ORIGINAL

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Western Washington Fish and Wildlife Office
510 Desmond Drive SE, Suite 102
Lacey, Washington 98503

In Reply Refer To:
1-3-05-F-0059

Secretary Magalie R. Salas
Federal Energy Regulatory Commission
888 First Street, NE
Washington DC 20426

Subject: Duplicate Biological Opinion for the Condit Hydroelectric Project (p-2342)

Dear Secretary Salas:

We understand that the biological opinion (Opinion) for the Condit Hydroelectric Project (p-2342), which we mailed to you on November 30, 2005, cannot be located. We are sending you a duplicate copy for your records.

If you have any questions regarding this Opinion, please contact Lou Ellyn Jones or Jim Michaels, of my staff at (360) 753-9440.

Sincerely,

Ken S. Berg, Manager
Western Washington Fish and Wildlife Office

cc:
Nick Jayjack, Federal Energy Regulatory Commission

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Western Washington Fish and Wildlife Office
510 Desmond Drive SE, Suite 102
Lacey, Washington 98503

In Reply Refer To:
1-3-05-F-0059

NOV 30 2005

Secretary Magalie R. Salas
Federal Energy Regulatory Commission
888 First Street, NE
Washington DC 20426

Subject: Re-initiation of formal consultation for the Condit Hydroelectric Project (p-2342)

Dear Secretary Salas:

This document transmits the U.S. Fish and Wildlife Service's (Service) reinitiation of consultation and Biological Opinion (Opinion) based on our review of the proposed project, which consists of interim operation of Condit Hydroelectric Project and dam removal, located in Skamania and Klickitat Counties in Washington State, and its effects to the bull trout (*Salvelinus confluentus*) and bull trout critical habitat in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Your December 2, 2004, request for re-initiation of formal consultation was received on December 3, 2004. The Federal Energy Regulatory Commission (FERC) previously requested formal consultation for effects of the interim dam operation and dam removal on the Columbia River Distinct Population Segment (DPS) of bull trout. The Service concluded that consultation with the issuance of its Opinion on September 9, 2002. On October 6, 2004, the U.S. Department of the Interior designated the White Salmon River from the mouth to approximately river mile (rm) 16 as bull trout critical habitat for the Columbia River DPS of bull trout. On March 10, 2005, FERC issued a notice of settlement agreement modification and solicitation of comments for the Condit Project. The amendment to the settlement agreement, which we assume will be adopted by FERC, extends the timeline for commencement of dam removal by two years and allows interim operation for an additional two years. In addition, the 2004 project description contains a report on sediment impacts which was not available when we completed our 2002 Opinion. On September 22, 2005, the U.S. Department of the Interior combined all of the listed populations of bull trout into one final critical habitat designation, and in doing so, replaced the final critical habitat designation dated October 6, 2004 for the Klamath River and Columbia River populations of bull trout. The actual critical habitat designation of 16 rm on the White Salmon River remains unchanged.

As provided in 50 CFR Part 402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and where (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 a previous opinion; (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 the original opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

Based on the critical habitat designation, the two-year time extension, and new information on sediment impacts, we agree that re-initiation of consultation is warranted. This Opinion analyzes the project effects to threatened bull trout as the result of the two year time extension and based on sediment impacts which we believe will occur over a larger geographical area than we assumed in our 2002 Opinion. Our 2005 Opinion also analyzes project effects to bull trout critical habitat. Our 2005 Opinion supplements the 2002 Opinion. All analysis and take coverage from the earlier Opinion is still valid except to the extent explicitly modified in the 2005 Opinion.

This Opinion is based on information provided in the Service's September 6, 2002 Opinion, the Project Final Environmental Impact Statement (FEIS 1996), the final supplemental Final Environmental Impact Statement (FSFEIS 2002), the 2004 Project Description and Appendices, which includes the sediment behavior analysis referenced in this Opinion, the final rule designating bull trout critical habitat in the Columbia River (USDI 2004, USDI 2005), and other documents filed with FERC that are now part of the official record for the Condit Project. A complete administrative record of this consultation is on file in the U.S. Fish and Wildlife Service's Western Washington Fish and Wildlife Office in Lacey, Washington.

The FERC designated PacifiCorp as their non-Federal representative for purposes of section 7 consultation on July 5, 2001. With regard to correspondence relating to section 7 consultations, we normally only provide copies to FERC and its designated non-Federal representative. We are sending PacifiCorp a copy of this letter and the Opinion and will provide one to any other party that requests it, in lieu of serving the entire Service List.

If you have any questions regarding this Opinion, please contact Lou Ellyn Jones or Craig Hansen, of my staff at (360) 753-9440.

Sincerely,

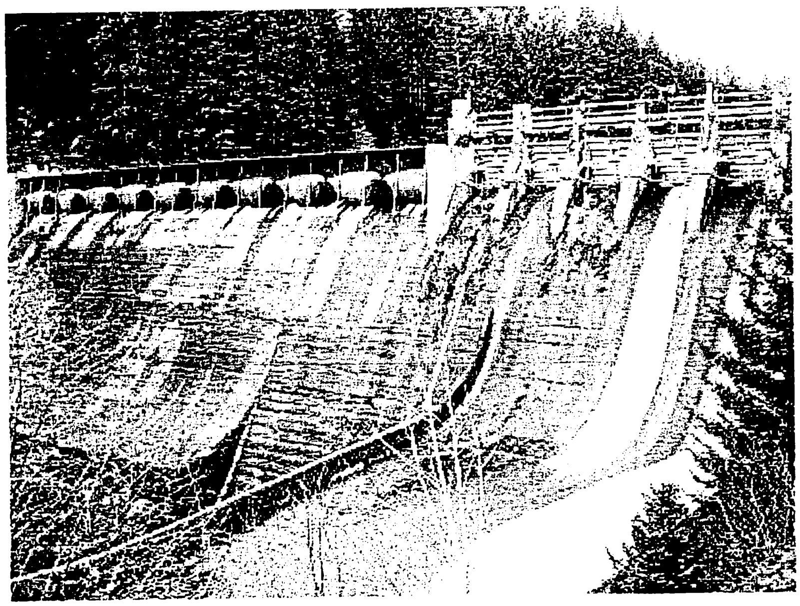
Craig Hansen

for Ken S. Berg, Manager
Western Washington Fish and Wildlife Office

cc:
NMFS, Portland, OR (S. Carlon)
American Rivers, Portland, OR (B. Swift)
PacifiCorp, Portland, OR (G. Miller)

bcc:
Solicitor's Office, Portland, OR. (B. Scott-Brier)

Reinitiation of Consultation On Bull trout (*Salvelinus confluentus*) and Consultation on Bull trout Critical Habitat For Condit Dam Removal And Dam Operation



Condit Dam, White Salmon River

FWS Reference: 1-3-05-F-0059

U.S. Department of the Interior
Fish and Wildlife Service
Western Washington Fish and Wildlife Office
Lacey, Washington

Prepared by: Lou Ellyn Jones
November 2005

TABLE OF CONTENTS

SCOPE OF CONSULTATION

The effects of interim operations up to 2006 and dam removal activities on bull trout have been addressed in a separate Biological Opinion (Opinion) dated September 6, 2002. This reinitiation of consultation covers the effects of interim project operation until 2008 and sediment impacts to bull trout in the Columbia River that are determined "likely to adversely affect" threatened bull trout. In addition, this consultation covers the effects of dam removal that are determined "likely to adversely affect" designated bull trout critical habitat. Our 2005 Opinion supplements the 2002 Opinion. All analysis and take coverage from the earlier Opinion is still valid except to the extent explicitly modified in the 2005 Opinion.

CONSULTATION HISTORY

Our 2002 Opinion provides the consultation history up to September 6, 2002. On October 6, 2004, the U.S. Department of the Interior designated the White Salmon River from the mouth to approximately river mile (rm) 16 as critical habitat for the Columbia River Distinct Population Segment (DPS) of bull trout. In a letter dated November 4, 2004, the Federal Energy Regulatory Commission (FERC) requested clarification from the U.S. Fish and Wildlife Service (Service) about the need to reinitiate formal consultation. In a letter dated November 19, 2004, the Service clarified for FERC that reinitiation was required. FERC requested reinitiation of formal consultation for bull trout critical habitat with a letter dated December 1, 2004. In a letter dated January 28, 2005, the Service stated that it had received the request for consultation and had all the information needed to reinitiate.

In a notice issued March 10, 2005, FERC requested comments on a modification to the Settlement Agreement that was signed by all parties to that agreement. The modification extended the timeline for interim operation and dam removal from 2006 to 2008 in order to allow PacifiCorp to generate additional revenue for permitting and mitigation and to provide additional time to obtain permits. For purposes of this consultation, we assume that FERC will accept the amendment and that project operations will continue until 2008, when dam removal activities will commence.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

Covered Activities

FERC proposes to extend the existing operating license for the Condit Hydroelectric Project through October 2006 (increasing the current license term from 28 to 41 years) and to incorporate the terms and conditions of a Settlement Agreement that provides for dam removal upon expiration of the proposed amended license term. An amendment to the Settlement Agreement, which we are assuming that FERC will incorporate into its license order to surrender, would extend the timeline for interim operation and dam removal until 2008.

Except for the extension in timeline, the proposed action has not changed since the issuance of our 2002 Opinion. PacifiCorp has provided us with an updated Project Description (2004) that supplements the Final Supplemental Final Environmental Impact Statement (2002) and provides greater detail on dam removal activities and site management plans discussed in the 2002 Opinion. In addition, the updated Project Description contains several appendices on sediment behavior required for the Water Quality 401 Certification. These documents have clarified our understanding of the project description and the effect of sediments released by dam removal.

We will briefly summarize the elements of the project description already discussed in the 2002 Opinion and discuss new information in greater detail. The 2002 Opinion organizes its discussion about the Proposed Action into three categories: (1) a description of project facilities; (2) dam removal activities; and (3) measures required by FERC. The project facilities section includes descriptions of existing hydroelectric operation, raising or lowering of the reservoir, instream flows, project maintenance, project outages due to load rejection, and spill events. The section on dam removal includes a description of site set-up, construction of access roads, removal of Condit dam, removal of the cofferdams, surge tank, wood stave pipeline, steel and wood penstock, lakebed restoration, water and gas line remediation, Northwestern Lake Bridge remediation, and removal of recreational facilities. The section on FERC requirements includes a list of site management plans required for protection of environmental resources and public safety. Please refer to the 2002 Opinion for a more details.

PacifiCorp proposes to blast an opening in the dam and allow the reservoir to drain completely in approximately six hours. The remainder of the dam, including the coffer dam originally erected during construction of the dam, will be removed over the next year. Initial dam breaching would occur in the late fall so that the bulk of the sediment impacts would occur during the rainy season, when the river is naturally more turbid. The schedule for construction is as follows:

August - September 2008	Mobilize, develop staging areas, and construct access roads
September - October 2008	Remove gates, install, relocate and modify water lines, water supply, bridge modifications
October 2008	Blast the drain tunnel and drain reservoir
November 2008 - July 2009	Dam demolition and removal of related facilities
August 2009	Demobilization

The information provided since issuance of our 2002 Opinion includes the following reports written in 2004: (1) Access roads, work areas and staging areas locations and tabulations; (2) Northwestern Bridge Evaluation Report: a Schematic Design Proposal for Bridge Pier Protection; (3) Updated Project Description, including greater detail about dam and appurtenant facilities removal and site management plans; (4) Sediment Behavior Analysis; and (5) Sediment Behavior Effects on Beneficial Uses. Of this new information, the site management plans and sediment behavior analysis are pertinent to our discussion of project effects on bull trout and bull trout critical habitat.

Each site management plan contains a monitoring plan, reporting schedule, and adaptive management component. The site management plans include the following:

- Revegetation Plan: The reservoir and other areas disturbed by construction activities will be restored to conditions representative of early succession native riparian vegetation in the locale with a woody shrub component. The focus is on minimizing erosion and delivery of sediment to the river and limiting the colonization of noxious weeds at the site.

- Wetland Mitigation Plan: This plan delineates and characterizes those wetlands that would have impacts due to dam removal, mostly low functioning wetlands fringing the reservoir and some alongside the White Salmon River downstream of the dam. PacifiCorp states that higher functioning wetlands will naturally replace these wetlands at approximately a 1:1 ratio in the reservoir site and downstream due to the existence of upslope seed sources and natural hydrology from perennial streams and seeps.

- Sediment assessment and management plan: This plan outlines methods that will be used to manage release of sediment in Northwestern Lake and to describe other work activities and plans for managing sediment at those sites. Pre-dam removal activities include: construction of an access road to the spillway; installation of a permanent water supply line below the pre-dam thalweg; scour protection for Northwestern Lake Bridge; relocation of the Mt. Adams Orchard Water supply facility; construction of the drain tunnel; removal of non-essential mechanical items on the dam, including the spillway gates, Tainter gate and radial gates; removal of large woody debris (LWD) from upstream of the dam; and use of water for dust suppression.

  PacifiCorp will employ Best Management Practices (BMPs) for construction activities to reduce erosion from surface runoff, including erosion control fencing, slope stabilization, and revegetation. Work that will increase river turbidity levels, such as removal of LWD, will be done in later September just prior to dam breaching. A spill prevention and containment plan will be in place for near-water work, and silt curtains and cofferdams will be used for in-water work, when appropriate. Concrete materials will be kept away from the river.

  A monitoring plan and schedule for water quality parameters is included in this section of the project description. Monitoring under this plan will incorporate both the construction period and for ten years thereafter to determine turbidity levels due to storm runoff from reservoir sediments.

- Bank stabilization plan: This plan relates to public safety in that it establishes criteria and methods for determining whether slopes in the former reservoir area are stable enough to allow for human access and whether unstable banks need to be actively managed to ensure that they reach a stable state in a controlled timeframe. One of the goals of the plan is to safely accomplish revegetation of slopes per the revegetation plan as soon as practicable.

- Canyon and woody debris management plan: This plan relates to the management of an unknown quantity of LWD that is presumed to be trapped in the reservoir sediments and would be exposed or eroded along with sediments once the dam is removed. The plan establishes criteria for determining whether LWD entrapped in reservoir sediments should be dislodged and or allowed to remain in place; whether LWD above or below the former dam site is creating a fish passage barrier; and methods for dislodging LWD from reservoir sediments or downstream, if that is necessary.

- Upland (non-reservoir) stormwater and erosion control plan: This plan establishes BMPs to minimize water quality impacts from construction activities taking place outside the reservoir and dam removal sites.

- Blasting plan: This plan relates to controlled blasting that will be used to remove sections of the dam and may be used to dislodge LWD that is causing a structural threat or fish passage barrier once the dam has been removed. The plan establishes methods to reduce the level of vibration, reduce water quality impacts, and increase public safety.

- Spill prevention and containment plan: This plan establishes BMPs for avoiding contaminated spills from construction equipment in the upland areas and minimizing the effects should spills occur.

- Sediment Behavior Analysis: The sediment management plan includes a sediment behavior analysis report (2004) predicting behavior of an estimated 2.4 million cubic yards of sediment expected to be released from dam removal and the effects of this release on water quality to the White Salmon and Columbia Rivers. The Beck report (1998) provided information on sediment impacts used in our 2002 Opinion. The more recent report builds upon our understanding about sediment processes at work in dam removal and projected water quality impacts in the White Salmon and Columbia Rivers.

In 1994, PacifiCorp undertook a study to characterize the contaminant level of sediments in Northwestern Lake. The U.S. Army Corps of Engineers (Corps) has developed a framework for evaluating sediments and the suitability of disposing of those sediments in the Columbia River referred to as the Dredge Material Evaluation Framework (dated 1998). PacifiCorp and the Corps are currently determining the degree to which additional sediment testing will be required under the Corps 404 permitting process (A. Poindexter *in litt.* 2005). We assume that sediments released by dam removal will be addressed appropriately by the Corps in accordance with the applicable provisions of the Dredge Material Evaluation Framework.

Per email communication dated September 20, 2005, PacifiCorp will include the Service in annual briefings made to the Washington State Department of Ecology to report on monitoring data collected for these plans. The briefings are intended to evaluate the success of meeting performance standards established in the site management plans and to contribute scientific information to inform future dam removal projects.

Action Area

The project action area is defined as the geographic extent of all direct and indirect effects of a proposed agency action (50 CFR 402.02 and 402.14(c)(2)). The 2002 Opinion defines the action area as: (1) the White Salmon River from its mouth to rm16, including Northwestern Lake; (2)

tributaries that enter this reach (Buck Creek, Gilmir Creek, Little Buck Creek, Mill Creek, Rattlesnake Creek, Spring Creek) from their confluence upstream to the point that they become impassible to bull trout; and (3) an area within the Columbia River extending five miles downstream from the mouth of the White Salmon River and about ¼ mile outward from the north shoreline.

Based on the sediment behavior report (G&G Associates 2004), we believe that the short-term project impacts from suspended sediments and turbidity will extend downstream to the mouth of the Columbia River. Based on observations of bull trout in the lower Columbia River mainstem, we have therefore defined the action area for this consultation as the White Salmon River from rm 16 to its mouth and the Columbia River mainstem from the mouth of the White Salmon River at rm 167 to Puget Island at approximately rm 47, a distance of about 120 miles (See Figure 1).

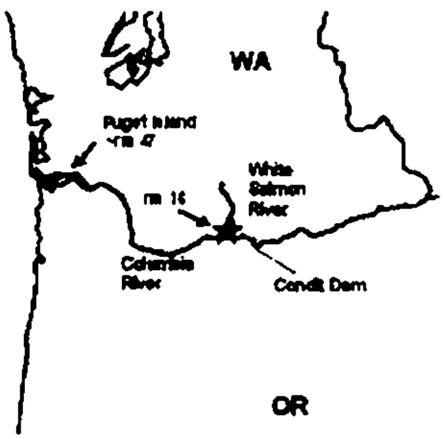


Figure 1 Action area

The Service has designated critical habitat in the White Salmon River from rm 0.0 to rm 16. Critical habitat was not designated along the mainstem Columbia River. Therefore, even though the action area includes the Columbia River mainstem, our analysis of effects to bull trout critical habitat will be confined to the designated areas of the White Salmon River. Our analysis of effects to bull trout will include the entire action area.

Conservation Measures

Conservation measures represent actions pledged in the project description by the action agency or applicant to minimize or compensate for effects of the projects on listed species. PacifiCorp has agreed to construct pockets in the drain tunnel to provide resting areas for fish to facilitate upstream migration. In addition, it will remove the cofferdams placed during the original dam construction and now buried in sediments by May of the year after dam removal so that anadromous fish and char can gain access to habitat upstream with minimal delay. PacifiCorp has also pledged to remove the lowest portions of the dam from July through November, the time of seasonal low flows, to ensure that all concrete will be removed from the river bottom and will complete all in-water work by the following August to lessen adverse effects on multiple year classes of anadromous fish and char.

STATUS OF THE SPECIES
(range wide and/or recovery unit)

Taxonomy

The bull trout (*Salvelinus confluentus*, family Salmonidae) is a char native to the Pacific Northwest and western Canada, first described as *Salmo spectabilis* by Girard in 1856 from a specimen collected on the lower Columbia River, and subsequently described as *Salmo confluentus* and *Salvelinus malma* (Cavender 1978). Bull trout and Dolly Varden (*Salvelinus malma*) were previously considered a single species (Cavender 1978, Bond 1992). Cavender

(1978) presented morphometric, meristic, osteological, and distributional evidence to document specific distinctions between Dolly Varden and bull trout. Bull trout and Dolly Varden were formally recognized as separate species by the American Fisheries Society in 1980 (Robins *et al.* 1980). Although bull trout and Dolly Varden co-occur in several northwestern Washington river drainages, there is little evidence of introgression (Haas and McPhail 1991), and the two species appear to be maintaining distinct genomes (Leary *et al.* 1993, Williams *et al.* 1995, Kanda *et al.* 1997, Spruell and Allendorf 1997). Lastly, the bull trout and the Dolly Varden each appear to be more closely related genetically to other species of *Salvelinus* than they are to each other (Grewe *et al.* 1990, Pleyte *et al.* 1992, Crane *et al.* 1994, Phillips *et al.* 1995). For example, the bull trout is most closely related to the Japanese char (*S. leucomaenis*) whereas the Dolly Varden is most closely related to the Arctic char (*S. alpinus*).

Physical Description

The bull trout is a long slender fish with a large head and jaws relative to its body-size. Its tail fin is only slightly forked, and even less so in young fish. Bull trout coloration can be variable, but generally, the body's background color is gray infused with green. Bull trout found in lakes may be silvery grey. The body is covered with small white and/or pale yellowish spots with intermingling pink or red spots that may not always be present. The ventral region can range from white to orange. Bull trout typically have 15-19 gill rakers, 63-66 vertebrae, and 22-35 pyloric caeca. Bull trout of large size can be differentiated from Dolly Varden with bull trout having a larger head and jaws in addition to the head being more flat. Bull trout have spotless fins with the lower fins having white anterior borders. The spotless fin characteristic of bull trout is often used by fisheries agencies to help promote angler identification of bull trout versus other fish, such as brook trout (*Salvelinus fontinalis*)(Behnke 2002).

Distribution

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

Listing History

On June 10, 1998, the Service issued a final rule listing the Columbia River and Klamath River populations of bull trout as threatened (63 FR 31647) under the authority of the Endangered Species Act (Act) of 1973. This decision conferred full protection of the Act on bull trout occurring in four northwestern States. The Jarbidge River population was listed as threatened on April 8, 1999 (64 FR 17110). The Coastal-Puget Sound and St. Mary-Belly River populations were listed as threatened on November 1, 1999 (64 FR 58910), which resulted in all bull trout in the coterminous United States being listed as threatened. The five populations discussed above are listed as DPS, *i.e.*, they meet the joint policy of the U.S. Fish and Wildlife Service and National Marine Fisheries Service regarding the recognition of distinct vertebrate populations (61 FR 4722).

The Service proposed to designate critical habitat for the bull trout on November 29, 2002 (67 FR 71235). On October 6, 2004, the Service designated critical habitat for the Columbia River and Klamath River DPSs of the bull trout (69 FR 59996). Critical habitat consists of areas: (1) occupied by the species where (a) physical or biological features essential to the conservation of the species (i.e., Primary Constituent Elements (PCEs)) exist and (b) which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species which the Service has determined are essential for the conservation of the species. Federal agencies are required to consult on any action which is likely to jeopardize the continued existence of any species proposed for listing or result in the destruction or adverse modification of proposed critical habitat pursuant to section 7(a)(4) of the Act of 1973, as amended ((16 U.S.C. 1531 et seq.)(50 CFR 402.10(a)). For the Columbia River DPS, the critical habitat designation totals approximately 1,707 miles of streams and 27,296 acres of lakes and marshes.

Distinct Population Segments and Population Units

Population units of bull trout exist in which all fish share an evolutionary legacy and which are significant from an evolutionary perspective (Spruell *et al.* 1999). These population units can range from a local population to multiple populations, and theoretically should represent a DPS. Although such population units are difficult to characterize, genetic data have provided useful information on bull trout population structure. For example, genetic differences between the Klamath River and Columbia River populations of bull trout were revealed in 1993 (Leary *et al.* 1993). The boundaries of the five listed DPSs of bull trout are based largely on this 1993 information.

Since the bull trout was listed, additional genetic analyses have suggested that its populations may be organized on a finer scale than previously thought. Data have revealed genetic differences between coastal populations of bull trout, which includes the lower Columbia River and Fraser River, and inland populations in the upper Columbia River and Fraser River drainages (Williams *et al.* 1997, Taylor *et al.* 1999). There is also an apparent genetic differentiation between inland populations within the Columbia River basin. This differentiation occurs between the (a) mid-Columbia River (John Day, Umatilla) and lower Snake River (Walla Walla, Clearwater, Grande Ronde, Imnaha rivers, etc.) populations and the (b) upper Columbia River (Methow, Clark Fork, Flathead River, etc.) and upper Snake River (Boise River, Malheur River, Jarbidge River, etc.) populations (Spruell *et al.* 2003). Genetic data indicate that bull trout inhabiting the Deschutes River drainage of Oregon are derived from coastal populations and not from inland populations in the Columbia River basin (Leary *et al.* 1993, Williams *et al.* 1997, Spruell and Allendorf 1997, Taylor *et al.* 1999, Spruell *et al.* 2003). In general, evidence since the time of listing suggests a need to further evaluate the distinct population segment structure of bull trout DPSs.

Life History

Bull trout exhibit both resident and migratory life-history strategies (Rieman and McIntyre 1993). Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. Migratory bull trout spawn in tributary streams where juvenile fish rear one to four years before migrating to either a lake (adfluvial form), river (fluvial form) (Fraley and Shepard 1989, Goetz 1989), or in certain coastal areas, to saltwater (anadromous) (Cavender 1978, McPhail and Baxter 1996, WDFW *et al.* 1997). Resident and migratory life-history forms may be found together but it is unknown if they represent a single population or separate populations (Rieman and McIntyre 1993). Either form may give rise to offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993). The multiple life-history strategies found in bull trout populations represent important diversity (both spatial and genetic) that help protect these populations from environmental stochasticity.

The size and age of bull trout at maturity depends upon the life-history strategy and habitat limitations. Resident fish tend to be smaller than migratory fish at maturity and produce fewer eggs (Fraley and Shepard 1989, Goetz 1989). Resident adults usually range from 150 to 300 millimeters (mm) (6 to 12 inches) total length. Migratory adults however, having lived for several years in larger rivers or lakes and feeding on other fish, grow to a much larger size and commonly reach 600 mm (24 inches) total length or more (Pratt 1985, Goetz 1989). The largest verified bull trout was a 14.6-kilogram (32-pound) adfluvial fish caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982). Size differs little between life-history forms during their first years of life in headwater streams, but diverges as migratory fish move into larger and more productive waters (Rieman and McIntyre 1993).

Ratliff (1992) reported that bull trout under 100 mm (4 inches) in length were generally only found in the vicinity of spawning areas, and that fish over 100 mm were found downstream in larger channels and reservoirs in the Metolius River Basin. Juvenile migrants in the Umatilla River were primarily 100-200 mm long (4 to 8 inches) in the spring and 200-300 mm long (8 to 12 inches) in October (Buchanan *et al.* 1997). The age at migration for juveniles is variable. Ratliff (1992) reported that most juveniles reached a size to migrate downstream at age 2, with some at ages 1 and 3 years. Pratt (1992) had similar findings for age-at-migration of juvenile bull trout from tributaries of the Flathead River. The seasonal timing of juvenile downstream migration appears similarly variable.

Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. The species is iteroparous (i.e., can spawn multiple times in their lifetime) and adults may spawn each year or in alternate years (Batt 1996). Repeat-spawning frequency and post-spawning mortality are not well documented (Leathe and Graham 1982, Fraley and Shepard 1989, Pratt 1992, Rieman and McIntyre 1996) but post-spawn survival rates are believed to be high.

Bull trout typically spawn from late August to November during periods of decreasing water temperatures (below 9 degrees Celsius/48 degrees Fahrenheit). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989, Pratt 1992, Rieman and McIntyre 1996). Migratory bull trout frequently begin spawning migrations as early as April and have been known to move upstream as far as 250 kilometers (km) (155 miles) to spawning grounds in Montana (Fraley and Shepard 1989, Swanberg 1997). In Idaho, bull trout moved 109 km (67.5 miles) from Arrowrock Reservoir to spawning areas in the headwaters of the Boise River (Flatter 1998). In the Blackfoot River, Montana, bull trout began spring spawning migrations in response to increasing temperatures (Swanberg 1997). Depending on water temperature, egg incubation is normally 100 to 145 days (Pratt 1992), and after hatching, juveniles remain in the substrate. Time from egg deposition to emergence of fry may surpass 220 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992, Ratliff and Howell 1992).

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macro-zooplankton, and small fish (Boag 1987, Goetz 1989, Donald and Alger 1993). Adult migratory bull trout feed on various fish species (Leathe and Graham 1982, Fraley and Shepard 1989, Brown 1992, Donald and Alger 1993). In coastal areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) in the ocean (WDFW *et al.* 1997).

Habitat Affinities

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). Habitat components that influence the species' distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and availability of migratory corridors (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993, 1995; Rich 1996; Watson and Hillman 1997). Watson and Hillman (1997) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993), individuals of this species should not be expected to simultaneously occupy all available habitats (Rieman *et al.* 1997a).

Bull trout are found primarily in cold streams, although individual fish are found in larger, warmer river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993, 1995; Buchanan and Gregory 1997; Rieman *et al.* 1997a). Water temperature above 15 degrees Celsius (59 degrees Fahrenheit) is believed to limit bull trout distribution, a limitation that may partially explain the patchy distribution within a watershed (Fraley and Shepard 1989, Rieman and McIntyre 1995).

Spawning areas are often associated with cold-water springs, groundwater infiltration, and the streams with the coldest summer water temperatures in a given watershed (Pratt 1992, Rieman and McIntyre 1993, Rieman *et al.* 1997a, Baxter *et al.* 1999). Water temperatures during spawning generally range from 5 to 9 degrees Celsius (41 to 48 degrees Fahrenheit) (Goetz 1989). The requirement for cold water during egg incubation has generally limited the spawning distribution of bull trout to high elevations in areas where the summer climate is warm. Rieman and McIntyre (1995) found in the Boise River Basin that no juvenile bull trout were present in streams below 1,613 m (5,000 feet). Similarly, in the Sprague River basin of south-central Oregon, Ziller (1992) found in four streams with bull trout that "numbers of bull trout increased and numbers of other trout species decreased as elevation increased. In those streams, bull trout were only found at elevations above 1,774 m (5,500 feet)."

Goetz (1989) suggested optimum water temperatures for rearing bull trout of about 7 to 8 degrees Celsius (44 to 46 degrees Fahrenheit) and for egg incubation of 2 to 4 degrees Celsius (35 to 39 degrees Fahrenheit). For Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water 8 to 9 degrees Celsius (46 to 48 degrees Fahrenheit), within a temperature gradient of 8 to 15 degrees Celsius (46 to 60 degrees Fahrenheit) available in a plunge pool.

In Nevada, adult bull trout have been collected at sites with a water temperature of 17.2 degrees Celsius (63 degrees Fahrenheit) in the West Fork of the Jarbidge River (S. Werdon, *pers. comm.*, 1998) and have been observed in Dave Creek where maximum daily water temperatures were 17.1 to 17.5 degrees Celsius (62.8 to 63.6 degrees Fahrenheit) (Werdon, *in litt.* 2001). In the Little Lost River, Idaho, bull trout have been collected in water having temperatures up to 20 degrees Celsius (68 degrees Fahrenheit); however, these fish made up less than 50 percent of all salmonids when maximum summer water temperature exceeded 15 degrees Celsius (59 degrees Fahrenheit) and less than 10 percent of all salmonids when temperature exceeded 17 degrees Celsius (63 degrees Fahrenheit) (Gamett 1999).

All life-history stages of bull trout are associated with complex forms of cover, including LWD, undercut banks, boulders, and pools (Fraley and Shepard 1989, Goetz 1989, Hoelscher and Bjornn 1989, Sedell and Everest 1991, Pratt 1992, Thomas 1992, Rich 1996, Sexauer and James 1997, Watson and Hillman 1997). Jakober (1995) observed bull trout overwintering in deep beaver ponds or pools containing LWD in the Bitterroot River drainage, Montana, and suggested that, because of the need to avoid anchor ice in order to survive, suitable winter habitat may be more restricted than summer habitat. Maintaining bull trout habitat requires stability of stream channels and of flow (Rieman and McIntyre 1993). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989, Pratt 1992, Pratt and Huston 1993).

Preferred bull trout spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989). In the Swan River, Montana, abundance of bull trout redds (spawning areas) was positively correlated with the extent of bounded alluvial valley reaches, which are likely areas of groundwater to surface water exchange (Baxter *et al.* 1999). Survival of bull trout embryos planted in stream areas of groundwater upwelling used by bull trout for spawning were significantly higher than embryos planted in areas of surface-water recharge not used by bull trout for spawning (Baxter and McPhail 1999). Pratt (1992) indicated that increases in fine sediment reduce egg survival and emergence.

Migratory corridors link seasonal habitats for all bull trout life-history forms. For example, in Montana, migratory bull trout make extensive migrations in the Flathead River system (Fraley and Shepard 1989), and resident bull trout in tributaries of the Bitterroot River move downstream to overwinter in tributary pools (Jakober 1995). The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993, M. Gilpin, *in litt.* 1997, Rieman *et al.* 1997a). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed, or stray, to non-natal streams. Local bull trout populations that are extirpated by catastrophic events may also become re-established by migrants.

Population Dynamics

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

Metapopulation concepts of conservation biology theory have been suggested relative to the distribution and characteristics of bull trout, although empirical evidence is relatively scant (Rieman and McIntyre 1993, Dunham and Rieman 1999, Rieman and Dunham 2000). A metapopulation is an interacting network of local populations with varying frequencies of migration and gene flow among them (Meffe and Carroll 1994). For inland bull trout, metapopulation theory is likely most applicable at the watershed scale where habitat consists of discrete patches or collections of habitat capable of supporting local populations; local populations are for the most part independent and represent discrete reproductive units; and long-term, low-rate dispersal patterns among component populations influences the persistence of at least some of the local populations (Rieman and Dunham 2000). Ideally, multiple local populations distributed throughout a watershed provide a mechanism for spreading risk because the simultaneous loss of all local populations is unlikely. However, habitat alteration, primarily through the construction of impoundments, dams, and water diversions has fragmented habitats, eliminated migratory corridors, and in many cases isolated bull trout in the headwaters of tributaries (Rieman *et al.* 1997a, Dunham and Rieman 1999, Spruell *et al.* 1999, Rieman and Dunham 2000). Accordingly, human-induced factors as well as natural factors affecting bull trout distribution have likely limited the expression of the metapopulation concept for bull trout to patches of habitat within the overall distribution of the species (Dunham and Rieman 1999). However, despite the theoretical fit, the relatively recent and brief time period during which bull trout investigations have taken place does not provide certainty as to whether a metapopulation dynamic is occurring (e.g., a balance between local extirpations and recolonizations) across the range of bull trout or whether the persistence of bull trout in large or closely interconnected habitat patches (Dunham and Rieman 1999) is simply reflective of a general deterministic trend towards extinction of the species where the larger or interconnected patches are relics of historically wider distribution (Rieman and Dunham 2000). Recent research (Whiteley *et al.*

2003) does, however, provide stronger genetic evidence for the presence of a metapopulation process for bull trout, at least in the Boise River basin of Idaho.

Reasons for Listing

Bull trout distribution, abundance, and habitat quality have declined rangewide (Bond 1992, Schill 1992, Thomas 1992, Ziller 1992, Rieman and McIntyre 1993, Newton and Pribyl 1994, IDFG *in litt.* 1995, McPhail and Baxter 1996). Several local extirpations have been documented, beginning in the 1950s (Rode 1990, Ratliff and Howell 1992, Donald and Alger 1993, Goetz 1994, Newton and Pribyl 1994, Berg and Priest 1995, Light *et al.* 1996, Buchanan *et al.* 1997, WDFW 1998). Bull trout were extirpated from the southernmost portion of their historic range, the McCloud River in California, around 1975 (Moyle 1976, Rode 1990). Bull trout have been functionally extirpated (*i.e.*, few individuals may occur there but do not constitute a viable population) in the Coeur d'Alene River basin in Idaho and in the Lake Chelan and Okanogan River basins in Washington (USFWS 1998).

These declines result from the combined effects of habitat degradation and fragmentation, the blockage of migratory corridors; poor water quality, angler harvest and poaching, entrainment (process by which aquatic organisms are pulled through a diversion or other device) into diversion channels and dams, and introduced nonnative species. Specific land and water management activities that depress bull trout populations and degrade habitat include dams and other diversion structures, forest management practices, livestock grazing, agriculture, agricultural diversions, road construction and maintenance, mining, and urban and rural development (Beschta *et al.* 1987; Chamberlain *et al.* 1991; Furniss *et al.* 1991; Meehan 1991; Nehlsen *et al.* 1991; Sedell and Everest 1991; Craig and Wissmar 1993; Frissell 1993; Henjum *et al.* 1994; McIntosh *et al.* 1994; Wissmar *et al.* 1994; MBTSG 1995a-e, 1996a-f; Light *et al.* 1996; USDA and USDI 1995, 1996, 1997).

Rangewide Trend

In the rules listing bull trout as threatened, the Service identified subpopulations (*i.e.*, isolated groups of bull trout thought to lack two-way exchange of individuals), for which status, distribution, and threats to bull trout were evaluated. Because habitat fragmentation and barriers have isolated bull trout throughout their current range, a subpopulation was considered a reproductively isolated group of bull trout that spawns within a particular river or area of a river system. Overall, 187 subpopulations were identified in the 5 DPS, 7 in the Klamath River, 141 in the Columbia River, 1 in the Jarbidge River, 34 in the Coastal-Puget Sound, and 4 in the St. Mary-Belly River populations. No new subpopulations have been identified and no subpopulations have been lost since listing. More detailed information on the range-wide trend of the bull trout is currently being developed for the 5-year status review and is not yet available.

New Threats

Since listing, no substantial new threats have been identified.

Ongoing Conservation Actions

Federal Conservation Actions

Federal conservation actions include: (1) the development of a draft *Bull Trout Recovery Plan*; (2) ongoing implementation of the *Interim Strategy for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California* (PACFISH; USDA and USDI 1995) and the *Interim Strategy for Managing Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana and Portions of Nevada* (INFISH; USDA 1995); (3) ongoing implementation of the Northwest Forest Plan; (4) ongoing implementation of the Northwest Power and Conservation Council Fish and Wildlife Program targeting sub basin planning; (5) ongoing implementation of the Federal Caucus Fish and Wildlife Plan; and (6) ongoing implementation of Department of Agriculture Conservation Reserve Programs.

State Conservation Actions

Idaho

Conservation actions by the State of Idaho include: (1) the development of a management plan for bull trout in 1993 (Conley 1993); (2) the approval of the *State of Idaho Bull Trout Conservation Plan* (Idaho Plan) in July 1996 (Batt 1996); (3) the development of 21 problem assessments involving 59 key watersheds; (4) the implementation of conservation actions identified in the problem assessments; and (5) the implementation of more restrictive angling regulations.

Montana

Conservation actions by the State of Montana include: (1) development of the *Montana Bull Trout Restoration Plan* issued in 2000 (MBTRT 2000), which defines strategies for ensuring the long-term persistence of bull trout in Montana; (2) formation of the Montana Bull Trout Restoration Team and Montana Bull Trout Scientific Group to produce a plan for maintaining, protecting, and increasing bull trout populations; (3) the development of watershed groups to initiate localized bull trout restoration efforts; (4) funding of habitat restoration projects, recovery actions, and genetic studies throughout the state; (5) the abolition of brook trout stocking programs; and (6) implementation of stricter angling regulations have also become more restrictive than in the past.

Nevada

Conservation actions by the State of Nevada include: (1) the preparation of a *Bull Trout Species Management Plan* that recommends management alternatives to ensure that "human activities will not jeopardize the future of bull trout in Nevada" (Johnson 1990); (2) implementation of more restrictive State angling regulations in an attempt to protect bull trout in the Jarbidge River in Nevada; and (3) the abolition of a rainbow trout stocking in the Jarbidge River.

Oregon

Since 1990, the state of Oregon has taken several actions to address the conservation of bull trout, including: (1) Establishing bull trout working groups in the Klamath, Deschutes, Hood, Willamette, Odell Lake, Umatilla and Walla Walla, John Day, Malheur, and Pine Creek river basins for the purpose of developing bull trout conservation strategies; (2) establishment of more restrictive harvest regulations in 1990; (3) reduced stocking of hatchery-reared rainbow trout and brook trout into areas where bull trout occur; (4) angler outreach and education efforts are also being implemented in river basins occupied by bull trout; (5) research to further examine life history, genetics, habitat needs, and limiting factors of bull trout in Oregon; (6) reintroduction of bull trout fry from the McKenzie River watershed to the adjacent Middle Fork of the Willamette River, which is historical unoccupied, isolated habitat; (7) the Oregon Department of Environmental Quality established a water temperature standard such that surface water temperatures may not exceed 10 degrees Celsius (50 degrees Fahrenheit) in waters that support or are necessary to maintain the viability of bull trout in the state (Oregon 1996); and (8) expansion of the Oregon Plan for Salmon and Watersheds (Oregon 1997) to include all at-risk wild salmonids throughout the state.

Washington

Conservation actions by the state of Washington include: (1) establishment of the Salmon Recovery Act (ESHB 2496) and Watershed Management Act (ESHB 2514) by the Washington State legislature to assist in funding and planning salmon recovery efforts; (2) abolition of a brook trout stocking in streams or lakes connected to bull trout-occupied waters; (3) changing angling regulations in Washington prohibit the harvest of bull trout, except for a few areas where stocks are considered "healthy"; (4) collecting and mapping updated information on bull trout distribution, spawning and rearing areas, and potential habitat; and (5) adopting new emergency forest practice rules based on the "Forest and Fish Report" process. These rules address riparian areas, roads, steep slopes, and other elements of forest practices on non-Federal lands.

Tribal Conservation Activities

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

Conservation Needs

Conservation needs reflect those biological and physical requirements of a species for its long-term survival and recovery. Based on the best available scientific information (Rieman and McIntyre 1993, MBTSG 1998, Hard 1995, Healey and Prince 1995, Rieman and Allendorf 2001), the conservation needs of the bull trout are to: (1) Maintain and restore multiple, interconnected populations in diverse habitats across the range of each DPS; (2) Preserve the diversity of life-history strategies (e.g., resident and migratory forms, emigration age, spawning frequency, local habitat adaptations); (3) Maintain genetic and phenotypic diversity across the range of each DPS; and (4) Protect populations from catastrophic fires across the range of each DPS. Each of these needs is described below in more detail.

1. *Maintain and Restore Multiple, Interconnected Populations in Diverse Habitats across the Range of Each DPS.*

Multiple local populations distributed and interconnected throughout a watershed provide a mechanism for spreading risk from stochastic events (Rieman and McIntyre 1993, Hard 1995, Healey and Prince 1995, Spruell *et al.* 1999, Rieman and Allendorf 2001). Current patterns in bull trout distribution and other empirical evidence, when interpreted in view of emerging conservation theory, indicate that further declines and local extinctions are likely (Rieman *et al.* 1997a, Dunham and Rieman 1999, Rieman and Allendorf 2001, Spruell *et al.* 2003). Based in part on guidance from Rieman and McIntyre (1993), bull trout core areas with fewer than five local populations are at increased risk of extirpation; core areas with between 5 to 10 local populations are at intermediate risk of extirpation; and core areas which have more than 10 interconnected local populations are at diminished risk of extirpation.

Maintaining and restoring connectivity between existing populations of bull trout is important for the persistence of the species (Rieman and McIntyre 1993). Migration and occasional spawning between populations increases genetic variability and strengthens population variability (Rieman and McIntyre 1993). Migratory corridors allow individuals access to unoccupied but suitable habitats, foraging areas, and refuges from disturbances (Saunders *et al.* 1991).

Because bull trout in the coterminous United States are distributed over a wide geographic area consisting of various environmental conditions, and because they exhibit considerable genetic differentiation among populations, the occurrence of local adaptation is expected to be extensive. Some readily observable examples of differentiation between populations include external morphology and behavior (e.g., size and coloration of individuals; timing of spawning and migratory forays). Conserving many populations across the range of the species is crucial to adequately protect genetic and phenotypic diversity of bull trout (Leary *et al.* 1993, Rieman and McIntyre 1993, Hard 1995, Healey and Prince 1995, Spruell *et al.* 1999, Taylor *et al.* 1999, Rieman and Allendorf 2001). Changes in habitats and prevailing environmental conditions are increasingly likely to result in extinction of bull trout if genetic and phenotypic diversity is lost.

2. Preserve the Diversity of Life-history Strategies.

The bull trout has multiple life history strategies, including migratory forms, throughout its range (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 to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams and lakes, greater fecundity resulting in increased reproductive potential, and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Frissell 1997, Rieman and McIntyre 1993, MBTSG 1998).

3. Maintain the Genetic Diversity and Evolutionary Potential of Bull Trout Populations.

When the long-term persistence of a species, taxon, or phylogenetic lineage is considered, it is necessary to consider the amount of genetic variation necessary to uphold evolutionary potential which is needed for that taxon to adapt to a changing environment. Effective population size provides a standardized measure of the amount of genetic variation that is likely to be transmitted between generations within a population. Effective population size is a theoretical concept that allows one to predict potential future losses of genetic variation within a population due to small population size and genetic drift. Individuals within populations with very small effective population sizes are also subject to inbreeding depression because most individuals within small populations share one or more immediate ancestors (parents, grandparents, etc.) after only a few generations and will be closely related.

The effective population size parameter (N_e) incorporates relevant demographic information that determines the evolutionary consequences of members in a population contributing to future generations (Wright 1931). When prioritizing populations for conservation, N_e is an important parameter because it is inversely related to the rate of loss of genetic diversity and the rate of increase in inbreeding in a population that is finite, but otherwise randomly mating (Waples 2002). Within a population, the census number of sexually mature adults per generation (N) and N_e are the same when the following conditions are met: constant and large population size, variance in reproductive success is binomial (number of progeny per parent follows a Poisson distribution), and sex ratio is equal. Because most populations do not conform to these conditions, the N_e to N ratio is usually below 1.0 (Frankham 1995), and the N_e to N ratio is thought to be between 0.15 and 0.27 in bull trout populations based on computer modeling (Rieman and Allendorf 2001).

A N_e of 50 or more is recommended to avoid the immediate effects of inbreeding and should be considered a minimum requirement for the short-term conservation of populations (Franklin 1980, Soulé 1987). Increased homozygosity of deleterious recessive alleles is thought to be the main mechanism by which inbreeding depression decreases the fitness of individuals within local populations (Allendorf and Ryman 2002). Deleterious recessive alleles are introduced into the genome via random mutations, and natural selection is slow to purge them because they are usually found in the heterozygous form where they are not detrimental. When populations become small, heterozygosity decreases at the rate of $1/(2 N_e)$ per generation which in turn causes an increase in the frequency of homozygosity of the deleterious recessive alleles. Hedrick and Kalinowski (2000) provide a review of studies demonstrating inbreeding depression in wild populations.

Effective population sizes of 500 to 5,000 have been recommended for the retention of evolutionary potential (Franklin and Frankham 1998, Lynch and Lande 1998). Populations of this size are able to retain additive genetic variation for fitness related traits gained via mutation (Franklin 1980).

Bull trout specific benchmarks 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, 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). In this study, the authors estimated N_e for bull trout to be between 0.5 and 1.0 times the mean number of adults spawning annually. Rieman and Allendorf (2001) concluded that an average of 100 (i.e., 100 x 0.5 = 50) adults spawning each year would be required to minimize risks of inbreeding in a population and 1,000 adults (i.e., 1,000 x 0.5 = 500) 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.

The combination of resident forms completing their entire life cycle within a stream and the homing behavior of the migratory forms returning to the streams where they hatched to spawn promotes reproductive isolation among local bull trout populations. This reproductive isolation creates the opportunity for genetic differentiation and local adaptations to occur. Nevertheless, within a core area local populations are usually connected through low rates of migration. This connection of local populations, linked by migration, is termed a metapopulation (Hanski and Gilpin 1997). Within a metapopulation, evolution primarily occurs at the local population level (i.e., it is the main demographic and genetic unit of concern). However, when longer time frames are considered (e.g., 10 plus generations), metapopulations become important. For example, metapopulations allow for the reintroduction of lost alleles and recolonization of extinct local breeding populations. Migration and gene flow among local populations ensures that the alleles within a metapopulation will be present in most local breeding populations and can be acted upon by natural selection (Allendorf 1983).

4. Maintain Phenotypic Diversity.

Healy and Prince (1995) reported that, because phenotypic diversity is a consequence of the genotype interacting with the habitat, the conservation of phenotypic diversity is achieved through conservation of the sub-population within its habitat. They further note that adaptive variation among salmonids has been observed to occur under relatively short time frames (e.g., changes in genetic composition of salmonids raised in hatcheries;

rapid emergence of divergent phenotypes for salmonids introduced to new environments). Healy and Prince (1995) conclude that while the loss of a few sub-populations within an ecosystem might have only a small effect on overall genetic diversity, the effect on phenotypic diversity and, potentially, overall population viability could be substantial. This concept of preserving variation in phenotypic traits that is determined by both genetic and environmental (i.e., local habitat) factors has also been identified by Hard (1995) as an important component in maintaining intraspecific adaptability (i.e., phenotypic plasticity) and ecological diversity within a genotype. He argues that adaptive processes are not entirely encompassed by the interpretation of molecular genetic data; in other words, phenotypic and genetic variation in adaptive traits may exist without detectable variation at the molecular genetic level, particularly for neutral genetic markers. Therefore, the effective conservation of genetic diversity necessarily involves consideration of the conservation of biological units smaller than taxonomic species (or DPSs). Reflecting this theme, the maintenance of local sub-populations has been specifically emphasized as a mechanism for the conservation of bull trout (Rieman and McIntyre 1993, Taylor *et al* 1999).

5 Protect Bull Trout from Catastrophic Fires.

The 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 against the effects of large fires may be to restore aquatic habitat structure and life history complexity of populations in areas susceptible to large fires (Gresswell 1999).

Rieman and Clayton (1997) discussed relations among the effects of fire and timber harvest, aquatic habitats, and sensitive species. They noted that spatial diversity and complexity of aquatic habitats strongly influence the effects of large disturbances on salmonids. For example, Rieman *et al.* (1997b) studied bull trout and redband trout 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 and after areas within the watersheds experienced debris flows, fish had become reestablished in many reaches, and densities increased. In some instances, fish densities were higher than those present before the fires or 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.

Status of the Columbia River DPS

The Service's listing rule recognizes 141 subpopulations of bull trout in the Columbia River DPS within Idaho, Montana, Oregon, and Washington, with additional subpopulations in British Columbia. Of these subpopulations, approximately 79 percent are unlikely to be reestablished if extirpated and 50 percent are at risk of extirpation from naturally occurring events due to their depressed status (USDI 1998). Many of the remaining bull trout occur as isolated subpopulations in headwater tributaries, or in tributaries where the migratory corridors have been lost or restricted. Few bull trout subpopulations are considered "strong" in terms of relative abundance and subpopulation stability. Those few remaining strongholds are generally associated with large areas of contiguous habitats such as portions of the Snake River basin in central Idaho, the upper Flathead Rivers in Montana, and the Blue Mountains in Washington and Oregon. The listing rule characterizes the Columbia River DPS as generally occurring as isolated subpopulations, without a migratory life form to maintain the biological cohesiveness of the subpopulations, and with trends in abundance declining or of unknown status (USDI 1998).

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). Reductions in the amount of riparian vegetation and road construction in the Columbia River basin due to timber harvest, grazing, and agricultural practices have contributed to habitat degradation through elevated stream temperatures, increased sedimentation, and channel embeddedness. 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 (i.e., mainstem hydropower and tributary irrigation diversions) have severely limited migration of bull trout in the Columbia River basin. Competition from non-native trout is also considered a threat to bull trout (USDI 1998).

Generally, where status is known and population data exist, bull trout populations in the Columbia River DPS are declining (Thomas 1992; Pratt and Huston 1993; Schill 1992). Bull trout in the Columbia River basin occupy about 45 percent of their estimated historic range (Quigley and Arbelbide 1997). Quigley and Arbelbide (1997) considered bull trout populations strong in only 13 percent of the occupied range in the interior Columbia River basin. Rieman et al. (1997) estimated that populations were strong in 6 to 24 percent of the subwatersheds in the entire Columbia River basin.

Status of Lower Columbia River Geographic Area

The lower Columbia River Geographic area, as described in the Final Rule listing for bull trout, includes all tributaries in Oregon and Washington downstream of the Snake River confluence near the town of Pasco, Washington. The Service identified 20 subpopulations in watersheds of nine major tributaries of the lower Columbia, including the Lewis (2), Klickitat (1), White Salmon (1), Willamette (3), Hood (2), Deschutes (3), John Day (3), Umatilla (2), and Walla Walla (3) Rivers. The present distribution of bull trout in the lower Columbia River basin is less than the historic range (Buchanan et al. 1997). Bull trout are thought to be extirpated from several tributaries in five river systems in Oregon (USDI 1998).

Migratory bull trout are present with resident fish or exclusively in at least 13 of the 20 subpopulations in the lower Columbia River. Many migratory fish are adfluvial and inhabit reservoirs created by dams. The Metolius River-Lake Bill Chinook subpopulation is the only subpopulation in this geographical area considered "strong" with an increasing abundance trend. The Service considers 5 of the 20 subpopulations at risk of extirpation caused by naturally occurring events exacerbated by isolation, single life history form and spawning area, and low abundance (USDI 1998).

The primary limiting factor affecting bull trout in the lower Columbia River area is the migratory barriers created by dams, which have fragmented bull trout populations and limited migration. Large dams separating areas of the Lower Columbia River include McNary, John Day, The Dalles, and Bonneville. Fish may pass in both directions on these dams, but the extent to which bull trout use the fish passage facilities is unknown (USDI 1998). The operation of Bonneville Dam and the potential impacts to bull trout in the Lower Columbia River is considered a research need in the Draft Recovery Plan (USFWS 2002a).

The Lower Columbia hydropower projects have both adult and juvenile fish passage facilities, but these fishways were designed for anadromous salmonids that are semelparous (spawn only once in a lifetime). These facilities do not include considerations for fish that are iteroparous (spawning more than once) or fish that wander upstream and downstream as adults to forage. Dams with fish passage may be a factor in isolating bull trout local populations if they are not readily passable by bull trout and/or if the dams do not provide an adult downstream migration route (USFWS 2002a). In addition to the dams on the Columbia River, the nine major tributaries have numerous dams, many of which do not provide upstream passage (USDI 1998).

The Draft Recovery Plan designated the Lower Columbia as one of 22 recovery units for bull trout in the Columbia River basin (USFWS 2002a). The overall status of the Lower Columbia River Recovery Unit of the Columbia River DPS, has not improved since the listing on June 10, 1998. The status has been affected by a number of actions addressed through Opinions prepared under section 7 of the Act, and by several permits issued for Habitat Conservation Plans (HCPs) under section 10(a)(1)(B) of the Act. Many of those actions were described in the 2002 Opinion for the Condit Project (USFWS 2002).

Section 7 consultations that have been completed in the Lower Columbia River Unit describe effects that are important in characterizing the current condition of the species. Our analysis showed that we consulted on a wide array of actions which had varying level of effects. Many of the actions resulted in only short-term adverse effects – some with long-term beneficial effects. Some of the actions resulted in long-term adverse effects. No actions that have undergone consultation were found to appreciably reduce the likelihood of survival and recovery of the bull trout. Furthermore no actions that have undergone consultation were anticipated to result in the loss of any subpopulations or local populations of bull trout. A more detailed analysis of consulted-on effects to the bull trout is available in our files and is hereby incorporated by reference.

The range-wide status of the bull trout has been affected by a number of HCPs that were prepared in conjunction with incidental take permit applications to the Service pursuant to section 10(a)(1)(B) of the Act. The 2002 Opinion discussed the Plum Creek Timber Company and the Washington Department of Natural Resources HCPs.

An HCP completed recently includes the J.L. Storedahl and Sons Inc. Daybreak Mine Expansion and Habitat Enhancement Project HCP, which addresses effects to listed species stemming from the expansion and reclamation of an existing gravel-mining operation on 300 acres adjacent to the East Fork Lewis River, Clark County, Washington. Bull trout currently are not known to utilize the East Fork Lewis River, but some populations in the lower Columbia River would potentially have access to the system for foraging, migration, and over-wintering purposes. The Service permitted the incidental take of bull trout resulting from gravel mining and processing activities, site reclamation, and habitat enhancement efforts. The term of the Storedahl HCP is 25 years.

STATUS OF BULL TROUT CRITICAL HABITAT
(range-wide and/or recovery unit)

This Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.2. Instead, we have relied upon the standard articulated in the statute 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.

Critical habitat is defined in section 3 of the Act as: (i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographic area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. "Conservation" is defined by the Act as the use of all methods and procedures which are necessary to bring any endangered or a threatened species to the point at which the measures provided pursuant to the Act are no longer necessary.

A final rule designating critical habitat for the Columbia River and Klamath River DPSs of the bull trout was issued on October 6, 2004 and replaced by another final rule designating critical habitat for all of the listed populations of bull trout on September 26, 2005. The Service determined that these areas are essential to the conservation of bull trout. Designated critical habitat includes only those areas that are currently known to be occupied by bull trout or that contain features and habitat characteristics that are necessary to sustain bull trout. The designation encompassed non-Federal lands that have greater than one half mile of river frontage. The final rule does not include waters that are managed under the Northwest Forest Plan or the Federal Columbia River Power System. Also excluded from the rule are state lands managed by Washington Department of Natural Resources and other lands that have conservation agreements provided through HCPs. The final rule determined that these areas do not meet the requirement of needing additional special management or protection (USDI 2004, USDI 2005).

In order to be included in a critical habitat designation, the habitat must be "essential to the conservation of the species." Critical habitat units (CHU) are patterned after recovery units identified in the Draft Recovery Plan (USFWS 2002a) for the Columbia River population segments. Using guidance from this plan, the Service identified habitat areas needed for the conservation of bull trout. To be included as critical habitat, an area had to provide one or more of the following three functions: (1) spawning, rearing, foraging, or overwintering habitat to support existing bull trout local populations; (2) movement corridors necessary for maintaining migratory life-history forms; and/or (3) suitable and historically occupied habitat that is essential for recovering existing local populations that have declined, or that is needed to reestablish local populations required for recovery.

The PCEs for bull trout critical habitat were determined from studies of their habitat requirements, life-history characteristics, and population biology. PCEs may include, but are not limited to, features such as spawning sites, feeding sites, and water quality or quantity.

Critical habitat for bull trout includes eight PCEs:

1. Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32 to 72F (0 to 22C) but are found more frequently in temperatures ranging from 36 to 59F (2 to 15C). These temperatures may vary depending on bull trout life history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation.

2. Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures.

3. Substrates 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. This should include a minimal amount of fine substrate less than 0.63 cm (0.25 in) in diameter.

4. A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operates under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing

daily and day-to-day fluctuations and minimizing departures form the natural cycle of flow levels corresponding with seasonal variation: This rule finds that reservoirs currently operating under a biological opinion that addresses bull trout provides management for PCEs as currently operated.

5. Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source.

6. Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.

7. An abundant food base including terrestrial organisms of riparian origin, aquatic macro invertebrates, and forage fish.

8. Permanent water of sufficient quantity and quality such that normal reproduction, growth and survival are not inhibited.

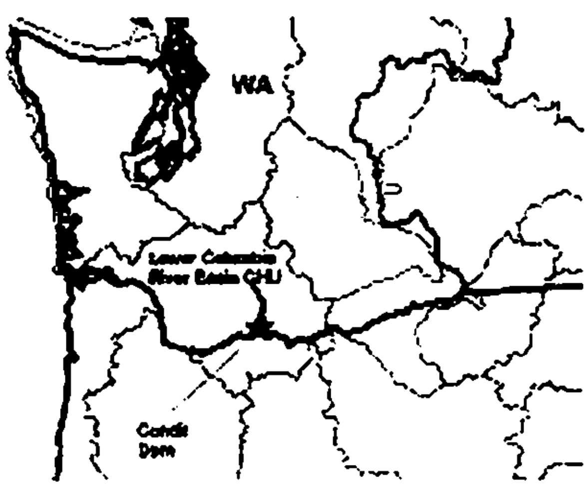


Figure 2 Critical habitat units

Within the Columbia and Klamath River bull trout DPSs, the Service designated 13 CHUs, the boundaries of which approximate the associated Recovery Units for the same geographic areas (See Figure 2). These CHUs identify, to the extent known, and using the best scientific data available, habitat areas that provide at least one of the physical or biological features essential to the conservation of the species (PCEs, as described above). The Service addressed local populations and factors specific to each river system, such as size (e.g., stream order), gradient, channel morphology, connectivity to other aquatic habitats, and habitat complexity and diversity, as well as range-wide considerations. In addition, areas important as migratory corridors were considered in terms of the various roles that migratory corridors have for bull trout, including the need to allow for genetic exchange between local populations and maintain metapopulation viability (USDI 2004, USDI 2005).

The lower Columbia CHU (Unit 19)

The Condit Dam project area is within the Lower Columbia River Basin CHU (Unit 19) consisting of portions of the Lewis, White Salmon, and Klickitat Rivers and associated tributaries in southwestern and south central Washington. This unit extends across Clark, Cowlitz, Klickitat, Skamania, and Yakima counties. Approximately 340 km (210 mi) of stream and three reservoirs covering 5,054 ha (12,488 ac) were proposed for critical habitat designation (USDI 2002). The Lewis River basin has three local populations of bull trout, and the Klickitat River has one. The Draft Bull Trout Recovery Plan concludes that maintaining the three local populations in the Lewis River and the one in the Klickitat, and establishing four additional populations within the Lewis River and one in the White Salmon River is essential to the conservation of bull trout (USFWS 2002a).

The Columbia River from the Pacific Ocean (rm 0) to Chief Joseph Dam (rm 544.6) provides foraging, migration and overwintering (FMO) habitat for tributary populations of bull trout. Habitat includes the free-flowing reaches of the Columbia River and the reservoirs to the ordinary high water elevations and normal operating pool elevations, respectively. (USDI 2002). Although proposed for designation as critical habitat in November 29, 2002, the unit encompassing the Columbia River mainstem was not included in the final rule (USDI 2004, USDI 2005).

ENVIRONMENTAL BASELINE

Regulations implementing the Act (50 CFR §402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities, and natural factors in the action area leading to the current status of the species, its habitat, and ecosystem. 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. Such actions include, but are not limited to, other hydroelectric projects, timber harvest, water diversions, and other land-management activities.

For the purposes of the analysis of effects to bull trout and bull trout critical habitat, we have determined that the action area encompasses the White Salmon River from rm 16 downstream to the confluence with the Columbia River, and the Columbia River mainstem from the confluence with the White Salmon River downstream to Puget Island near the mouth of the Columbia River. The following discussion will focus on the status and distribution of bull trout in the action area. *Detailed discussions concerning the status and limiting factors of bull trout in these areas are* contained in the draft recovery plan (USFWS 2002a) which is incorporated herein by reference.

Setting

White Salmon River

The White Salmon River originates on the southwest flank of 12,307-foot high Mount Adams, and then flows south for about 45 miles where it joins the Columbia River (NPPC 1990 as cited in USFWS 2002). The White Salmon basin totals about 386 square miles, and varies in elevation from 72 feet to over 12,300 feet. The topography is highly varied, including mountainous terrain, deeply incised canyons, rolling hills and flatter valley floors. Trout Lake Valley is the largest valley in the basin and is located about 25 miles upstream from the river's mouth.

Stream gradients within the basin are steep and often involve waterfalls. The White Salmon River drops 5,000 feet between its headwaters and Trout Lake (rm 25), and another 1,800 feet between Trout Lake and its confluence with the Columbia River (NPPC 1990 as cited in USFWS 2002). Upstream of Northwestern Lake, river gradients generally range between 2 and 11 percent (PacifiCorp 2001b as cited in USFWS 2002). The reach underneath Northwestern Lake before it was inundated, and below Condit Dam, has about a 1 percent gradient. The gradient of the lowermost 4,200 feet of the White Salmon River is influenced by the backwater effect of the Bonneville Pool. Significant waterfalls occur between rm 20.5 and 21.5 (a number of three- to eight-foot high cascades and waterfalls), near rm 16.3 (a series of four waterfalls, six-, eight-, twelve- and 21-feet high), at rm 12.4 (15-foot high water fall), and at rm 7.6 (a six- and twelve-foot high waterfall) (NPPC 1990 as cited in USFWS 2002) (Figure 3).

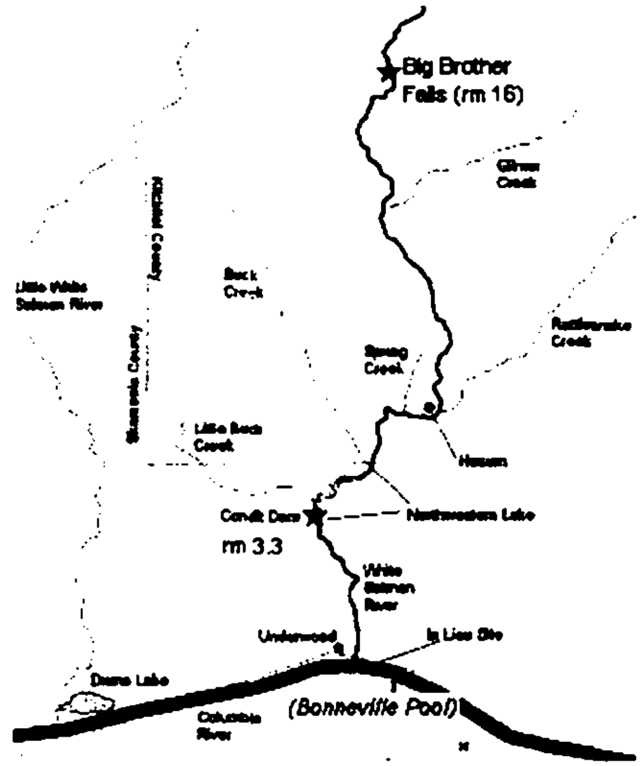


Figure 3 White Salmon River

Northwestern Lake stratifies during the summer with the thermocline developing between one and five meters in depth. The maximum surface water temperature recorded during the two year study was 17.1 degrees Celsius. At depths greater than five meters, the water temperature seldom exceeded 10 degrees Celsius. Dissolved oxygen levels exceeded nine parts per million (ppm) at all depths (PacifiCorp 1991b as cited in USFWS 2002).

The White Salmon River is located in a climatic transition zone on the eastern edge of the Cascade Mountains, resulting in wet winters and dry summers. The average annual precipitation is about 49 inches, with 85 percent of this amount occurring from October through March (NPPC 1990 as cited in USFWS 2002). Monthly mean flows range from a low of 644 cubic feet per second (cfs) for the month of September to a high of 1,538 cfs for May. The 100-year flood event is estimated to be 13,600 cfs. On February 8, 1996, a rain on snow event resulted in exceptionally high reservoir inflows, causing the spillway flashboards to fail, and an instantaneous peak discharge estimated at about 45,000 cfs (USGS 2002 as cited in USFWS 2002).

The White Salmon River is located in the grand fir/Douglas-fir vegetation zone, but exhibits a diverse mixture of microclimates and vegetation. Areas of Douglas-fir, western hemlock and western red cedar are common, as well as ponderosa pine and Oregon oak. Common understory vegetation includes Oregon grape, dogwood, vine maple, blackberry, elderberry, huckleberry, soapbrush and manzanita (NPPC 1990 as cited in USFWS 2002).

The basin is essentially rural, with most residents scattered along the river or concentrated in the unincorporated towns of Trout Lake, BZ Corner, and Husum. The community of White Salmon (population 1,900) is the largest population center within or straddling the White Salmon River basin. Land-use in the basin is primarily timber production, forest range and agriculture. About 47 percent of the basin is within the Gifford Pinchot National Forest and is managed for timber production, livestock grazing and recreation (NPPC 1990 as cited in USFWS 2002). The remaining land is either private land or State land managed by the Department of Natural Resources. About 4,500 acres, located primarily in Trout Lake Valley and along the valley between BZ Corner and White Salmon, are cultivated for the production of alfalfa, grain sorghum, corn, potatoes and fruit orchards. Pastureland for the grazing of beef and dairy cattle occurs along the White Salmon River and its tributaries.

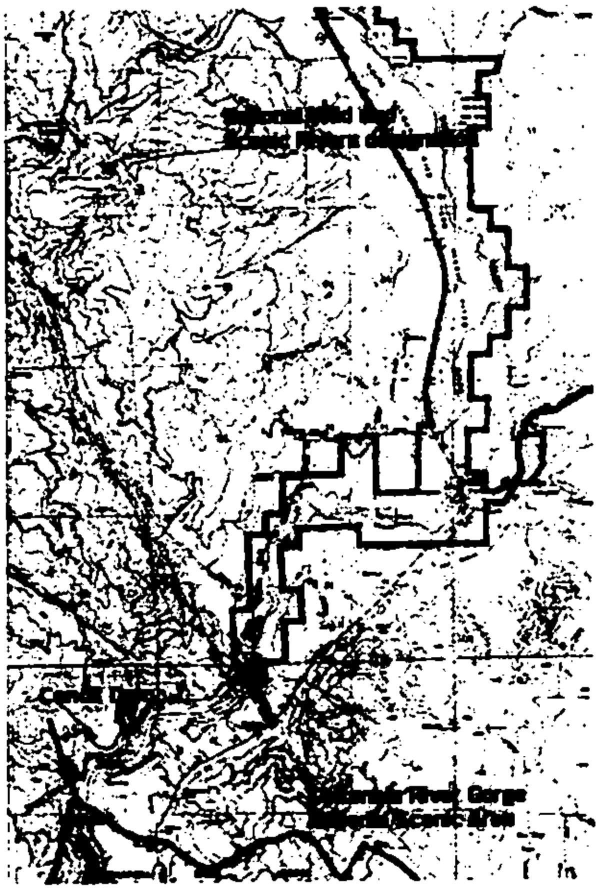


Figure 4 Land use designations

The White Salmon River falls within the land use planning jurisdiction of Klickitat County, Skamania County, the U.S. Forest Service, and the Columbia River Gorge Commission. The White Salmon River between rm 5.0 and rm 12.7 is part of the National Wild and Scenic Rivers system, and between the mouth and rm 3.3, it is included in the Columbia River Gorge. National Scenic Area (Figure 4).

The Lower Columbia River Mainstem

The Columbia River is naturally a very dynamic system. It has been affected and shaped over eons by a variety of natural forces, including volcanic activity, storms, floods, natural events and climatological changes. These forces have had and continue to have a significant influence on biological factors, including flows and habitat. Over the past century, human activities have affected the physical conditions in the lower Columbia River, including migration barriers, such as dams, changes to flow hydrographs, isolation of the floodplain, diking and filling of wetland areas, and changes to the channel from navigational activities. Land use in the Lower Columbia River basin includes 74 percent forest land and 17 percent agriculture. Urban land use is a small percent of the basin (5 percent) (USGS 1996).

Bonneville Dam (rm 146.1) is 20 miles downstream from the mouth of the White Salmon River. From Bonneville Dam downstream, the Columbia River drains an area of about 18,000 square miles (USGS 1996). Major tributaries of the Columbia River include the White Salmon, Sandy, Willamette, Lewis, Kalama, and Cowlitz Rivers. The Klickitat River enters Bonneville Pool from the north and the Hood River from the south, just upstream of the White Salmon River. Numerous minor tributaries enter the Columbia River in the Bonneville pool and below Bonneville Dam.

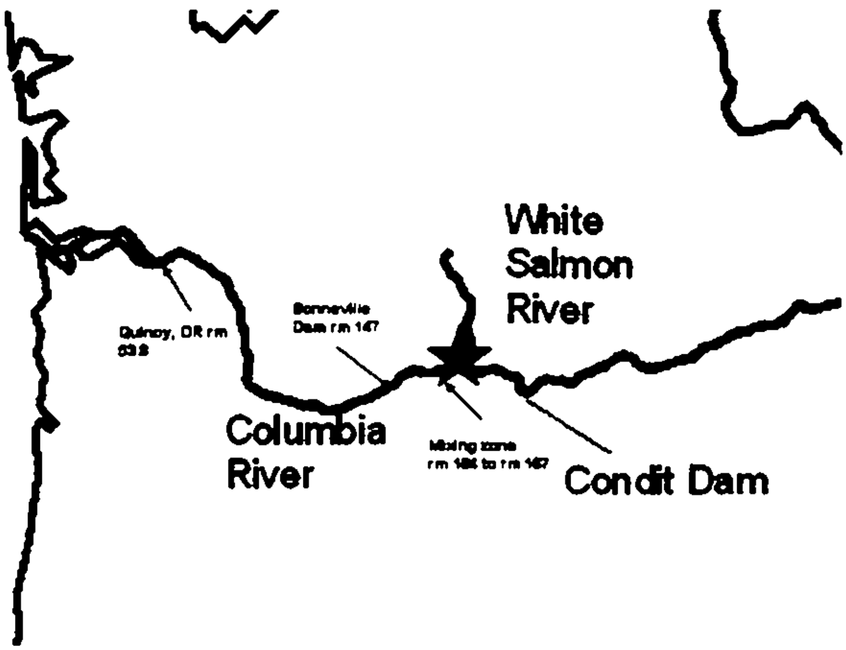


Figure 5 Water quality sampling locations

Most precipitation in the Lower Columbia basin falls from November through March. Mean annual precipitation varies, but is higher than in other parts of the Columbia River, ranging from 113 inches in Cougar, Washington to 37 inches in Portland, Oregon (USGS 1996). Streamflow in the Columbia River is affected by spring snowmelt, winter rainstorms, and dam regulation.

In addition to the dams on the Columbia, 17 reservoirs exist in the Willamette, three in the Lewis, and two in the Cowlitz basin that affect streamflow. Spring snowmelt typically produces higher flows than winter storms, and flows in the Lower Columbia River are regulated for daily flood control during spring snowmelt. Between 1968 and 2000, the average flow near Bonneville Dam in the Columbia River at the USGS stream gauge #1418910 (Warrendale, Oregon) was 210,604 cfs (Dennis Gathard, G & G Associates *in litt.* 2005) (Figure 5). One of the significant changes to the Lower Columbia River mainstem has been the reduction of the peak seasonal discharges and changes in the velocity and timing of flows as the result of water storage by Columbia River basin reservoirs. For instance, flow regulation that began in the 1970s has reduced the 2-year flood peak discharge, as measured at the Dalles, Oregon, from 580,000 cfs to 360,000 cfs (Corps 1999, as cited in USFWS 2002).

Temperatures remain uniform through the Lower Columbia River; with the highest water temperatures occurring in August. The daily mean water temperature measured near Bonneville Dam during water years 1969 through 1992 during July, August and September reached or exceeded 20 degrees Celsius at the 90 percentile. Trend data from 1974-1994 indicates significant upward trends for temperatures over time. The warmest tributary is the Willamette River; the Lewis and Kalama Rivers contribute the coldest water to the Columbia River from July to September. Warmer water temperatures coincide with high air temperatures and low streamflows, and temperatures generally increase on a gradient from upstream to downstream

(USGS 1996). Data collected at The Dalles, Oregon shows that from 1989 to 1992, temperatures ranged from 1.7 to 25 degrees Celsius, with a mean of 13.7 degrees Celsius (Corps and Grant County PUD 2001 as cited in FERC 2002).

The background concentration of total suspended solids (TSS) in the Lower Columbia increases in a downstream direction. The Willamette and the Cowlitz Rivers, with median concentrations of 21 ppm, produce higher levels of TSS concentrations than other tributaries. Water quality data for the Columbia River gathered between the years 1968 and 2000 at the Warrendale gage show that TSS concentrations averaged 15 ppm. The average TSS for the months of October, November and December at the Warrendale gauge is 7.5 ppm. Data gathered between 1993 and 2002 at Quincy, Oregon showed an average TSS of 28 ppm. The TSS concentrations in the Columbia River during the sampling periods mentioned ranged from 1 to 363 ppm (G & G Associates 2004) (Figures 6 and 7).

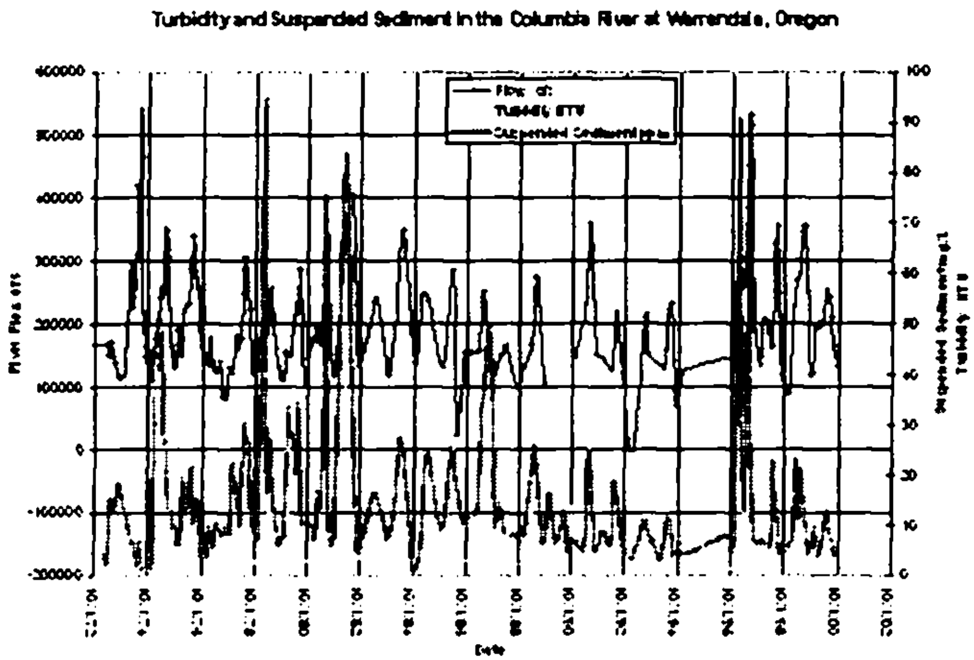


Figure 6 Turbidity and suspended sediment at Warrendale, Oregon

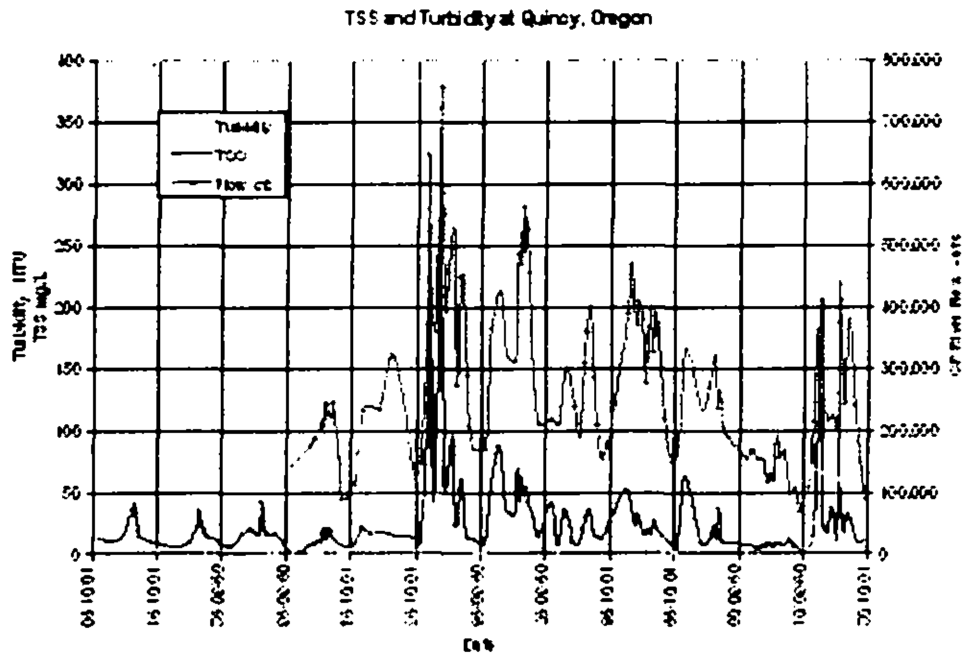


Figure 7 Turbidity and suspended sediment at Quincy, Oregon

Concentrations of suspended sediment are related to flows, with higher concentrations in spring and fall/winter storm runoff. The Lower Columbia River is classified as a Class A water body (excellent) under Washington State Water Quality Standards – Surface Waters (WAC 173-201A-030).

STATUS OF THE SPECIES
(in the action area)

White Salmon River

There are no known populations of bull trout in the upper White Salmon River watershed (above the impassable falls at rm 16), nor were any known historically. Despite many fish surveys in the tributaries of the upper White Salmon basin (including extensive bull trout surveys in 2000), no bull trout were ever documented (Hiss et al. 2000; WDFW 2000; USFS 2001a as cited in USFWS 2004). In the lower White Salmon River (below rm 16), two sightings of bull trout were documented, in 1986 and 1989, above Condit Dam at Northwestern Lake, both by Washington Department of Fish and Wildlife (WDFW) biologists (WDFW 1998). Gill net sets and creel censuses in Northwestern Lake have since been conducted for many years without recording any bull trout catch (WDFW 1998). Historical records (1943) indicate bull trout were present above Condit Dam in Rattlesnake Creek (Hiss et al. 2000 as cited in USFWS 2004); however, present habitat conditions in Rattlesnake Creek are believed to be unsuitable for bull trout (WDFW 2000).

The WDFW documented two sightings by sport anglers downstream from Condit Dam in recent years. These fish are believed to be migratory bull trout originating from Hood River that utilize the lower White Salmon River as foraging, migration, and overwintering habitat (WDFW 1998).

It appears that there is a very low likelihood of a bull trout presence in the upper White Salmon River above the barrier falls at rm 16. The observations in Northwestern Lake suggest that a population of bull trout once existed above Condit Dam although there is no evidence to suggest that one currently exists in the area. A spawning population in the lower White Salmon River would likely have consisted of fluvial bull trout that migrated to the mainstem Columbia River to overwinter and feed. Currently, there is no connectivity between the mainstem White Salmon River and the Columbia River due to the lack of fish passage at Condit Dam.

The White Salmon River up to the impassable falls (rm 16) is considered core habitat for bull trout recovery (USFWS 2002a). Because bull trout sightings are so rare, and no spawning and rearing areas have been identified, the White Salmon River is not considered a core area. The reasoning for this is that the river does include existing habitat having the essential elements that would allow for the full expression of life history forms of one or more populations of bull trout and habitat that can be restored to include the essential elements. Removal of Condit Dam and restoring the fluvial life history form in the White Salmon River is considered necessary for recovery of bull trout within the Lower Columbia Recovery Unit (USFWS 2002a).

Migration and occasional spawning between populations increases genetic variability and strengthens population variability (Rieman and McIntyre 1993). Benefits to bull trout with a migratory life-history form having access to the Columbia River would include: (1) greater growth in the productive waters of the larger river; (2) increased size associated with greater fecundity, resulting in an increased reproductive potential; and (3) increased ability to disperse so that spawning streams may be recolonized in the event that a local populations suffers a catastrophic loss (Rieman and McIntyre 1993; MBTSG 1998; Frissell 1999). Recovery of bull trout in the Lower Columbia River Recovery Unit will require not only restoring and maintaining connectivity between local populations in each core area, but reestablishing connectivity between the local populations in each core area with the Columbia River.

Watershed analysis indicates the upper White Salmon River watershed is "functioning at risk" due to the presence of an extensive road network, past riparian timber harvest, and high water temperatures in the watershed (USFS 2003).

Lower Mainstem Columbia River

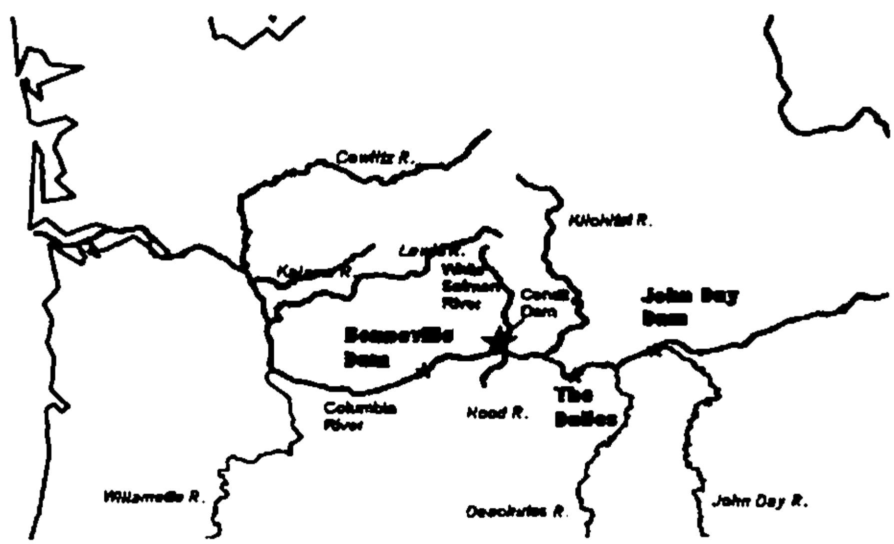


Figure 8 Lower Columbia River tributaries

Historically, the mainstem Columbia River was likely used as a migration corridor, foraging area, and overwintering habitat by bull trout that originated in the Lewis, White Salmon, and Klickitat Rivers (USFWS 2002a). Historical records indicate Dolly Varden (bull trout) were caught in fishwheels operated on the mainstem Columbia in the late 1800s (Donaldson and Cramer 1971 as cited in John Young, USFWS *in litt.* 2005). Records also indicate bull trout observations at the fish ladder at Bonneville Dam in 1941, 1947, 1982, 1986, and 1994 (C. Sprague, Corps of Engineers, *in litt.* as cited in J. Young, *in litt. 2005*) and in the lower Columbia River near Jones Beach, near Puget Island (rm 47) (NMFS, *in litt.* as cited in J. Young, *in litt.* 2005).

Five adult bull trout were caught (1994–1998) in the northern Pikeminnow Fishery conducted by the WDFW in Bonneville Pool and in the mainstem Columbia River below Bonneville Dam (Wachtel *in litt.* 2000 as cited in USFWS 2002a Chapter 6). More recently, bull trout have been reported from the lower reaches of the Kalama and Lewis Rivers (J. Byrne, WDFW pers. comm.) and the Sandy River (PGE, *in litt.*, as cited in USFWS 2002a Chapter 6). Bull trout have been observed at the mouth of the Klickitat River (WDFW 1998; Wachtel, *in litt.* 2000 as cited in USFWS 2002 Chapter 6). A single bull trout was observed March 21, 2005 at the Bonneville fish passage facility (Bianca Streif USFWS *in litt.* 2005).

Of the lower Columbia River tributaries, bull trout populations are known to occur in the Hood, Klickitat, Deschutes, John Day, Willamette, and Lewis River basins (Figure 8). Fish from the Hood, Deschutes, Willamette, and Lewis Rivers are genetically related and similar to coastal populations. While it is possible that bull trout found in the lower mainstem Columbia could have originated in any of these river systems, we believe it is most likely that they came from the Hood River or, possibly, the Klickitat River.

Two subpopulations of the bull trout occur in the Hood River basin within the Middle Fork Hood River drainage: (1) Lawrence Lake (upstream of Clear Branch Dam) and (2) Middle Fork Hood River (downstream of Clear Branch Dam and including tributaries). Historically, bull trout distribution included primarily the mainstem, Middle Fork and tributaries, and a short reach of the West Fork; and bull trout likely used the Columbia River for juvenile rearing and adult foraging (Buchanan *et al.* 1997 as cited in USFWS 2004b). Punchbowl Falls is suspected to be a natural barrier to fish migrations in the West Fork Hood River during low flows; only one bull trout has been captured at this location (Pribyl *et al.* 1995, Buchanan *et al.* 1997 as cited in USFWS 2004b). Resident and migratory fish are present in both subpopulations, and total numbers of mature fish are believed to be below 300 individuals basin-wide (Buchanan *et al.* 1997 as cited in USFWS 2004b).

Snorkle surveys of the Lawrence Lake subpopulation detected 40 to 301 total bull trout annually from 1992 through 1996, including juveniles (Buchanan *et al.* 1997 as cited in USFWS 2004b). Although upstream passage is now provided by a trap at Clear Branch Dam, the Service considers this subpopulation isolated until information is available on trap effectiveness. The Service considers the subpopulation at risk of stochastic extirpation due to its inability to be refounded, single life history form, limited spawning area, and low numbers.

Bull trout in the Middle Fork Hood River subpopulation are believed to spawn in Compass Creek and the Middle Fork Hood River. Nineteen fish greater than 200 mm (7.9 in. in fork length were collected during surveys of Compass Creek in 1995 (Buchanan et al. 1997 as cited in USFWS 2004b).

The mouth of the Hood River empties into Bonneville Pool, across the Columbia River from the mouth of the White Salmon River. Tagging studies indicate that bull trout originating in the Hood River migrate into the Columbia River. The extent of the migrations is unknown; however two bull trout tagged in the Hood River system were recovered in Drano Lake in the mouth of the Little White Salmon River and Coberg Beach at rm 182 (ODFW *in litt.* as cited in J. Young *in litt.* 2005). A bull trout tagged in 1994 was captured in 1995 11 km downstream from the mouth of Hood River (Buchanan et al 1997 as cited in USFWS 2002a Chapter 6).

The Klickitat River core area, just upstream of the White Salmon River, supports one known population of bull trout, a population that is probably restricted to a resident life history due to a falls near the confluence which may limit this population's interactions with bull trout in the mainstem (USFWS 2002a). Both resident and fluvial forms may persist in this basin. Bull trout have been caught in the lower Klickitat River that were 360 mm and 432 mm in size (WDFW 1998 as cited in J. Young *in litt.* 2005), indicating that they were probably the larger, migratory fish. Their origin is unknown. There are no population estimates for the resident population. Bull trout foraging in the lower Columbia River may originate in this basin, but there is no direct evidence for this.

Bull trout populations above the three dams on the Lewis River are considered adfluvial, primarily foraging in the reservoirs and returning to tributaries to spawn. Upstream passage for all migratory fish to the Lewis River from the Columbia River is blocked by Merwin Dam located at rm 20 (USFS 2003). Two verified bull trout observations occurred below Merwin Dam (F. Shrier *in litt.* as cited in USFWS 2002a Chapter 20). No further observations have occurred, although anecdotal reports indicate that bull trout or Dolly Varden have been caught in the lower Lewis River (WDF and WDG, undated as cited in USFWS 2002a Chapter 20). Prior to dam construction, fluvial migrations of bull trout probably occurred seasonally between the lower Lewis River and the mainstem Columbia River. The origin of bull trout observed below Merwin Dam is unknown and could be fish coming in from the Columbia River or passing downstream over the dams. The bull trout population in Merwin reservoir is very small and the probability of injury or death from passing over Merwin dam is high.

Bull trout inhabiting the Willamette River basin occupy only one portion of a single core area. Most of the estimated 300 fish in the population of this core area are in the McKenzie River mainstem. Numerous dams throughout the Willamette basin lack fish passage, or have impaired fish passage. It is not known whether bull trout use the lower Willamette or enter the Columbia River, however, given the numerous dams throughout the basin and higher water temperatures in the lower Willamette River, we would not expect bull trout to use these areas for foraging or overwintering (USFWS 2002a Chapter 5).

The lower Deschutes Core Area is estimated to support approximately 1,500 to 3,000 individuals, with a stable or increasing trend in abundance (USFWS 2002a Chapter 7). Dams are considered a major factor affecting bull trout in the upper and lower Deschutes River, interrupting or eliminating passage. Although bull trout have been found below the Pelton and Round Butte dams, it is not known whether bull trout from this basin migrate to the Columbia River.

Hydropower projects are believed to have negative impacts on the downstream migration of steelhead kelts, or adult fish that spawn more than once (Ferguson *et al.* 2005). These negative impacts occur because the fish passage facilities on the Federal Columbia River Power System are designed to provide upstream passage for spawning adult salmon and downstream passage for salmon smolts; steelhead use the fish passage facilities differently from salmon. Adult kelts migrating downstream can be injured or killed by passing through turbines or smolt bypass systems designed for smaller fish. Injury and mortality associated with passage through the turbines is assumed to increase with fish length (Bell *et al.* 1967, 1981 as cited in Ferguson *et al.* 2005). Adults migrating upstream can be subject to "fallback" (falling back over the dam) during high flows or spill events, so that they, too, can be injured or killed. We assume that bull trout foraging, overwintering, and migratory behavior would make them similarly vulnerable to the increased risk of passage through these dams, particularly since these migrations can occur during any time of the year. We therefore believe that bull trout found in Bonneville Pool or below Bonneville Dam are more likely to have originated from tributaries nearby, rather than from tributaries separated from foraging areas by dams.

Large mainstem rivers, such as the Columbia, are important to the conservation of the bull trout because they provide the connection between the tributaries with spawning and rearing habitat, and foraging, migratory and overwintering habitat. 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 1993 as cited in USFWS 2002c). Multiple life history strategies help to maintain the stability and persistence of bull trout populations to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams and lakes, greater fecundity resulting in increased reproductive potential, and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Rieman and McIntyre 1993; MBTSG 1998; Frissell 1999).

Restoring and maintaining connectivity between existing populations of bull trout is important for the persistence of the species (Rieman and McIntyre 1993). Currently, bull trout in the Lewis and White Salmon River basins do not have access to the Columbia River because of the lack of fish passage at dams that are barriers to fish passage. Restoring and maintaining connectivity between existing bull trout populations in river drainages of the Lower Columbia Recovery Unit would allow the migratory forms to develop in bull trout populations that have been restricted due to isolation by the dams to adfluvial (e.g., Yale Lake and Swift Creek Reservoir) or resident life histories (e.g., West Fork Klickitat River).

Status of Bull Trout Critical Habitat
(in the action area)

The lower White Salmon River from the confluence with the Columbia River upstream to the barrier falls at rm 16 has been designated as critical habitat for bull trout (USDI 2004, USDI 2005). Designated critical habitat in the White Salmon River consists of 16.0 rm and is further divided into three segments:

1. The White Salmon River from the confluence with the Columbia River (Bonneville Pool) (rm 0.0) to Condit Dam (rm 3.3). This section is essential in providing connectivity between the White Salmon River and the Columbia River when fish passage at Condit Dam is restored.

2. Northwestern Lake from Condit Dam (rm 3.3) to the entrance of the White Salmon River (rm 4.8) at the northeastern end of the reservoir. Northwestern Lake currently provides for FMO habitat for a possible remnant population of bull trout and may support establishment of a spawning population in the upper watershed. Following the removal of Condit Dam, the critical habitat designation in this stream segment will consist only of the restored river channel that is currently contained within Northwestern Lake. This restored section of the White Salmon River will provide FMO habitat for a restored bull trout population.

3. Entrance of the White Salmon River (rm 4.8) to the waterfall at rm 16. The mainstem White Salmon River provides FMO habitat for a possible remnant population of bull trout and would provide FMO habitat for a recovered population.

The following discusses the status of primary constituent elements in the action area (the White Salmon River).

<u>PCE 1 Cool water temperatures</u>

Water temperatures in the White Salmon River are generally excellent for bull trout, due to the glacial source of water, inflows from numerous springs and groundwater, and the location of long stretches of the river through a steep, shaded bedrock canyon. However, water temperatures immediately below the dam and at the downstream end of the bypass reach are about 3 degrees and 5 degrees Celsius warmer, respectively, than temperatures at the inlet to Northwestern Lake (PacifiCorp 1993 as cited in USFWS 2002). The highest water temperature (17.1 degrees Celsius) recorded by PacifiCorp occurred in the bypass reach (PacifiCorp 1991 as cited in USFWS 2002). Below the powerhouse, temperatures are elevated about 1 degree Celsius in summer months (PacifiCorp 1993 as cited by USFWS 2002). Riparian conditions are impaired throughout the watershed, therefore contributing to higher temperatures in the tributaries (Haring 2003).

The river below the dam has large pools that could provide thermal refugia from higher temperatures down to the backwatered area near the mouth. Below the dam, for example, habitat surveys indicated that the river is 50 percent riffles and 50 percent pools/glides (Hennelly et al 1994 as cited in Haring 2003). Above Northwestern Lake, 25 large deep pools have been reported (Haring 2003).

<u>PCE 2 Complex stream channel</u>

"Complex stream channels" refers to LWD, side channels, pools, and undercut banks that provide complexity of aquatic habitat. LWD is not common in the lower White Salmon River mainstem, which may be due at least partially to the high energy flows in the confined channel, which would tend to transport LWD out of the system, and partially because of the loss of large pieces of LWD due to timber harvest in the watershed. LWD is often removed by recreational rafters (USFWS 2004). LWD accumulations did reportedly exist historically (Haring 2003).

Pools, runs, and glides, and pockets of spawning gravels exist upstream of Northwestern Lake to the falls at rm 16. Bonneville Pool inundates the lower 0.75 miles of the White Salmon River. This reach is a low gradient channel that probably accumulated gravel and was likely very productive historically. Riparian conditions are impaired throughout the watershed, therefore limiting the recruitment of LWD and contributing to higher temperatures in the tributaries (Haring 2003).

PCE 3 Good quality substrate

This primary constituent element relates to the presence of substrates of sufficient amount, size, and composition to ensure success of bull trout egg and embryo overwinter survival, fry emergence and young of the year and juvenile survival. We believe that bull trout historically spawned and reared in this basin, however, we do not know where those spawning areas might be.

Stream gradients within the basin can be steep; upstream of Northwestern Lake river gradients range between 2 and 11 percent; underneath Northwestern Lake before it was inundated and below Condit Dam, the river has about a 1 percent gradient (PacifiCorp 2001b as cited in USFWS 2002). In the high energy areas, pockets of gravel collect along the channel margins and at the downstream end of the numerous large pools; the lower gradient areas likely had gravel throughout. The lowermost 0.75 miles of the White Salmon, historically a low gradient gravel-bedded river, is inundated by Bonneville Pool. Condit Dam blocks transport of sediments downstream so that gravel presence is low below the dam, especially in the bypass reach, which is 1.7 miles downstream of the dam. In addition, the steep canyon below the dam has little gravel on the banks that might be recruited to the river (Haring 2003).

PCE 4 Natural hydrograph

Above Condit Dam, the White Salmon River has a natural range of variability of flows, with spring snowmelt causing an increase in average daily flows to 1,538 cfs in May. Low flows average 644 cfs in September. Low flows are maintained by glacial snowmelt and groundwater seeps and springs. High flows are generally caused by rain on snow events when warm air temperatures and heavy rains cause widespread snowmelt. The 100-year flood event is estimated to be 13,600 cfs (Haring 2003).

Condit Dam affects the natural flow regime of the river. As discussed in our 2002 Opinion, project operations use up to 98 percent of the flows for power generation, passing 15 cfs downstream as a minimum flow. Project operations also result in higher peak discharge during storm events when spill gates are opened to prevent overtopping of the dam. Emergency shutdown or failure can result in abrupt and severe flow fluctuations.

PCE 5 Springs, seeps and groundwater sources

Flows and temperatures in the mainstem White Salmon River are generally excellent for salmonids due to glacial melt runoff and springs or seeps that arise from the porous basalt layers present throughout the watershed. In the reach at rm 17.15, for example, a spring emerges from the basalt layer 40 feet below the canyon rim to provide over 700 cfs, or more than 50 percent of the average summer flow to the White Salmon River (Haring 2003).

According to the project description (PacifiCorp 2004), a total of 17 seeps or streams have been observed entering Northwestern Lake. It is unknown whether additional seeps exist below the canyon walls that are currently inundated by the reservoir.

PCE 6 Migratory corridors

Numerous waterfalls occur above Condit Dam that may have been historic or current barriers to upstream migration of salmonids. These include Husum Falls at rm 7.6 (a six- and twelve-foot high waterfall), BZ Falls at rm 12.4 (a 15-foot high water fall), Big Brother Falls between rm 16 and rm 16.3 (a series of four waterfalls, six-, eight-, twelve-, and 21-feet high), and falls between rm 20.5 and 21.5 (a number of three- to eight-foot high cascades and waterfalls (NPPC 1990 as cited in USFWS 2002). Prior to the construction of Condit Dam, there were reports of Chinook, coho, and possibly chum salmon upstream as far as Husum Falls and steelhead upstream of BZ Falls. We would expect that bull trout could historically access stream habitats up to rm 16.

Condit Dam is a complete barrier to upstream passage for bull trout and other salmonids. In addition, the dam prevents bull trout and other fish species from migrating safely downstream. This barrier prevents bull trout from accessing spawning, rearing, overwintering and foraging habitats and also prevents salmon from accessing historical spawning areas.

PCE 7 Abundant food base

The White Salmon River basin supports anadromous salmon downstream of the dam, although the native stocks are at a high risk of extinction (Nehlsen et al. 1991 as cited in Haring 2003). Resident rainbow and cutthroat are found throughout the watershed. The presence of Condit Dam is considered the primary limiting factor of anadromous salmonid production in the White Salmon River because of the blockage of fish passage, the reduction of available spawning and rearing habitat, the blockage of LWD and gravel transport, which creates salmonid spawning and rearing habitat, the low instream flows in the bypass reach, which limit available habitat, and flow fluctuations which can scour salmon redds and displace or strand juvenile salmon (Haring 2003).

The presence of Bonneville Pool at the mouth of the White Salmon River limits the production of salmon which provide forage for bull trout (Haring 2003).

PCE 8 Permanent water supply with good water quality

The flow pattern of the White Salmon River is relatively constant because of glacial melt, large water recharge potential, and storage capacity (Haring 2003). Low flows are maintained by snowmelt and numerous springs throughout the watershed. White Salmon River water quality is considered excellent, based on data collected by PacifiCorp (1991b as cited in USFWS 2002). During the study period, dissolved oxygen levels ranged between 9.5 and 14.2 ppm, and pH ranged between 7 and 8. The White Salmon River has high conductivity, indicative of high fish productivity (Haring 2003).

The river is subject to numerous water withdrawals for irrigation in both the upper and lower watershed. Although degraded water quality parameters for temperature, fecal coliform, and nutrients have occurred in the upper watershed, above the falls at rm 16, the lower White Salmon mainstem has remained relatively unaffected, probably due to the glacially-fed summer flows and numerous seeps and springs (Haring 2003).

Dam operation provides a minimum flow of 15 cfs (or 2 percent of the average annual flow of 1,125 cfs) to the 1.7 mile long bypass reach below the dam, resulting in increased water temperatures and decreased productivity for forage species. Dam operation also involves flow fluctuations and higher peak discharges, which may strand juvenile salmonids, de-water or scour salmon redds. PacifiCorp holds a vested water right of 1,400 cfs for power generation (FERC 1996).

EFFECTS OF THE PROPOSED ACTION

"Effects of the action" is defined in section 7 of the Act's implementing regulations as:

> "the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline. Indirect effects are those that occur later in time but that are reasonably likely to occur. Interrelated actions are those that are part of the larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consultation. Regulations implementing section 7(a)(2) of the Act require the Service to consider the effects of activities that are interrelated or interdependent with the proposed Federal action (50 CFR 402.02)."

Both interrelated and interdependent activities are assessed by applying the "but for" test which asks whether any action and its resulting impact would occur "but for" the proposed action.

The Consultation Handbook (USFWS and NMFS 1998) provides the following direction for determining the effects of FERC relicensing actions and of other ongoing water projects (i.e., those existing before the listing of the species under the Act, considered in a section 7 consultation):

"When analyzing these water projects, as well as water contract renewals for Bureau of Reclamation (Bureau) programs and ongoing discretionary operations of Bureau and Corps water facilities, use the same approach as for other types of section 7 analyses:

- "The total effects of all past activities, <u>including effects of the past operation of the project</u> (emphasis added), current non-Federal activities, and Federal projects with completed section 7 consultations, for the environmental baseline;

- To this baseline, future direct and indirect impacts of the operation over the new license or contract period, including effects of any interrelated and interdependent activities, and any reasonably certain future non-Federal activities (cumulative effects), are added to determine the total effect on listed species and their habitat."

Our 2002 Opinion addressed the effects on bull trout of continued operation of the Condit Project until 2006, dam removal activities, the additional FERC measures, and conservation measures. This Opinion will not repeat those discussions except to summarize. This Opinion will discuss the extent that bull trout may be affected by the continued operation of Condit Dam until 2008, the extent that bull trout in the Columbia River may be affected by sediment releases from dam removal, and the extent that bull trout critical habitat may be affected by the continued operation of Condit Dam until 2008 and dam removal (See Table 1 for a summary of the effects covered in the 2002 and 2005 Opinions).

Ongoing project operations for an additional two years

The ongoing effects of dam operation at Condit dam, as discussed in our 2002 Opinion, include loss of connectivity between foraging and spawning and rearing habitat for bull trout due to the complete blockage of migration. The dam also blocks other salmonids, major forage species, from using the spawning and rearing habitat above the dam and contributes to a depression of the forage base for bull trout. The dam results in alteration of downstream habitats due to blockage of gravel and LWD transport, continued low instream flows of 15 cfs (about 2 percent of average annual flows), abrupt or severe flow fluctuations and high ramping rates due to operations, maintenance, and emergency shutdowns due to load rejection, and increased stream temperatures. Higher temperatures, low flows, and habitat alterations may preclude or limit bull trout or forage species from using the bypass channel or the channel below the powerhouse. Impacts to forage species from abrupt project shutdowns or maintenance may include scour of redds, displacement of fry downstream, fish stranding, and loss of spawning and rearing habitat.

In our 2002 Opinion, we discussed the risk to bull trout, if present above the dam, of injury or death from entrainment over the spillway or through the turbines. As there have been no observations of bull trout above the dam since 1989, despite numerous surveys, we believe that the likelihood of current bull trout presence above the dam is extremely low. The risk of injury or death due to entrainment, therefore, is extremely low.

Condit Dam is likely the main cause for the decline of the White Salmon bull trout subpopulation because it isolates spawning and rearing habitat from a very significant foraging habitat in the Columbia River. In addition, Condit Dam is believed to be the major limiting factor for salmonid production in the White Salmon River. An illustration of the significance of ongoing dam operations to salmonid production appears in the Washington State Conservation Commission's analysis of Salmonid Habitat Limiting Factors for Water Resources Inventory Area 29. The Water Resources Inventory Area 29 includes the Wind and White Salmon Rivers, but the original report, issued in 1999, did not include an analysis of the White Salmon River. The report stated, "Due to the presence of Condit Dam, anadromous salmonid production potential in the White Salmon River watershed [is] considered . . . limited to the extent that a[n] . . . analysis [of other limiting factors] would be of little benefit." After PacifiCorp announced that dam removal was viable, the state issued a limiting factors analysis for the White Salmon River (Haring 2003).

Table 1 Summary of effects to bull trout and bull trout critical habitat

Deconstructed action	Physical results	Location	Results in	Effects to bull trout	Proposed dam removal mitigating factors	In 2002 BO?	In 2005 BO?	Effects on BT Critical Habitat (PCEs)
Condit Hydroelectric Project								
Continued operation of project until 2008								
Upstream migration barrier	Blocks upstream passage for bull trout and salmon	WSR	Blocks access to spawning/ rearing habitat, and FMO habitat for bull trout. Limits salmon and steelhead spawning and rearing	Loss of connectivity and forage base is significant and a major factor in the decline of WSR bull trout population	Restoring connectivity and forage base in the WSR are essential to bull trout recovery	Yes	Summary	Would improve: migratory corridors and forage base
Downstream migration barrier	Absence of safe downstream migration	WSR	Injury or mortality if entrained over spillway or turbines; blocks access to FMO habitat	Loss of connectivity and forage base is significant and a major factor in the decline of WSR bull trout population	Restoring connectivity and forage base in the WSR are essential to bull trout recovery	Yes	Summary	Would improve: migratory corridors and forage base
Barrier to downstream movement of gravel	Scouring/ coarsening of downstream channel	WSR below dam	Decreased spawning success for salmon and steelhead	Loss of forage base for bull trout	Increased gravel recruitment to the lower WSR would increase forage base.	Yes	Summary	Would improve: forage base
Barrier to downstream movement of LWD and nutrient cycling	Low amount of LWD in WSR below the dam	WSR	Decreased cover, channel complexity, and habitat for bull trout and prey resources	Loss of FMO habitat for bull trout; loss of forage base	Increased LWD would increase FMO habitat and increase forage base	Yes	Summary	Would improve: stream complexity and forage base
Required instream flow 15cfs	2% of average annual flow	WSR	Decreased spawning and rearing habitat for salmon; increases water temperatures; decreased FMO habitat for BT	Loss of forage base and overwintering habitat	Restoring natural flows would improve water temperatures, increase salmon production and available bull trout FMO habitat	Yes	Summary	Would improve: natural hydrograph
Load rejection and plant shutdowns	Abrupt drop of instream flows below powerhouse;	WSR	Scouring and dewatering of salmon redds; fish stranding; reduced salmonid habitat	Loss of forage base	Restoring natural flows would increase salmon production and available bull trout FMO habitat	Yes	Summary	Would improve: natural hydrograph

Drawdown for maintenance and inspection	Higher flows during drawdown, lower during refill; rapid ramping rate	WSR	Scouring and dewatering of salmon redds; fish stranding; reduced salmonid habitat	Loss of forage base	Restoring natural flows would increase salmon production and available bull trout FMO habitat	Yes	Summary	Would improve: natural hydrograph
Temperature changes	Higher water temps in reservoir, bypass reach, and below powerhouse	NW Lake and WSR	Avoidance/reduction in FMO habitat for bull trout; reduced salmon spawning and rearing in bypass reach and below powerhouse	Loss of bull trout FMO habitat; loss of forage base	Restoring natural range of temperatures would increase forage base and bull trout FMO habitat	Yes	Summary	Would improve: temperature and forage base
Reservoir drawdown	lowering of pool elevation	NW Lake	Initial increase in forage for BT (if present) but long term decline in prey species	Loss of forage base	Restoring connectivity to bull trout FMO habitat	Yes	Summary	Would improve: forage base

Deconstructed action	Physical results	Location	Results in	Effects on bull trout	Proposed dam removal mitigating factors	In 2002 BO?	In 2005 BO?	Effects on BT Critical Habitat (PCEs)
Construction activities related to dam removal								
Fish salvage	Trapping and handling	WSR	Injury or mortality of bull trout or prey species	Injury or mortality	Low likelihood of bull trout presence	Yes	No	Not applicable
Dam removal and related activities	Approximately 10,000 cfs released	WSR	Entrainment of bull trout or prey species downstream	Injury or mortality of bull trout or prey species	Impacts very short term; low likelihood of bull trout presence	Yes	No	Not significant (release of 10,000 cfs is within a natural range of flows)
	Increase in suspended sediments	WSR, mouth of WSR	Increased total suspended sediments in water column	Injury or mortality of bull trout or prey species; stress; behavioral changes	Initial impacts extremely then decreasing. Low likelihood of bull trout presence; bull trout will avoid sediment plumes.	Yes	Yes, due to anticipated longer duration of effects	Short term adverse impact: water quality
	Increase in suspended sediments	Columbia R to mouth	Increased total suspended sediments in water column	Avoidance; stress, behavioral changes	Impacts short term; bull trout will avoid sediment plumes.	No	Yes	Not applicable (CH not designated in Columbia)
	Bedload filling of pools and in lieu site	WSR and mouth of WSR	Filling of large pool at mouth of WSR; filling of pools in WSR	Loss of thermal refuge for bull trout and prey species; loss of spawning and rearing habitat for prey species	Bull trout can use pools upstream of affected reach by the following summer. Sand will flush from	Yes	No	Mid term adverse impact; long term improvement: stream complexity and temperature

						pools in lower WSR within year or two.			
Long term effects of dam removal									
	Northwestern Lake will disappear	Change from lacustrine to lotic habitat	WSR above dam	Loss of lacustrine foraging habitat; increased lotic habitat for bull trout foraging, migration and overwintering	If bull trout are present, will lose lake foraging; however dam removal will increase connectivity and bull trout FMO habitat.	Low likelihood of bull trout presence currently; dam removal would improve FMO for bull trout	Yes	No	Would improve: stream complexity and forage base
	Exposure								
	Very short term - < one day								
	Short term - 1 to 30 days								
	Mid term - One to 12 months								
	Long term - One to five years								
	Very long term - Over five years								

Because of the low likelihood of bull trout being currently present in Northwestern Lake or the White Salmon River above the dam, we believe that the likelihood of death or injury to bull trout due to continued project operations during the next two years is very low. The primary effects of continued operation until 2008 are: (1) extending the duration of time that bull trout are restricted from accessing foraging, spawning, and overwintering habitat upstream of the dam; and (2) continued depression of the forage base in the White Salmon River. Given the fact that these impacts have been ongoing since the dam was built in 1913, we do not believe that an additional two years of operation will have a significant effect on bull trout populations.

Effects of dam removal on bull trout in the Columbia River

Dam removal, like any other construction activity, releases suspended sediment into the stream, degrading water quality, and changing bedload transport and sediment volume and size distribution. In addition, dam removal can cause impacts due to entrainment of fish, and impacts to pools and other habitat. These effects were discussed at length in our 2002 Opinion, and we will not repeat that discussion here.

The action area of our 2002 Opinion was the White Salmon River from rm 16 to the mouth and the Columbia River north shore for five miles downstream of the mouth of the White Salmon River, i.e., encompassing the mixing zone. Based on the sediment behavior analysis (G & G Associates 2004), and the furthest extent downstream of bull trout observations, we believe that sediment effects to bull trout may extend as far downstream as Puget Island at rm 47 in the Columbia River. In addition, we feel that sediment impacts in the White Salmon River could have a longer duration than originally assumed.

To assess the sediment levels at which adverse affects will occur in the Columbia River and determine the downstream extent of sediment impacts for this project, we used the guidance attached in Appendix A, prepared at the Service's Western Washington Fish and Wildlife Office. This guidance uses the findings in Newcombe and Jensen (1996 as cited in USFWS 2002) on impacts to fish resulting from suspended sediment. The guidance in Appendix A requires a measurement of the suspended sediment concentration levels (mg/L or ppm) and duration of time that sediment impacts would occur. We assume that the effects of suspended sediments on bull trout would be similar to other salmonids.

We used the sediment behavior analysis provided by G & G Associates (2004) to predict TSS levels in ppm at four locations over time after dam removal (See Table 2). The four locations are: (1) the White Salmon River below Condit Dam; (2) the "mixing zone" (the Columbia River, 3 miles downstream from the mouth of the White Salmon River); (3) the Columbia River just upstream of Bonneville Dam; and (4) the Columbia River at Quincy, Oregon rm 53.8 (Figure 5). We assume that the effects of the sediment behavior report was done using best professional standards and best available science.

Using the Severity-of-Ill-Effects scores from Figure 2 in Appendix A for adult salmonids, we determined that adverse affects to bull trout will occur in the White Salmon and Columbia Rivers when:

> Average daily TSS levels equal or exceed 1 ppm for 11 months or more;
> Intermittent TSS spikes lasting less than a day are 55 ppm or more; and
> Intermittent TSS spikes lasting approximately 2 days are 20 ppm or more.

The sediment behavior report identifies three processes by which sediments will erode from the reservoir area and travel downstream after dam removal. These three processes are important to note because they provide an understanding of the timing, duration, magnitude, and frequency of the sediment releases, which are necessary to determine sediment impacts to bull trout.

1. River Channel Formation (channel incision) will drive sediment transport during the first year, as the river begins to reform a channel through the reservoir sediments, undermining and eroding banks in the process. Erosion will be extremely high from this process initially, decreasing after a more stable river channel forms within about one year.

2. Surface erosion of reservoir sediments will be the predominant source of sediments after the first year, occurring intermittently with storm events for about three to five years. This process is caused by stormwater runoff over the surface of the former reservoir, and it will decline as drainage conveyances form and vegetation begins to stabilize the soil.

3. Floodplain formation in the reservoir area may occur over the next 30 years after dam removal, however, it will occur episodically, and the amount of sediment transported in each successive floodplain formation event will decline with time. The predicted frequency of such events after the first five years is less than once a year.

An estimated 2.4 million cubic yards (cy) of sediment are trapped behind Condit Dam in Northwestern Lake, mostly sand, silt or clay that can be transported by river flows as either bedload or suspended sediment. Of that total amount, between 1.6 and 2.2 million cy will erode once the dam is removed. The "in lieu site," at the mouth of the White Salmon River, will trap approximately 32 percent of all the sands and larger particles (greater than 1 mm), and 34 percent of the silts (median size 0.03 mm), or about 451,000 to 897,000 cy, depending upon the elevation of Bonneville Pool (G & G Associates 2004). Medium-sized sand particles arriving at the in lieu site after that pool has already filled will enter the Columbia River and settle near the confluence. The effect of filling the in lieu site on bull trout has been discussed in the 2002 Opinion.

As the suspended sediment plume enters the Columbia River and moves downstream, the higher flows in the Columbia will dilute concentrations. Most of the silt particles that do not settle in the in lieu site will settle out in the Bonneville Pool. Clay sized particles (less than 0.01 mm) will pass through Bonneville Dam and remain in suspension throughout the remainder of the river system (G & G Associates 2004); we therefore do not expect the spawning habitat for forage species below Bonneville Dam to be altered by settling of these particles.

Dilution from tributaries in the Columbia River will further decrease TSS levels as the sediment plume moves downstream. The initial pulse will take 48 hours to reach Bonneville Dam and an additional 50 hours or more to reach the ocean. During the first day, TSS levels in the Columbia River should occur in the following ranges: 2,333 to 5,833 ppm (mixing zone); 1,100 to 2,630 ppm (Bonneville Dam); 917 to 2,192 ppm (Quincy, Oregon). At these concentrations, bull trout may experience impaired homing, a reduction in feeding rate and feeding success, coughing, increased respiration rate, and behavioral changes, such as alarm, abandonment of cover, and avoidance. The concentrations should last less than a day as the sediment plume passes through.

Table 2 Anticipated levels and range of TSS

Condit Hydroelectric Project							
From: G & G Associates. 2004. *Condit Hydroelectric Project Removal - Sediment behavior analysis report.* Prepared for PacifiCorp, Portland, Oregon.							
Rapid draining of reservoir	**Frequency**	**Magnitude**	**Duration**	**Caused by**	**Predicted range of TSS spike**	**Physical effects**	
White Salmon River below dam	One time event after dam breach	10,000 cfs Extremely high	6 hours	Draining reservoir	100,000 - 250,000 ppm	Filling of pool at mouth	
Columbia River mixing zone	One time event after dam breach	10,000 cfs Extremely high	6 hours	Draining reservoir	2,333 - 5,833 ppm		
Columbia River at Bonneville Dam	One time event after dam breach	10,000 cfs Extremely high	6 hours	Draining reservoir	1,100 - 2,630 ppm		
Columbia River at Quincy, OR	One time event after dam breach	10,000 cfs Extremely high	6 hours	Draining reservoir	917 - 2,192 ppm		
River Channel formation	**Frequency**	**Magnitude**	**Duration**	**Caused by**	**Anticipated daily average TSS at 7 days**	**Anticipated daily average TSS at 30 days**	**Anticipated daily average TSS 90 days**
White Salmon River below dam	Initial high peaks, declining sharply w/ time	Normal flows	Sustained daily average	Slope failures; removing *obstructions, storm flows*	30,000 ppm	6,000 ppm	3,000 ppm
Columbia River mixing zone	Initial high peaks, declining sharply w/ time	Normal flows	Sustained daily average	Slope failures; removing obstructions, storm flows	20 ppm	10 ppm	7 ppm

Columbia River at Bonneville Dam	Initial high peaks, declining sharply w/ time	Normal flows	Sustained daily average	Slope failures; removing obstructions, storm flows	8 ppm	1 ppm	1 ppm		
Columbia River at Quincy, OR	Initial high peaks, declining sharply w/ time	Normal flows	Sustained daily average	Slope failures; removing obstructions, storm flows	6 ppm	1 ppm	1 ppm		
River Channel formation	**Frequency**	**Magnitude**	**Duration**	**Caused by**	**Predicted range of TSS spikes at 7 days**	**Predicted range of TSS spikes at 30 days**	**Predicted range of TSS spikes at 90 days**	**Predicted range of TSS spikes at 6 m**	**Predicted range of TSS spikes at 1 yr**
White Salmon River below dam	Initial high peaks, declining sharply w/ time	Normal flows	up to 2 days	Slope failures; removing obstructions, storm flows	15,000 - 60,000 ppm	4,000 - 12,000 ppm	1,000 - 6,000 ppm	100 - 3,000 ppm	100 - 3,000 ppm
Columbia River mixing zone	Initial high peaks, declining sharply w/ time	Normal flows	up to 2 days	Slope failures; removing obstructions, storm flows	10 - 400 ppm	3 - 80 ppm	2-40 ppm	1 - 20 ppm	1 - 20 ppm
Columbia River at Bonneville Dam	Initial high peaks, declining sharply w/ time	Normal flows	up to 2 days	Slope failures; removing obstructions, storm flows	4 - 180 ppm	1 - 36 ppm	1 - 18 ppm	0 - 9 ppm	0 - 9 ppm
Columbia River at Quincy, OR	Initial high peaks, declining sharply w/ time	Normal flows	up to 2 days	Slope failures; removing obstructions, storm flows	3 - 150 ppm	1 - 30 ppm	0 - 15 ppm	0 - 8 ppm	0 - 8 ppm
Surface Erosion (First 3 to 5 Years)	**Frequency**	**Magnitude**	**Duration**	**Caused by**	**Anticipated daily average TSS at 7 days**	**Anticipated daily average TSS 30 days**	**Anticipated daily average TSS at 1 yr**	**Anticipated daily average TSS at 3 yr**	**Anticipated daily average TSS at 5 y**
White Salmon River below dam	Storm runoff for 3-5 years	Higher during initial storms, then gradually declining	Sustained daily average	Surface runoff, declines with re-vegetation and drainage conveyances	22 ppm	22 ppm	22 ppm	7 ppm	7 ppm

Columbia River mixing zone	Storm runoff for 3-5 years	Higher during initial storms, then gradually declining	Sustained daily average	Surface runoff, declines with re-vegetation and drainage conveyances	0.1 ppm	0.1 ppm	0.1 ppm	0.0 ppm	0.0 ppm
Columbia River at Bonneville Dam	Storm runoff for 3-5 years	Higher during initial storms, then gradually declining	Sustained daily average	Surface runoff, declines with re-vegetation and drainage conveyances	0.1 ppm	0.1 ppm	0.1 ppm	0.0 ppm	0.0 ppm
Columbia River at Quincy, OR	Storm runoff for 3-5 years	Higher during initial storms, then gradually declining	Sustained daily average	Surface runoff, declines with re-vegetation and drainage conveyances	0.1 ppm	0.1 ppm	0.1 ppm	0.0 ppm	0.0 ppm
Surface Erosion (First 3 to 5 Years)	**Frequency**	**Magnitude**	**Duration**	**Caused by**	**Predicted TSS spike at 7 days**	**Predicted TSS spikes at 30 days**	**Predicted TSS spikes at 1 yr**	**Predicted TSS spikes at 3 yrs**	**Predicted TSS spikes at 5 yrs**
White Salmon River below dam	Storm runoff for 3-5 years	Higher during initial storms, then gradually declining	Peaks of < 1 d	Surface runoff, declines with re-vegetation and drainage conveyances	158 ppm	158 ppm	158 ppm	62 ppm	62 ppm
Columbia River mixing zone	Storm runoff for 3-5 years	Higher during initial storms, then gradually declining	Peaks of < 1 d	Surface runoff, declines with re-vegetation and drainage conveyances	1.1 ppm	1.1 ppm	1.1 ppm	0.4 ppm	0.4 ppm
Columbia River at Bonneville Dam	Storm runoff for 3-5 years	Higher during initial storms, then gradually declining	Peaks of < 1 d	Surface runoff, declines with re-vegetation and drainage conveyances	0.5 ppm	0.5 ppm	0.5 ppm	0.2 ppm	0.2 ppm
Columbia River at Quincy, OR	Storm runoff for 3-5 years	Higher during initial storms, then gradually declining	Peaks of < 1 d	Surface runoff, declines with re-vegetation and drainage conveyances	0.4 ppm	0.4 ppm	0.4 ppm	0.2 ppm	0.2 ppm

Floodplain formation (Intermittent and Infrequent)	Frequency	Magnitude	Duration	Caused by	Likely/ possible peak TSS at 1 yr	Likely/ possible peak TSS at 3 yrs	Likely / possible peak TSS at 5 yrs	Likely/ possible peak TSS at 10 yrs	Likely/ possible peak TSS at 20 yrs
White Salmon River below dam	Peak floods occurring < once a year	Initially high, then lower TSS and probability of occurrence	~ 1 day	Successively higher floods undermine slopes and erode embankments	4,000 ppm/ 6,000 ppm	1,500 ppm/ 3,000 ppm	1,000 ppm/ 3,000 ppm	850 ppm/ 1,000 ppm	500 ppm/ 1,000 ppm
Columbia River mixing zone	Peak floods occurring < once a year	Initially high, then lower TSS and probability of occurrence	~ 1 day	Successively higher floods undermine slopes and erode embankments	27 ppm/ 40 ppm	10 ppm/ 20 ppm	7 ppm/ 20 ppm	6 ppm/ 7 ppm	3 ppm/ 7 ppm
Columbia River at Bonneville Dam	Peak floods occurring < once a year	Initially high, then lower TSS and probability of occurrence	~ 1 day	Successively higher floods undermine slopes and erode embankments	12 ppm/ 18 ppm	5 ppm/ 9 ppm	3 ppm/ 9 ppm	3 ppm/ 3 ppm	2 ppm/ 3 ppm
Columbia River at Quincy, OR	Peak floods occurring < once a year	Initially high, then lower TSS and probability of occurrence	~ 1 day	Successively higher floods undermine slopes and erode embankments	10 ppm/ 15 ppm	4 ppm/ 8 ppm	3 ppm/ 8 ppm	2 ppm/ 3 ppm	1 ppm/ 3 ppm

Dam removal will result in an increase of White Salmon River flows to about 8,000 to 10,000 cfs, or about 3 percent to 4 percent of the Columbia's flow. After the initial flush of reservoir waters, predicted to last about six hours, the percentage of White Salmon flows to the Columbia River flows will drop to less than 1 percent, which is normal. Suspended sediment levels in the Columbia River will also drop by an order of magnitude because of the correspondingly higher dilution. Predicted ranges of TSS by day 7 after dam removal would be: 10 - 400 ppm (mixing zone); 4 – 180 ppm (Bonneville Dam); 3 – 150 ppm (Quincy, Oregon) (G & G Associations 2004). At these concentrations, we would expect bull trout in the Columbia to experience changes in feeding success, coughing and increased respiration, and behavioral changes.

Thirty days after dam removal, TSS concentrations in the Columbia River are expected to drop even further: 3 to 80 ppm (mixing zone); 1 to 36 ppm (Bonneville Dam); 1 to 30 ppm (Quincy, Oregon). At these levels, we would expect bull trout to intermittently experience short-term physiological stress from TSS spikes lasting up to two days. At ninety days after dam removal, the predicted ranges would drop to: 2 to 40 ppm (mixing zone); 1 to 18 ppm (Bonneville Dam); and 0 to 15 ppm (Quincy, Oregon). At these levels, bull trout may experience slight physiological stress, including changes in feeding rate and success, coughing and increased respiration, and behavioral changes, but at these levels and the duration of exposure, we believe the effects would be insignificant (i.e., immeasurable). Background levels of TSS concentrations in the Columbia River, as discussed earlier in the Environmental Baseline, range from 1 to 363 ppm with an average of 28 ppm. Fish in the Lower Columbia River are normally exposed, at least seasonally, to TSS levels in this range.

Bull trout use of the action area is for FMO. We expect that bull trout will avoid plumes of elevated suspended sediments and seek the mouths of tributaries where inflowing water would be less turbid. The sediment plumes will disrupt normal foraging and migrating behaviors. These impacts are expected to be short-term and temporary in nature. Bull trout exposed to these levels of suspended sediments would experience short-term physiological stress, reductions in feeding rates and feeding success, and avoidance of the area, as described in Appendix A.

Effects of dam removal on bull trout in the White Salmon River

Our 2002 Opinion assumed that suspended sediment levels in the White Salmon River would return to normal from one to two years after dam removal (Beck 1998 as cited in USFWS 2002). However, based on our review of the sediment behavior report, we believe that short-term sediment spikes may occur in the White Salmon River up to five years after dam removal from surface erosion and during high flood events, particularly if vegetation does not establish quickly on the slopes of the former reservoir.

We believe that vegetation will establish quickly and will reduce the risk of surface erosion. PacifiCorp will revegetate areas in the former reservoir that can sustain vegetation, i.e., those that have a soil, instead of bedrock, substrate. In addition, after the flood event of 1996, which occurred in February, grasses began to appear within months, and willow shoots within two years (M. Garrett, pers. comm. 2005), indicating that a similar recovery after dam removal is a reasonable expectation. During large scale flood events, average daily TSS levels could increase for short periods (less than a day), causing bull trout to avoid the area and seek out areas of less turbid water, such as the confluences with tributaries.

Table 3 summarizes our effects determinations from "worst case" sediment impacts to bull trout in the White Salmon and Columbia River as the result of Condit dam removal. Effects include "likely to adversely affect", "not likely to adversely affect", and "no effect." This figure also identifies the location of the discussion, whether contained in the 2002 Opinion or the 2005 Opinion.

Table 3 Magnitude of effects to bull trout from suspended sediments

Condit Hydroelectric Project								
Condit Dam removal								
Rapid draining of reservoir (1st day)	**Frequency**	**Duration**	**Worst case exposure**	**SIE Score**	**Bull trout effects**	**Duration of effect**	**Magnitude of Effects**	**2002 or 2005 BO?**
White Salmon River below dam	1 time event	6 hours	250,000 ppm	12	40-60% mortality	Very short term	LAA	2002
Columbia River mixing zone	1 time event	6 hours	5,833 ppm	9	Major stress	Very short term	LAA	2002
Columbia River at Bonneville Dam	1 time event	6 hours	2,630 ppm	9	Major stress	Very short term	LAA	2005
Columbia River at Quincy, OR	1 time event	6 hours	2,192 ppm	8	Major stress	Very short term	LAA	2005
River Channel formation (Day 7)	**Frequency**	**Duration**	**Worst case exposure**	**SIE Score**	**Bull trout effects**	**Duration of effect**	**Effects call**	**2002 or 2005 BO?**
White Salmon River below dam	Sustained	daily averages	30,000 ppm	12	40-60% mortality	Short term	LAA	2002
	Intermittent spikes	up to 2 days	60,000 ppm	12	40-60% mortality	Short term	LAA	2002
Columbia River mixing zone	Sustained	daily averages	20 ppm	6	Moderate stress	Short term	LAA	2002
	Intermittent spikes	up to 2 days	400 ppm	8	Major stress	Short term	LAA	2002
Columbia River at Bonneville Dam	Sustained	Daily averages	8 ppm	6	Moderate stress	Short term	LAA	2005
	Intermittent spikes	up to 2 days	180 ppm	7	Moderate stress	Short term	LAA	2005
Columbia River at Quincy, OR	Sustained	Daily averages	6 ppm	6	Moderate stress	Short term	LAA	2005
	Intermittent spikes	up to 2 days	150 ppm	7	Moderate stress	Short term	LAA	2005
River Channel formation (Day 30)	**Frequency**	**Duration**	**Worst case exposure**	**SIE Score**	**Bull trout effects**	**Duration of effect**	**Effects call**	**2002 or 2005 BO?**
White Salmon River below dam	Sustained	Daily averages	6,000 ppm	12	40-60% mortality	Mid term	LAA	2002
	Intermittent spikes	up to 2 days	12,000 ppm	10	0-20% mortality	Short term	LAA	2002
Columbia River mixing zone	Sustained	Daily averages	23 ppm	7	Moderate stress	Mid term	LAA	2002
	Intermittent spikes	up to 2 days	80 ppm	7	Moderate stress	Short term	LAA	2002

Columbia River at Bonneville Dam	Sustained	Daily averages	1 ppm	5	Minor stress	Mid term	NLTAA	n/a
	Intermittent spikes	up to 2 days	36 ppm	7	Moderate stress	Short term	LAA	2005
Columbia River at Quincy, OR	Sustained	Daily averages	1 ppm	5	Minor stress	Mid term	NLTAA	n/a
	Intermittent spikes	up to 2 days	30 ppm	6	Moderate stress	Short term	LAA	2005
River Channel formation (90 d)	**Frequency**	**Duration**	**Worst case exposure**	**SIE Score**	**Bull trout effects**	**Duration of effect**	**Effects call**	**2002 or 2005 BO?**
White Salmon River below dam	Sustained	Daily averages	3,000 ppm	12	40-60% mortality	Mid term	LAA	2002
	Intermittent spikes	up to 2 days	6,000 ppm	10	0-20% mortality	Short term	LAA	2002
Columbia River mixing zone	Sustained	daily averages	7 ppm	7	Moderate stress	Mid term	LAA	2002
	Intermittent spikes	up to 2 days	40 ppm	7	Moderate stress	Short term	LAA	2002
Columbia River at Bonneville Dam	Sustained	daily averages	1 ppm	5	Minor stress	Mid term	NLTAA	n/a
	Intermittent spikes	up to 2 days	18 ppm	6	Moderate stress	Short term	NLTAA	n/a
Columbia River at Quincy, OR	Sustained	daily averages	1 ppm	5	Minor stress	Mid term	NLTAA	n/a
	Intermittent spikes	up to 2 days	15 ppm	6	Moderate stress	Short term	NLTAA	n/a
River Channel formation (6m)	**Frequency**	**Duration**	**Worst case exposure**	**SIE Score**	**Bull trout effects**	**Duration of effect**	**Effects call**	**2002 or 2005 BO?**
White Salmon River below dam	Intermittent spikes	up to 2 days	3,000 ppm	10	0-20% mortality	Short term	LAA	2002
Columbia River mixing zone	Intermittent spikes	up to 2 days	20 ppm	6	Moderate stress	Short term	LAA	2002
Columbia River at Bonneville Dam	Intermittent spikes	up to 2 days	9 ppm	5	Minor stress	Short term	NLTAA	n/a
Columbia River at Quincy, OR	Intermittent spikes	up to 2 days	8 ppm	5	Minor stress	Short term	NLTAA	n/a
Surface Erosion (Year one)	**Frequency**	**Duration**	**Worst case exposure**	**SIE Score**	**Bull trout effects**	**Duration of effect**	**Effects call**	
White Salmon River below dam	Sustained	daily averages	22 ppm	8	Major stress	Mid term	LAA	2005
	Intermittent spikes	< 1 day	158 ppm	7	Moderate stress	Very short term	LAA	2005

Columbia River mixing zone	Sustained	daily averages	0.1 ppm	~2	Behavioral	Mid term	NLTAA	n/a
	Intermittent spikes	< 1 day	1.1 ppm	3	Behavioral	Very short term	NLTAA	n/a
Columbia River at Bonneville Dam	Sustained	daily averages	0.1 ppm	~2	Behavioral	Mid term	NLTAA	n/a
	Intermittent spikes	< 1 day	0.5 ppm	2	Behavioral	Very short term	NLTAA	n/a
Columbia River at Quincy, OR	Sustained	daily averages	0.1 ppm	~2	Behavioral	Mid term	NLTAA	n/a
	Intermittent spikes	< 1 day	0.4 ppm	1	Behavioral	Very short term	NLTAA	n/a
Surface Erosion (Year 3-5)	**Frequency**	**Duration**	**Worst case exposure**	**SIE Score**	**Bull trout effects**	**Duration of effect**	**Effects call**	**2002 or 2005 BO?**
White Salmon River below dam	Sustained	daily averages	7 ppm	8	Major stress	Long term	LAA	2005
	Intermittent spikes	< 1 day	62 ppm	6	Moderate stress	Very short term	LAA	2005
Columbia River mixing zone	Sustained	daily averages	0.0 ppm	0	No effect	Long term	No effect	n/a
	Intermittent spikes	< 1 day	0.4 ppm	1	Behavioral	Very short term	NLTAA	n/a
Columbia River at Bonneville Dam	Sustained	daily averages	0.0 ppm	0	No effect	Long term	No effect	n/a
	Intermittent spikes	< 1 day	0.2 ppm	1	Behavioral	Very short term	NLTAA	n/a
Columbia River at Quincy, OR	Sustained	daily averages	0.0 ppm	0	No effect	Long term	No effect	n/a
	Intermittent spikes	< 1 day	0.2 ppm	1	Behavioral	Very short term	NLTAA	n/a
Floodplain formation (after 5 years)	**Frequency**	**Duration**	**Worst case exposure**	**SIE Score**	**Bull trout effects**	**Duration of effect**	**Effects call**	**2002 or 2005 BO?**
White Salmon River below dam	Intermittent spikes < once per year	~1 day	3,000	9	Major stress	Short term	LAA	2002
Columbia River mixing zone	Intermittent spikes < once per year	~1 day	20 ppm	5	Minor stress	Short term	NLTAA	n/a
Columbia River at Bonneville Dam	Intermittent spikes < once per year	~1 day	9 ppm	5	Minor stress	Short term	NLTAA	n/a
Columbia River at Quincy, OR	Intermittent spikes < once per year	~1 day	8 ppm	5	Minor stress	Short term	NLTAA	n/a

	Duration of effect								
	Very short term - < one day								
	Short term - 1 to 30 days								
	Mid term - One to 12 months								
	Long term - One to five years								
	Very long term - Over five years								
From: G & G Associates. 2004. Condit hydroelectric project removal - sediment behavior analysis report. Prepared for PacifiCorp. Portland, Oregon.									

Effects on bull trout critical habitat

PCE 1 Cool water temperatures

As discussed in our 2002 Opinion, Northwestern Lake is subject to solar warming, resulting in slightly warmer water releases to the bypass reach and below the powerhouse. The reduced flows (15 cfs) in the bypass reach absorb ambient temperatures more readily than the naturally higher river flows so that in summer months, temperatures below the powerhouse can be elevated, rendering this area less suitable for bull trout foraging.

Dam removal will restore the White Salmon River's excellent natural temperature regime to the two miles of stream channel currently inundated by Northwestern Lake and the lower 3.3 miles of river. As discussed in our 2002 Opinion, dam removal will result in sediment releases to the lower river, which will fill numerous pools with sand. This reduction in the amount of thermal refugia habitat in the lower river is temporary, as we expect the sand to erode from the pools within a year or two.

PCE 2 Complex stream channels

The ongoing operation of Condit Dam results in a continuing loss of two miles of mainstem river habitat currently inundated by Northwestern Lake. Ongoing project operations also contribute to simplification of stream channel habitat downstream of the dam because the dam blocks transport of LWD and spawning gravels. Dam removal will allow natural stream processes to occur, which will make possible more complex stream habitats to develop over time.

PCE 3 Good quality substrate

The ongoing operation and presence of the dam blocks the transport of spawning gravels to the lower river. Dam removal will restore these natural sediment transport processes to the lower White Salmon River. We would expect spawning gravels to increase below the dam and above the dam, where the reservoir now exists.

PCE 4 Natural hydrograph

Ongoing project operations and the presence of the dam result in lower flows to the bypass reach, flow fluctuations and higher peak discharges. Dam removal will result in a one time peak flow event of approximately 10,000 cfs which is expected to scour habitats below the dam. Dam removal will restore a natural hydrograph to river flows downstream of the dam.

PCE 5 Springs, seeps and groundwater sources

Effects of project operation on groundwater sources, seeps, and springs are unknown. However, reservoirs can reduce the inflow of groundwater into the water body due to hydrostatic pressure (Bakke, pers comm. 2005). If there is an effect from dam removal on groundwater sources, we would expect it to be beneficial by restoring groundwater inflows to the river.

PCE 6 Migratory corridors

Ongoing project operations means the continuing presence of a complete block to bull trout and anadromous salmon. Dam removal will provide connectivity for bull trout between spawning, rearing and overwintering foraging areas and will restore the forage base for bull trout by reopening access for salmonids to spawning habitat above the dam.

PCE 7 Abundant food base

Ongoing project operations have a continual dampening effect on salmonid production in the basin. Dam removal will result in short-term impacts to the production of forage species in the lower river. However, dam removal will improve all of the dam related factors limiting salmonid production and thereby improve the forage base for bull trout. While the reservoir provides foraging opportunities for bull trout, dam removal will allow bull trout to access foraging areas both upstream and downstream of the reservoir.

PCE 8 Permanent water supply with good water quality

Dam removal will restore flows to the bypass reach below the dam, resulting in a long-term improvement in water quantity in the bypass reach after a temporary period of elevated turbidity due to construction activities. The dam removal activities will increase total suspended solids and turbidity to extreme levels for about one year. Increased TSS levels will occur in short-term spikes due to adjustments of the stream channel to dam removal and storm events, as well as increases in the average daily concentrations. These sediment impacts are temporary and will begin to normalize after the channel has adjusted to dam removal and vegetation has become established on the reservoir slopes.

Indirect Effects and Interrelated and Interdependent Actions

Interrelated and interdependent actions related to dam removal may include changes in white water recreation, recreational and tribal fishing, and land use. Our 2002 Opinion discussed the potential effect of changes in recreational fishing, tribal fishing, and land use, so we will not discuss those topics further. The White Salmon River is a popular destination for whitewater recreational rafting. Rafters currently use Northwestern Lake as a stopping point. After the dam has been removed, rafters may need to find and use different exit points along the river, which could lead to the development of alternative trails and access points. Although alternative trails and access points could be a source of surface erosion and introduce sediments to the river, they are likely to be an alternative, and not additional, source of sediments. We therefore believe the effects would be insignificant to bull trout. Critical habitat PCEs would not be adversely affected because there would be little change, except location, from current conditions.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, 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 the jeopardy determination because they require separate consultation pursuant to section 7 of the Act.

Our 2002 Opinion discussed the cumulative effects on bull trout of modest population growth, road construction, agriculture, and grazing. Since our Opinion was issued, Klickitat County has launched a planning process to evaluate energy development projects in the southern portion of the county and issued a Final Environmental Impact Statement in 2004 (Anchor Environmental 2004). The Klickitat County Energy Overlay area would include parts of the action area in the White Salmon River watershed outside the Wild and Scenic Rivers Area and the Columbia Gorge Scenic Area, which consists of the Northwestern Lake and vicinity.

This area is currently zoned agricultural or rural. Energy development projects may include wind, thermal, gas-fired, solar, and biomass plants, and may result in changes in land use from agricultural to industrial, increased development density, construction of new roads, transmission lines and other infrastructure, water supply and wastewater treatment facilities. Depending upon the type of energy project, impacts could also include increased water withdrawal and increases in water temperature if water is used for cooling an energy facility. These activities and changes in land use are likely to cause increased stormwater runoff, resulting in degradation of the aquatic environment, however, it is unknown the extent to which this would occur as specific plans and locations of sites across the county have not been released. Increases in water temperature, a reduction in water available for stream flows, and increased stormwater runoff would likely make stream habitats less suitable for bull trout or their forage species.

CONCLUSION

Based on the best scientific and commercial data available and after reviewing the current status of the Columbia bull trout and bull trout critical habitat, the environmental baseline for the action area, the analysis of effects of ongoing operations for an additional two years (through October 2008), subsequent dam removal in 2008-2009, and the anticipated cumulative effects, it is the Service's Opinion that the action, as proposed, is not likely to jeopardize the continued existence of the bull trout in the Lower Columbia Recovery Unit or in the listed Columbia River DPS and is not likely to destroy or adversely modify designated critical habitat.

The Service reached these conclusions for the following reasons:

Bull trout

1. The effects of the proposed action are likely confined to the Hood River core population. No other core populations within the Columbia DPS are likely to be affected by this action.

2. The effects of dam removal on individual bull trout in the Columbia mainstem and the White Salmon River will be short term. During intermittent periods of high suspended sediment, bull trout can use other foraging areas in the Columbia River, the mouths of tributaries, or the White Salmon River above Northwestern Lake.

3. The number of bull trout from the Hood River core population exposed to the adverse effects of the action is relatively low.

4. Sediment effects associated with the proposed action in the White Salmon River and the lower Columbia River mainstem are restricted to FMO habitats. At this time there is no evidence to suggest that a spawning population of bull trout exists in the White Salmon or Columbia Rivers.

5. Suspended sediments downstream of Bonneville Dam are so fine that they are not expected to settle in the Columbia River. Therefore, adverse impacts to salmon (bull trout forage species) spawning areas below the dam due to sediment deposition are not expected to occur.

6. The removal of Condit Dam will restore the natural chemical, biological and physical processes of the White Salmon River and help reverse the adverse effects caused by the hydroelectric project.

7. The number of bull trout exposed to the effects of the action is relatively low. These individuals are likely to be from the Hood River core area, one of eight bull trout core areas of the Lower Columbia Geographical Area and two of the 141 subpopulations of the bull trout in the Columbia DPS. The action is unlikely to reduce the number and reproduction of bull trout in the Hood River core area and, therefore, the DPS. The long-term effect would be to increase distribution and numbers due to increased FMO habitat, and spawning and rearing habitat.

Bull trout critical habitat

For a short time, suspended sediment will adversely affect one of the PCEs, i.e., water quality, in designated critical habitat in the White Salmon River. Project removal will result in either no effect or a beneficial effect to the functioning of all eight PCEs in designated critical habitat in the White Salmon River. The short-term adverse effects of project removal will affect a very small proportion of designated critical habitat within the range of the bull trout in the Columbia River DPS and is not anticipated to alter the function and conservation role of the critical habitat for the species.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the 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 that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, 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 FERC and PacifiCorp, and made binding conditions of any license or permit issued, as appropriate, for the exemption of section 7(o)(2) to apply. FERC has a continuing duty to regulate the activity covered by this incidental take statement. If FERC (1) fails to assume and implement the terms and conditions, or (2) fails to require applicants to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or license document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the action agencies must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement.

AMOUNT OR EXTENT OF INCIDENTAL TAKE

Individual Columbia River bull trout are likely to be present in the action area when the proposed action will occur. Because the effects of the action will harass or harm individual fish, take is reasonably certain to occur. The Service anticipates incidental take of bull trout will be difficult to detect or quantify for the following reasons: (1) low likelihood of finding dead or injured juveniles or adults; (2) delayed mortality; (3) rapid rate of fish decomposition; and (4) high probability of scavenging by predators. However, the following level of take of this species can be anticipated by loss of water quantity, forage base, habitat complexity and water quality as a result of activities associated with PacifiCorp's operation of the Condit Hydroelectric Project for two additional years and the subsequent removal of the project in 2008-2009. The location, life form, and life stages affected by that take are also addressed below:

1. Take of all adult and sub-adult migratory bull trout in the 3.3-mile length of the White Salmon River from Condit Dam to the mouth in the form of harass for two years, due to

additional years of operation of the hydroelectric project (from the present to October 2008). This form of take is related to habitat degradation from elevated water temperatures, flow fluctuations, blockage of gravel and LWD transport, and migration blockage. We do not believe that take due to entrainment over the dam (covered in our 2002 Opinion) will occur because the likelihood of current bull trout presence above the dam is very low.

2. Take of all adult and sub-adult migratory bull trout in the 3.3-mile length of the White Salmon River from Condit Dam to the mouth in the form of harass during years 3 to 5 after dam removal, due to elevated suspended sediment levels caused by surface erosion or floodplain formation triggered by extreme storm events. The increased sediment levels are likely to be intermittent and short-term, and could occur during the fall and winter months after dam removal. (Our 2002 Opinion discussed the take associated with years one and two after dam removal).

3. Take of all adult and sub-adult migratory bull trout in the Columbia River from the mixing zone to Puget Island (rm 54) in the form of harm for the first day and harass for up to 30 days after dam removal due to elevated suspended sediment levels associated with rapid draining of the reservoir and river channel formation.

EFFECT OF THE TAKE

In this Opinion, the Service has determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

Due to the incorporation of all necessary conservation measures into the project design, no reasonable and prudent measures or the implementation of terms and conditions are required for the Condit Dam removal and continued project operation for an additional two years.

The Service believes that all adult and sub-adult migratory bull trout associated with approximately 3.3 miles of the White Salmon River and approximately 120 miles of the Columbia River downstream to Puget Island will be incidentally taken as a result of the proposed action. The conservation measures and project design as described in this document are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, e.g., as could occur from a change in the project description, such incidental take represents new information requiring reinitiation of consultation. The Federal Energy Regulatory Commission must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the conservation measures or the development of reasonable and prudent measures.

The Service is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest Service Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the Service Law Enforcement Office at (425) 883-8122, or the Service's Western Washington Fish and Wildlife Office at (360) 753-9440.

CONSERVATION RECOMMENDATIONS

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

> Develop an analysis of sediment transport dynamics as they actually occur, post dam removal, to verify that the assumptions and modeling of the sediment behavior analysis are valid and to enable better predictions of future dam removal impacts on bull trout and other salmonids.

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

REINITIATION NOTICE

This concludes reinitiation of formal consultation on both the operation of PacifiCorp's Condit Hydroelectric Project from the present until October 2008 and its removal in 2008-2009, in response to FERC's December 1, 2004, request for reinitiation of consultation. As provided in 50 CFR §402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (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 that was 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.

Questions about this Opinion should be directed to Lou Ellyn Jones or Craig Hansen at (360) 753-9440.

REFERENCES AND LITERATURE CITED

Allendorf, F.W. 1983. Isolation, gene flow, and genetic differentiation among populations. Pages 51-65 *in* C. Schonewald-Cox, S. Chambers, B. MacBryde, and L. Thomas (eds). Genetics and Conservation. Benjamin and Cummings, Menlo Park, CA.

Allendorf, F.W. and N. Ryman. 2002. The role of genetics in population viability analysis. Pages 50-85 *in* S.R. Beissinger and D.R. McCullough (eds). Population Viability Analysis. The University of Chicago Press, Chicago, IL.

Anchor Environmental, L.L.C. 2004. Klickitat County energy overlay final environmental impact statement. Prepared for Klickitat County.

Batt, P.E. 1996. State of Idaho bull trout conservation plan. Office of the Governor, Boise, ID. 20pp.

Baxter, C.V. 2002. Fish Movement and Assemblage Dynamics in a Pacific Northwest Riverscape. Ph.D. Dissertation, Oregon State University, Corvallis, OR. 174 pp.

Baxter, C.V., C.A. Frissell, and F.R. Hauer. 1999. Geomorphology, Logging Roads, and the Distribution of Bull Trout Spawning in a Forested River Basin: Implications for Management and Conservation. Transactions of the American Fisheries Society 128:854-867.

Baxter, J.S., and J.D. McPhail. 1999. The influence of redd site selection, groundwater upwelling, and over-winter incubation temperature on survival of bull trout (*Salvelinus confluentus*) from egg to alevin. Canadian Journal of Zoology/Revue Canadien de Zoologie 77:1233-1239.

Behnke, R.J. 2002. Trout and salmon of North America. George Scott (ed). Free Press, New York, NY 384pp.

Berg, R.K., and E.K. Priest. 1995. Appendix Table 1: A list of stream and lake fishery surveys conducted by U.S. Forest Service and Montana Fish, Wildlife and Parks fishery biologists in the Clark Fork River drainage upstream of the confluence of the Flathead River the 1950's to the present. Montana Fish, Wildlife, and Parks, Job Progress Report, Project F-78-R-1, Helena, MT.

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. Pages 191-232 *in* E.D. Salo and T.W. Cundy (eds). Streamside Management Forestry and Fisheries Interactions. Institute of Forest Resources, University of Washington, Seattle, WA, Contribution No. 57.

Boag, T.D. 1987. Food habits of bull char, *Salvelinus confluentus*, and rainbow trout, *Salmo gairdneri*, coexisting in a foothills stream in northern Alberta. Canadian Field-Naturalist 101: 56-62.

Bond, C.E. 1992. Notes on the nomenclature and distribution of the bull trout and the effects of human activity on the species. Pages 1-4 *in* P.J. Howell, and D.V. Buchanan (eds). Proceedings of the Gearhart Mountain Bull Trout Workshop, Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Bonneau, J.L., and D.L. Scarnecchia. 1996. Distribution of juvenile bull trout in a thermal gradient of a plunge pool in Granite Creek, Idaho. Transactions of the American Fisheries Society 125: 628-630.

Brewin, P.A., M.K. Brewin, and M. Monita. 1997. Distribution maps for bull trout in Alberta. Pages 206-216 *in* W.C. Mackay, M.K. Brewin, and M. Monita (eds). Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

Brown, L.G. 1992. On the zoogeography and life history of Washington native char Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*). Washington Department of Wildlife, Fisheries Management Division Report, Olympia, WA.

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

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

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

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

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

Chamberlain, T. W., R. D. Harr, and F. H. Everest. 1991. Timber harvesting, silviculture and watershed processes. Pages 181-205 *in* W. R. Meehan (ed). Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

Conley, J.M. 1993. Bull trout management plan. Idaho Department of Fish and Game, Boise, ID. April 1993.

Craig, S.D., and R.C. Wissmar. 1993. Habitat conditions influencing a remnant bull trout spawning population, Gold Creek, Washington (draft report). Fisheries Research Institute, University of Washington. Seattle, WA.

Crane, P.A., L.W. Seeb, and J.E. Seeb. 1994. Genetic relationships among *Salvelinus* species inferred from allozyme data. Canadian Journal of Fisheries and Aquatic Science 51:182-197.

Donald, D.B., and D.J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Canadian Journal of Zoology/Revue Canadien de Zoologie 71:238-247.

Dunham, J.B., and B.E. Rieman. 1999. Metapopulation structure of bull trout: Influences of physical, biotic, and geometrical landscape characteristics. Ecological Applications 9:642-655.

FERC (Federal Energy Regulatory Commission). 1996. Final environmental impact statement Condit hydro electric project Skamania and Klickitat Counties, WA. FERC No. 2342. Washington DC.

FERC (Federal Energy Regulatory Commission). 2002. Final supplemental final environmental impact statement Condit hydroelectric project FERC No. 2342. Washington, DC.

Ferguson, J.W., G.M. Matthews, R.L. McComas, R.F. Absolon, D.A. Brege, M.H. Gessel, and L.G. Gilbreath. 2005. Passage of adult and juvenile salmonids through federal Columbia River power system dams. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-64, *160 p*.

Flatter, B. 1998. Life history and population status of migratory bull trout (*Salvelinus confluentus*) in Arrowrock Reservoir, Idaho. Prepared for U.S. Bureau of Reclamation by Idaho Department of Fish and Game, Nampa, ID.

Fraley, J.J., and B.B. Shepard. 1989. Life history, ecology and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and river system, Montana. Northwest Science 63:133-143.

Frankham, R. 1995. Effective population size/adult population size ratios in wildlife: a review. Genetical Research 66:95-107.

Franklin, I.A. 1980. Evolutionary changes in small populations. Pages 135-150 *in*: Soulé

M. and B.A. Wilcox (eds). Conservation Biology: an evolutionary-ecological perspective. Sinauer Associates, Sunderland, MA.

Franklin, I.R. and R. Frankham. 1998. How large must populations be to retain evolutionary potential? Animal Conservation 1:69-70.

Frissell, C.A. 1997. A spatial approach to species viability: Conservation of fishes in the Columbia River Basin. Biological Station Open File Report Number 101-97. Flathead Lake Biological Station, University of Montana, Polson, MT.

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

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Road construction and maintenance. American Fisheries Society Special Publication 19:297-323.

Gamett, B. 1999. The history and status of fishes in the Little Lost River drainage, Idaho. Salmon-Challis National Forest, Idaho Department of Fish and Game, U.S. Bureau of Land Management, Sagewillow, Inc. May 1999 draft.

Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus*, literature review. U.S. Department of Agriculture, U.S. Forest Service, Willamette National Forest, Eugene, OR.

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

Gresswell, R.E. 1999. Fire and aquatic ecosystems in forested biomes of North America. Transactions of the American Fisheries Society 128:193-221.

Grewe, P.M., N. Billington, and P.D.N. Hebert. 1990. Phylogenetic relationships among members of *Salvelinus* inferred from mitochondrial DNA divergence. Canadian Journal of Fisheries and Aquatic Science 47:984-991.

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

Hanski, I. and M.E. Gilpin. 1997. Metapopulation Biology: Ecology, Genetics and Evolution. Academic Press, London, UK. 512 pp.

Hard, J. 1995. A quantitative genetic perspective on the conservation of intraspecific diversity. American fisheries Society Symposium 17:304-326.

Haring D. 2003. Addendum to Wind/White Salmon water resource inventory area 29 salmonid habitat limiting factors analysis (originally issued July 1999) White Salmon River watershed. A report prepared for the Washington Conservation Commission April 2003.

Healy, M.C. and A. Prince. 1995. Scales of variation in life history tactics of Pacific salmon and the conservation of phenotype and genotype. American Fisheries Society Symposium 17:176-184.

Hedrick, P.W. and S. T. Kalinowski. 2000. Inbreeding depression in conservation biology. Annual Review of Ecology and Systematics 31:139-162.

Henjum, M.G., J.R. Karr, D.L. Bottom, D.A. Perry, J.C. Bednarz, S.G. Wright, S.A. Beckwitt, and E. Beckwitt. 1994. Interim protection for late-successional forests, fisheries, and watersheds. National forests east of the Cascade Crest, Oregon, and Washington. A report to the Congress and President of the United States Eastside Forests Scientific Society Panel. American Fisheries Society, American Ornithologists Union Incorporated, The Ecological Society of America, Society for Conservation Biology, The Wildlife Society. The Wildlife Society Technical Review 94-2.

Hiss, J., T. Lawson, and K. Meyer. 2000. Gifford Pinchot National Forest bull trout consultation baseline. Version 6.2. Unpublished agency report. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, Washington, and U.S. Forest Service, Gifford Pinchot National Forest, Vancouver, WA.

Hoelscher, B., and T.C. Bjornn. 1989. Habitat, density and potential production of trout and char in Pend Oreille Lake tributaries. Project F-71-R-10, Subproject III, Job No. 8. Idaho Department of Fish and Game, Boise, ID.

Howell, P.J., and D.V. Buchanan. 1992. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Jakober, M. 1995. Autumn and winter movement and habitat use of resident bull trout and west slope cutthroat trout in Montana. M.S. Thesis, Montana State University, Bozeman, Montana.

Johnson, G.L. 1990. Bull Trout Species Management Plan. Nevada Department of Wildlife. Federal Aid Project No. F-20-26, Job No. 207.4.

Kanda, N., R., Leary, and F. W. Allendorf. 1997. Population genetic structure of bull trout in the upper Flathead River drainage. Pages 299-308 *in* W.C. Mackay, M.K. Brewin and M. Monita (eds). Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

Leary, R.F., F.W. Allendorf, and S.H. Forbes. 1993. Conservation genetics of Bull trout in the Columbia and Klamath River drainages. Conservation Biology 7:856-865.

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

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

Lynch, M. and R. Lande. 1998. The critical effective size for a genetically secure population. Animal Conservation 1:70-72.

McPhail, J.D., and J.S. Baxter. 1996. A review of bull trout (*Salvelinus confluentus*) life-history and habitat use in relation to compensation and improvement opportunities. Department of Zoology, University of British Columbia. Fisheries Management Report No. 104. Vancouver, British Columbia, Canada.

Meffe, G.K., and C.R. Carroll. 1994. Principles of conservation biology. Sinauer Associate, Inc. Sunderland, MA.

Miller, P.S. and R.C. Lacy. 1999. VORTEX: a stochastic simulation of the extinction process. Version 8 user's manual. Conservation breeding specialists group (SSC/IUCN), Apple Valley, MN.

MBTRT (Montana Bull Trout Restoration Team). 2000. Restoration plan for bull trout in the Clark Fork River basin and Kootenai River basin Montana. Montana Fish, Wildlife and Parks, Helena, MT. June 2000.

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

MBTSG (Montana Bull Trout Scientific Group). 1995b. Bitterroot River drainage bull trout status report. Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1995c. Blackfoot River drainage bull trout status report. Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1995d. Flathead River drainage bull trout status report (including Flathead Lake, the North and Middle forks of the Flathead River and the Stillwater and Whitefish River). Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1995e. South Fork Flathead River drainage bull trout status report (upstream of Hungry Horse Dam). Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1996. Assessment of methods for removal or suppression of introduced fish to aid in bull trout recovery. A report prepared for the Montana Bull Trout Restoration Team c/o Montana Fish, Wildlife, and Parks. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1996a. Swan River drainage bull trout status report (including Swan Lake). Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1996b. Lower Clark Fork River drainage bull trout status report (Cabinet Gorge Dam to Thompson Falls). Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1996c. Middle Clark Fork River drainage bull trout status report (from Thompson Falls to Milltown, including the lower Flathead River to Kerr Dam). Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1996d. Lower Kootenai River drainage bull trout status report (below Kootenai Falls). Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1996e. Middle Kootenai River drainage bull trout status report (between Kootenai Falls and Libby Dam). Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1996f. Upper Kootenai River drainage bull trout status report (including Lake Koocanusa, upstream of Libby Dam). Prepared for Montana Bull Trout Restoration Team. Helena, MT.

MBTSG (Montana Bull Trout Scientific Group). 1998. The relationship between land management activities and habitat requirements of bull trout. Prepared for Montana Bull Trout Restoration Team. Helena, MT.

Moyle, P.B. 1976. Inland Fishes of California. University of California Press, Berkeley, CA.

Nehlsen, W., J. Williams, and J. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(02):4-21.

Newton, J.A., and S. Pribyl. 1994. Bull trout population summary: Lower Deschutes River sub basin. Oregon Department of Fish and Wildlife, The Dalles, Oregon. Oregon administrative rules, proposed amendments to OAR 340-41-685 and OAR 340-41-026. January 11, 1996.

Oregon. 1996. Oregon administrative rules, proposed amendments to OAR 340-41-685 and OAR 340-41-026. January 11, 1996.

Oregon. 1997. Coastal Salmon Restoration Initiative. The Oregon Plan. State of Oregon.

PacifiCorp. 2004. Project description: Condit hydroelectric project FERC project no. 2342. Portland, OR.

Phillips, R.B., S.L. Sajdak, and M.J. Domanico. 1995. Relationships among charrs based on DNA sequences. Nordic Journal of Freshwater Research 71:378-391.

Pleyte, K.A., S.D. Duncan, and R.B. Phillips. 1992. Evolutionary relationships of the salmonid fish genus Salvelinus inferred from DNA sequences of the first internal transcribed spacer (ITS 1) of ribosomal DNA. Mol. Phylog. Evol. 1:223-230.

Pratt, K.L. 1985. Pend Oreille trout and char life history study. Idaho Department of Fish and Game in cooperation with the Pend Oreille Idaho Club.

Pratt, K.L. 1992. A review of bull trout life history. Pages 5-9 *in* P.J. Howell, and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Pratt, K.L., and J.E. Huston. 1993. Status of bull trout (*Salvelinus confluentus*) in Lake Pend Oreille and the lower Clark Fork River. Draft report. Prepared for the Washington Water Power Company, Spokane, WA.

Quigley, T.M. and S.J. Arbelbide, tech. editors. 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins: volume III. General Technical Report PNW- GTR-405. U.S. Department of Agriculture, Forest Service, and U.S. Department of Interior, Bureau of Land Management.

Ratliff, D.E. 1992. Bull trout investigations in the Metolius River-Lake Billy Chinook system. Pages 37-44 *in* P. J. Howell and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Ratliff, D.E., and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 *in*: P.J. Howell and D.V. Buchanan (eds). Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Rich, C.F., Jr. 1996. Influence of abiotic and biotic factors on occurrence of resident bull trout in fragmented habitats, western Montana. M.S. Thesis, Montana State University, Bozeman, MT.

Rieman, B.E., and F.W. Allendorf. 2001. Effective population size and genetic conservation criteria for bull trout. North American Journal of Fisheries Management 21:756-764.

Rieman, B., and J. Clayton. 1997. Wildfire and native fish: Issues of forest health and conservation of sensitive species. Fisheries 22:6-14.

Rieman, B.E., and J.B. Dunham. 2000. Metapopulations and salmonids: a synthesis of life history patterns and empirical observations. Ecology of Freshwater Fish 9:1-2.

Rieman, B.E., D.C. Lee, and R.F. Thurow. 1997a. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management. 17:1111-1125.

Rieman, B.E., D. Lee, G. Chandler, and D. Myers. 1997b. Does wildfire threaten extinction for salmonids: responses of redband trout and bull trout following recent large fires on the Boise National Forest. Pages 47-57 *in* J. Greenlee (ed). Proceedings of the symposium on fire effects on threatened and endangered and habitats. International Association of Wildland Fire, Fairfield, WA.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. General Technical Report INT-302. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Rieman, B.E., and J.D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124(3):285-296.

Rieman, B.E., and J.D. McIntyre. 1996. Spatial and temporal variability in bull trout redd counts. North American Journal of Fisheries Management 16:132-141.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.H. Lachner, R.N. Lea, and W.B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. American Fisheries Society Special Publication 12, Bethesda, MD.

Rode, M. 1990. Bull trout, *Salvelinus confluentus suckley*, in the McCloud River: status and recovery recommendations. Administrative Report Number 90-15. California Department of Fish and Game, Sacramento, CA.

Saunders, D.A., R.J. Hobbs, and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: A review. Conservation Biology 5:18-32.

Schill, D.J. 1992. River and stream investigations. Job Performance Report, Project F-73-R-13. Idaho Department of Fish and Game, Boise, ID.

Sedell, J.R., and F.H. Everest. 1991. Historic changes in pool habitat for Columbia River Basin salmon under study for TES listing. Draft U.S. Department of Agriculture Report, Pacific Northwest Research Station, Corvallis, OR.

Sexauer, H.M., and P.W. James. 1997. Microhabitat use by juvenile trout in four streams located in the eastern Cascades, Washington. Pages 361-370 *in* W.C. Mackay, M.K. Brewin and M. Monita (eds). Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

Simpson, J.C., and R.L. Wallace. 1982. Fishes of Idaho. University Press of Idaho. Moscow, ID.

Soulé, M.E. 1987. Viable Populations for Conservation. Cambridge University Press, Cambridge, UK. 206pp.

Spruell, P., and F. Allendorf. 1997. Nuclear DNA analysis of Oregon bull trout. Final report to the Oregon Department of Fish and Wildlife. Division of Biological Sciences, University of Montana.

Spruell, P., B.E. Rieman, K.L. Knudsen, F.M. Utter, and F.W. Allendorf. 1999. Genetic population structure within streams: microsatellite analysis of bull trout populations. Ecology of Freshwater Fish 8:114-121.

Spruell, P., A.R. Hemmingsen, P.J. Howell, N. Kanda, and F.W. Allendorf. 2003. Conservation genetics of bull trout: Geographic distribution of variation at microsatellite loci. Conservation Genetics 4:17-29.

Swanberg, T. R. 1997. Movements of and habitat use by fluvial bull trout in the Blackfoot River, Montana. Transactions of the American Fisheries Society 126:735-746.

Taylor, B.E., S. Pollard, and D. Louie. 1999. Mitochondrial DNA variation in bull trout (*Salvelinus confluentus*) from northwestern North America: implications for zoogeography and conservation. Molecular Ecology 8:1155-1170.

Thomas, G. 1992. Status of bull trout in Montana. Report prepared for Montana Department of Fish, Wildlife and Parks, Helena, MT.

USDA (U.S. Department of Agriculture). 1995. Inland Native Fish Strategy Environmental Assessment. Forest Service, Intermountain, Northern, and Pacific Northwest Regions.

USDA (U.S. Department of Agriculture), and USDI (U.S. Department of the Interior). 1995. Decision Notice/Decision Record Finding of No Significant Impact, Environmental Assessment for the Interim Strategies for Managing Anadromous Fish-producing Watersheds in Eastern Oregon, and Washington, Idaho, and portions of California (PACFISH).

USDA (U.S. Department of Agriculture), and USDI (U.S. Department of the Interior). 1996. Status of the Interior Columbia Basin, Summary of Scientific Findings.

USDA (U.S. Department of Agriculture), and USDI (U.S. Department of the Interior). 1997. Interior Columbia River Basin Ecosystem Management Project, Upper Columbia River Basin Draft Environmental Impact Statement. Vol I., Vol II, Vol III.

USDI (United States Department of Interior). 1998. Endangered and threatened wildlife and plants; determination of threatened status for the Klamath River and Columbia River Distinct Population Segments of bull trout. U.S. Fish and Wildlife Service. June 10, 1998. Federal Register Vol. 64(111): 31647-31674.

USDI (U.S. Department of Interior). 2004. Endangered and threatened wildlife and plants, designation of critical habitat for the Klamath River and Columbia River populations of bull trout; final rule. 50 CFR Part 17.

USDI (U.S. Department of Interior). 2005. Endangered and threatened wildlife and plants, designation of critical habitat for the bull trout; final rule. 50 CFR Part 17.

USFS (U.S. Forest Service). 2001a. Bull trout survey report submitted to U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, Washington. February 2001. U.S. Forest Service, Gifford Pinchot National Forest, Vancouver, WA.

USFS (U.S. Forest Service). 2003. Biological Assessment. USDA Forest Service programmatic activities affecting Columbia River and Coastal-Puget Sound Bull Trout, Lower Columbia River Steelhead, Middle Columbia River Steelhead, Puget Sound Chinook Salmon, Lower Columbia River Chinook Salmon, Lower Columbia Southwest Washington Coho, Columbia River Chum, Proposed Critical Habitat for Bull Trout, and Essential Fish Habitat – Gifford Pinchot National Forest - Columbia River Gorge National Scenic Area, Washington. Gifford Pinchot National Forest, Vancouver, WA. October, 2003.

USFWS (U.S. Fish and Wildlife Service). 1998. Klamath River and Columbia River bull trout population segments: status summary and supporting document lists. Prepared by the Bull Trout Listing Team.

USFWS (U.S. Fish and Wildlife Service). 2002. Biological Opinion for Condit Hydroelectric Project (P-2342) (FWS Reference: 1-3-02-F-0839), for Columbia River distinct population segment (DPS) of bull trout (*Salvelinus confluentus),* Skamania and Klickitat Counties, Washington. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, Lacey, WA.

USFWS (U.S. Fish and Wildlife Service). 2002a. Bull trout (*Salvelinus confluentus*) draft recovery plan. Chapters 1 5, 6, 7, & 20. U.S. Fish and Wildlife Service, Portland, OR.

USFWS (U.S. Fish and Wildlife Service). 2002c. Biological and Conference Opinion for the Columbia River channel improvements project. U.S. Fish and Wildlife Service, Oregon State Office, Portland, OR.

USFWS (U.S. Fish and Wildlife Service). 2004. Biological Opinion for USDA Forest Service Programmatic Activities affecting Columbia River and Coastal-Puget Sound bull trout and proposed and designated bull trout critical habitat on the Gifford Pinchot National Forest and Columbia River Gorge National Scenic Area in Washington 2004-2009. Reference No. 1-3-04-PF-0943 and 1-3-04-C-0944. U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office. October 2004.

USFWS (U.S. Fish and Wildlife Service). 2004a. Biological and Conference Opinion on the effects to the bull trout *(Salvelinus confluentus)* and bull trout proposed critical habitat from continued implementation of Forest Service Land and Resource Management Plans and Bureau of Land Management Resource Management Plans as amended by the 1994 Northwest Forest Plan Record of Decision as amended by the October 24, 2003, Supplemental Environmental Impact Statement regarding Aquatic Conservation Strategy Clarification Amendments to the 1994 Northwest Forest Plan Record of Decision. USDI Fish and Wildlife Service. Pacific Regional Office, Oregon Fish and Wildlife Office, Western Washington Fish and Wildlife Office. January 9, 2004.

USFWS (U.S. Fish and Wildlife Service). 2004b. Biological and conference opinion on the effects to the bull trout (*Salvelinus confluentus*) and bull trout proposed critical habitat from continued implementation of Forest Service Lland and Resource Management Plans and Bureau of Land Management Resource Management Plans as amended by the 1994 Northwest Forest Plan Record of Decision as amended by the October 24, 2003 Supplemental Environmental Impact Statement regarding Aquatic Conservation Strategy Clarification Amendments to the 1994 Northwest Forest Plan record of decision. U.S. Fish and Wildlife Service, Pacific Regional Office, Oregon Fish and Wildlife Office, Western Washington Fish and Wildlife Office. January 9, 2004, revised March 18, 2004.

USFWS and NMFS (U.S. Fish and Wildlife Service and National Marine Fisheries Service). 1998. Consultation handbook: procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act. Final Issued March 1998.

USGS (U.S. Geological Survey). 1996. Water quality of the lower Columbia River basin: analysis of current and historical water-quality data through 1994. Water-Resources Investigations Report 95-4294 prepared in cooperation with the Lower Columbia River Bi-State Water-quality Program. Portland, OR.

Waples, R.S. 2002. Definition and estimation of effective population size in the conservation of endangered species. Pages 147-168 *in* S.R. Beissinger and D.R. McCullough (eds). Population Viability Analysis. The University of Chicago Press, Chicago, IL.

Watson, G., and T. W. Hillman. 1997. Factors affecting the distribution and abundance of bull trout: An investigation at hierarchical scales. North American Journal of Fisheries Management 17:237-252.

WDFW (Washington Department of Fish and Wildlife). 1997. Grandy Creek trout hatchery biological assessment. FishPro Inc., and Beak Consultants.

WDFW (Washington Department of Fish and Wildlife). 1998. Washington State salmonid stock draft inventory: bull trout/Dolly Varden. Washington Department of Fish and Wildlife, Olympia, WA 437 pp.

WDFW (Washington Department of Fish and Wildlife). 2000. Bull trout population assessment in the Columbia River Gorge. FY-2000 annual report. Vancouver, WA.

Whiteley, A. R., P. Spruell, and F.W. Allendorf. 2003. Population genetics of Boise Basin bull trout (*Salvelinus confluentus*). Final report to Rocky Mountain Research Station, Contract:RMRS # 00-JV-1122014-561.

Williams, R. N., R. P. Evans, and D. K. Shiozawa. 1995. Mitochondrial DNA diversity in bull trout from the Columbia River basin. Idaho Bureau of Land Management Technical Bulletin No. 95-1.

Williams, R. N., R. P. Evans, and D. J. Shiozawa. 1997. Mitochondrial DNA diversity in bull trout from the Columbia River basin. Pages 283-297 *in* W.C. Mackay, M.K. Brewin, and M. Monita (eds). Friends of the Bull Trout Conference Proceedings. Bull Trout Task Force (Alberta), c/o Trout Unlimited Calgary, Alberta, Canada.

Wright, S. 1931. Evolution of Mendelian populations. Genetics 16:97-159.

Ziller, J. S. 1992. Distribution and relative abundance of bull trout in the Sprague River sub basin, Oregon. Pages 18-29 *in* P.J. Howell, and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Personal Communication

Jim Byrne, Biologist, Washington State Department of Fish and Wildlife, Vancouver, Washington. March 23, 2005 and April 5, 2005 telephone conversation with Lou Ellyn Jones, USFWS, regarding bull trout in the mainstem Lower Columbia River.

Bakke, Paul. Fluvial geomorphologist, USFWS. May 13, 2005 discussion with Lou Ellyn Jones, USFWS, regarding the effects of dam removal on groundwater sources to a reservoir.

Garrett, Mark. Wildlife Biologist, PacifiCorp. September 19, 2005 telephone conversation with Lou Ellyn Jones, USFWS, regarding the revegetation of reservoir slopes after the 1996 flood event.

Werdon, S. 1998. Personal conservation on August 5, 1998, between Selena Werdon, U.S. Fish and Wildlife Service, Reno, Nevada, and Sam Lohr, U.S. Fish and Wildlife Service, Boise, Idaho, concerning bull trout observed by survey teams during the *Salvelinus confluentus* Curiosity Society meeting August 4-6.

In litt. References

Dennis Gathard, G & G Associates. Electronic mail dated 5/23/05, to Lou Ellyn Jones, USFWS regarding USGS streamgage data from the lower Columbia River used in the Sediment Behavior analysis report.

Gilpin, M., University of California. 1997. Bull trout connectivity on the Clark Fork River, letter to Shelly Spalding, Montana Department of Fish, Wildlife and Parks, Helena, Montana. 5 pp.

IDFG (Idaho Department of Fish and Game). 1995. List of streams compiled by IDFG where bull trout have been extirpated, fax from Bill Horton, IDFG.

Adrianne Poindexter, PacifiCorp. Electronic mail dated 7/21/05, to Lou Ellyn Jones, USFWS regarding sediment quality testing in Northwestern Lake.

Bianca Streif. USFWS. Electronic mail dated 3/23/05, to Jeff Chan, USFWS regarding bull trout observation at the Bonneville fish passage facility by Dean Ballinger at the Pacific States Marine Fisheries Commission Smolt Monitoring Program.

Werdon, S., U.S. Fish and Wildlife Service. 2001. Email message concerning bull trout observed in Dave Creek, Jarbidge River basin, during temperature monitoring survey conducted in 1999.

John A. Young. USFWS. Electronic mail dated 4/4/05, to Lou Ellyn Jones, USFWS regarding bull trout information in Lower Columbia mainstem.

APPENDIX A: SEDIMENTATION

Last updated April 6, 2005

The general impacts of sedimentation or the effects that sediment has within an aquatic system are well known. However, when a biologist is reviewing a biological assessment (BA) or biological evaluation (BE) for a section 7 consultation, an effects determination needs to be made based on the data or information provided. In most cases, the information is not supplied or is not available for the biologist to conduct a thorough review and make that vital link between the project and the effect on listed fishes, specifically bull trout (*Salvelinus confluentus*), and their habitat.

The information that is needed by the biologist is very specific and is usually unknown by the action agency. The specific information needed relates to the physical and biological effects of sediment in a stream. The physical questions include:

1. Will the project result in increased sediment input into the stream?
2. How much sediment will result and for what duration?
3. How far downstream will the sediment move?

Based on these physical questions, the biological effects to listed fish species then need to be determined. The biological questions include:

1. What levels of sedimentation cause adverse effects?
2. What are the biological effects of sediment on fish and their habitat (the rationale to support the "take")?
3. What life stage(s) are affected by the sediment input?

OBJECTIVES

The objectives of this document are to answer the biological questions related to sediment effects on fish. However, because of the interrelationship between the physical and biological processes related to sediment, parts of the physical questions may be addressed. Paul Bakke, has been asked to address the physical questions and his information will be incorporated into this document. This document will be a "living document" that will be continuously updated as new physical and biological information, data, and literature are obtained and reviewed. This document will be useful to those biologists reviewing BAs and BEs to help in determining project related impacts from sediment and the effects on bull trout.

It was not the intent of the document to conduct a thorough literature review on the subject. Currently there are at least 19 major reviews on sediment impacts or effects on fish, invertebrates, and primary production (Waters 1995). Pertinent literature was reviewed to obtain the background information needed to answer the biological questions. As further documents are reviewed, the content of this document can be expanded to strengthen any section.

SEDIMENT CLASSIFICATIONS AND DEFINITIONS

Sediment within a stream can be classified into a variety of different categories: turbidity, suspended sediment, bedload, deposited sediment, and wash load (Waters 1995; Bash et al. 2001). Geomorphologists may classify sediment differently than a fisheries biologist. Sediment category definitions include:

- Turbidity - Optical property of water which results from the suspended and dissolved materials in the water that cause light to be scattered rather than transmitted in straight lines. Turbidity is measured in nephelometric turbidity units (NTUs). Measurements of turbidity can quickly estimate the amount of sediment within a sample of water.
- Suspended sediment - Represents the actual measure of mineral and organic particles transported in the water column. Suspended sediment is measured in mg/l and is an important measure of erosion, and is linked to the transport of nutrients, metals, and industrial and agricultural chemicals through the river system.
- Bedload - Consists of larger particles on the stream bottom that move by sliding, rolling, or saltating along the substrate surface. Bedload is measured in tons/day, or tons/year.
- Deposited sediment - The intermediate sized sediment particles that settle out of the water column in slack or slower moving water. Based on water velocity and turbulence, these intermediate size particles may be suspended sediment or bedload.
- Wash load - Finest particles in the suspended load that are continuously maintained in suspension by the flow turbulence, and thus, significant quantities are not found in the bed.

Suspended sediment, turbidity, and deposited sediment should not be considered mutually exclusive as to particle size, because they will overlap considerably depending on velocity, turbulence, and gradient (MacDonald et al. 1991; Waters 1995). Turbidity cannot always be correlated with suspended solid concentrations due to the effects of size, shape and refractive index of particles (Bash et al. 2001). Turbidity and suspended sediment affect the light available for photosynthesis, visual capability of aquatic animals, gill abrasion and physiological effects to fish. Suspended and deposited sediment affect the habitat available for macroinvertebrates, quality of gravel for fish spawning, and amount of habitat for fish rearing (Waters 1995).

The size of particles within the stream is also important. The quantity of "fines" within a stream ecosystem usually is associated with degradation of a fish population (Castro and Reckendorf 1995). Particle diameters less than 6.4 mm are generally defined as "fines" (Bjornn et al. 1977; Bjornn and Reiser 1991; Shepard et al. 1984; Hillman et al. 1987; Chapman 1988; Reiman and McIntyre 1993; Castro and Reckendorf 1995; MBTRT 1998).

DOCUMENTS AND BACKGROUND INFORMATION

In determining the overall impact of a project on bull trout, and to specifically understand whether increased sediment may adversely affect bull trout, the biologist will need to review specific information relating to the watershed and stream in which the project is located.

Important documents to review include:

1. Washington State Conservation Commission's Limiting Factors Analysis. The 1998 Washington State Legislative session produced a number of bills aimed at salmon recovery. One bill was to identify the limiting factors to salmonid populations within watersheds in Washington State. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon." Limiting factors analyses have been developed for numerous watersheds. The status of the limiting factors analyses for each Water Resource Inventory Area (WRIA) can be found at http://salmon.scc.wa.gov. The Endangered Species Division has final copies of completed documents.

2. Washington Department of Fish and Wildlife's (1998) Salmonid Stock Inventory (SaSI). The Washington Department of Fish and Wildlife (WDFW) inventoried bull trout and Dolly Varden (*S. malma*) stock status throughout the State. The intent of the inventory is to help identify available information and to guide future restoration planning and implementation. SaSI defines the stock within the watershed, life history forms, status and factors affecting production. Spawning distribution and timing for different life stages are provided (migration, spawning, etc.), if known.

3. U.S. Fish and Wildlife Service's (USFWS 1998a) Matrix of Diagnostics/Pathways and Indicators (MPI). The MPI was designed to facilitate and standardize determination of project effects on bull trout. The MPI provides a consistent, logical line of reasoning to aid in determining when and where adverse affects occur and why they occur. The MPI provides levels or values for different habitat indicators to assist the biologist in determining the level of effects or impacts to bull trout from a project and how these impacts may cumulatively change habitat within the watershed.

4. Individual Watershed Resources. Other resources may be available within a watershed that will provide information on habitat, fish species, and recovery and restoration activities being conducted. The action agency may cite a publication or identify a local watershed group within the BA or BE. These local groups provide valuable information specific to the watershed.

5. Washington State Department of Ecology (DOE) - The DOE has long and short-term water quality data for different streams within the State. Data can be found at www.ecy.wa.gov/programs/eap/fw_riv/rv_main. Clicking on a stream or entering a stream name will provide information on current and past water quality data. This information will be useful for determining the specific turbidity/suspended sediment relationship for that stream (more information below).

6. Washington State Department of Ecology (DOE) - The DOE has also been collecting benthic macroinvertebrates and physical habitat data to describe conditions under natural and anthropogenic disturbed areas. Data can be found at

www.ecy.wa.gov/programs/eap/fw_benth/93-98. Clicking on a stream or entering a stream name will provide habitat and macroinvertebrate data.

7. U.S. Forest Service, Watershed Analysis Documents - The U.S. Forest Service (USFS) is required by the Record of Decision for Amendments to the USFS and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl to conduct a watershed analysis for watersheds located on FS lands. The watershed analysis determines the existing condition of the watershed and makes recommendations for future projects that move the landscape towards desired conditions. Watershed analysis documents are available from individual National Forests or from the Forest Plan Division.

8. U.S. Fish and Wildlife Service - Bull Trout Recovery Plans and Critical Habitat Designations. The draft Bull Trout Recovery Plan for the Columbia River Distinct Population Segment (DPS) (also the Jarbidge River and the St. Mary-Belly River DPS) and the proposed critical habitat designations provide current species status, habitat requirements, and limiting factors for bull trout within specific individual recovery units. These documents are available from the Endangered Species Division as well as the Service's web page (www.fws.gov).

These documents and websites will provide baseline and background information on the current stream and watershed conditions. This information is critical to determining future sediment impacts to the aquatic system. A stream has a natural amount of sediment that is transported through the system. The amount of sediment is based on numerous factors: precipitation, topography, geology, streamflow, riparian vegetation, stream geomorphological characteristic, human disturbance, etc (Bash et al. 2001). However, the baseline or background levels need to be analyzed with respect to the limiting factors within the watershed.

Different watersheds have different levels of turbidity or suspended sediment. A glaciated stream will have higher sediment levels than a spring fed stream. Aquatic organisms have adapted to the natural variation in sediment load that occurs seasonally within the stream (ACMRR 1976; Birtwell 1999). Field experiments have found a thirty-fold increase in tolerance of fish to suspended solids between August and November when naturally occurring concentration are expected to be high (Cederholm and Reid 1987). The questions are determining whether this natural seasonal variation in sediment has been altered due to human disturbances and whether additional input of sediment may result in increased bull trout impacts.

The introduction of sediment at levels in excess of natural amounts can have multiple adverse affects on channel conditions and bull trout (Rhodes et al. 1994). The effect of sediment beyond natural background conditions can be fatal at high levels. Low levels may result in sublethal effects such as loss or reduction of foraging capability, reduced growth, and reduced resistance to disease, increased stress, and interference with orientation in homing and migration (McLeay et al 1987; Newcombe and McDonald 1991; Bash et al. 2001).

Work-timing windows are usually incorporated into projects to minimize construction impacts to fish. Work-timing windows are time periods when salmonids are at a stage in their life cycle when they are least sensitive to disturbances or are least likely to be present. This is typically outside of the spawning or egg incubating period. Work-timing windows allow the fish to either move away from impacts or to better cope with short term, minimal changes to the habitat and/or decreased water quality. The work-timing windows are usually in July through September. This time may reduce impacts to spawning fish and egg incubating periods, but may exacerbate impacts to juveniles, sub-adults, and adults. Protective mucous secretions are inadequate during the summer months, when natural sediment levels are low in a stream system, and thereby sediment introduction at this time may increase fish risk to stress and disease (Bash et al. 2001).

BIOLOGICAL EFFECTS OF SEDIMENT ON BULL TROUT

Classification of Sediment Effects

In the absence of detailed local information on population dynamics and habitat use, any increase in the proportion of fines in substrates should be considered a risk to the productivity of an environment and to the persistence of associated bull trout populations (Rieman and McIntyre 1993). Specific effects of sediment on fish and their habitat can be put into three classes that include (Newcombe and MacDonald 1991; Waters 1995; Bash *et al.* 2001):

Lethal: Direct mortality to any life stage, reduction in egg-to-fry survival, and loss of spawning or rearing habitat. These effects damage the capacity of the ecosystem to produce fish and future populations.

Sublethal: Reduction in feeding and growth rates, decrease in habitat quality, reduced tolerance to disease and toxicants, respiratory impairment, and physiological stress. While not leading to immediate death, may produce mortalities and population decline over time.

Behavioral: Avoidance and distribution, homing and migration, and foraging and predation. Behavioral effects change the activity patterns or alter the kinds of activity usually associated with an unperturbed environment. Behavior effects may lead to immediate death or population decline or mortality over time.

Aquatic systems are complex interactive systems, and isolating the effects of sediment to fish is difficult (Castro and Reckendorf 1995). Environmental factors affecting sedimentation impacts on salmonids include duration of exposure, frequency of exposure, toxicity, temperature, life stage of fish, angularity and size of particle, severity/magnitude of pulse, time of occurrence, general condition of biota, and availability of and access to refugia (Bash et al. 2001). The difficulty in determining which environmental variables act as limiting factors has made it difficult to establish the specific effects of sediment impacts on fish (Chapman 1988). For example, excess fines in the spawning gravels may not lead to smaller populations of adults if the amount of juvenile winter habitat limits the number of juveniles that reach adulthood. Often there are multiple independent variables with complex inter-relationships that can influence population size.

The ecological dominance of a given species is often determined by environmental variables. A chronic input of sediment could tip the ecological balance in favor of one species in mixed salmonid populations or in species communities composed of salmonids and nonsalmonids (Everest et al. 1987). Bull trout have more spatially restrictive biological requirements at the individual and population levels than other salmonids (USFWS 1998b). Therefore, they are especially vulnerable to environmental changes such as sediment deposition.

Bull trout are apex predators that prey on a variety of species including terrestrial and aquatic insects and fish (Reiman and McIntyre 1993). Fish are common in the diet of individual bull trout that are over 110 millimeters or longer. Large bull trout may feed almost exclusively on fish. Therefore, when analyzing impacts of sediment on bull trout, it is very important to consider other fish species. While sediment may not directly impact bull trout, the increased sediment input may affect the spawning and population levels of Chinook and coho salmon, cutthroat trout, and steelhead, which are potential prey species for bull trout. The following effects of sediment are not just bull trout specific. All salmonids can be affected similarly.

Direct effects

Gill trauma

High levels of suspended sediment and turbidity can result in direct mortality of fish by damaging and clogging gills. Fish gills are delicate and easily damaged by abrasive silt particles (Bash et al. 2001). As sediment begins to accumulate in the gill filaments, fish excessively open and close their gills to expunge the silt. If irritation continues, mucus is produced to protect the gill surface, which may impede the circulation of water over the gills and interfere with fish respiration (Bash et al. 2001). Gill flaring or coughing abruptly changes buccal cavity pressure and is a means of clearing the buccal cavity of sediment. Gill sediment accumulation may result when fish become too fatigued to continue clearing particles via the cough reflex (Servizi and Martens 1991).

Spawning, redds, eggs, and alevins

The effects of suspended sediment, deposited in a redd and potentially reducing water flow and smothering eggs or alevins or impeding fry emergence, are related to sediment particle sizes of the spawning habitat (Bjornn and Reiser 1991). Sediment particle size determines the pore openings in the redd gravel. With small pore openings, more suspended sediments are deposited and water flow is reduced compared to large pore openings.

Survival of eggs is dependent on a continuous supply of well oxygenated water through the streambed gravels (Cederholm and Reid 1987). Eggs and alevins are generally more susceptible to stress by suspended solids than are adults. Accelerated sedimentation can reduce the flow of water and, therefore, oxygen to eggs and alevins which can decrease egg survival, decrease fry emergence rates (Cederholm and Reid 1987; Chapman 1988; Bash et al. 2001), delay development of alevins (Everest et al. 1987), reduce growth and cause premature hatching and emergence (Birtwell 1999). Fry delayed in their timing of emergence are less able to compete for environmental resources than other fish that have undergone normal development and emergence (intra- or interspecific competition) (Everest et al. 1987).

Several studies have documented that fine sediment can reduce the reproductive success of salmonids. Natural egg-to-fry survival of coho salmon, sockeye and kokanee has been measured at 23%, 23% and 12%, respectively (Slaney et al. 1977). Substrates containing 20% fines can reduce emergence success by 30-40% (MacDonald et al. 1991). Decreases of 30% in mean egg-to-fry survival can be expected to reduce salmonid fry production to extremely low levels (Slaney et al. 1977).

Although bull trout generally have a narrow, specific spawning habitat requirement and therefore, spawn in a small percentage of the stream habitat available to them (MBTRT 1998), they seem to be more tolerant of sedimentation during development and emergence than other salmonids. Survival of bull trout embryos through emergence appears to be unaffected when the percentage of fines comprise up to 30% of the streambed. However, at levels above 30%, embryo survival through emergence dropped off sharply with survival below 20% for substrates with 40% fine material (Shepard et al. 1984).

<u>*Indirect effects*</u>

Macroinvertebrates

Turbidity and suspended solids can affect macroinvertebrates in multiple ways through increased *invertebrate drift, feeding impacts, respiratory problems, and loss of habitat* (Cederholm and Reid 1987). Certain groups of macroinvertebrates are favored by salmonids as food items. These include mayflies, caddisflies, and stoneflies. These species prefer large substrate particles in riffles and are negatively affected by fine sediment (Everest et al. 1987; Waters 1995).

The effect of light reduction from turbidity has been well documented and results in increased invertebrate drift (Waters 1995; Birtwell 1999). This may be a behavioral response associated with the night-active diel drift patterns of macroinvertebrates. While increased turbidity results in increased macroinvertebrate drift, it is thought that the overall invertebrate populations would not fall below the point of severe depletion (Waters 1995).

Increased suspended sediment can affect macroinvertebrates by abrasion of respiratory surface and interference with food uptake for filter-feeders (Birtwell 1999). Increased suspended sediment levels tend to clog feeding structures and reduce feeding efficiencies, which results in reduced growth rates, increased stress, or death of the invertebrates (Newcombe and MacDonald 1991). Invertebrates living in the substrate are also subject to scouring or abrasion which can damage respiratory organs (Bash et al. 2001).

Benthic invertebrates inhabit the stream bottom. Therefore, any modification of the streambed by deposited sediment will most likely have a profound effect upon the benthic invertebrate community (Waters 1995). Increased sediment can affect macroinvertebrate habitat by filling of interstitial space and rendering attachment sites unsuitable. This may cause invertebrates to seek a more favorable habitat (Rosenberg and Snow 1975). The degree to which substrate particles are surrounded by fine material was found to have a strong correlation with macroinvertebrate abundance and composition (Birtwell 1999). At an embeddedness of one-third, insect abundance can decline by about 50 percent, especially for riffle-inhabiting taxa (Waters 1995).

Feeding Efficiency

Increased turbidity and suspended sediment can affect a number of factors related to feeding for salmonids, including feeding rates, reaction distance, and prey selection (Bash *et al.* 2001). Changes in feeding behavior are primarily related to the reduction in visibility that occurs in turbid water. Effects on feeding ability are important as salmonids must meet energy demands to compete with other fishes for resources and to avoid predators.

Distance of prey capture and prey capture success both were found to decrease significantly when turbidity was increased (Berg and Northcote 1985). Waters (1995) states that loss of visual capability, leading to reduced feeding, is one of the major sublethal effects of high suspended sediment. Increases in turbidity was reported to decrease the percentage of prey captured (Bash et al. 2001). At 0 NTUs, 100% of the prey items were consumed; at 10 NTUs, fish frequently were unable to capture prey species; at 60 NTUs, only 35% of the prey items were captured. At 20 to 60 NTUs, significant delay in the response of fish to prey was observed. Loss of visual capability and capture of prey leads to depressed growth and reproductive capability.

Sigler *et al.* (1984) found that a reduction in growth occurred in steelhead and coho salmon when turbidity was as little as 25 NTUs. The slower growth was presumed to be from a reduced ability to feed; however, more complex mechanisms such as the quality of light may also affect feeding success rates. Redding *et al.* (1987) found that suspended sediment may inhibit normal feeding activity, as a result of a loss of visual ability or as an indirect consequence of increased stress.

Habitat Effects

Compared to other salmonids, bull trout have more specific habitat requirements that appear to influence their distribution and abundance (Reiman and McIntyre 1993). All life history stages are associated with complex forms of cover including large woody debris, undercut banks, boulders, and pools. Other habitat characteristic important to bull trout includes channel and hydrologic stability, substrate, temperature, and the presence of migration corridors (Reiman and McIntyre 1993).

The physical implications of sediment in streams include degradation of spawning and rearing habitat, simplification and damage to habitat structure and complexity, loss of habitat, and decreased connectivity between habitat (Bash et al. 2001). Biological implications of this habitat damage include underutilization of stream habitat, abandonment of traditional spawning habitat, displacement of fish from their habitat, and avoidance of habitat (Newcombe and Jensen 1996).

As sediment enters a stream it is transported downstream under normal fluvial processes and deposited in areas of low shear stress (MacDonald and Ritland 1989). These areas are usually behind obstructions, near banks (shallow water) or within interstitial spaces. This episodic filling of successive storage compartments continues in a cascading fashion downstream until the flow drops below the threshold required for movement or all pools have reached their storage capacities (MacDonald and Ritland 1989). As sediment load increases, the stream compensates by geomorphologic changes in increased slope, increased channel width, decreased depths, and decreased flows (Castro and Reckendorf 1995). These processes contribute to increased erosion and sediment deposition which further degrade salmonid habitat.

Loss of acceptable habitat and refugia, as well as decreased connectivity between habitat reduces the carrying capacity of streams for salmonids (Bash et al. 2001). In systems lacking adequate number, distribution, and connectivity of habitat, fish may travel longer distance or use less desirable habitat and may encounter a variety of other conditions that can increase biological demands.

The addition of fine sediment (less than 6.4 mm) to natural streams during summer decreased abundance of juvenile Chinook salmon in almost direct proportion to the amount of pool volume lost to fine sediment (Bjornn *et al.* 1977; Bash et al. 2001). Similarly, the inverse relationship between fine sediment and densities of rearing Chinook salmon indicates the importance of winter habitat and high sediment loads (Bjornn *et al.* 1977). As fine sediments fill the interstitial spaces between the cobble substrate, juvenile Chinook salmon were forced to leave preferred habitat and to utilize cover that may be more susceptible to ice scouring, predation, and decreased food availability (Hillman *et al.* 1987). Deposition of sediment on substrate may lower winter carrying capacity for bull trout (Shepard *et al.* 1984). Food production in the form of aquatic invertebrates may also be reduced.

Juvenile bull trout densities are highly influenced by substrate composition (Shepard et al. 1984; Reiman and McIntyre 1993; MBTRT 1998). During the summer, juvenile bull trout hold positions close to the stream bottom and often seek cover within the substrate itself. When streambed substrate contains more than 30% fine materials, juvenile bull trout densities drop off sharply (Shepard et al. 1984). Any loss of interstitial space or streambed complexity through the deposition of sediment would result in a loss of summer and winter habitats (MBTRT 1998). The reduction of rearing habitat will ultimately reduce the potential number of recruited juveniles and therefore reducing population numbers (Shepard et al. 1984).

Although an avoidance response by fish to increased sediment may be an initial adaptive survival strategy, displacement from cover could be detrimental. It is possible that the consequences of fish moving from preferred habitat, to avoid increasing levels of suspended sediment, may not be beneficial if displacement is to sub-optimal habitat, and that they also become stressed and more vulnerable to predation (Birtwell 1999).

Physiological Effects

Sublethal levels of suspended sediment may cause undue physiological stress on fish, which may reduce the ability of the fish to perform vital functions (Cederholm and Reid 1987). At the individual fish level, stress may affect physiological systems, reduce growth, increase disease, and reduce its ability to tolerate additional stress (Bash et al. 2001). At the population level, the effects of stress may include reduced spawning success, increased larval mortality, and reduced recruitment to succeeding life stages and, therefore, overall population declines (Bash et al. 2001).

Tolerance to suspended sediment may be the net result of a combination of physical and physiological factors related to oxygen availability and uptake by fish (Servizi and Martens 1991). The energy needed to perform repeated coughing (see Gill trauma section) increases metabolic oxygen demand. Metabolic oxygen demand is related to water temperature. As temperatures increase, so does metabolic oxygen demand, but concentrations of oxygen available in the water decreases. Therefore the fishes tolerance to suspended sediment may be primarily related to the capacity of the fish perform work associated with the cough reflex. However, as sediment increases, fish have less capability to do work, and therefore less tolerance for suspended sediment (Serizi and Martens 1991).

Redding *el al.* (1987) observed higher mortality in young steelhead trout exposed to a combination of suspended sediment (2500 mg/l) and a bacteria pathogen, than when exposed to the bacteria alone. Physiological stress in fishes may decrease immunological competence, growth, and reproductive success (Bash *et al.* 2001).

Behavioral effects

Increased turbidity and suspended sediment may result in behavior changes in salmonids. This includes avoidance, distribution, homing and migration. Many behavioral effects result from changes in stream habitat (see Habitat effects). As suspended sediment concentration increases, habitat may be lost which results in abandonment and avoidance of preferred habitat. Stream reach emigration is a bioenergetics demand that may affect the growth or reproductive success of the individual fish (Bash et al. 2001). Pulses of sediment results in downstream migration of fish, which disrupts social structures and causes downstream displacement of other fish (McLeay et al 1987; Bash et al. 2001). Loss of territoriality and the breakdown of social structure can lead to secondary effects of decreased growth and feed rates, which may lead to mortality (Berg and Northcote 1985; Bash et al. 2001).

Downstream migration by bull trout provides access to more prey, better protection from avian and terrestrial predators, and alleviates potential intraspecific competition or cannibalism in rearing areas (MBTRT 1998). Benefits of migration from tributary rearing areas to larger rivers or estuaries may be increased growth potential. Increased sedimentation may result in premature or early migration of both juveniles and adults or avoidance of habitat and migration of nonmigratory resident bull trout. Migration exposes fish to many new hazards, including passage of sometimes difficult and unpredictable physical barriers, increased vulnerability to predators, exposure to introduced species, exposure to pathogens, and the challenges of new and unfamiliar habitats (MBTRT 1998).

High turbidity may delay migration back to spawning sites, although turbidity alone does not seem to affect homing. Delays in spawning migration and associated energy expenditure may reduce spawning success and therefore population size (Bash et al. 2001).

EFFECTS DETERMINATION

The question of when "take" of an individual(s) occurs for a specific project is not easy to answer. There are numerous factors which affect the determination for which data may be unavailable. Unknowns include project specific sediment input, existing sediment conditions, stream conditions (velocity, depth, etc.) during construction, weather or climate conditions (precipitation, wind, etc.), fish presence or absence (bull trout plus prey species), best management practices employed and effectiveness, plus many others. Without specific project related water quality monitoring data, determining the level of take for the project will be subjective.

The Western Washington Fish and Wildlife Office (WWFWO) is currently drafting protocol to obtain specific project related sediment data. This protocol will be used to identify project related sediment input during construction, as well as long-term sedimentation that may result after completion of the project (i.e. high-flow events, channel adjustments, etc.). Following the protocol will be vital to obtain consistent information on project related sediment input to assist in effects determinations and quantifying take in biological opinions.

Newcombe and Jensen (1996) provide a basis for determining when a project will "likely to adversely affect" bull trout. Newcombe and Jensen (1996) conducted a literature review of pertinent documents on sediment effects to salmonids and nonsalmonids. They developed a model that calculated the severity of effect (SEV) based on the suspended sediment dose (exposure) and concentration.

A 15-point scale is used to qualitatively rank the effects of sediment on fish (Table 1). Specific SEV levels will be used to determine when a project is "likely to adversely affect" bull trout.

The following procedure will be used:

1. Select either a or b below.

a. Based on water quality monitoring data, determine the amount of sediment and the duration of sediment input into the stream. (Currently not enough data are available to use this step. As more project specific data becomes available this step will be used).

b. Use State water quality standards. Because action agencies must meet State water quality standards you can use the standard for determining sediment input into the stream. The Washington State water quality standards for turbidity are provided in Table 2.

The State water quality standard allows for a mixing zone downstream of the project site. The point of compliance is based on stream discharge (Table 3).

The water quality standard must be converted from turbidity (NTUs) to suspended solids (mg/l). A ratio of 1:1 to 1:5 has been derived for converting turbidity to suspended solids (Birtwell 1999). Washington Department of Ecology or U.S. Geological Survey data should be used to determine specific turbidity: suspended solid ratios for the stream on which the project will be conducted (see Documents and Background Information section). If site specific ratios can not be determined use worse case ratio of 1:4 or 1:5.

2. Based on the background information gathered, determine what life stage(s) of bull trout will be affected by sedimentation (see Documents and Background Information section). Use Figures 1 through 4 to determine what SEV level will result for the life stage affected by the project.

3. Use Table 4 to determine what ESA determination is made for the life stage affected.

4. If a LAA determination is made, then the basis for the rationale for "take" occurring is based on the SEV value obtained. The rationale is not just for that specific level (SEV = 6), but includes previous SEVs as well.

5. Use Table 5 to provide the basis for quantifying the "take." If water quality monitoring data were available, this information would be used to quantify the take (in terms of bull trout associated with x amount of habitat. Table 5 provides all the project specific water quality monitoring data received by the Service for individual projects. The data include the distance from the project where water quality sampling occurred and whether water quality standards were met. As additional monitoring data is obtained, this table will be used to quantify "take" for different projects.

References

ACMRR/IABO Working Party on Ecological Indices of Stress to Fishery Resources. 1976. Indices for measuring responses of aquatic ecological systems to various human influences. Food and Agriculture Organization of the United Nations, Fisheries Technical Paper 151, Rome, Italy.

Bash, J., C. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. Center for Streamside Studies, University of Washington, November 2001.

Berg, L., and TG Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch)* following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42: 1410-1417.

Birtwell, Ian K. 1999. The Effects of Sediment on Fish and Their Habitat. Canadian Stock Assessment Secretariat Research Document 99/139.

Bjornn, T.C., M.A. Brusven, M.P. Molnau, J.H. Milligan, R.A. Klamt, E. Chacho, and C. Schaye. 1977. Transport of granitic sediment in streams and its effects on insects and fish. University of Idaho, Idaho cooperative Fisheries Research Unit, Completion Report, Project B-036-IDA, Bulletin 17. Moscow.

Bjornn, TC, and DW Reiser. 1991. Habitat requirement of salmonids in streams. Pages 83-138. In: Influences of forest and rangeland management on salmonid fishes and their habitats. Editor: Meehan WR. American Fisheries Society Special Publication 19.

Castro, J., and Reckendorf, F. 1995. RCA III: effects of sediment on the aquatic environment; potential NRCS actions to improve aquatic habitat. Natural Resources Conservation Service, Oregon State University, Department of Geosciences.

Cederholm, C.J. and L.M. Reid. 1987. Impact of Forest Management on Coho Salmon (*Oncoryhynchus kisutch*) Populations of the Clearwater River, Washington: a Project Summary. Pages 373-398 in Salo, E.O., and T.W. Cundy, editors. Streamside Management: Forestry and Fishery Interactions. University of Washington Institute of Forest Resources Contribution 57.

Chapman, D.W. 1988. Critical Review of Variable Used to Define Effects of Fines in Redds of Large Salmonids. Transactions of the American Fisheries Society. 117:1-21.

Everest, F.H., R.L. Beschta, J.C. Scrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm. 1987. Fine sediment and salmonid production: a paradox. Pages 98-142 in Salo, E.O., and T.W. Cundy, editors. 1987. Streamside management: forestry and fishery interactions. University of Washington Institute of Forest Resources Contribution 57.

Hillman, TW., JS Griffith, and WS Platts. 1987. Summer and winter habitat selection by juvenile Chinook salmon in a highly sedimented Idaho stream. Transactions of the American Fisheries Society 116:185-195.

MacDonald, A. and K.W. Ritland. 1989. Sediment Dynamics in Type 4 and 5 Waters, A Review and Synthesis. Timber Fish and Wildlife. TFW-012-89-002.

MacDonald, L.H., A.W. Smart, and R.C. Wissmar. 1991. Monitoring guidelines to evaluate the effects of forestry activities on stream in the Pacific Northwest and Alaska. Region 10, U.S. Environmental Protection Agency. EPA 90/9-91-001.

McLeay, DJ., IK Birtwell, GF Hartman, and GL Ennis. 1987. Responses of Arctic grayling (*Thymallus arcticus*) to acute and prolonged exposure to Yukon placer mining sediment. Canadian Journal of Fisheries and Aquatic Sciences 44:658-673.

Montana Bull Trout Restoration Team. 1998. The Relationship Between Land Management Activities and Habitat Requirements of Bull Trout. C/o Montana Fish, Wildlife and Parks. Helena Montana.

Newcombe, C.P., and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. North American Journal of Fisheries Management 11:72-82.

Newcombe, CP and JOT Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693-727.

Redding, JM., CB Screak, and FH Everest. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. Transactions of the American Fisheries Society 116:737-744.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and Habitat Requirements for Conservation of Bull Trout. U.S. Forest Service, General Technical Report INT-302. Intermountain Research Station, Boise, ID.

Rosenberg, DM, and NB Snow. 1975b. A design for environmental impact studies with special reference to sedimentation in aquatic systems of the Mackenzie and Porcupine river drainages. Pages 65-78 in Proceedings of the circumpolar conference on northern ecology. National Research Council of Canada, Ottawa.

Servizi, JA, and DW Martens. 1991. Effect of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon (*Oncorhynchus kisutch)*. Canadian Journal of Fisheries and Aquatic Sciences 48: 493-497.

Shepard, BB, SA Leathe, TM Waver, and MD Enk. 1984 or 1985? Monitoring levels of fine sediment within tributaries to Flathead Lake, and impacts of fine sediment on bull trout recruitment. Pages 146-156 in F. Richardson and R.H Hamre, editors. Wild trout III. Federation of Fly Fishers and Trout Unlimited, Vienna, Virginia.

Sigler, JW, TC Bjornn, and FH Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113:142-150.

Slaney, PA, TG Halsey, and AF Tautz. 1977. Effects of forest harvesting practices on spawning habitat of stream salmonids in the Centennial Creek watershed, British Columbia. British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch, Fisheries management Report 73, Victoria.

U.S. Fish and Wildlife Service. 1998a. A framework to assist in making Endangered Species Act determinations of effect for individual or grouped actions at the bull trout subpopulation watershed scale. Western Washington Fish and Wildlife Office, Lacey, WA. 45pp.

U.S. Fish and Wildlife Service. 1998b. Bull trout interim conservation guidance. Western Washington Fish and Wildlife Office, Lacey, WA. 47pp.

Washington Department of Fish and Wildlife. 1988. 1998 Washington Salmonid Stock Inventory. Appendix. Bull Trout and Dolly Varden. July 1998.

Waters, Thomas F., 1995. *Sediment in Streams: Sources, Biological Effects, and Control.* American Fisheries Society Monograph 7.

TABLES

Table 1 – Scale of the severity (SEV) of ill effects associated with excess suspended sediment

SEV	Description of Effect
	Nil effect
0	No behavioral effects
	Behavioral effects
1	Alarm reaction
2	Abandonment of cover
3	Avoidance response
	Sublethal effects
4	Short-term reduction in feeding rates; short-term reduction in feeding success
5	Minor physiological stress; increase in rate of coughing; increased respiration rate
6	Moderate physiological stress
7	Moderate habitat degradation; impaired homing
8	Indications of major physiological stress; long-term reduction in feeding rate; long-term reduction in feeding success; poor condition
	Lethal and paralethal effects
9	Reduced growth rate; delayed hatching; reduced fish density
10	0-20% mortality; increased predation; moderate to sever habitat degradation
11	> 20 – 40% mortality
12	> 40 – 60% mortality
13	> 60 – 80% mortality
14	> 80 – 100% mortality

Table 2 - Turbidity water quality standards for various classes of surface waters in the State of Washington.

Washington State Classes for Surface Waters	**Turbidity Characteristic**
Class AA (extraordinary)	Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is <= 50 NTU or have > 10 percent increase in turbidity when the background turbidity is > 50 NTU.
Class A (excellent)	Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is <=50 NTU or have > 10 percent increase in turbidity when the background turbidity is > 50 NTU
Class B (good)	Turbidity shall not exceed 10 NTU over background turbidity when the background turbidity is <=50 NTU or have > 20 percent increase in turbidity when the background turbidity is > 50 NTU

Table 3 - Turbidity mixing zones for turbidity water quality standards.

Waterbody Type	Point of Compliance
Stream: <= 10 cfs Stream Flow at Time of Construction	100 ft downstream of activity causing turbidity exceedance
>10 cfs up to 100 cfs Stream Flow at Time of Construction	200 ft downstream of activity causing turbidity exceedance
> 100 cfs Stream Flow at Time of Construction	300 ft downstream of activity causing turbidity exceedance

Table 4 - ESA Effect calls for different bull trout life stages in relation to the duration of effect and severity-of-ill-effect.

Life Stage	SEV	ESA Effect Call
Egg/alevin	1 to 4	not applicable - alevins are still in gravel and are not feeding.
	5 to 14	LAA - any stress to egg/alevin reduces survival
Juvenile	1 to 4	NLAA
	5 to 14	LAA
Subadult and Adult	1 to 5	NLAA
	6 to 14	LAA

Table 5 - Water quality monitoring data received by the Western Washington Fish and Wildlife Office showing distance downstream where data was recorded and whether water quality standards were met

Project	Distance downstream from project water data was recorded	Distance downstream State water quality standards are met.
Debris jam removal (SR - 20)	Not provided	Met standard
Rock placed in stream (Hoh River emergency bank protection)	100 - 200 ft	Met standard
Bridge construction (SR - 90) Stated removal of coffer dams and diversion resulted in increased turbidity.	Not provided	NTUs over standard 19 days checked, standard not met 7 days. NTUs over standard 25, 3, 7, 2, 2, 7, 16.
River scour protection (SR 12) Contract no. C-6186	300' and 600'	Day 1 - Standard not met at 300', did meet at 600' Day 2 - Met standard 300' Day 3 - Did not meet at 300' and 600' (9.3 NTUs over) Day 4 - Did not meet at 300' or 600' - up to 4.5 NTUs over Next 5 monitoring days - met standard
Bridge construction	200'	Standard not met and had spike in turbidity as high as 169 NTU's
Culvert replacement project not described (SR241) – Contract # 6270 - Sulpher Cr.	100' and 200'	Standard not met 200' downstream. Increase NTUs over 30 NTUs
Bank stabilization (Saxon Cr.)	300'	Met standard - First 9 days of project, 1 sampling day - 35.2 NTUs over standard and 3.53 NTUs over standard. Remaining time within standard.
Culvert replacement - Stossel Creek Way	Not provided	Standard met on all occasions except one – 24 NTUs over background - during initial dewatering.

FIGURES

Figure 1. Juvenile and adult salmonids: average severity-of-ill-effect scores

Concentration (mg/l)	162755	10	11	11	12	12	13	14	14	-	-	-
	59874	9	10	10	11	12	12	13	13	14	-	-
	22026	8	9	10	10	11	11	12	13	13	14	-
	8103	8	8	9	10	10	11	11	12	13	13	14
	2981	7	8	8	9	9	10	11	11	12	12	13
	1097	6	7	7	8	9	9	10	10	11	12	12
	403	5	6	7	7	8	9	9	10	10	11	12
	148	5	5	6	7	7	8	8	9	10	10	11
	55	4	5	5	6	6	7	8	8	9	9	10
	20	3	4	4	5	6	6	7	8	8	9	9
	7	3	3	4	4	5	6	6	7	7	8	9
	3	2	2	3	4	4	5	5	6	7	7	8
	1	1	2	2	3	3	4	5	5	6	7	7
		1	3	7	1	2	6	2	7	4	11	30
		Hours			Days			Weeks		Months		

Figure 2. Adult salmonids: average severity-of-ill-effect scores.

Concentration (mg/l)											
162755	11	11	12	12	13	13	14	14	-	-	-
59874	10	10	11	11	12	12	13	13	14	14	-
22026	9	10	10	11	11	12	12	13	13	14	14
8103	8	9	9	10	10	11	11	12	12	13	13
2981	8	8	9	9	10	10	11	11	12	12	13
1097	7	7	8	8	9	9	10	10	11	11	12
403	6	7	7	8	8	9	9	10	10	11	11
148	5	6	6	7	7	8	8	9	9	10	10
55	5	5	6	6	7	7	8	8	9	9	9
20	4	4	5	5	6	6	7	7	8	8	9
7	3	4	4	5	5	6	6	7	7	7	8
3	2	3	3	4	4	5	5	6	6	7	7
1	2	2	3	3	4	4	5	5	5	6	6
	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		

Figure 3. Juvenile salmonids: average severity-of-ill-effect scores.

Concentration (mg/l)											
	162755	9	10	11	11	12	13	14	14	-	-	-
	59874	9	9	10	11	11	12	13	14	14	-	-
	22026	8	9	9	10	11	11	12	13	13	14	-
	8103	7	8	9	9	10	11	11	12	13	13	14
	2981	6	7	8	9	9	10	11	11	12	13	13
	1097	6	6	7	8	9	9	10	11	11	12	13
	403	5	6	6	7	8	9	9	10	11	11	12
	148	4	5	6	6	7	8	9	9	10	11	11
	55	4	4	5	6	6	7	8	8	9	10	11
	20	3	4	4	5	6	6	7	8	8	9	10
	7	2	3	4	4	5	6	6	7	8	8	9
	3	1	2	3	4	4	5	6	6	7	8	8
	1	1	1	2	3	4	4	5	6	6	7	8
		1	3	7	1	2	6	2	7	4	11	30
		Hours			Days			Weeks		Months		

Figure 4. Eggs and aleyins of salmonids: average severity-of-ill-effect scores.

Concentration (mg/l)											
162755	7	9	10	11	12	13	14	-	-	-	-
59874	7	8	9	10	12	13	14	-	-	-	-
22026	7	8	9	10	11	12	13	-	-	-	-
8103	7	8	9	10	11	12	13	14	-	-	-
2981	6	7	8	10	11	12	13	14	-	-	-
1097	6	7	8	9	10	11	12	14	-	-	-
403	6	7	8	9	10	11	12	13	14	-	-
148	5	6	7	9	10	11	12	13	14	-	-
55	5	6	7	8	9	10	12	13	14	-	-
20	5	6	7	8	9	10	11	12	13	-	-
7	4	5	7	8	9	10	11	12	13	14	-
3	4	5	6	7	8	10	11	12	13	14	-
1	4	5	6	7	8	9	10	11	13	14	-
	1	3	7	1	2	6	2	7	4	11	30
	Hours			Days			Weeks		Months		