective BMP deployment and construction monitoring. We also expect that inputs of traction sand and de-icer resulting from operations and maintenance will have insignificant effects on the functionality of this PCE. Although the Bridges will increase the amount of highway surface that requires winter maintenance by almost 3 acres, we do not expect potentially increased inputs of traction sand and de-icers to significantly reduce the functionality of critical habitat. Stormwater treatment for the Bridges will treat slightly more area than the snowshed, providing a slight beneficial effect. Furthermore, traction sand washed off the roadway will be trapped in grit chambers and removed as needed by maintenance personnel. In contrast, we expect operations and maintenance will lead to occasional inputs of chemical contaminants from the roadway that will temporarily reduce the functionality of critical habitat. As described above, we expect these adverse effects to critical habitat to result primarily from delivery of dissolved heavy metals to Keechelus Lake either in plow spray or untreated stormwater.

Analysis of effects on PCE 9 requires information beyond that provided by the MPI. Regarding PCE 9, we do not expect the Project to influence the abundance and productivity of non-native predators or competitors. Brook trout are present in the Project area, and the Project is likely to have a neutral effect on this PCE.

Our opinion is that the Project effects to PCEs 1 and 8 that persist for the life of the Project are adverse effects to designated critical habitat, because they reduce the functional capacity of critical habitat in this area of Keechelus Lake to meet the conservation needs of bull trout.

While Project effects may reduce the capacity of the affected area to support bull trout, these adverse effects are unlikely to affect the functional capacity of the entire Yakima critical habitat unit to support the survival and recovery of bull trout. The area affected represent much less than 1 percent of all critical habitat in the unit, adverse effects to some PCEs are matched with beneficial effects to other PCEs, and compensatory restoration activities replace some of the

impaired functions. We believe these localized adverse effect to critical habitat will have insignificant impacts on the functional capacity of the entire Yakima unit of designated critical habitat.

2.5.6 **Effects of Interrelated and Interdependent Actions**

"Interrelated and Interdependent Actions" are actions that would not occur but for the proposed Project, and therefore they are a connected action and effect that must be analyzed together with the proposed Project. The Service's consultation handbook provides a detailed discussion about how to recognize such actions (USDI and USDC 1998; page 4-25).

We do not anticipate any interrelated and interdependent actions with this Project beyond those we described in our original biological opinion for the entire I-90 Snoqualmie Pass East project.

2.6 CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

In our original biological opinion for the entire I-90 Snoqualmie Pass East project, the Service described an array of potential cumulative effects that could occur in the Upper Yakima watersheds. These activities included logging on private lands, conversion of private timberlands to housing developments, transfer of private timberlands to federal management, residential development near the highway, and recreational developments. No new information or new cumulative effects have come to our attention in the intervening period, so we include our former analysis by reference. For this description of cumulative effects, the Service assumes that future non-Federal activities in the area of the proposed action will continue into the future at present or increased intensities. Accordingly, these actions will contribute to some habitat indicators continuing to "function at risk" or to be "not properly functioning."

2.7 CONCLUSION

After reviewing the current status of the bull trout and its designated critical habitat range-wide, the environmental baseline for the bull trout and its designated critical habitat in the action area, the effects of the proposed action, and cumulative effects, it is the Service's biological opinion that the Project, as proposed, is not likely to jeopardize the continued existence of the coterminous U.S. population of the bull trout, and is not likely to destroy or adversely modify designated critical habitat for the bull trout at the rangewide scale. The following sections describe the key findings of our analyses at each relevant scale.

2.7.1 **No Jeopardy Determination**

The range-wide status of the bull trout is variable among and within the five interim recovery units that comprise the threatened coterminous U.S. population. Each of these units is necessary to maintain the bull trout's distribution, as well as its genetic and phenotypic diversity, all of which are important to ensure the species' resilience to changing environmental conditions. The

Columbia River interim recovery unit (where the action area is located) is especially important to the survival and recovery of the bull trout because it contains nearly 80 percent of all core areas range-wide, and over 80 percent of all local populations within the coterminous U.S. range of the bull trout. The Columbia River Interim Recovery Unit is vast, and contains a mix of core areas with increasing, stable, and declining demographic trends. The Yakima core area is among those with a relatively stable population trend at an estimated abundance level that is less than the goal for this unit in the Service's draft recovery plan. The proposed Project would likely maintain this situation. Slight degradation of some habitat conditions and slight improvements in others at the local scale will not be sufficient to change population trends or distribution at the local population, core area, interim recovery unit or range-wide scales.

The bull trout is threatened within all of the interim recovery units by the combined effects of habitat degradation, habitat fragmentation and modifications associated with water withdrawals, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams, other water diversion structures, or impassible culverts, poor water quality, incidental angler harvest, entrainment into diversion channels and penstocks, and introduced non-native species.

Based on recovery planning to date, conservation of the bull trout at the coterminous U.S. scale is dependent upon maintaining and enhancing the condition of local populations and core areas within the five interim recovery units. Proposed Federal actions that are compatible with achieving recovery objectives at local and core area scales are not likely to jeopardize the continued existence of the bull trout at the range-wide scale.

The baseline condition of the bull trout population in the Yakima Core Area is "not properly functioning." Although abundance at the scale of the entire core area may be increasing slightly, the distribution of bull trout in the core area appears to be shrinking, with apparent extirpation having occurred in several tributaries and several more having populations with extremely low abundance. Numerous historic and ongoing factors continue to limit the potential for population recovery at the core-area scale. Foremost among these are facilities and operations of the Bureau of Reclamation's Yakima Basin Project. Baseline habitat conditions are variable, with habitat conditions generally better in the headwaters. Cumulative effects include potential residential and recreational development on private lands low in the watershed with associated impacts to habitat quality.

The Project will have adverse effects on the Gold Creek local population (in the Yakima Core area). Adverse direct effects and adverse indirect effects to water quality will cause sub-lethal injury of bull trout in sub-adult and adult life stages. Adverse effects are associated with temporary impacts associated with site preparation, construction activities, and ongoing operations and maintenance activities.

Within the context of all the factors that influence the dynamics of bull trout populations, we think the scope and severity of these effects will be too limited to result in changes in the reproduction, numbers, or distribution of the local populations affected. Restorative components included in the Project and other beneficial effects such as riparian plantings will ameliorate some of the Project's adverse effects. Appreciable uncertainty surrounds some aspects of Project

effects, but our expectation is that negative and beneficial effects are likely to balance near a neutral outcome at the core area scale. The local population potentially affected by the Project is relatively isolated from other local populations, with some potential for emigration but no opportunity for immigration. Connectivity among local populations has been identified as a factor that contributes to the persistence of bull trout populations. The Project will not affect levels of connectivity among local populations. The Project also will not reduce the distribution of local populations in the core area. Therefore, our opinion is that the effects of this Project are unlikely to change bull trout population dynamics at either the local or the core-area scale. The Project is also unlikely to influence interactions between bull trout core areas.

No significant interrelated or interdependent actions or cumulative effects beyond those analyzed in our original biological opinion are anticipated to occur during the term of the proposed Project.

Considering the effects of the proposed Project, together with cumulative effects, we believe the status of the bull trout in the upper Yakima watershed and the Yakima Core Area are likely to be maintained with implementation of the Project. Over the long term, we expect the negative effects of the Project to be imperceptible at the larger scales of the interim recovery unit or coterminous range. Therefore, the proposed action is not likely to jeopardize the continued existence of the bull trout at the range-wide scale.

Incidental take of bull trout is likely to occur as a result of implementation of the proposed action. The Incidental Take Statement accompanying this biological opinion includes mandatory Reasonable and Prudent Measures and Terms and Conditions intended to minimize this incidental take.

2.7.2 No Adverse Modification Determination

The range-wide status of designated critical habitat for the bull trout is variable among and within CHUs. General habitat conditions in the Yakima CHU show a pattern in which lower reaches of drainages are fairly degraded, likely influenced by a high level of development, roads, forestry, agriculture, irrigation diversions, grazing, mining, and other infrastructure and land management. These reaches also have 303(d) listed impairments of water quality, with temperature, turbidity, and instream flow being most common. In contrast, the upper reaches of drainages are generally of higher quality and have less anthropogenic impacts, although there is substantial variation. For example, some spawning and rearing habitats are predominately in wilderness and are in excellent condition, whereas others are in areas with high densities of forest roads and are degraded.

The overall condition of the Yakima CHU is "functioning at risk," with considerable variability within and between watersheds. The Upper Yakima watershed where the action area is located has a baseline condition near the low end of the functionality spectrum. Past logging and associated forest roads, residential and recreational developments, transportation and power transmission infrastructure, and reservoir management for irrigation have all impacted PCEs, leading to most being rated as "functioning at risk" or "not properly functioning." Critical habitat in the action area consists of lacustrine FMO habitat, used primarily by adults and sub-adults for foraging and overwintering.

The Project is most likely to affect PCEs 1, 3, 4, 7, and 8. We expect adverse effects to PCEs 1 and 8 and insignificant effects to the other PCEs. The magnitude of potential effects of the Project on groundwater dynamics is highly uncertain. Blasting and excavation could intercept or otherwise change groundwater flow paths, potentially converting some groundwater to surface flow, and the point of entry of groundwater into the Lake could shift. Bridge construction, especially installation of piers could affect subsurface water flow paths and quantities, create turbid groundwater, and potentially elevate groundwater pH. Conversion of groundwater to surface flow could slightly increase water temperatures, and by reducing the volume of groundwater upwelling, could reduce the attractiveness of the action area to bull trout. Regarding PCE 8, we expect operations and maintenance will lead to occasional inputs of chemical contaminants from the roadway that will temporarily reduce the functionality of critical habitat. We expect these adverse effects to critical habitat to result primarily from delivery of dissolved heavy metals to Keechelus Lake, either in plow spray or untreated stormwater. We expect Project effects to both of these PCEs to reduce the functional capacity of critical habitat in Keechelus Lake to meet the conservation needs of bull trout. Design features and conservation measures included in this Project may contribute to improvements in critical habitat function relative to its functional capacity at the time of designation.

While Project effects may reduce the capacity of these affected reaches to support bull trout, these adverse effects are unlikely to affect the functional capacity of the entire Yakima critical habitat unit to support the survival and recovery of bull trout. The area affected represents much less than 1 percent of all critical habitat in the unit, adverse effects to some PCEs are matched with beneficial effects to other PCEs, and compensatory restoration activities replace some of the impaired functions. At the scale of the Yakima critical habitat unit, our opinion is that the Project's localized adverse effects to critical habitat will have insignificant impacts on the overall functional capacity of the unit.

Our opinion is that overall Project effects are consistent with the conservation role of critical habitat range-wide to support viable core area populations. On that basis, implementation of the proposed Project is not likely to destroy or adversely modify bull trout critical habitat at the range-wide scale.

2.8 REASONABLE AND PRUDENT ALTERNATIVES

Regulations implementing Section 7 of the Act (50 C.F.R. §402.02 *et seq.*) define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) would, the Service believes, avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat.

Because the proposed action is not likely to jeopardize the continued existence of the bull trout or destroy or adversely modify proposed critical habitat for the bull trout, no reasonable and prudent alternatives are required.

INCIDENTAL TAKE STATEMENT

1. Introduction

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 Service 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 Service as intentional or negligent actions or omissions that create the likelihood of injury to listed species by annoying it 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, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the Federal Highway Administration so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The Federal Highway Administration has a continuing duty to regulate the activity covered by this incidental take statement. If the Federal Highway Administration fails to assume and implement the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) will lapse. In order to monitor the impact of incidental take, the Federal Highway Administration must report the progress of the action and its impact on the species to the Service as specified in this Incidental Take Statement [(50 CFR §402.14(i)(3)].

2. Anticipated Amount or Extent of Take of Bull Trout

In the "Effects of the Action" section of the accompanying biological opinion, the Service estimated the number of bull trout that would be exposed to adverse effects from this Project after making several simplifying assumptions. The rationale for these assumptions is presented in the "Effects of the Action" section. These assumptions necessarily introduce uncertainty into our estimate of incidental take. We also estimated the amount of habitat that will be adversely affected based on information contained in the Project BA.

The primary mechanisms of incidental take will be (1) harassment resulting from direct exposure of adults and sub-adults to noise from blasting (2) harm caused by direct exposure to increased suspended sediment during Project construction, (3) harm due to exposure to occasional pulses of contaminants in plow spray and untreated stormwater. Note that we expect incidental take from mechanism (2) above to be similar to incidental take we estimated in our original biological opinion for the Project. Because the new Bridge design does not result in new or different effects regarding turbidity and sedimentation, in this ITS, we do not authorize any additional incidental take for this aspect of Project effects. The amount of incidental take expected to occur from mechanisms (1) and (3) is summarized in the following table:

Table ITS-1: Summary of incidental take of bull trout.

	Direct Effect Type and Severity				
	Harm (contaminants)		Harassment (blasting)		
Life Stage	Lethal	Sub-lethal	Lethal	Sub-lethal	**Total**
Adult	-	Behavioral avoidance of about 5 acres	-	2	2
Sub-adult	-		-	4	4
Total	-		-	6	6

All incidental take discussed here will occur to the Gold Creek local populations in the Yakima Core Area within the Columbia River interim recovery unit. We expect incidental take to occur during site preparation (blasting) and during ongoing operations and maintenance (contaminants)(Table ITS-1). We expect incidental take due to site preparation activities to occur across two years. Incidental take due to contaminant exposure during operations and maintenance will occur infrequently across the estimated 75-year design life of the proposed Bridges.

The Service acknowledges that the amount of incidental take of bull trout resulting from the Project will be difficult to detect due to: (1) primarily nocturnal activity patterns, tendency to hide in or near the substrate, small body size and cryptic coloration and behavior of sub-adult bull trout (2) the low likelihood of finding an injured or dead individual in the relatively complex habitats in the action area, and (3) high rate of removal of injured individuals by predators or scavengers. Given these difficulties, any detection of incidental take can provide valuable information to enable the Service to develop better methods for avoiding and minimizing incidental take, and to refine estimates of incidental take for future projects of a similar nature in similar contexts.

The Service believes that attempts to precisely track the quantity of incidental take occurring during Project implementation would likely result in more harm to bull trout than the Project alone. To comply with the Act, however, the Federal Highway Administration must ensure that its activities do not result in levels of take exceeding that anticipated in this incidental take statement. To reconcile this conflict, we propose the following approaches to monitoring surrogates that provide indices of Project effects to bull trout.

- Risk of bull trout harassment due to blasting noise is related to both the setback distance of the blast from the shoreline and the size of the charge detonated in each delay (Wright and Hopky 1998). If combinations of setback distance and charge size are used that could result in increased pressure waves reaching the Lake (i.e., combinations of closer distances and larger charges than specified in Table 1.4), or if more than 2 seasons of blasting near the lakeshore are required to complete site preparation, then incidental take of bull trout may be exceeded and consultation with the Service should be reinitiated.

3. Effect of the Take

In the accompanying Biological Opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species.

4. Reasonable and Prudent Measures

The Service believes that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize and monitor the impacts of take of the bull trout likely to be caused by the proposed Project.

RPM 1. Minimize incidental take resulting from exposure to blasting noise.

5. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Federal Highway Administration must comply with the following terms and conditions, which implement the reasonable and prudent measures described above, and are designed to minimize impacts to bull trout. These terms and conditions are mandatory.

To implement RPM 1:

T&C 1. For vent holes (line drilling), use hole size, spacing, and orientation that is likely to result in 10% or greater reduction in ground vibration (see Park et al. 2008, entire).

T&C 2. Blasting delay and the means to be used to ensure the delay is accurately and consistently achieved were not specified in the existing conservation measures for the Project. If multiple charges are used for blasting near the shoreline, use electronic detonators to achieve at least 20 to 25 milliseconds as the minimum delay between detonations (Wright and Hopky 1998, pg. 9).

T&C 3. Do not use ammonium nitrate-fuel oil (ANFO) mixtures for blasting near the shoreline of Keechelus Lake due to the potential for production of toxic by-products (ammonia) (Wright and Hopky 1998, pg. 5).

T&C 4. At least one month before beginning blasting near the shoreline of Keechelus Lake, submit to the Service for review information regarding shoreline blasting that describes how T&Cs 1 to 3 will be met.

T&C 5. After blasting is completed, if any vent holes or other holes remain, fill them with inert material to avoid potential entrapment of bull trout or other fish.

6. Reporting Requirements

In order to monitor the impacts of implementation of the reasonable and prudent measures, the Federal Highway Administration shall prepare a report describing the progress of the proposed Project, and impacts to the bull trout (50 CFR § 402.14(I)(3)). The report shall be submitted to the Central Washington Field Office on or before May 1 of the year when contaminant monitoring is completed and only one or no exceedances of criteria occurred, or within two months of detecting a second exceedance. The report shall list and describe:

1. Adverse effects to bull trout resulting from Project activities including number and life stages of affected individuals detected, if any.
2. Dates when Project implementation began and ended for each construction season covered.
3. Deviations from the proposed Project description.
4. Any evidence of blast-induced fish injury or mortality in Keechelus Lake (e.g., visible floating fish; increase in activity of scavenging birds near the blast area).

Any post-mortem information available regarding cause of death of fish suspected to have been affected by blasting.

5. Results of all other monitoring activities, including turbidity monitoring during construction, and during ongoing operations. Continued submission of the ongoing series of Construction or Regulatory Updates can substitute for this requirement.
6. Implementation of any conservation recommendations (see below).

Upon locating a dead, injured, or sick specimen of an endangered or threatened species, initial notification must be made to the nearest Service Law Enforcement Office (Richland, Washington; Special Agent Corky Roberts, telephone 509.546.8344). Care should be taken in handling sick or injured specimens to ensure effective treatment and care or the handling of dead specimens to preserve biological material in the best possible state for later analysis of cause of death. In conjunction with the care of sick or injured endangered species or preservation of biological materials from a dead animal, the finder has the responsibility to carry out instructions provided by Law Enforcement to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

The Service believes that Table ITS-1 presents our best estimates of the bull trout and their habitat that will be incidentally taken as a result of the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reimtiating of consultation. The Federal Highway Administration must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures. Because incidental take for this Project is difficult to estimate and detect, the Service must be contacted if implementation plans change substantially from those described and the project effects no longer fall within the effects analyzed in the accompanying biological opinion.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The Service provides the following recommendations:

CR 1. Deploy bubble curtains/air curtains in Keechelus Lake to disrupt shock waves from blasting near the shoreline (Wright and Hopky 1998, pg. 9).

CR 2. Stockpile spill containment supplies near the Bridges to facilitate rapid deployment should an accidental spill occur of materials potentially harmful to fish. Maintain this stockpile as a component of ongoing operations and maintenance of the Bridges for the life of the structures.

CR 3. We appreciate the need for avalanche conveyance under the bridges to maintain sufficient free-board to accommodate multiple sequential avalanches. We recommend adding as much "roughness" as possible given this conveyance

constraint in order to increase habitat complexity and increase the duration of large wood retention in the Lake near the avalanche chutes. We suggest that roughness in the form of willow plantings near the shoreline would have small effects on avalanche conveyance, but meaningful benefits in terms of increased habitat complexity. Anchoring large wood pieces with rootwads near the outer edge of the lakebed area disturbed by construction also could increase habitat complexity and potentially prolong the residence time of avalanche debris. Because this anchored large wood could be mostly or completely submerged during the avalanche season, it might not detract from avalanche conveyance.

CR 4. Provide at least one route from the shoreline of Keechelus Lake to forested cover between avalanche chutes upslope of the Bridges which has a slope shallow enough to be useable by wildlife. The purpose of this escape route is to allow wildlife that crosses under the Bridges to move safely away from the highway rather than become trapped between the highway and unclimbable rock cuts.

CR 5. Although rock cuts north of the Bridges will not be too conducive to wildlife movement, consider adding some monitoring efforts to detect wildlife crossings that could occur beneath the avalanche bridges as part of the overall wildlife monitoring plan of the I-90 Snoqualmie Pass East project.

CR 6. Blasting near Keechelus Lake will provide an opportunity to learn about the effects of such activities on aquatic habitats and species. Development and implementation of a hydroacoustic monitoring program in the Lake during blasting could provide valuable information about the magnitude and extent of effects on bull trout and other species. This information could also be useful in the planning of future projects that require blasting near waters occupied by listed salmonids.

CR 7. Work with IDT agencies and monitoring partners (e.g., Central Washington University) to monitor the effects of untreated winter runoff and plow spray on concentrations of dissolved copper and zinc in Keechelus Lake near the Bridges. Use best available sampling protocols and analysis methods which are capable of detecting very low concentrations of these metals. Sample during runoff events that occur: (1) after an extended period of contaminant accumulation on the roadway, (2) when icing of stormwater treatment facilities is sufficient to reduce or negate their effectiveness, and (3) when heavy snow or rain following the period of accumulation leads to delivery of untreated stormwater or plow spray directly to Keechelus Lake. Monitoring only when all these conditions were met may be challenging for many reasons (e.g., difficulty in forecasting their occurrence and preparing appropriately), potentially leading to a long delay in obtaining informative results. Given these issues, a more efficient approach may be to monitor contaminant levels in Keechelus Lake beneath the bridges for a set period. Report results of this monitoring to the Service.

In order to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR §402.16, reinitiating of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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APPENDIX 2A: Bull Trout Life History and Population Dynamics

1. Historic and Current Range

Bull trout are native to northwestern North America, historically occupying a large geographic range extending from California north into the Yukon and Northwest Territories of Canada and east into western Montana and Alberta (Cavender 1978). They are generally found in interior drainages, but also occur on the Pacific Coast in Puget Sound and in the large drainages of British Columbia.

The historic range of the bull trout is likely to have contracted and expanded over time in relation to natural environmental and climate changes; the distribution of the species was likely patchy even in pristine environments. Despite uncertainty about the exact historical range, the number and size of historical populations, and the role of natural factors in the status of the species, there is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and continue to pose significant risks of further extirpations of local populations.

Bull trout currently occur in rivers and tributaries in Montana, Idaho, Washington, Oregon (including the Klamath River basin), Nevada, two Canadian Provinces (British Columbia and Alberta), and several cross-boundary drainages in southeast Alaska. East of the Continental Divide, bull trout are found in the headwaters of the Saskatchewan River in Alberta, and the MacKenzie River system in Alberta and British Columbia (Cavender 1978; McPhail and Baxter 1996; Brewin and Brewin 1997). The current distribution of bull trout is highly fragmented.

The distribution of bull trout has shrunk in the Pacific Northwest and northern California. The distribution of bull trout has been reduced by an estimated 55 percent in the Klamath River DPS and 79 percent in the Columbia River DPS since pre-settlement times, due primarily to local extirpations, habitat degradation, and isolating factors (Quigley and Arbelbide 1997). Within the Puget Sound basin, bull trout distribution is similar to historic conditions, but population abundance has significantly decreased. In California, bull trout were historically found only in the McCloud River, which represented the southernmost extension of the species' range. The last confirmed report of bull trout in the McCloud River was in 1975, and this population is now considered to be extirpated (Rode 1990).

2. Life History

Bull trout populations exhibit three different life-history types: resident, migratory, and anadromous. Resident and migratory forms exist throughout the range of the bull trout (Rieman and McIntyre 1993) and spend their entire lives in freshwater. The anadromous life- history form is currently only known to occur in the Coastal-Puget Sound region within the coterminous United States (Volk 2000; Kraemer 1994; Mongillo 1993). Multiple life-history types may be expressed in the same population, and diversity of life-history types is considered important to the stability and viability of bull trout populations (Rieman and McIntyre 1993).

Life history type determines where the majority of the growth and maturation occurs. Anadromous bull trout growth and maturation mostly occurs in estuarine and marine waters.

Juvenile bull trout displaying the anadromous life history spend 1 to 3 years near freshwater natal areas before moving to estuary and/or nearshore marine areas to mature (Rieman and McIntyre 1993). Migratory bull trout mostly grow and mature in lakes, reservoirs, and large river systems. Like anadromous bull trout, juvenile migratory bull trout typically rear in or near natal streams for 1 to 3 years before migrating downstream into larger rivers or lakes. In some systems, age 0+ fish may migrate directly to lakes (Riehle et al. 1997). Resident bull trout populations are generally found in small headwater streams where the fish remain for their entire lives.

2.1 Freshwater Habitat

Bull trout have more specific habitat requirements than other salmonids (Rieman and McIntyre 1993). Growth, survival, and long-term persistence are dependent upon several habitat characteristics, including: cold water, complex instream habitat, a stable substrate with a low percentage of fine sediments, high channel stability, and connectivity among streams supporting bull trout populations. Stream temperature and substrate type, in particular, are critical factors for the long-term persistence of bull trout. Spawning is often associated with the coldest, cleanest, and most complex stream reaches within basins. Consequently, bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1995), and should not be expected to occupy all available habitats at the same time (Rieman et al. 1997a).

Although bull trout clearly prefer cold waters and nearly pristine habitat, they can occur in degraded habitats. It is likely that small remnant populations of bull trout persisting in degraded rivers are using less than optimal habitat because that may be all that is available. In basins with high productivity, such as the Skagit River basin, bull trout may be using marginal areas when optimal habitat becomes fully occupied (C. Kraemer, WDFW, pers. comm. 2002). Bull trout have been documented using habitats that may be atypical or characterized as likely to be unsuitable (USFWS 2000).

2.1.1 Temperature. Bull trout are typically associated with the coldest stream reaches within basins. For long-term persistence, bull trout populations need a stream temperature regime that ensures sufficient amounts of cold water are present at the locations and during the times needed to complete their life cycle. Temperature is most frequently recognized as the factor limiting bull trout distribution (Dunham et al. 2003a; Dunham and Chandler 2001; Rieman and McIntyre 1993), which partially explains their generally patchy distribution within watersheds (Fraley and Shepard 1989; Rieman and McIntyre 1995). When maximum daily temperatures did not exceed approximately 11 to 12° C, the probability of occurrence for juvenile bull trout in Washington was high (75 percent) (Dunham et al. 2001). The most productive bull trout habitat in several Oregon streams had temperatures which seldom exceeded 15 °C (Buckman et al. 1992; Ratcliff 1992; Ziller 1992).

Stream temperatures must drop below 9 or 10 °C before spawning occurs (McPhail and Murray 1979; Riehle 1993). Water temperature also seems to be an important factor in determining early survival, with cold water temperatures resulting in higher egg survival and faster growth rates for fry and juveniles (Pratt 1992). Optimum incubation temperatures range from 2 to 6 °C, while at 8 to 10 °C, survival ranged from 0 to 20 percent (McPhail and Murray 1979). Stream

temperatures for tributary rearing juvenile bull trout are also quite low, ranging from 6 to 10 °C (Buchanan and Gregory 1997; Goetz 1989; Pratt 1992; McPhail and Murray 1979).

Although bull trout require a narrow range of cold water temperatures to rear, migrate, and reproduce, they are known to occur in larger, warmer river systems that may cool seasonally, and which provide important migratory corridors and forage bases. For migratory corridors, bull trout typically prefer water temperatures ranging between 10 to 12 °C (McPhail and Murray 1979; Buchanan and Gregory 1997). When bull trout migrate through stream segments with higher water temperatures they tend to seek areas offering thermal refuge such as confluences with cold tributaries (Swanberg 1997), deep pools, or locations with surface and groundwater exchanges in alluvial hyporheic zones (Frissell 1999).

Increases in stream temperatures can cause direct mortality, increased susceptibility to disease or other sublethal effects, displacement by avoidance (McCullough et al. 2001, Bonneau and Scarnechia 1996), or increased competition with species more tolerant of warm stream temperatures (Rieman and McIntyre 1993; Craig and Wissmar 1993 cited in USDI 1997; MBTSG 1998). Brook trout, which can hybridize with bull trout, may be more competitive than bull trout and displace them, especially in degraded drainages containing fine sediment and higher water temperatures (Selong et al. 2001; Leary et al. 1993). Recent laboratory studies suggest bull trout are at a particular disadvantage in competition with brook trout at temperatures >12 °C (McMahon et al. 2001; Selong et al. 2001).

2.1.2 Substrate. Bull trout show a strong affinity for stream bottoms and a preference for deep pools in cold water streams (Goetz 1989; Pratt 1992). Stream bottom and substrate composition are highly important for spawning site selection and juvenile rearing (Rieman and McIntyre 1993; Graham et al 1981; McPhail and Murray 1979). Fine sediments can influence incubation survival and emergence success (Weaver and White 1985; Pratt 1992; Suttle et al. 2004) but may also limit access to substrate interstices that are important cover during rearing and over-wintering (Goetz 1994; Jakober 1995). Rearing densities of juvenile bull trout have been shown to be lower when there are higher percentages of fine sediment in the substrate (Shepard et al. 1984). Due to this close connection to substrate, bed load movements and channel instability can negatively influence the survival of young bull trout.

2.1.3 Cover and Stream Complexity. Bull trout of all age classes are closely associated with cover, especially during the day (Baxter and McPhail1997; Fraley and Shepard 1989). This association appears to be more important for bull trout than for other salmonids (Pratt 1992; Rieman and McIntyre 1993). Cover may be in the form of overhanging banks, deep pools, turbulence, large wood, or debris jams. Young bull trout also use interstitial spaces in the substrate for cover. Bull trout distribution and abundance are positively correlated with pools and complex forms of cover, such as large or complex woody debris and undercut banks, but may also include coarse substrates (cobble and boulder) (Rieman and McIntyre 1993; Jakober 1995; MBTSG 1998). Juvenile and adult bull trout frequently inhabit side channels, stream margins and pools with suitable cover (Sexauer and James 1993) and areas with cold hyporheic zones or groundwater upwellings (Baxter and Hauer 2000).

Large pools offering a wide range of water depths, velocities, substrates, and cover, are characteristic of high quality aquatic habitat and are an important component of channel complexity. Large wood in streams creates pools and undercut banks, deflects streamflow, retains sediment, stabilizes the stream channel, increases hydraulic complexity, and improves feeding opportunities (Murphy 1995). All these functions of large wood enhance the quality of habitat for salmonids and contribute to channel stability (Bisson et al. 1987). By forming pools and retaining sediment, large wood also helps maintain water levels in small streams during periods of low stream flow (Lisle 1986).

Reduction of wood in stream channels, either from present or past activities, generally reduces pool frequency, quality, and channel complexity (Bisson et al. 1987; House and Boehne 1987; Spence et al. 1996). Studies conducted with Dolly Varden, a species similar to bull trout, showed that population density declined with the loss of woody debris after clearcutting or the removal of logging debris from streams (Bryant 1983; Dolloff 1986; Elliott 1986; Murphy et al. 1986).

2.1.4 Channel and Hydrologic Stability. Maintaining bull trout habitat requires stream channel and flow stability (Rieman and McIntyre 1993). Bull trout are exceptionally sensitive to activities that directly or indirectly affect stream channel integrity. Juvenile and adult bull trout frequently inhabit areas of reduced water velocity, such as side channels, stream margins, and pools that are easily eliminated or degraded by management activities (Rieman and McIntyre 1993).

Channel dewatering caused by low flows and bed aggradation (accumulation of rock and sediment) can block access for spawning fish, resulting in year class failures (Weaver 1992). Aggradation of the streambed can be accelerated by management activities that increase the frequency of landslides (e.g., road building and timber harvest) or that constrict stream channels (e.g., undersized culverts at stream crossings).

Patterns of stream flow and the frequency of extreme flow events that influence substrates may be important factors in population dynamics (Rieman and McIntyre 1993). With lengthy overwinter incubation and a close tie to the substrate, embryos and juveniles may be particularly vulnerable to flooding and channel scour associated with the rain-on-snow events that are common in some parts of the range (Rieman and McIntyre 1993).

2.1.5 Migration and Habitat Connectivity. Bull trout are highly migratory. The persistence of migratory bull trout populations requires intact migration corridors. Migration corridors link wintering areas with foraging, spawning, and rearing areas used at different times of the year, and by different life-history stages (MBTSG 1998, Rieman and McIntyre 1993). In the Coastal-Puget Sound DPS, migratory corridors may link marine and freshwater habitats as well as linking lake, river, and tributary complexes that are necessary for bull trout to complete their life cycle. Migratory corridors also link local populations, providing opportunities for gene flow and demographic exchange.

Bull trout migratory movements include both spawning migrations and downstream emigration of juveniles from headwater rearing areas to feeding and maturation areas. Migratory bull trout

may begin their spawning migrations as early as April and have been known to migrate upstream as far as 250 kilometers (155 miles) to spawning grounds (Fraley and Shepard 1989). Current radio-telemetry work being done in the upper Columbia River basin is revealing movement patterns of migratory bull trout that extend over 160 kilometers (100 miles), from the headwaters of the Wenatchee and Methow basins to the Columbia River and the pools formed by Rocky Reach, Rock Island, and Wells Dams (J. De La Vergne, pers. comm. 2001; BioAnalysts 2004). During these long migrations, bull trout use a wide variety of habitats. Compared to spawning migration, relatively little published information is available about juvenile emigration. Age of emigration varies from one to three years old (Rieman and McIntyre 1993), and annual timing of emigration is highly variable and can extend from spring until winter.

Stream habitat alterations that restrict or eliminate bull trout migration corridors include degradation of water quality (especially increasing temperatures and increased amounts of fine sediments), alteration of natural stream flow patterns, impassable barriers (such as dams and culverts), and structural modification of stream habitat (such as channelization or removal of cover). Dam and reservoir construction and operations have altered major portions of bull trout habitat throughout the Columbia River basin. Dams without fish passage create barriers to fluvial and adfluvial bull trout which isolates populations. The operations of dams and reservoirs alter the natural hydrograph, thereby affecting forage, water temperature, and water quality (USDI 1997). Many populations of "resident" bull trout that are isolated above artificial barriers to migration are remnants of populations that once supported larger, more fecund, migratory forms.

2.2 Marine Phase

Anadromous bull trout forage and mature in the nearshore marine habitats on the Washington coast and in Puget Sound. The marine and estuarine residency period for bull trout is poorly understood. Thorpe's (1994) review found little evidence in the literature that the estuary was used for physiological adjustment or as a refuge from predation, but he did find clear evidence of a trophic advantage to estuarine residency (abundant prey). While in the estuary, native char can grow very quickly. Subadults grow from 20 to 40 mm per month and reach a length of 250 to 350 mm before their upstream migration in late summer and early fall (Kraemer 1994). During their marine residency, subadults from Dolly Varden populations on Vancouver Island gained 74 mm and adults gained 45 mm in length (Smith and Slaney 1979).

Kraemer (1994) speculated that the distribution of native char in marine waters may be closely tied to the distribution of bait fish and coincident with their spawning beaches. Char from Puget Sound have been found to prey on surf smelt, Pacific herring, Pacific sand lance, pink salmon smolts, chum salmon smolts, and a number of invertebrates (Kraemer 1994). The Quinault Indian Nation documented smelt as a prey item for native char in the Queets River. Kraemer (as cited in Nightingale and Simenstad 2001) observed that native char in estuaries typically foraged in water less than 3 meters deep and were often seen foraging in water less than 0.5 meters deep.

Anadromous migrations of bull trout have been studied in Rivers of the Olympic Peninsula in Washington. Radio-tagged bull trout from the Hoh River have migrated out into the marine environment and then back into a number of other coastal drainages, including the Queets, and Quinault Rivers, and have showed complex movement patterns within and between rivers

(Brenkman and Corbett 2005). In Alaska and British Columbia, downstream migration of Dolly Varden occurs in spring and early summer and upstream migration occurs from late spring through early winter (ADFG 1963; Armstrong 1965; Smith and Slaney 1979). In southeast Alaska, Dolly Varden spent an average of 116 days in marine waters (Armstrong 1965). Armstrong (1965) also reported that Dolly Varden migrated directly to saltwater and did not backtrack or linger in the river.

Anadromous char undertake fairly extensive marine migrations. Anadromous Dolly Varden typically stay close to the shoreline, but sometimes move up to 30 miles off shore (e.g., ADFG 1963). Dolly Varden move extensive distances in salt water, and may enter freshwater streams that are far from their natal streams (DeCicco 1992; Thorpe 1994). Kraemer (1994) has documented fish in Puget Sound as far as 25 miles from their natal stream. Marking studies used to investigate migratory patterns of Dolly Varden in southeast Alaska found marked fish in 25 different stream systems as far as 72 miles from their natal stream (Armstrong 1965). About forty percent of the marked fish appeared to migrate to other streams during the winter, but most fish remained within tens of miles of their natal streams.

Nearshore marine habitats have been significantly altered by human development (PSWQAT 2000). Construction of bulkheads and other structures have modified the nearshore areas and resulted in habitat loss that has directly affected forage fish for bull trout. Other impacts to the marine environment include alterations to water quality resulting from fish pathogens, nutrients and toxic contaminants, urbanization, and stormwater runoff from basins that feed Puget Sound. Global changes in sea level and climate may also have more widespread ramifications on these habitats, and on the Puget Sound ecosystem as a whole (Klarin et al. 1990; Thom 1992).

2.3 Food Habits

Like many fish, different life stages of bull trout feed at different trophic levels. Adult bull trout are apex piscivores, and require a large prey base and home range. Adult and subadult migratory bull trout feed primarily on various trout and salmon species, whitefish (*Prosopium* spp.), yellow perch (*Perca flavescens*), and sculpin (*Cottus* spp.). Subadult and adult migratory bull trout move throughout and between basins in search of prey. Anadromous bull trout in the Coastal-Puget Sound DPS also feed on ocean fish such as surf smelt (*Hypomesus pretiosus*) and sandlance (*Ammodytes hexapterus*). Resident and juvenile bull trout prey on terrestrial and aquatic insects, macrozooplankton, amphipods, mysids, crayfish, and small fish (Wyman 1975; Rieman and Lukens 1979 in Rieman and McIntyre 1993; Boag 1987; Goetz 1989; Donald and Alger 1993). A recent study in the Cedar River Watershed of western Washington found bull trout diets also include aquatic insects, crayfish, and salamanders (Connor et al. 1997).

2.4 Reproductive Biology

Bull trout become sexually mature between 4 and 9 years of age, and may spawn in consecutive or alternate years (Shepard et al. 1984; Pratt 1992). Spawning typically occurs from August through December in cold, low-gradient 1st- to 5th-order tributary streams, over loosely compacted gravel and cobble having groundwater inflow (Shepard et al. 1984; Brown 1992; Rieman and McIntyre 1996; Swanberg 1997; MBTSG 1998; Baxter and Hauer 2000). Surface/groundwater interaction zones, which are typically selected by bull trout for redd

construction, have high dissolved oxygen, constant cold water temperatures, and increased macro-invertebrate production. Spawning sites frequently occur near cover (Brown 1992).

Hatching occurs in winter or early spring, and alevins may stay in the gravel for up to three weeks before emerging. The total time from egg deposition to fry emergence from the gravel may exceed 220 days.

Post-spawning mortality, longevity, and repeat-spawning frequency are not well known (Rieman and McIntyre 1996), but lifespans may exceed 10 to13 years (McPhail and Murray 1979; Pratt 1992; Rieman and McIntyre 1993). Adult adfluvial bull trout may live as long as 20 years, and may require as much as 20 months in the lake or reservoir habitat to facilitate adequate energy storage and gamete development before they return to spawn again (67 FR 71236).

Migratory bull trout are highly visible during spawning due to their large size and location in relatively small streams during periods of low flow. Channel complexity and cover are important components of spawning habitat to reduce both predation risk and potential for poaching.

3. Population Dynamics

Bull trout are considered to display complex metapopulation dynamics (Dunham and Rieman 1999). Size of suitable habitat patches appears to play an important role in the persistence of bull trout populations, along with habitat connectivity and human disturbance, especially road density. Analyses of spatial and temporal variation in bull trout redds indicates weak spatial clustering in patterns of abundance through time (Rieman and McIntyre 1996). Spatial heterogeneity in patterns of abundance was high, however, at a regional scale. This combination of patterns suggests that maintenance of stable regional populations may require maintenance of connected patches of high quality habitat where dispersal and demographic support can occur readily among patches (Rieman and McIntyre 1996).

The importance of maintaining the migratory life-history form of bull trout, as well as migratory runs of other salmonids that may provide a forage base for bull trout, is repeatedly emphasized in the scientific literature (Rieman and McIntyre 1993; MBTSG 1998; Dunham and Rieman 1999; Nelson et al. 2002). Isolation and habitat fragmentation resulting from migratory barriers have negatively affected bull trout by: (1) reducing geographical distribution (Rieman and McIntyre 1993; MBTSG 1998); (2) increasing the probability of losing individual local populations (Rieman and McIntyre 1993; MBTSG 1998; Nelson et al. 2002; Dunham and Rieman 1999); (3) increasing the probability of hybridization with introduced brook trout (Rieman and McIntyre 1993); (4) reducing the potential for movements in response to developmental, foraging, and seasonal habitat requirements (MBTSG 1998; Rieman and McIntyre 1993); and (5) reducing reproductive capability by eliminating the larger, more fecund migratory form from many subpopulations (MBTSG 1998; Rieman and McIntyre 1993). Therefore, restoring connectivity and restoring the frequency of occurrence of the migratory form will reduce the probability of local and subpopulation extinctions. Remnant populations, that lack connectivity due to elimination of migratory forms, have a reduced likelihood of persistence (Rieman and McIntyre 1993; Rieman and Allendorf 2001).

Lakes and reservoirs provide important refugia for bull trout. In general, lake and reservoir environments are relatively more secure from catastrophic natural events than stream systems (67 FR 71236). They provide a sanctuary for bull trout, allowing them to quickly rebound from temporary adverse effects to spawning and rearing habitat. For example, if a major wildfire burns a drainage and eliminates most or all aquatic life (a rare occurrence), bull trout sub-adults and adults that survive in the lake may return the following year to repopulate the burned drainage. This underscores the need to maintain migratory life forms and habitat connectivity in order to increase the likelihood of long-term population persistence.

4. Threats and Conservation Needs

Threats are factors that reduce a species' likelihood of survival and recovery and lead to listing under the Act. Conservation needs are ecological conditions necessary to sustain stable or increasing populations of listed species, and measures that will create these conditions. Conservation needs alleviate or reverse the effects of threats and contribute to increasing the likelihood of survival and recovery of listed species.

4.1 Reasons for Listing

Factors contributing to the decline of bull trout populations were described in the final rules for listing. They include restriction of migratory routes by dams and other unnatural barriers; forest management, grazing, and agricultural practices; road construction; mining; introduction of non-native species; and residential development resulting in adverse habitat modification, over-harvest, and poaching (Bond 1992; Thomas 1992; Rieman and McIntyre 1993; Donald and Alger 1993; WDFW 1997).

Extensive habitat loss and fragmentation of subpopulations have been documented for bull trout in the Columbia River basin and elsewhere within its range (Rieman and McIntyre 1993). Road construction, grazing, and agricultural practices in the Columbia River basin have degraded habitat conditions by contributing to elevated stream temperatures, increased sedimentation and channel embeddedness, and reductions in the extent of riparian vegetation. Mining activities have compromised habitat conditions by discharging waste materials into streams and diverting and altering stream channels. Residential development has threatened water quality by introducing domestic sewage and altering riparian conditions. Dams of all sizes (e.g., mainstem hydropower and tributary irrigation diversions) have severely limited migration of bull trout in the Columbia River basin. Competition from and hybridization with non-native trout are also considered threats to bull trout (USDI 1998; 1999).

Wildfire in the dry forests of the interior Columbia Basin also presents a substantive threat to bull trout populations. Although bull trout evolved with wildfire, and can benefit from it, fire suppression in some areas has altered fire regimes so drastically that they no longer resemble historic fire regimes in which bull trout evolved (Rieman et al. 1997b; Rieman and Clayton 1997; Gresswell 1999). Species that have narrow habitat requirements, such as bull trout, that inhabit degraded and fragmented aquatic systems are considered vulnerable to fire and fire-related disturbance (Dunham et al. 2003b). In this context, wildfire could threaten long-term persistence of bull trout because it exerts selection pressures different than those that produced the phenotypes and genotypes present today.

4.2 New Threats

No new threats since listing have been specifically identified at the range-wide scale, but previously identified threats, or new threats at the local scale, may not have been fully appreciated. Examples include the proposed introduction of northern pike (*Esox lucius*) as a sport fish in Montana and expansion of the range of whirling disease (*Myxobolus cerebralus*).

4.3 Conservation Needs

Conservation needs are measures necessary to redress the threats that led to the listing of a species. As described in the "habitat" sections above, the habitat conservation needs of bull trout are often generally expressed as the need to provide the four "Cs"; cold, clean, complex, and connected habitat. Cold stream temperatures, clean water quality that is relatively free of sediment and contaminants, complex channel characteristics, including abundant large wood and undercut banks, and large patches of such habitat that are well connected by unobstructed migratory pathways are all needed to promote long-term conservation of bull trout.

In addition to habitat conservation needs, other needs are associated with sustaining population dynamics. These conservation needs include: (1) maintain and restore multiple, interconnected populations in diverse habitats across the range; (2) preserve the diversity of life-history strategies; and (3) maintain genetic and phenotypic diversity across the range. Each of these needs is described below in more detail. These conservation needs apply to bull trout at multiple scales ranging from the coterminous listing down to local populations.

4.3.1 *Interconnected Populations*. Maintaining multiple bull trout populations distributed and interconnected throughout their current range will also provide a mechanism for spreading the risk of extinction from stochastic events (Rieman and McIntyre 1993; Rieman and Allendorf 2001; Spruell et al. 1999; Healey and Prince 1995; Hard 1995). Bull trout still occur widely, but in reduced numbers, across most portions of their historical range. Within this broad distribution, significant declines and local extinctions have occurred. Current patterns in distribution and other empirical evidence indicate that further declines and local extinctions are likely (Rieman et al. 1997a; Spruell et al. 2003; Rieman and Allendorf 2001; Dunham and Rieman 1999). Maintenance of widespread and interconnected populations improves the chances that declining populations can be "rescued" from extinction by immigrants from more robust populations, or if local extinctions occur, that recolonization will follow.

Preservation of interconnected populations and multiple life histories enable bull trout to persist through natural disturbance events, such as large fires. Bull trout evolved under historic fire regimes in which disturbance to streams from forest fires resulted in a mosaic of diverse habitats. However, forest management and fire suppression over the past century have increased homogeneity of terrestrial and aquatic habitats, increasing the likelihood of large, intense forest fires in some areas. Because the most severe effects of fire on native fish populations can be expected where populations have become fragmented by human activities or natural events, an effective strategy to ensure persistence of native fishes in habitats susceptible to large fires may be to restore aquatic habitat structure and life-history complexity of populations in these areas (Gresswell 1999).

The spatial diversity and complexity of aquatic habitats strongly influence the effects of large disturbances on salmonids (Rieman and Clayton 1997). For example, Rieman et al. (1997b) studied bull trout and redband trout (*Oncorhynchus mykiss*) responses to large, intense fires that burned three watersheds in the Boise National Forest in Idaho. Although the fires were the most intense on record, there was a mix of severely burned to unburned areas left after the fires. Fish were apparently eliminated in some stream reaches, whereas others contained relatively high densities of fish. Within a few years after the fires, after areas within the watersheds had experienced debris flows, fish became reestablished in many reaches. In some instances, fish densities were higher than those present before the fires even in streams that were not burned (Rieman et al. 1997b). These responses were attributed to spatial habitat diversity that supplied refuge areas for fish during the fires, and the ability of bull trout and the redband trout to move among stream reaches. For bull trout, the presence of migratory fish within the system was also important (Rieman and Clayton 1997; Rieman et al.1997b).

In terms of conserving bull trout, the appropriate strategy to reduce the risk of fires on bull trout habitat is to emphasize the restoration of watershed processes that create and maintain habitat diversity, provide bull trout access to habitats, and protect or restore migratory life-history forms of bull trout. Both passive (e.g., encouraging natural riparian vegetation and floodplain processes to function appropriately) and active (e.g., reducing road density, removing barriers to fish movement, and improving habitat complexity) actions offer the best approaches to protect bull trout from the effects of large fires.

4.3.2 *Life-History Diversity.* Bull trout populations exhibit multiple life-history forms, including migratory forms, throughout the range of the species (Rieman and McIntyre 1993). Migratory forms appear to develop when habitat conditions allow movement between spawning and rearing streams and larger rivers or lakes, where foraging opportunities may be enhanced (Frissell 1997). For example, multiple life-history forms (e.g., resident and fluvial) and multiple migration patterns have been noted in the Grande Ronde River (Baxter 2002). Parts of this river system have retained habitat conditions that allow free movement between spawning and rearing areas and the mainstem of the Snake River. Such multiple life-history strategies help to maintain the stability and persistence of bull trout populations in the face of environmental changes. Migratory bull trout may enhance persistence of metapopulations due to their high fecundity, large size, and dispersal across space and time, which promotes recolonization should resident populations suffer a catastrophic loss (Frissell 1997; Rieman and McIntyre 1993; MBTSG 1998).

4.3.3 *Genetic and Phenotypic Diversity.* Genetic diversity promotes both short-term fitness of populations and long-term persistence of a species by increasing the likelihood that the species is able to survive changing environmental conditions. This beneficial effect can be displayed both within and among populations. Within a genetically diverse local population of bull trout, different individuals may have various alleles that confer different abilities to survive and reproduce under different environmental conditions (Leary et al. 1993; Spruell et al. 1999; Hard 1995). If environmental conditions change due to natural processes or human activities, different allele combinations already present in the population may be favored, and the population may persist with only a change in allele frequencies. A genetically homogeneous population that has lost variation due to inbreeding or genetic drift may be unable to respond to environmental change and be extirpated. The prospect of local extirpation highlights the importance of genetic

diversity among local populations. Recolonization of locations where extirpations have occurred may be promoted if immigrants are available that possess alleles that confer an advantage in variable environmental conditions. Extending this reasoning to the entire range of the species, reduction in rangewide genetic diversity of bull trout through the loss of local populations can reduce the species ability to respond to changing conditions, leading to a higher likelihood of extinction (Rieman and McIntyre 1993; Leary et al. 1993; Spruell et al. 1999; Hard 1995; Rieman and Allendorf 2001).

Barriers to migration are an important factor influencing patterns of genetic variability in bull trout (Spruell et al. 2003; Costello et al. 2003). Although barriers increase the vulnerability of isolated populations to stochastic factors, they also insulate these populations from the homogenizing effects of gene flow. If isolated populations were founded by ancestors with rare alleles, genetic drift, unimpeded by gene flow, can lead to fixation of these rare alleles. Subsequent downstream migration from these isolated populations may be important in maintaining the evolutionary potential of metapopulations, because they provide inputs of genetic diversity (Costello et al. 2003).

The amount of genetic variation necessary for a population to adapt to a changing environment can be estimated using the concept of effective population size (N_e). Effective population size is the average number of individuals in a population which are assumed to contribute genes equally to the succeeding generation. Effective population size provides a standardized measure of the amount of genetic variation that is likely to be transmitted between generations within a population.

Specific benchmarks for bull trout have been developed concerning the minimum N_e necessary to maintain genetic variation important for short-term fitness and long-term evolutionary potential. These benchmarks are based on the results of a generalized, age-structured, simulation model, called VORTEX (Miller and Lacy 1999), used to relate effective population size to the number of adult bull trout spawning annually under a range of life histories and environmental conditions (Rieman and Allendorf 2001). Using the estimate that N_e for bull trout is between 0.5 and 1.0 times the mean number of adults spawning annually, Rieman and Allendorf (2001) concluded that (1) an average of 100 adults spawning each year would be required to minimize risks of inbreeding in a population, and (2) an average of 1,000 adults is necessary to maintain genetic variation important for long-term evolutionary potential. This latter value of 1,000 spawners may also be reached with a collection of local populations among which gene flow occurs.

Bull trout populations tend to show relatively little genetic variation within populations, but substantial divergence among populations (e.g., Spruell et al. 2003). For example, Spruell et al. (1999) found that bull trout at five different spawning sites within a tributary drainage of Lake Pend Oreille, Idaho, were differentiated based on genetic analyses (microsatellite DNA), indicating fidelity to spawning sites and relatively low rates of gene flow among sites. This type of genetic structuring indicates limited gene flow among bull trout populations, which may encourage local adaptation within individual populations (Spruell et al. 1999; Healey and Prince 1995; Hard 1995; Rieman and McIntyre 1993).

Current information on the distribution of genetic diversity within and among bull trout populations is based on molecular characteristics of individual genes. While such analyses are extremely useful, they may not reflect variability in traits whose expression is dependent on interactions among many genes and the environment (Hard 1995, Reed and Frankham 2001; but see Pfrender et al. 2000). Therefore, the maintenance of phenotypic variability (e.g., variability in body size and form, foraging efficiency, and timing of migrations, spawning, and maturation) may be best achieved by conserving populations, their habitats, and opportunities for the species to take advantage of habitat diversity (Healey and Prince 1995; Hard 1995).

Local adaptation may be extensive in bull trout because populations experience a wide variety of environmental conditions across the species' distribution, and because populations exhibit considerable genetic differentiation. Thus, conserving many populations across their range is essential to adequately protect the genetic and phenotypic diversity of bull trout (Hard 1995; Healey and Prince 1995; Taylor et al.1999; Rieman and McIntyre 1993; Spruell et al. 1999; Leary et al. 1993; Rieman and Allendorf 2001). If genetic and phenotypic diversity is lost, changes in habitats and prevailing environmental conditions could increase the likelihood of bull trout suffering reductions in numbers, reproductive capacity, and distribution.

Based on this information about the life history and conservation needs of bull trout, the Service concludes that each subpopulation or local population is an important genetic, phenotypic, and geographic component of its respective interim recovery unit. Adverse effects that compromise the persistence of a bull trout subpopulation or local population can reduce the distribution, as well as the phenotypic and genetic diversity of the unit.

4.4 Recovery Planning

Recovery plans developed by the Service typically contain the most detailed articulation of the conservation needs of listed species. The goal of the draft recovery plan for bull trout is to ensure the long-term persistence of self-sustaining, complex interacting groups (or multiple local populations that may have overlapping spawning and rearing areas) of bull trout distributed across the species' native range.

The recovery of bull trout will depend on the reduction of the adverse effects from dams, logging, agricultural practices, road building, urbanization, fisheries management, and by remedying legacy effects from past activities. Other general conservation needs described in the draft recovery plan, but not mentioned in the preceding paragraphs, include:

- Prevent and reduce negative effects of nonnative fishes and other nonnative taxa on bull trout
- Establish fisheries management goals and objectives compatible with bull trout recovery, and implement practices to achieve those goals
- Characterize, conserve, and monitor genetic diversity and gene flow among local populations of bull trout (USFWS 2002).

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APPENDIX 2B. Crosswalk between the Bull Trout Matrix and Bull Trout Critical Habitat Primary Constituent Elements

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The purpose of this document is to provide a consistent means for analyzing baseline conditions and project effects to both the bull trout and designated critical habitat for the bull trout using the Matrix of Pathways and Indicators.

The Matrix of Pathway Indicators (Matrix or MPI) for bull trout is used to evaluate and document baseline conditions and to aid in making effect determinations for proposed projects (USFWS 1999). The Matrix analysis incorporates one population pathway and six habitat pathways which represent different features or functions of populations and habitat that can be affected by projects. These features and functions are characterized by measurable indicators of population performance and habitat conditions (4 population indicators and 19 physical habitat indicators). Analysis of these indicators provides a systematic approach for evaluating the existing baseline condition and potential project impacts, using metrics meaningful to bull trout.

Designated critical habitat for the bull trout (75 FR 63898) includes nine primary constituent elements (PCEs). These PCEs correspond to physical, chemical, and biological features included in the Matrix habitat indicators. Table Appendix 2B - 1 shows the correspondence between the PCEs for bull trout critical habitat and the Matrix habitat indicators. The following paragraphs describe each of the nine PCEs and the Matrix indicators (named using italics font) relevant to them.

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

   The analysis of *floodplain connectivity* considers the hydrologic linkage of off-channel areas with the main channel and maintenance of wetland function and riparian vegetation and succession supported by overbank flow. Floodplain and riparian areas provide hydrologic connectivity for springs, seeps, groundwater upwelling and wetlands and contribute to the maintenance of the water table. The *sediment* and *substrate embeddedness* indicators describe the level of fine sediment in the gravel which affects hyporheic flow. Fine sediment fills interstitial spaces making the movement of water through the substrate less efficient. The *chemical contamination/nutrients* and *temperature* indicators evaluate the water quality of groundwater. The *off-channel habitat* indicator suggests how much off-channel habitat is available, and generally side-channels are connected to adjacent channels via subsurface water. The *change in peak/base flows* indicator considers whether or not peak flow, base flow, and flow timing are comparable to an undisturbed watershed of similar size, geology, and geography. Peak flows, base flows, and flow timing are directly related to subsurface water connectivity and the degree to which soil compaction has decreased infiltration and increased surface runoff. The *drainage network increase* and *road density and location*

indicators assess the influence of the road and trail networks on subsurface water connectivity. If there is an increase in drainage network and roads are located in riparian areas, it is likely that subsurface water is being intercepted before it reaches a stream. If groundwater is being intercepted then it is likely that water quality is being degraded through increased temperatures, fine sediment, and possibly chemical contamination. *Streambank condition* addresses groundwater influence through an assessment of stability. The *disturbance history* indicator evaluates disturbance across the watershed and provides a picture of how management may be affecting hydrology. The *riparian conservation areas* indicator determines whether riparian areas are intact and providing connectivity. If riparian areas are intact it is much more likely that springs, seeps, and groundwater sources are able to positively affect water quality and quantity.

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

The *physical barriers* indicator provides the most direct assessment of this PCE. Analysis of this indicator includes consideration of whether man-made barriers within the watershed allow upstream and downstream passage of all life stages at all flows. However, some indicators further evaluate physical impediments and others evaluate the biological or water quality impediments that may be present. The *temperature, sediment, substrate embeddedness,* and *chemical contamination/nutrients* indicators assess whether other barriers may be created, at least seasonally, by conditions such as high temperatures, high concentrations of sediment, or contaminants. The *average wetted width/maximum depth ratio* indicator can help identify situations in which water depth for adult passage may be a problem. A very high average wetted width/maximum depth value may indicate a situation where low flows, when adults migrate, are so spread out that water depth is insufficient to pass adults. The *change in peak/base flows* indicator can help determine if change in base flows have been sufficient to prevent adult passage during the spawning migration. The *persistence and genetic integrity* indicator addresses biological impediments by evaluating negative interactions (e.g., predation, hybridization, and competition) with other species.

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

None of the indicators directly address this PCE, but a number of them address it indirectly. The *sediment* and *substrate embeddedness* indicators document the extent to which substrate interstitial spaces are filled with fine sediment. Interstitial spaces provide important habitat for aquatic macroinvertebrates, sculpin, and other substrate-oriented prey which are important food sources for bull trout. The *chemical contamination/ nutrients* indicator evaluates the level to which a stream is contaminated by chemicals or has a high level of nutrients. Chemicals and nutrients greatly affect the type and diversity of aquatic invertebrate communities present in a water body. The *large woody debris* and *pool frequency and quality* indicators assess habitat complexity. High stream habitat

complexity is associated with diverse and abundant macroinvertebrate and fish prey. The *off-channel habitat* and *floodplain connectivity* indicators document the presence of off-channels which are generally more productive than main channels. Off channel areas are important sources of forage, particularly for juveniles. The *streambank condition* and *riparian conservation areas* indicators both shed light on the very basis of the food base of a stream. Vegetation along streambanks and in riparian areas provide important habitat for terrestrial macroinvertebrates that can fall into the water as well as sources of nutrient inputs that support aquatic invertebrate production.

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.**

   Several indicators address this PCE directly. The *sediment* and *substrate embeddedness* indicators provide insight into how complex substrates are within a stream by documenting percent fines and embeddedness. As percent fines and embeddedness increase, substrate complexity decreases. The *large woody debris* indicator provides an excellent picture of habitat complexity. The indicator rates the stream based on the amount of in-channel large woody debris. Habitat complexity increases as large wood increases. The *pool frequency and quality* and *large pools* indicators address habitat complexity by rating the stream based on the frequency of pools and their quality. Habitat complexity increases as the number of pools and their quality increase. The *off-channel habitat* indicator directly addresses complexity associated with side channels. The indicator is rated based on the amount of off-channel habitat, cover associated with off-channels, and flow energy levels. *Average wetted width/maximum depth ratio* is an indicator of channel shape and pool quality. Low ratios suggest deeper, higher quality pools. The *streambank condition* and *riparian conservation areas* indicators both shed light on the complexity of river and stream shorelines. Vegetation along streambanks and in riparian areas provides important habitat complexity and channel roughness. The *streambank condition* indicator also provides information about the capacity of an area to produce undercut banks, which can be a very important habitat feature for bull trout. The *floodplain connectivity* indicator addresses complexity added by side channels and the ability of floodwaters to spread across the floodplain to dissipate energy and provide access to high-flow refugia for fish. The *road density and location* indicator addresses complexity by identifying if roads are located in valley bottoms. Roads located in valley bottoms reduce complexity by eliminating vegetation and replacing complex habitats with riprap or fill, and often confine the floodplain. The *disturbance regime* indicator documents the frequency, duration, and size of environmental disturbance within the watershed. If scour events, debris torrents, or catastrophic fires are frequent, long in duration, and large, then habitat complexity will be greatly reduced.

5. **Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form;**

geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.

The *temperature* indicator addresses this PCE directly. The indicator rates streams according to how well temperatures meet bull trout requirements. Other matrix indicators address temperature indirectly. The *off-channel habitat* and *floodplain connectivity* indicators address how well stream channels are hydrologically connected to off-channel areas. Floodplains and off-channels are important to maintaining the water table and providing connectivity to the channel for springs, seeps, and groundwater sources which contribute cool water to channels. The *average wetted width/maximum depth ratio* indicator also corresponds to temperature. Low width to depth ratios indicate that channels are narrow and deep with little surface area to absorb heat. The *streambank condition* indicator documents bank stability. If the streambanks are stabilized by vegetation rather than substrate then it is likely that the vegetation provides shade which helps prevent increases in temperature. The *change in peak/base flows* indicator evaluates flows and flow timing characteristics relative to what would be expected in an undisturbed watershed. If base flow has been reduced, it is likely that water temperature during base flow has increased since the amount of water to heat has decreased. The *road density and location* and *drainage network increase* indicators documents where roads are located. If roads are located adjacent to a stream then shade is reduced and temperature is likely increased. Roads also intercept groundwater and can reduce this cooling influence, as well as discharge typically warmer stormwater. The *disturbance history* indicator describes how much of the watershed has been altered by vegetation management and therefore indicates how much shade has been removed. The *riparian conservation areas* indicator addresses stream shade which keeps stream temperatures cool. The presence of *large pools* may provide thermal refugia when temperatures are high.

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.**

The *sediment* and *substrate embeddedness* indicators directly address this PCE. These indicators evaluate the percent fines within spawning areas and the percent embeddedness within rearing areas. The *streambank condition* and *riparian conservation areas* indicators indirectly address this PCE by documenting the presence or lack of potential fine sediment sources. If streambanks are stable and riparian conservation areas are intact then there is a low risk of introducing fine sediment from bank erosion. Also, the *floodplain connectivity* indicator indirectly addresses this PCE. If the stream channel is connected to its floodplain, then there is less risk of bank erosion during high flows because stream energy is reduced as water spreads across the floodplain. The *increase in drainage network* and *road density and location* indicators assess the effects of roads on the channel network and hydrology. If the drainage network has significantly increased

as a result of human-caused disturbance or road density is high within a watershed and roads are located adjacent to streams, then it is likely that in-channel fine sediment levels will be elevated above natural levels. The *disturbance regime* indicator documents the nature of environmental disturbance within the watershed. If the disturbance regime includes frequent and unpredictable scour events, debris torrents, and catastrophic fire, then it is likely that fine sediment levels will be elevated above background levels. A consideration for all indicators directly or indirectly influencing this PCE is that it is desirable to achieve an appropriate balance of stable areas to provide undercut banks and eroding areas that are sources for recruiting new spawning gravels. Too little sediment in a stream can also be detrimental.

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.**

   The *change in peak/base flows* indicator addresses this PCE directly by documenting the condition of the watershed hydrograph relative to an undisturbed watershed of similar size, geology, and geography. There are several indicators that address this PCE indirectly. The *streambank condition* indicator documents bank stability. If the streambanks are stabilized by vegetation rather than substrate then it is likely that the streambank can store water during moist periods and releases that water during dry periods which contributes to water quality and quantity. The *floodplain connectivity* indicator is relevant to water storage within the floodplain which directly affects base flow. Floodplains are important to maintaining the water table and providing connectivity to the channel for springs, seeps, and groundwater sources which contribute to water quality and quantity. The *increase in drainage network* and *road density and location* indicators assess the influence of the road and trail networks on hydrology. If there is an increase in drainage network and roads are located in riparian areas, it is likely is being intercepted and quickly routed to a stream which can increase peak flow. The *disturbance history* indicator evaluates disturbance across the watershed and provides a picture of how management may be affecting hydrology; for example, it may suggest the degree to which soil compaction has decreased infiltration and increased surface runoff. The *riparian conservation areas* indicator determines whether riparian areas are intact, functioning, and providing connectivity. If riparian areas are intact it is much more likely that springs, seeps, and groundwater sources are able to positively affect water quality and quantity.

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

   This PCE is closely related to PCE 7, with PCE 8 adding a water quality component (i.e., there is a high level of overlap in indicators that apply to both PCEs 7 and 8). The *temperature* and *chemical contamination/nutrients* indicators directly address water quality by comparing water temperatures to bull trout water temperature requirements, and documenting 303(d) designated stream reaches. Several other indicators indirectly address this PCE by evaluating the risk of fine sediment being introduced that would

result in decreased water quality through increased turbidity. The *streambank condition* and *riparian conservation areas* indicators indirectly address this PCE by documenting the presence or lack of potential fine sediment sources. If streambanks are stable and riparian conservation areas are intact then there is a low risk of introducing fine sediment from bank erosion. Also, the *floodplain connectivity* indicator indirectly addresses this PCE. If the stream channel is connected to its floodplain, then there is less risk of bank erosion during high flows because stream energy is reduced as water spreads across the floodplain. *Average wetted width/maximum depth ratio* is an indication of water volume, which indirectly indicates water temperature, (i.e., low ratios indicate deeper water, which in turn indicates possible high-flow refugia). This indicator in conjunction with *change in peak/base flows* is an indicator of potential water quality and quantity deficiencies, particularly during low flow periods. The *increase in drainage network* and *road density and location* indicators assess the effects of roads on the channel network and hydrology. If the drainage network has significantly increased as a result of human-caused disturbance or road density is high within a watershed and roads are located adjacent to streams, then it is likely that suspended fine sediment levels will be elevated above natural levels. If roads are located adjacent to a stream then shade is reduced and temperature is likely increased. Roads also intercept groundwater and can reduce this cooling influence, as well as discharge typically warmer stormwater. The *disturbance regime* indicator documents the nature of environmental disturbance within the watershed. If the disturbance regime includes frequent and unpredictable scour events, debris torrents, and catastrophic fire, then it is likely that turbidity levels will be elevated above background levels.

9. **Sufficiently low levels of occurrence of nonnative 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 only indicator that directly addresses this PCE is the *persistence and genetic integrity* indicator. This indicator addresses the likelihood of predation, hybridization, or displacement of bull trout by competitive species. The *temperature* indicator can provide indirect insights about whether conditions are conducive to supporting "warm water" species.

Appendix 2B Table 1. Relationship of the Matrix Indicators to the Primary Constituent Elements of Bull Trout Critical Habitat

Habitat Pathways (bold) and Indicators	**PCE 1 - Springs, Seeps, Groundwater**	**PCE 2- Migratory Corridors***	**PCE 3 - Abundant Food Base**	**PCE 4 - Complex Habitats**	**PCE 5 - Temperature**	**PCE 6 - Substrate**	**PCE - 7 Hydrograph**	**PCE 8 - Water Quality/ Quantity**	**PCE 9 - Nonnative Species***
Water Quality									
Temperature	X	X			X			X	X
Sediment	X	X	X	X		X			
Chemical Contamination/Nutrients	X	X	X					X	
Habitat Access									
Physical Barriers		X							
Habitat Elements									
Substrate Embeddedness	X	X	X	X		X			
Large Woody Debris			X	X					
Pool Frequency and Quality			X	X					
Large Pools				X	X				
Off-Channel Habitat	X		X	X	X				
Refugia	X	X	X	X	X	X	X	X	X
Channel Conditions and Dynamics									
Wetted With/Max. Depth Ratio		X		X	X			X	
Streambank Condition	X		X	X	X	X	X	X	
Floodplain Connectivity	X		X	X	X	X	X	X	
Flow/Hydrology									
Changes in Peak/Base Flows	X	X			X		X	X	
Drainage Network Increase	X				X	X	X	X	
Watershed Conditions									
Road Density and Location	X			X	X	X	X	X	
Disturbance History	X				X		X		
Riparian Conservation Areas	X		X	X	X	X	X	X	
Disturbance Regime				X		X		X	

* = PCE is also related to the population pathway, *persistence and genetic integrity* indicator

Chapter 3

Northern Spotted Owl (*Strix occidentalis caurina*)

3.1 INTRODUCTION

This Opinion is for reinitiation of consultation on the replacement of the proposed large snowshed with avalanche Bridges. This change in design will occur along a section of highway about 0.3-mile long, within the overall 15-mile Project area covered in the original consultation for the I-90 Snoqualmie Pass East Project (Service reference 13260-2008-0070). Reinitiation of consultation was triggered by: (1) this change in design resulting in increased permanent impacts to habitat for northern spotted owls, and (2) the Service revising the designation of critical habitat to include areas near I-90, including the location of the avalanche Bridges.

WSDOT submitted their request for reinitiation of consultation before the final rule revising designation of spotted owl critical habitat was released. The Service originally intended to use the information in the WSDOT's BA to complete a formal conference on proposed revised critical habitat. After the final rule was published, however, we coordinated with WSDOT and FHWA to consider completing formal reinitiation of consultation for effects to final revised critical habitat. The Service found the information provided in the BA to be adequate to complete formal reinitiation of consultation, and through coordination with WSDOT, pursued that approach.

This Opinion analyzes effects from proposed design changes on revised critical habitat, but not effects on the northern spotted owl. This apparent incongruity requires explanation. Our original consultation did not include consideration of removal of critical habitat, because noise from blasting was the only project effect that would reach critical habitat designated at that time. Subsequent revision of critical habitat led to the proposed design modification resulting in removal of about 5.5 acres of critical habitat, an effect not analyzed in our original consultation, clearly triggering reinitiation of consultation. In contrast, our original consultation adequately analyzed the effects of the proposed design modification on the northern spotted owl. The Service completed its original consultation on the entire I-90 Snoqualmie Pass East Project in 2008, analyzing the effects of construction and operation of the complete 15-mile project. At the time of this consultation, designs were not finalized and estimates of effects were somewhat coarse. In conformance with the Service's standard procedure for accommodating uncertainty about project effects, our original biological opinion estimated effects on spotted owl habitat based on the worst likely scenario. A subsequent reinitiation of consultation (Service reference 13260-2009-I-0131) on Phase 1B of construction (near the area of the avalanche Bridges) provided an indication of the potential magnitude of our original overestimation of habitat effects. Updated footprint information provided in WSDOT's Phase 1B reinitiation package indicated that about 15 acres of nesting/roosting/foraging (NRF) habitat would be removed. In our original consultation, the Service estimated Phase 1 NRF habitat removal to be about 22 acres. Because the revised estimate of NRF effects provided by WSDOT in the re-initiation package was less than the Service's estimate of Phase 1 effects in the original consultation, the Service concluded that changes in effects due to a revised footprint were already adequately covered in the original consultation. The current reinitiation of consultation presents a similar situation. The proposed design modification will increase NRF habitat effects by 2.3 acres (about 3.2 acres were expected to be removed with the large snowshed design), but we know our original estimate of effects was an overestimate by at least 7 acres. Likewise, updated analysis

of the noise effects associated with the new design revealed these were entirely within the area of noise disturbance analyzed in the original consultation. Consequently, we determined that no new analysis of effects on spotted owls was required.

The Service's opinion is that it would be premature to reduce our overall estimate of habitat effects to match WSDOT's modified estimate of total NRF habitat effects at this time. Designs for new phases of construction are in flux, and most of the expected NRF habitat removal will occur in these later phases of construction. We feel that reconciliation of habitat effects would be best accomplished in response to post-construction implementation monitoring reports.

The remainder of this Opinion will analyze Project effects to revised designated critical habitat. The action area is within the East Cascades North (ECN) unit, subunit ECN-4 of revised designated critical habitat for the spotted owl (USDI 2012). In Washington, the ECN unit is roughly similar in extent to the Washington East Cascades physiographic province which was used in prior consultations on critical habitat for northern spotted owls.

3.2 STATUS OF NORTHERN SPOTTED OWL CRITICAL HABITAT

This section provides a rangewide overview of the current condition of spotted owl revised critical habitat. Subsequent sections of the Opinion will zoom-in to the scale of the physiographic province, watershed, and the Project's action area to describe the status of critical habitat at these hierarchical scales. These descriptions of baseline conditions provide the context within which the Service evaluates the effects of the Project on the functionality of critical habitat.

3.2.1 **Legal Status**

On December 4, 2012, the Service published a final rule designating revised critical habitat for the spotted owl (USDI 2012). This final rule designates 9,577,969 acres of critical habitat in 11 units and 60 subunits in California, Oregon, and Washington. Critical Habitat Unit (CHU) 7, East Cascades North (ECN), CHU Subunit (CHSU) ECN-4, is located in the Project area.

Since the final rule revising spotted owl critical habitat was published in the Federal Register, the Service has become aware of minor discrepancies between published acreages in the rule and acreages derived from spatial analysis of final Geographic Information System (GIS) shapefiles and maps released with the rule. Most of these discrepancies reflect unintentional inclusion of private lands in the acreage values in the final rule. These private lands were excluded from the map layers. The Service is currently preparing an amendment to the final rule that will resolve these discrepancies. In the interim, the Service regards acreage values derived from GIS sources to be the most accurate. As a result, slight differences in acreages between the final rule and this BO will occur.

Designation of critical habitat serves to identify those lands that are necessary for the recovery of the listed species. The Service's primary objective in designating critical habitat was to identify capable and existing spotted owl habitat and highlight specific areas where management of the spotted owl and its habitat should be given highest priority.

3.2.2 **Primary Constituent Elements for Northern Spotted Owl Critical Habitat**

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. Based on our current knowledge of the physical or biological features and habitat characteristics required to sustain the northern spotted owl's life-history processes, the primary constituent elements of critical habitat are as follows:

Note that PCE 1 must occur in concert with PCE 2, 3, or 4:

(1) Forest types that may be in early-, mid-, or late-seral stages and that support the northern spotted owl across its geographical range. In the Washington East Cascades these forest types are primarily:

- (a) Western hemlock,
- (b) Mixed conifer and mixed evergreen,
- (c) Grand fir,
- (d) Pacific silver fir,
- (e) Douglas-fir,
- (f) The moist end of the ponderosa pine coniferous forests zones at elevations up to approximately 3,000 ft (900 m).

(2) Habitat that provides for nesting and roosting. Nesting and roosting habitat provides structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risks for adults and young. In many cases the same habitat also provides for foraging (PCE 3). These habitats must provide:

- (a) Sufficient foraging habitat to meet the home range needs of territorial pairs of northern spotted owls throughout the year.
- (b) Stands for nesting and roosting that are generally characterized by:
  - (i) Moderate to high canopy cover (60 to over 80 percent);
  - (ii) Multilayered, multispecies canopies with large (20–30 in (51–76 cm) or greater dbh) overstory trees;
  - (iii) High basal area (greater than 240 ft^2/ac (55 m^2/ha));
  - (iv) High diversity of different diameters of trees;
  - (v) High incidence of large live trees with various deformities (e.g., large cavities, broken tops, mistletoe infections, and other evidence of decadence);
  - (vi) Large snags and large accumulations of fallen trees and other woody debris on the ground; and
  - (vii) Sufficient open space below the canopy for northern spotted owls to fly.

(3) Habitat that provides for foraging, which varies widely across the northern spotted owl's range, in accordance with ecological conditions and disturbance regimes that influence vegetation structure and prey species distributions. Across most of the owl's range, nesting and roosting habitat is also foraging habitat, but in some regions northern spotted owls may use additional habitat types for foraging as well. Foraging habitat for the East Cascades ecological zone generally includes the following:

- (a) Stands of nesting and roosting habitat;
- (b) Stands composed of Douglas-fir and white fir/Douglas-fir mix;
- (c) Mean tree size greater than 16.5 in (42 cm) quadratic mean diameter;

(d) Increasing density of large trees (greater than 26 in (66 cm)) and increasing basal area (the total area covered by trees measured at breast height) increases foraging habitat quality;
(e) Large accumulations of fallen trees and other woody debris on the ground; and
(f) Sufficient open space below the canopy for northern spotted owls to fly.

(4) Habitat to support the transience and colonization phases of dispersal, which in all cases would optimally be composed of nesting, roosting, or foraging habitat (PCEs 2 or 3), but which may also be composed of other forest types that occur between larger blocks of nesting, roosting, and foraging habitat. In cases where nesting, roosting, or foraging habitats are insufficient to provide for dispersing or nonbreeding owls, the specific dispersal habitat PCEs for the northern spotted owl may be provided by the following:
(a) Habitat supporting the transience phase of dispersal, which includes:
(i) Stands with adequate tree size and canopy cover to provide protection from avian predators and minimal foraging opportunities; in general this may include, but is not limited to, trees with at least 11 in (28 cm) dbh and a minimum 40 percent canopy cover; and
(ii) Younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, if such stands contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the transience phase.
(b) Habitat supporting the colonization phase of dispersal, which is generally equivalent to nesting, roosting, and foraging habitat as described in PCEs (2) and (3), but may be smaller in area than that needed to support nesting pairs.

In summary, the Primary Constituent Elements (PCEs) of revised designated critical habitat for the northern spotted owl are: (1) Forest types that may be in early-, mid-, or late-seral stages and that support the northern spotted owl across its geographical range, in combination with, (2) habitat that provides for nesting and roosting, (3) habitat that provides for foraging, and (4) habitat to support the transience and colonization phases of dispersal (USDI 2012). This 2012 revision of designated critical habitat supersedes previous designations in 1992 and 2008 (USDI 2012).

3.2.3 Conservation Role of Northern Spotted Owl Critical Habitat

The conservation role of spotted owl critical habitat is to adequately support the life-history needs of the species to the extent that well-distributed and interconnected northern spotted owl nesting populations are likely to persist within properly functioning ecosystems at the critical habitat unit and range-wide scales. In general, we would anticipate that management actions that are consistent with the overall purpose for which a critical habitat unit was designated would not likely destroy or adversely modify critical habitat as those terms are used in the context of section 7(a)(2) of the Act. Such actions include activities whose intent is to restore ecological processes or long-term forest health to forested landscapes that contain northern spotted owl

habitat, such as those actions described in the Revised Recovery Plan for the Northern Spotted Owl (USDI 2011). However, each proposed action will be considered on a case-by case basis.

3.2.4 Current Condition of Northern Spotted Owl Critical Habitat

The current condition of critical habitat incorporates the effects of all past human activities and natural events that led to the present-day status of the habitat (USDI and USDC 1998, pg. 4-19). With the revision of spotted owl critical habitat, the rangewide condition has been "reset" as of December 4, 2012.

3.2.4.1 Rangewide Condition

As per our December 4, 2012, final rule (effective date of January 3, 2013), revised designated critical habitat for the northern spotted owl has effectively "reset" the rangewide condition (USDI 2012). Approximately 9,577,342 acres of suitable, dispersal, and forested (capable) habitats were designated rangewide (Table 3.1).

Table 3.1. Summary of northern spotted owl critical habitat and habitat conditions by State and Physiographic Province[1].

State	Physiographic Province	Total Designated CH Acres	Nesting/ Roosting	Dispersal	forested, but not dispersal	non-forested	Percent of CH Nesting/ Roosting	Percent of CH in Dispersal or NR habitat
WA	East Cascades	1,022,960	416,069	336,795	224,757	45,338	40.7%	73.6%
WA	Olympic	507,165	238,390	159,491	102,684	6,600	47.0%	78.5%
WA	West Cascades	1,387,567	667,173	422,585	268,548	29,262	48.1%	78.5%
OR	Cascades East	529,652	181,065	220,324	113,780	14,484	34.2%	75.8%
OR	Cascades West	1,965,407	1,161,780	518,419	266,004	19,204	59.1%	85.5%
OR	Coast Range	1,151,874	535,602	397,554	216,262	2,456	46.5%	81.0%
OR	Klamath Mountains	911,681	481,577	279,493	146,921	3,691	52.8%	83.5%
CA	Cascades	243,205	98,243	104,993	37,834	2,135	40.4%	83.6%
CA	Coast	149,044	58,278	36,173	47,690	6,903	39.1%	63.4%
CA	Klamath	1,708,787	752,131	588,604	322,875	45,177	44.0%	78.5%
	TOTALS	**9,577,342**	**4,590,308**	**3,064,430**	**1,747,354**	**175,249**	**47.9%**	**79.9%**

[1] - Data available at http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Maps.asp (critical habitat shapefile) and http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Maps.asp (spotted owl habitat).

This revision of critical habitat represents an increase in the total land area identified from previous designations in 1992 and 2008. This increase in area is due, in part, to: (a) The unanticipated steep decline of the northern spotted owl and the impact of the barred owl (*Strix varia*), requiring larger areas of habitat to maintain sustainable spotted owl populations in the face of competition with the barred owl (Dugger et al. 2011, p. 2467); (b) the recommendation

from the scientific community that the conservation of more occupied and high-quality habitat is essential to the conservation of the species (Forsman et al. 2011, p. 77); (c) the need to provide for redundancy in northern spotted owl populations, by maintaining sufficient suitable habitat for northern spotted owls on a landscape level in areas prone to frequent natural disturbances, such as the drier, fire-prone regions of its range (in other words, "back-up" areas of habitat so that owls have someplace to go if their habitat burns or trees die due to insect infestation, etc.) (Noss et al. 2006, p. 484; Thomas et al. 2006, p. 285; Kennedy and Wimberly 2009, p. 565); and (d) in contrast to the previous critical habitat designation, the inclusion of some State lands in areas where Federal lands are not sufficient to meet the conservation needs of the northern spotted owl.

Consulted-upon effects at the rangewide scale are accounted for through a take and effects tracking system in the Service's Environmental Conservation Online System (ECOS) database. To date (https://ecos.fws.gov/tails/sec/nsoTableD.do, accessed February 6, 2013), ECOS reports 3,586 acres were removed or downgraded from critical habitat rangewide. The vast majority of these impacts originated in the Oregon Coast Range and Klamath Mountains Physiographic Provinces, and less than half (1,900 acres) occurred in land use allocations under the NWFP that were intended to emphasize maintenance of spotted owl habitat values (i.e., late-successional reserves). The Service's opinion is that combined effects that occurred on 0.06 percent of critical habitat rangewide are unlikely to change the overall functionality of the rangewide critical habitat network.

3.2.4.2 Zones of Habitat Associations

Differences in patterns of habitat associations across the range of the northern spotted owl suggest four different broad zones of habitat use, which we characterize as the (1) West Cascades/Coast Ranges of Oregon and Washington, (2) East Cascades, (3) Klamath and Northern California Interior Coast Ranges, and (4) Redwood Coast (Figure 3.1). We configured these zones based on a qualitative assessment of similarity among ecological conditions and habitat associations within the 11 different regions analyzed during the critical habitat designation process (see USDI 2012). These 4 zones efficiently capture the range in variation of some of the physical or biological features essential to the conservation of the northern spotted owl. We summarize the physical or biological features for each of these four zones, emphasizing zone-specific features that are distinctive within the context of general patterns that apply across the entire range of the northern spotted owl.

3.2.4.2.1 West Cascade/Coast Ranges of Oregon and Washington. This zone includes five regions west of the Cascade crest in Washington and Oregon (Western Cascades North, Central and South; North Coast Ranges and Olympic Peninsula; and Oregon Coast Ranges; USDI 2011, p. C–13). Climate in this zone is characterized by high rainfall and cool to moderate temperatures. Variation in elevation between valley bottoms and ridges is relatively low in the Coast Ranges, creating conditions favorable for development of contiguous forests. In contrast, the Olympic and Cascade ranges have greater topographic variation with many high-elevation areas supporting permanent snowfields and glaciers. Douglas-fir and western hemlock dominate forests used by northern spotted owls in this zone. Root diseases and wind-throw are important natural disturbance mechanisms that form gaps in forested areas. Flying squirrels (*Glaucomys*

sabrinus) are the dominant prey, with voles and mice also representing important items in the northern spotted owl's diet.

Our habitat modeling indicated that vegetation structure had a dominant influence on owl population performance, with habitat pattern and topography also contributing. High canopy cover, high density of large trees, high numbers of sub-canopy vegetation layers, and low to moderate slope positions were all important features.

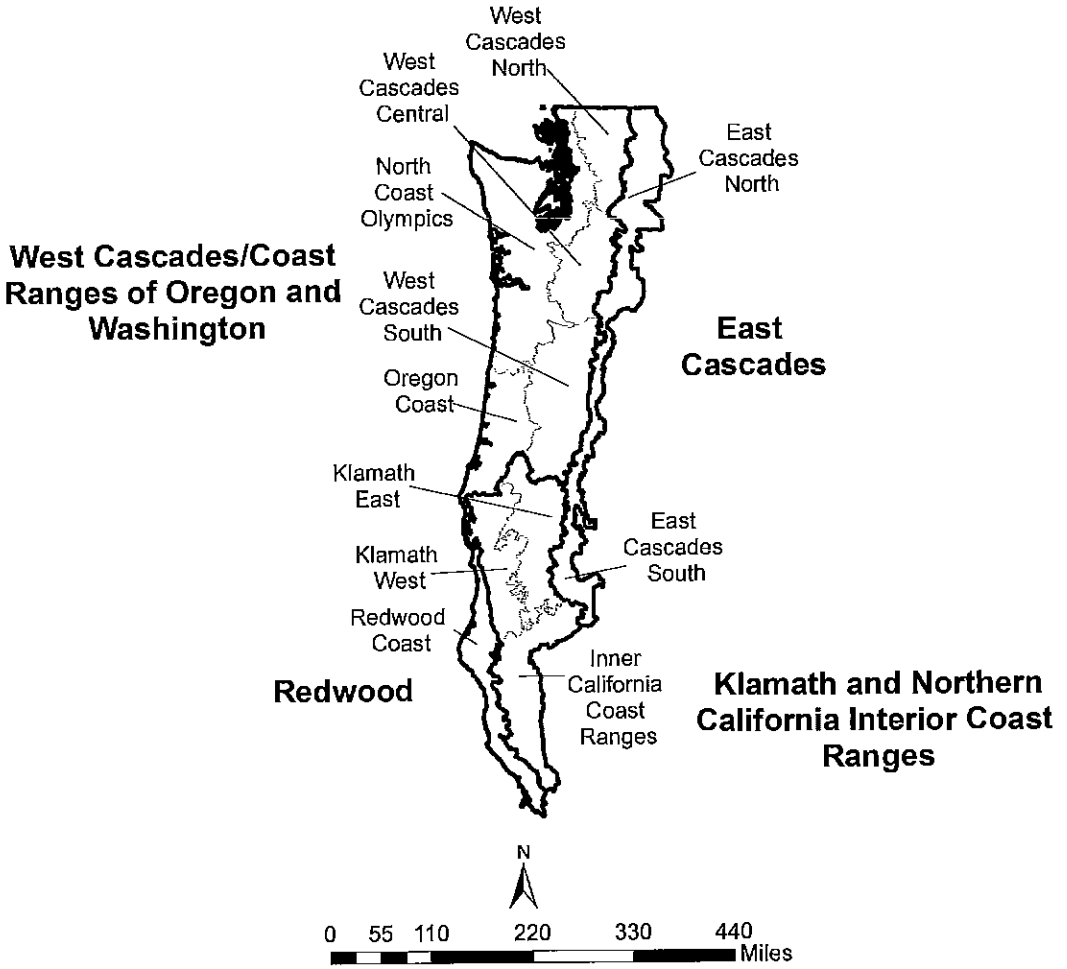
Nesting habitat in this zone is mostly limited to areas with large trees with defects such as mistletoe brooms, cavities, or broken tops. The subset of foraging habitat that is not nesting/roosting habitat generally had slightly lower values than nesting habitat for canopy cover, tree size and density, and canopy layering. Prey species (primarily northern flying squirrel) in this zone are associated with mature to late-successional forests, resulting in small differences between nesting, roosting, and foraging habitat.

3.2.4.2.2 East Cascades. This zone includes the Eastern Cascades North and Eastern Cascades South regions (USDI 2011, p. C–13). This zone is characterized by a continental climate (cold, snowy winters and dry summers) and a high frequency of natural disturbances due to fires and outbreaks of forest insects and pathogens. Flying squirrels are the dominant prey species, but the diet of northern spotted owls in this zone also includes relatively large proportions of bushy-tailed woodrats (*Neotoma cinerea*), snowshoe hare (*Lepus americanus*), pika (*Ochotona princeps*), and mice (Forsman et al. 2001, pp. 144–145).

Our modeling indicates that habitat associations in this zone do not show a pattern of dominant influence by one or a few variables (USDI 2011, Appendix C). Instead, habitat association models for this zone included a large number of variables, each making a relatively modest contribution (20 percent or less) to the predictive ability of the model. The features that were most useful in predicting habitat quality were vegetation structure and composition, and topography, especially slope position in the north. Other efforts to model habitat associations in this zone have yielded similar results (e.g., Gaines et al. 2010, pp. 2048–2050; Loehle et al. 2011, pp. 25–28).

Relative to other portions of the subspecies' range, nesting and roosting habitat in this zone includes relatively younger and smaller trees, likely reflecting the common usage of dwarf mistletoe (*Arceuthobium douglasii*) brooms (dense growths) as nesting platforms (especially in the north). Forest composition that includes high proportions of Douglas-fir is also associated with this nesting structure. Additional foraging habitat in this zone generally resembles nesting and roosting habitat, with reduced canopy cover and tree size, and reduced canopy layering. High prey diversity suggests relatively diverse foraging habitats are used. Topographic position was an important variable, particularly in the north, possibly reflecting competition from barred owls (Singleton et al. 2010, pp. 289, 292). Barred owls, which have been present for over 30 years in northern portions of this zone, preferentially occupy valley-bottom habitats, possibly compelling northern spotted owls to establish territories on less productive, mid-slope locations (Singleton et al. 2010, pp. 289, 292).

Figure 3.1. Eleven regions and four zones of habitat associations of northern spotted owls in Washington, Oregon, and California.



3.2.4.2.3 Klamath and Northern California Interior Coast Ranges. This zone includes the Klamath West, Klamath East, and Interior California Coast regions (USDI 2011, p. C–13). This region in southwestern Oregon and northwestern California is characterized by very high climatic and vegetative diversity resulting from steep gradients of elevation, dissected topography, and large differences in moisture from west to east. Summer temperatures are high, and northern spotted owls occur at elevations up to 5,800 ft (1,768 m). Western portions of this zone support a diverse mix of mesic forest communities interspersed with drier forest types. Forests of mixed conifers and evergreen hardwoods are typical of the zone. Eastern portions of this zone have a Mediterranean climate with increased occurrence of ponderosa pine. Douglas-fir dwarf mistletoe is rarely used for nesting platforms in the western part of the northern spotted owl's range, but is commonly used in the east.

The prey base for northern spotted owls in this zone is correspondingly diverse, but dominated by dusky-footed woodrats, bushy-tailed woodrats, and flying squirrels. Northern spotted owls

have been well studied in the western Klamath portion of this zone (Forsman et al. 2004, p. 217), but relatively little is known about northern spotted owl habitat use in the eastern portion and the California Interior Coast Range portion of the zone

Our habitat association models for this zone suggest that vegetation structure and topographic features are nearly equally important in influencing owl population performance, particularly in the Klamath. High canopy cover, high levels of canopy layering, and the presence of very large dominant trees were all important features of nesting and roosting habitat. Compared to other zones, additional foraging habitat for this zone showed greater divergence from nesting habitat, with much lower canopy cover and tree size. Low to intermediate slope positions were strongly favored. In the eastern Klamath, presence of Douglas-fir was an important compositional variable in our habitat model (USDI 2011, Appendix C).

3.2.4.2.4 Redwood Zone. This zone is confined to the northern California coast, and is represented by the Redwood Coast region (USDI 2011, p. C–13). It is characterized by a maritime climate with moderate temperatures and generally mesic conditions. Near the coast, frequent fog delivers consistent moisture during the summer. Terrain is typically low-lying (0 to 3,000 ft (0 to 900 m)). Forest communities are dominated by redwood, Douglas-fir–tanoak (*Lithocarpus densiflorus*) forest, coast live oak (*Quercus agrifolia*), and tanoak series. Dusky footed woodrats are the dominant prey items for northern spotted owls in this zone.

Habitat association models for this zone diverged strongly from models for other zones. Topographic variables (slope position and curvature) had a dominant influence with vegetation structure having a secondary role. Low position on slopes was strongly favored, along with concave landforms.

Several studies of northern spotted owl habitat relationships suggest that stump-sprouting and rapid growth of redwood trees, combined with high availability of woodrats in patchy, intensively managed forests, enables northern spotted owls to occupy a wide range of vegetation conditions within the redwood zone. Rapid growth rates enable young stands to develop structural characteristics typical of older stands in other regions. Thus, relatively small patches of large remnant trees can also provide nesting habitat structure in this zone.

3.2.4.3 Climate Change

There is growing evidence that recent climate change has impacted a wide range of ecological systems (Stenseth et al. 2002, entire; Walther et al. 2002, entire; Ådahl et al. 2006, entire; Karl et al. 2009, entire; Moritz et al. 2012, entire; Westerling et al. 2011, p. S459; Marlon et al. 2012, p. E541). Climate change, combined with effects from past management practices, is exacerbating changes in forest ecosystem processes and dynamics to a greater degree than originally anticipated under the NWFP. Environmental variation affects all wildlife populations; however, climate change presents new challenges as systems may change beyond historical ranges of variability. In some areas, changes in weather and climate may result in major shifts in vegetation communities that can persist in particular regions.

Climate change will present unique challenges to the future of northern spotted owl populations and their habitats. Northern spotted owl distributions (Carroll 2010, entire) and population

dynamics (Franklin et al. 2000, entire; Glenn et al. 2010, entire; Glenn et al. 2011a, entire; Glenn et al. 2011b, entire) may be directly influenced by changes in temperature and precipitation. In addition, changes in forest composition and structure as well as prey species distributions and abundance resulting from climate change may impact availability of habitat across the historical range of the subspecies. The Revised Recovery Plan for the Northern Spotted Owl provides a detailed discussion of the possible environmental impacts to the habitat of the northern spotted owl from the projected effects of climate change (USDI 2011, pp. III-5 to III-11).

Because both northern spotted owl population dynamics and forest conditions are likely to be influenced by large-scale changes in climate in the future, we have attempted to account for these influences in our designation of critical habitat by recognizing that forest composition may change beyond the range of historical variation, and that climate changes may have unpredictable consequences for both Pacific Northwest forests and northern spotted owls. Our critical habitat designation also recognizes that forest management practices that promote ecosystem health under changing climate conditions will be important for northern spotted owl conservation.

3.3 ENVIRONMENTAL BASELINE OF NORTHERN SPOTTED OWL CRITICAL HABITAT

Regulations implementing the Act (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of State and private actions which are contemporaneous with the consultation in progress.

The 2012 final rule describes habitat functional types slightly differently than in previous final rules. Whereas suitable habitat was previously defined as including nesting, roosting, and foraging functions, the current final rule combines nesting and roosting habitat into a single category, and distinguishes foraging habitat as a separate functional type and PCE. This partitioning reflects advances in our scientific understanding about how spotted owls use patches of habitat with different characteristics. Although the Service has described foraging habitat separately, the approach that most action agencies use to map spotted owl habitat for project analysis does not distinguish foraging habitat. These mapping approaches traditionally differentiate between suitable (which combines nesting, roosting, and foraging functions), dispersal, and non- habitat. Nesting and roosting habitat provide foraging opportunities for spotted owls. But for foraging, spotted owls use a wider variety of stand types that may not include the structural and compositional characteristics needed for nesting and roosting. Thus, the habitat mapping approach used by action agencies likely underestimates the amount of actual foraging habitat used by spotted owls (e.g., younger or more fragmented stands used to access secondary prey species such as pika and snowshoe hare). Because we do not currently have the ability to distinguish Project effects on foraging habitat separate from Project effects on nesting and roosting habitat, in this Opinion we evaluate the baseline condition of critical habitat and effects to critical habitat in terms of nesting, roosting, and foraging habitat combined, with dispersal habitat evaluated separately, as we have done in the past, For the purposes of this BO, we will use the terms suitable habitat, NRF, and nesting/roosting synonymously.

We describe the baseline condition of critical habitat at two scales; (1) the modeling region scale, which corresponds to Critical Habitat Units, and is similar in extent to the physiographic province scale used in past consultations on spotted owl critical habitat, and (2) the critical habitat subunit scale, which roughly corresponds to the area supporting a population of spotted owls. The modeling region or critical habitat unit scale is meant to provide a broad context for evaluating the functionality of critical habitat, noting the distinctive ecological, climatic, and topographic setting represented by each critical habitat unit. The baseline at the subunit scale approaches the scale of the action area and provides a more localized basis for evaluating the particular functional role of critical habitat in the vicinity of proposed actions.

3.3.1 Baseline Conditions at the Scale of East Cascades North Critical Habitat Unit

The ECN modeling region was designated critical habitat Unit 7. Unit 7 contains 1,345,523 ac (557,002 ha) and nine subunits ranging in size from about 60,000 to 300,000 acres. This unit consists of the eastern slopes of the Cascade range, extending from the Cascade Crest eastward to the edge of habitats occupied by spotted owls in Washington and Oregon. From north to south, the ECN extends from the Canadian border south to the Deschutes National Forest near Bend, OR. Terrain of this region is glaciated and steeply dissected, especially in the northern portion of the unit. This region is characterized by a continental climate (cold, snowy winters and dry summers). In Washington, ponderosa pine and Douglas-fir forest are dominant at low elevations, Douglas-fir/grand fir mixed-conifer forest are characteristic of mid-elevations, and higher elevations support forests of silver fir, hemlock, and subalpine fir. Each of these forest types has corresponding fire regimes, which can be coarsely characterized as high-frequency, low-intensity fire regimes at lower elevations, mid elevations have mixed-severity regimes, and high elevations have high-severity regimes. Forest composition, particularly the presence of grand fir and western larch, distinguishes this modeling region from the East Cascades South modeling region. In the ECN, dwarf mistletoe provides an important component of nesting habitat, enabling northern spotted owls to nest within stands of relatively younger and smaller trees. Increased precipitation from marine air passing east through Snoqualmie Pass and the Columbia River Gorge has resulted in an increase of moist forest conditions, similar to those found in western Washington, in these areas within the ECN (Hessburg *et al.* 2000b, p. 165). In the southern portion of the unit, the terrain and ecology are different, with ponderosa pine predominating on flat terrain at low elevations and spotted owl habitat being found primarily on buttes and the slopes of the Cascade Range in forests of Douglas-fir, grand/white fir, and true firs. There is substantially less habitat in the Deschutes area of Oregon compared to the area north of Sisters, Oregon, and into Washington. Consequently, the majority of remaining spotted owls in this unit are found in Washington.

The Washington East Cascades physiographic province is located entirely within the ECN modeling region (Critical Habitat Unit 7). The Service used the habitat modeling approach developed for monitoring the Northwest Forest Plan and described in the 15-year monitoring report (Davis et al. 2011), to estimate baseline habitat condition in the ECN (Table 3.2). We considered the categories labeled by Davis et al. (2011) as 'highly suitable' and 'suitable' as representative of NRF habitat in the analysis area, while we considered the category 'marginal' to best represent dispersal-only habitat. Because NRF habitat also functions as dispersal habitat, this category was combined with dispersal-only to represent the dispersal habitat baseline.

Table 3.2. Amount and percentage of habitat functional types in the East Cascades North CHU.

CH Unit #	CH Unit Name	Designated CH Acres	Nesting/ Roosting acres	Dispersal acres	Forested, but not dispersal acres	Non-forested acres	Percent of CH in Nesting/ Roosting	Percent of CH in Dispersal or NR habitat
7	East Cascades North	1,359,263	506,020	485,940	312,206	55,097	37.2%	73.0%

Notes:

- All habitat estimates are approximate values based on 2006 data.
- Due to rounding errors associated with GIS, the acreage values reported here may differ slightly from values reported elsewhere.
- Nesting/roosting habitat represents forest conditions ranked as "suitable" or "highly suitable" for spotted owl use in Davis et al 2011.
- Dispersal habitat represents conifer stands that meet a minimum d.b.h. of ≥ 11 inch and conifer cover ≥ 40 percent.
- At this time, foraging habitat has not been mapped as a separate category. In some areas, dispersal habitat may function as foraging habitat.

3.3.2 Baseline Conditions at the Scale of the Critical Habitat Subunit and the Action Area

The ECN-4 subunit consists of approximately 223,282 ac (90,171 ha) in Kittitas County, Washington, and comprises lands managed by the U.S. Forest Service and the State of Washington (Table 3.3). The U.S. Forest Service manages 99,641 ac (40,323 ha) as Late-successional Reserves (LSR) to maintain functional, interactive, late-successional, and old-growth forest ecosystems and 118,676 ac (48,027 ha) under the Matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. The Washington Department of Fish and Wildlife manages 4,498 ac (1,820 ha). Threats in this subunit include current and past timber harvest, competition with barred owls, and removal or modification of habitat by forest fires, insects, and diseases. This subunit is expected to provide demographic support of the overall population. This subunit also has a key role in maintaining connectivity between northern spotted owl populations, both north to south in the East Cascades North Unit and west to east between the West and East Cascades units. This role is shared with the West Cascades North-2 subunit and the West Cascades Central-1 subunit to the west. ECN-4 is located primarily in the Upper Yakima River watershed.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 78 percent of the area of ECN-4 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by non-territorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued

maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

Table 3.3. Amount and percentage of habitat functional types in the Subunit ECN-4.

Sub Unit	Total Designated acres	Nesting/ Roosting acres	Dispersal acres	Forested, but not Dispersal acres	Non-forested acres	Percent Nesting/ Roosting	Percent Nesting/ Roosting and Dispersal
ECN-4	223,282	96,381	82,486	37,778	6,637	43.2%	80.1%

The upper Yakima watershed has experienced extensive timber harvest, especially in the last 60 years. Harvest has been particularly intensive on intermingled private forest lands, resulting in highly fragmented forested habitats and high road densities. In addition to timber harvest, other features that contribute to forest fragmentation in the watershed are the Keechelus and Kachess reservoirs, Lake Easton, railroad lines, electric transmission lines, I-90, and recreational facilities, including four ski areas, two developed campgrounds, many dispersed camping areas, and a growing network of trails that are used for summer and winter recreation (USFS 1997).

The Snoqualmie Pass area is considered to have reduced dispersal opportunity for spotted owls due to limited federal land ownership and development on private lands (USDI 1992a). No large spotted owl populations occupying a large reserve occur in the I-90 corridor, but the Manastash Ridge LSR to the south and the Swauk LSR to the north are large reserves expected to support large clusters of owls (these NWFP designations overlap to a large degree with designated critical habitat). Connectivity concerns in this corridor are primarily with north-south interchange of dispersing young and adults. Considerable removal of suitable habitat for spotted owls in the corridor has resulted in potential isolation of the northern and southern populations of spotted owls in the Washington Cascades (USDI 1992a). The I-90 corridor is also an area of relatively low mountain passes capable of supporting forest vegetation needed to promote spotted owl movement between the Eastern and Western Cascades physiographic provinces. Forest fragmentation in the vicinity of these low elevation passes has also reduced opportunities for east-west movement of spotted owls.

The I-90 project occurs primarily within the Snoqualmie Pass Adaptive Management Area (SPAMA), which is bounded to the south by the Manastash Ridge LSR, and to the north by the Alpine Lakes Wilderness. The specific objectives of the SPAMA within the context of the NWFP was to develop a plan for providing late-successional forest in areas of "checkerboard" land ownership, recognizing that this area is a critical connective link in the north-south movement of organisms in the Cascade Range (USDA and USDI 1994b). The management plan for the SPAMA was completed in 1997 and emphasized the ecological connectivity function of this land allocation. The management plan adopted the standards and guidelines for late-successional reserves and Aquatic Conservation Strategy as the baseline for management. In

addition, the SPAMA had a goal for open road density of 2 mi/mi^2 for each sub-watershed. Recreation was recognized as an important use of the SPAMA that was consistent with AMA objectives (USDA and USDI 1997). Recreation Emphasis Areas are located primarily near lakes and reservoirs and adjacent to I-90 (USDA and USDI 1997). The remainder of the AMA is designated as a Connectivity Emphasis Area and management of late-successional habitat is similar to LSR management (USDA and USDI 1997).

Connectivity models developed for the Snoqualmie Pass Adaptive Management Area Plan included a spotted owl model. Results of this modeling suggest that within the Project area, dispersal opportunities for spotted owls under current conditions are good in two areas; the Gold Creek area, around the north end of Lake Keechelus, and in the vicinity of Swamp Lake and Crystal Springs (USDA and USDI 1997). The best opportunities for spotted owl dispersal, however, occurred beyond the Project boundaries in the area between Lake Kachess and Lake Cle Elum (USDA and USDI 1997; Floberg 1998).

The Plum Creek I-90 Land Exchange resulted in an increase of about 27,000 acres of federal ownership in the portion of the Snoqualmie Pass Adaptive Management Area near the proposed project, including about 7,400 acres of suitable spotted owl habitat (USDI 1999). These lands are near the geographic center of the I-90 Area of Special Concern identified in the ISC strategy (Thomas et al. 1990). Federal ownership of these lands will likely improve connectivity compared to former management under the Plum Creek Timber Company Habitat Conservation Plan (USDI 1999). This land exchange addresses the connectivity issues identified by the ISC Strategy and the Snoqualmie Pass Adaptive Management Area Plan, largely by consolidating ownership and providing more continuous spotted owl dispersal opportunities in this area.

The Cascades Conservation Partnership and other entities have purchased and transferred over 115 square miles of private land to public ownership, mostly in the Snoqualmie Pass area, for the purpose of habitat restoration and preservation. Most lands purchased to date had been owned by the Plum Creek Timber Company and had been managed under the provisions of that company's Habitat Conservation Plan. Lands transferred to the Okanogan and Wenatchee National Forest will be managed as either part of the SPAMA or as part of LSRs in which they are located. The first deed transfer from the partnership to the OWNF occurred in February of 2001. The total area transferred was 640 acres, including 200 acres of nesting, roosting, and foraging habitat, (to be added to the Manastash Ridge LSR, RW-125). The Service was unable to determine the total area of suitable spotted owl habitat transferred to public ownership through these programs due to incomplete information about forest structure on some of the transferred parcels.

Large numbers of dispersing juvenile spotted owls are likely to pass through the upper Yakima watershed and encounter the Project. Although the current abundance of spotted owls has declined in nearby reserves and the number of owls in the SPAMA is uncertain, there are still a relatively large number of activity centers within typical dispersal distance of the Project. Even with reduced levels of productivity indicated by demography studies, over the many years of Project construction and operation, many transient spotted owls are likely to pass through this crossroads in the Cascades.

Among subunits in the ECN CHU, subunit ECN-4 has a relatively high proportion (43.2 percent) of its area currently supporting Nesting/Roosting habitat, and a high proportion of all habitat types combined (80.1 percent; Table 3.3). This reflects, in part, good conditions for forest growth in this subunit associated with increased moisture flow through Snoqualmie Pass and more moderate terrain compared to more northern subunits. These conditions also promoted aggressive past logging. However, rapid regeneration and tree growth combined with protective management both in LSRs and within the Snoqualmie Pass Adaptive Management Area, which occupy over half of the subunit, are contributing to restoration of habitat function for spotted owls.

3.3.3 Factors Affecting the Environment of the Northern Spotted Owl in the Action Area

This section describes all federal, state, tribal, local, and private actions already affecting the species and/or critical habitat or that will occur contemporaneously with the proposed action. It also includes a discussion of the effects of natural disturbances and interactions with barred owls on the condition of spotted owls and their habitats at the action-area scale. For the purposes of this BO, and to provide context, we will evaluate the status of the environmental baseline and the effects of the action at both the action area and subunit ECN-4 scales.

3.3.3.1 Consulted-Upon Effects

Although the action area and ECN-4 have a long history of forest management, no consulted-upon effects have occurred since the final rule revising critical habitat (USDI 2012) was issued. This "reset" of the baseline has had the effect of re-characterizing the Washington East Cascades Physiographic Province in terms of the area essential to the conservation of the northern spotted owl (Table 3.1).

Effects to spotted owl habitat in ECN-4 will likely be described during reinitiation of consultation on some other projects that have not been fully implemented, including the Teanaway Fuel Breaks Project (Service reference 13260-2009-F-0074).

3.3.3.2 Natural Disturbances

A variety of disturbances due to fire, insects, and diseases has occurred, and continues to occur, across ECN-4. During the summer of 2012, parts of the Table Mountain Fire (42,312 ac) and Yakima Complex Fires (2,300 ac) burned within ECN-4. The Table Mountain Fire occurred in the Swauk Creek drainage. Preliminary information suggests large areas of high-severity fire occurred at higher elevations in lodgepole pine (*Pinus contorta*) forests, and primarily mixed-severity fire occurred at lower elevations in mixed-conifer forests occupied by spotted owls. The Yakima Complex consisted of many smaller fires that occurred across the sub-unit. Analysis of the effects of both these fires on spotted owl habitat is pending.

Except for these events, fire has not had substantial effects on critical habitat in the Project area in the recent past. The Lost Lake fire, about 1 km west of Lake Keechelus burned within a fire perimeter of about 650 acres in 1985. The amount of dispersal and suitable habitat affected by this fire are unknown. This fire area is located near both Yakima Pass and Snoqualmie Pass, important low mountain passes for east-west spotted owl movements across the Cascades. The Polallie Ridge and Easton Ridge fires in 2006 and 2007 together burned about 900 acres within ECN-4, but these fires are estimated to have only affected about 4 acres of NRF habitat.

In 2004, the OWNF conducted a forestwide forest health assessment that revealed increased tree damage and mortality resulting from fir engraver and western spruce budworm (*Choristoneura occidentalis*) (USDA 2004). Aerial surveys of the Okanogan and Wenatchee National Forests annually report tree mortality from fir engraver. Before 2003, tree mortality caused by this insect was scattered with relatively few acres affected. Most fir engraver attacks were associated with root disease. However, in 2003, a significant increase in fir engraver activity was observed. Within ECN-4 acreage with at least one tree per acre killed increased by 879 percent between 2002 and 2003. In 2002 a total of 3,123 acres with fir engraver-caused mortality were observed. In 2003 the area affected increased to 27,457 acres. Increased fir engraver activity resulted from the combined effects of four years of drought and five years of moderate to severe defoliation by western spruce budworm. Elevated levels of mortality are expected to continue as long as extensive areas of true fir continue to be defoliated. Defoliation and associated fir engraver-caused mortality will probably continue for several years in and around the Project area.

For the past several years defoliation has occurred from a western spruce budworm outbreak. This has resulted in some direct mortality, top killing, reductions in tree growth, and increased activity of Douglas-fir beetles. Extensive defoliator-caused mortality has not yet been observed from defoliators, primarily because several years of repeated foliage loss is necessary to kill trees.

3.3.3.3 Presence and Effects of Barred Owls

During the second half of the 20th century, barred owls expanded their range from eastern to western North America, and the range of the barred owl now completely overlaps that of the northern spotted owl (Gutiérrez et al. 1995, p. 3; Crozier et al. 2006, p. 761). Barred owls compete with northern spotted owls for habitat and resources for breeding, feeding, and sheltering, and the presence of barred owls has significant negative effects on northern spotted owl reproduction, survivorship, and successful occupancy of territories. While there are important differences in ecology between barred owls and northern spotted owls, barred owls select very similar habitat for breeding, feeding, and sheltering, and loss of habitat has the potential to intensify competition between species. Dugger et al. (2011, pp. 2464–2465) found that northern spotted owl occupancy and colonization rates decreased as both barred owl presence increased and available habitat decreased. These authors concluded that, while conserving habitat will not completely alleviate the barred owl threat, increased habitat protection for northern spotted owls may be necessary to provide for sustainable populations in the presence of barred owls in some areas (Dugger et al. 2011, p. 2467). Maintaining high-quality habitat has been important since the northern spotted owl was initially listed as a threatened species in 1990, and competitive pressure from barred owls has intensified the need to conserve and restore large areas of contiguous, high-quality habitat across the range of the northern spotted owl (Dugger et al. 2011, p. 2464; Forsman et al. 2011, p. 76; USDI 2011, Recovery Action 32 [RA32], p. III-67).

The presence of barred owls has significant negative effects on northern spotted owl reproduction (Olson et al. 2004, p. 1048), survival (Anthony et al. 2006, p. 32), and number of territories occupied (Kelly et al. 2003, p. 51; Olson et al. 2005, p. 928). The determination of population trends for the northern spotted owl has been confounded by the finding that northern

spotted owls are less likely to call when barred owls are also present; therefore, they are more likely to be undetected by standard survey methods (Olson et al. 2005, pp. 919–929; Crozier et al. 2006, pp. 766–767). As a result, it is difficult to determine whether northern spotted owls no longer occupy a site, or whether they may still be present but are not detected. The 2011 Revised Recovery Plan for the Northern Spotted Owl concludes that "barred owls are contributing to the population decline of northern spotted owls, especially in Washington, portions of Oregon, and the northern coast of California." (USDI 2011, p. B-12).

3.3.3.4 Climate Change

Anticipating the effects of climate change at the scale of the action area is difficult due to uncertainties associated with downscaling models that predict climate changes. But some general changes to the ecosystems in ECN-4 are expected. Littell et al. (2010) assessed forest ecosystems, disturbance, and climate change in Washington. Their modeling suggested that by the end of the 2060's, only 13 percent of the current area will be climatically suitable for Douglas-fir; the projected area burned per year may double or triple over current levels by the 2080's; and mountain pine beetle attacks in the future are likely to be more successful and beetle populations will be moving to higher elevations. All of the impacts assessed in their study are likely to occur by the 2040's at the northern edge of the Columbia Basin in the Okanogan Highlands and in the northeastern North Cascades. The impacts of climate on fire regimes, insect attacks, tree water stress and both Douglas-fir and pine species' ranges will likely interact strongly in the northeastern Cascade Range earlier rather than later in the twenty-first century.

So while there is enormous uncertainty in anticipating the effects of climate change at the action area scale, our best estimate is that climate change will result in a net degradation to the PCEs of designated critical habitat. Areas within the Washington East Cascades that are better suited in terms of species diversity, distribution, and abundance, are mostly likely to persist and endure intensified fire, insect, and disease disturbances.

3.3.3.5 Baseline Summary

ECN-4 appears to provide the functional habitat suitability in the manner for which it was designated. ECN-4 has relatively high proportions of Nesting/Roosting habitat and all habitat types combined, compared to other ECN subunits (Table 3.3). Although no consulted-upon effects have occurred in ECN-4, a moderate amount of natural disturbances (e.g., insect and disease processes) are occurring. The presence of barred owl is likely having a significant negative effect on the reproduction (Olson et al. 2004, p. 1048), survival (Anthony et al. 2006, p. 32), and number of territories occupied (Kelly et al. 2003, p. 51; Olson et al. 2005, p. 928) by spotted owls. Conservation of existing spotted owl habitat and restoration of additional habitat may partially alleviate the negative effects of competition with barred owls. Climate change will present unique challenges to the future of northern spotted owl populations and their habitats. Systems may change beyond historical ranges of variability resulting in both the intensification of natural disturbances and potential shifts in forest composition and structure.

3.4. EFFECTS OF THE ACTION ON REVISED SPOTTED OWL CRITICAL HABITAT

The Service regulations for implementing the Act define "effects of the action" as "the direct and indirect effects of an action on the species together with the effects of other activities that are

interrelated or interdependent with that action, that will be added to the environmental baseline" (50 C.F.R. §402.02). "Indirect effects" are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur. Any adverse effect requires the Service to conduct a jeopardy/adverse modification analysis (Section 7[a][2] of the Act).

3.4.1 Factors to Be Considered

The Service evaluates the degree of effect resulting from a proposed action by considering the proximity, distribution, timing, type, duration, frequency, intensity, and severity of effects (USDI and USDC 1998). The standard to be analyzed here is whether the proposed action will result in the "destruction or adverse modification" of spotted owl critical habitat. Pursuant to current national policy and the statutory provisions of the Act, destruction or adverse modification is determined on the basis of whether, with implementation of the proposed Federal action, critical habitat would remain functional (or retain the current ability for the PCEs to be functionally established) to serve the intended conservation role for the species. The PCEs essential to the conservation of the spotted owl are (1) forest types that support the spotted owl across its geographic range, (2) nesting and roosting habitat, (3) foraging habitat and (4) dispersal habitat (USDI 2012).

The Service's approach to analyzing the significance of Project effects on spotted owl critical habitat includes three steps:

1. Describe Project effects in terms of the factors listed above, focusing on habitat modification, disturbance, beneficial effects, and effects of interrelated actions;
2. Describe the likely consequences of these effects on primary constituent elements of critical habitat, considering especially whether affected critical habitat would remain functional or retain its current ability to develop the habitat characteristics necessary to serve its intended conservation role for the spotted owl.
3. Describe concurrent and cumulative effects, and consider what interactions these effects are likely to have with Project effects, and consider the consequences of these effects on the functionality of critical habitat.

Together, these steps allow the Service to reach conclusions about whether the Project alters PCEs to an extent that appreciably reduces the ability of critical habitat to fulfill its conservation role in the survival and recovery of the spotted owl at multiple scales.

As described above, we characterized the Project as consisting of the following three project elements:

1. Site Preparation, rock excavation and blasting.
2. Bridge Construction, including work below the ordinary high water mark.
3. Operations and Maintenance, including drainage and stormwater treatment.

We used these Project elements to structure our analyses of effects to northern spotted owl designated critical habitat.

All Project elements may affect northern spotted owl critical habitat. Site preparation will result in adverse effects due to habitat/PCE removal associated with rock excavation, and disturbance from blasting and hauling material is also possible. Both bridge construction and operation and maintenance may result in noise disturbance that is sufficiently loud and frequent throughout

enough of the year to preclude critical habitat from performing the conservation functions for which it was designated.

3.4.2 **Habitat Modification**

Due to the increased footprint of the rock cuts above the Bridges, the amount of material removed and impacted mature forest has increased. An approximate additional 96,000 cubic yards of material will be removed. These rock cuts are necessary to meet design objectives for avalanche and rock fall passage. As a result of these rock cuts, an additional 2.3 acres of mature forest will be removed beyond what was estimated to be removed for the large snowshed, resulting in permanent removal of 5.46 acres that are capable of supporting the PCEs of critical habitat.

Potential suitable habitat at this location is limited to spotted owl dispersal habitat. No documented spotted owl territories overlap the impacted habitat. Forested habitat that will be impacted by the Bridges does not contain the constituent elements as described for PCE 2 or 3. However, PCEs 1 and 4 are likely present in the impacted area. Site preparation for the Bridges will permanently remove approximately 5.46 acres of early successional, mid-successional, and mature forest. The impacted forested area is most likely used by spotted owls as dispersal or transient habitat only, due to persistent noise disturbance associated with its location in close proximity and upslope of I-90.

Although the BA for the Project concluded that removal of these 5.46 acres of habitat would not represent an adverse effect to critical habitat because these acres are located on a steep slope and are exposed to near constant noise from the highway, the Service does not agree with this finding. The Service's opinion is that this permanent removal of PCEs from this area does constitute an adverse effect to revised critical habitat. We agree that the location and steep slope of these affected acres suggests that the consequences of this adverse effect are likely to be minor on the overall functionality of critical habitat subunit ECN-4.

3.4.3 **Disturbance**

The activities as now proposed will occur mostly within the original project footprint using similar construction equipment, but there will likely be increased disturbance associated with the removal and hauling of additional material. Thus the duration of the disturbance effect will likely increase, but the magnitude of the effect will remain the same.

Blasting for material removal will occur higher on the slope above the Bridges than was previously proposed with the snowshed. However, this change in blasting elevation will not change the extent of the terrestrial action area, so no changes in noise impacts to spotted owl suitable habitat will occur. Blasting will occur only during the day, which will reduce its potential to detract from the foraging function of critical habitat. Additional rock excavation may generate additional haul trips to move freed material. These haul trips could occur around the clock. The noise generated by these additional trips, however, will be very similar to truck noise along the existing highway and material will be stored at existing approved locations. Also, this additional source of noise will be offset by the reduction in noise from crane operations compared to the proposed snowshed, which involved placement of more steel girders by crane than the Bridges.

The potential effects of long-term operation and maintenance of the bridges on critical habitat is difficult to compare to potential effects of the snowshed. Traffic noise from the Bridges may be greater than from the mostly enclosed snowshed. But the snowshed would require a ventilation system that could be equally noisy. The avalanche bridges may require more ongoing avalanche control using explosives that the snowshed, also contributing to a potential for increased noise disturbance. But we expect avalanche control with the Bridges to be limited to conditions that occur very infrequently (about once every 50 years), suggesting potential impacts to habitat functionality from this noise source would be very limited. Regardless of the design, we consider critical habitat functionality near the proposed avalanche Bridges to be compromised by near constant traffic noise on the highway. Given uncertainties associated with comparing noise effects during long term operation and maintenance, our opinion is that differences in noise production from the design modification are likely to result in insignificant effects to the PCEs of spotted owl critical habitat.

3.4.4 **Beneficial Effects**

We do not foresee the proposed design modification leading to any beneficial effects to revised critical habitat.

3.4.5 **Summary of Project Effects to Spotted Owl Critical Habitat**

Overall, we expect the proposed design modification to result in permanent removal of 5.46 acres of dispersal habitat, which represents an adverse effect to PCEs 1 and 4. About 2.3 acres of this total currently supports forests that is more mature, but this forest is still structurally simple and therefore most likely to function as dispersal habitat. We do not expect any Project element to result in adverse effects to critical habitat due to noise disturbance.

The small-scale removal of dispersal habitat in a location where a steep slope and persistent traffic noise compromise the function of critical habitat will have slight functional effect on subunit ECN-4. The capacity of sub-unit ECN-4 to provide the functions for which it was designated will not be appreciably altered from its baseline condition. The extent and severity of these effects are unlikely to be detectable at any larger scale than the action area. With implementation of the proposed Federal action, critical habitat would remain functional (or retain its current ability for the PCEs to be functionally established) to serve the intended conservation role for the species from the sub-unit to the range-wide scale.

3.4.6 **Interrelated and Interdependent Actions**

"Interrelated and Interdependent Actions" are defined in the Service's consultation handbook (USDI and USDC 1998; page xv). In brief, they are actions that would not occur but for the proposed Project and are a connected action and effect.

The Service does not anticipate any interrelated and interdependent actions with the proposed design modification.

3.5 CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the Act.

Most of the action area is within federal ownership, reducing the potential for cumulative effects. However, large parts of the landscape near the Project area have a checkerboard pattern of land ownership. The Plum Creek Timber Company is the major non-federal land owner in the area. All Plum Creek lands are covered by a Habitat Conservation Plan and were excluded from critical habitat designation, leading to a checkerboard distribution of critical habitat in the Project area. Plum Creek is seeking to sell most of their holdings near the Project. Depending on the purchaser, the sale of Plum Creek lands could have either adverse or beneficial effects for the functionality of spotted owl critical habitat. Adverse effects would result from subdivision of Plum Creek sections in the checkerboard ownership landscape into residential lots. Residential development with its accompanying network of roads would further fragment forested habitats in the area and diminish habitat value for spotted owls. Plum Creek land ownership in this area is sufficiently extensive that large-scale conversion to residential development would appreciably reduce functionality of critical habitat at the subunit scale. The ramifications of this effect could extend beyond the population of spotted owls in the upper Yakima watershed, because this area near Snoqualmie Pass is believed to be a crossroads of demographic and genetic exchange among spotted owl populations in the Washington Eastern Cascades and Western Cascades physiographic provinces. Reducing the permeability of this landscape could contribute to worsening demographic trends for spotted owl populations throughout the Washington Cascades. Plum Creek has expressed an interest in selling large blocks (up to 18 sections per township) of their lands near Snoqualmie Pass to conservation buyers. The Service is using its Section 6 Cooperative Endangered Species Conservation Fund to work with the Washington State Department of Natural Resources and private conservation organizations to purchase these lands. This outcome could have beneficial effects if the conservation buyers developed management plans that promoted the development of late-successional forests, reduced road densities, and maintained these conditions over the long term. In direct contrast to the effects of residential development, a conservation strategy that improved the habitat quality and permeability of this area to spotted owls could contribute to improving critical habitat function and demographic trends of spotted owls throughout the Washington Cascades.

Residential development pressure on other private lands in the area is strong and is expected to continue throughout the Project construction period and into the period of Project operations and maintenance. The limited spatial extent of private ownership lands other than those held by Plum Creek reduces the potential for this smaller scale development to affect landscape functionality of critical habitat for spotted owls. Development of these lands will likely reduce the quantity and quality of suitable and dispersal habitat for spotted owls. Residential development would also likely have detrimental effects on prey populations (flying squirrels and woodrats) by reducing forest structural diversity and complexity, increasing predation by domestic dogs and cats, and fragmenting habitat. These cumulative effects, working at more local scales, would have a slight negative effect on the numbers, distribution and reproduction of

spotted owls in the Project area. Again, the particular importance of the Snoqualmie Pass area in connecting spotted owl populations in the Cascades amplifies the negative effect of small scale developments that would be insignificant in many other areas.

Development of recreational facilities is also an important component of cumulative effects in the Project area. Recreation developments are affecting habitat quantity and quality and the permeability of the landscape to spotted owl movement. Ski area development and increasing demand for motorized and non-motorized winter recreation is encouraging the development of an expanding network of recreational facilities. The recreational networks in the area frequently link private, state and federal lands. Although the total footprint of these facilities is not large, the zone of influence of these trail networks in terms of visual and noise disturbance to wildlife (see Gaines et al. 2003) is substantial and growing. Little specific information is available about the effects of winter recreation on spotted owls and their prey. But it is reasonable to think that relatively high starvation rates of juvenile spotted owls during natal dispersal suggest that winter conditions may present physiological challenges to these inexperienced predators (Forsman et al. 2002). Recreation-related disturbance, if it results in heightened energy use, could increase starvation risk, especially when combined with reduced foraging opportunities during the non-winter seasons due to noise effects from highway construction. Snow compaction from winter recreation may also have negative effects on the availability of some prey species (Olliff et al. 1999). Recreation, especially winter recreation, is a cumulative effect in the Project area that is likely contributing to negative trends in spotted owl survival.

3.6 CONCLUSION

The Service has reviewed the status of designated critical habitat for the spotted owl, the environmental baseline, the effects of the proposed action, interrelated and interdependent actions, and the cumulative effects. Based on this review, it is the Service's biological opinion that the proposed action is not likely to destroy or adversely modify designated critical habitat. The basis for this conclusion is summarized as follows:

1. The change in the rangewide status of designated critical habitat due to consulted-upon effects is within expectations of the Service's overall conservation strategy. Rangewide, few consulted upon effects have occurred since the 2012 designation of critical habitat for the spotted owl, and the network continues to function in the manner for which it was designated.

2. There have been no consulted-upon effects in subunit ECN-4, although reinitiation of consultation may reveal some anticipated effects. Analysis is pending on the effects of the Table Mountain and Yakima Complex Fires and associated suppression activities which occurred during the late summer of 2012 and partly overlapped ECH-4. The baseline condition of ECN-4 is moderate, reflecting a long history of intensive timber harvest, development of irrigation, transportation and power transmission infrastructure, and residential and recreational development. Good forest growth conditions and protective forest management in portions of ECN-4 are contributing to recovery of critical habitat functionality within this subunit which is essential to spotted owl population connectivity in the Washington Cascades.

3. The proposed action would permanently remove 5.46 acres of dispersal habitat from subunit ECN-4. The action will remove the PCEs 1 and 4 of designated critical habitat. The removal of a relatively small patch of dispersal habitat in a location where a steep slope and persistent traffic noise compromise the function of critical habitat will have insignificant negative effects on the conservation functions of critical habitat subunit ECN-4.

4. Cumulative effects may include both the beneficial effects of habitat preservation and restoration and the negative effects of residential and recreational development. The balance of these two effects is difficult to estimate, but given intense development pressure, the Service assumes that cumulative effects will exert a net negative effect on the functionality of critical habitat in ECN-4.

The relatively minor adverse effects of the Project on spotted owl critical habitat is unlikely to change the existing ability of critical habitat sub-unit ECN-4 to support its intended conservation role in the survival and recovery of the spotted owl. Small negative effects on dispersal habitat at the action area (sub-unit) scale are unlikely to influence functionality of critical habitat at the provincial (unit) or rangewide scales. Given that critical habitat will remain functional across scales from sub-unit to rangewide, and retain the current ability for PCEs to become functionally established, we conclude that the action, as proposed, will not destroy or adversely modify designated critical habitat for the spotted owl.

3.7 REASONABLE AND PRUDENT ALTERNATIVES

Regulations implementing Section 7 of the Act (50 C.F.R. §402.02 *et seq.*) define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) would, the Service believes, avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat.

Because the proposed action is not likely to destroy or adversely modify designated critical habitat for the spotted owl, no reasonable and prudent alternatives are required.

The Act does not extend the incidental take provisions to designated critical habitat. As such, no incidental take statement, reasonable and prudent measures, or terms and conditions apply.

3.8 REINITIATION-CLOSING STATEMENT

This concludes formal consultation pursuant to the regulations implementing the Act, 50 C.F.R. §402.16. Reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not

considered in this BO; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this BO; or (4) a new species is listed or critical habitat designated that may be affected by the action.

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