BIOLOGICAL ASSESSMENT

POTENTIAL IMPACTS FROM THE TIETON HYDROELECTRIC PROJECT ON ESA LISTED BULL TROUT AND STEELHEAD IN THE YAKIMA BASIN

Prepared for
Tieton Hydropower, L.L.C.

Prepared by
Alex Kalin
Steven P. Cramer
Caryn G. Ackerman

300 S.E. Arrow Creek Lane
Gresham, OR 97080
www.spcramer.com
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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>BA</td>
<td>Biological Assessment</td>
</tr>
<tr>
<td>BO</td>
<td>Biological Opinion</td>
</tr>
<tr>
<td>BPA</td>
<td>Bonneville Power Administration</td>
</tr>
<tr>
<td>BLM</td>
<td>United States Bureau of Land Management</td>
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<tr>
<td>cfs</td>
<td>cubic feet per second</td>
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<tr>
<td>CPUE</td>
<td>catch per unit effort</td>
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<tr>
<td>DO</td>
<td>dissolved oxygen</td>
</tr>
<tr>
<td>EA</td>
<td>Environmental Assessment</td>
</tr>
<tr>
<td>EPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
<tr>
<td>ESA</td>
<td>Endangered Species Act</td>
</tr>
<tr>
<td>FERC</td>
<td>Federal Energy Regulatory Commission</td>
</tr>
<tr>
<td>fps</td>
<td>feet per second</td>
</tr>
<tr>
<td>kV</td>
<td>kilovolts</td>
</tr>
<tr>
<td>kWh</td>
<td>kilowatt hours</td>
</tr>
<tr>
<td>mg/L</td>
<td>milligrams per liter</td>
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<tr>
<td>NMFS</td>
<td>National Marine Fisheries Service</td>
</tr>
<tr>
<td>ODFW</td>
<td>Oregon Department of Fish and Wildlife</td>
</tr>
<tr>
<td>psi</td>
<td>pounds per square inch</td>
</tr>
<tr>
<td>RM</td>
<td>River Mile</td>
</tr>
<tr>
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<tr>
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<tr>
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<tr>
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<td>Washington Department of Game</td>
</tr>
<tr>
<td>WDFW</td>
<td>Washington Departments of Fish and Wildlife</td>
</tr>
<tr>
<td>YIN</td>
<td>Yakama Indian Nation</td>
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1. INTRODUCTION

The Yakima Tieton Irrigation District and Tieton Hydropower are seeking the necessary approvals under the ESA to construct and operate a 13.6-megawatt powerhouse on the existing outlet of Rimrock Dam. This BA evaluates the potential effects of the operation of the proposed hydropower project (FERC No. 3701) on federally listed species.

1.1 Proposed Action

The proposed action is construction and operation of a hydropower project on the outlet to Tieton Dam. There will be no alteration of the dam, its intake or its outflows.
The US Bureau of Reclamation (USBR) owns and operates Tieton Dam, which impounds the Tieton River at RM 21.2 to form Rimrock Lake, located approximately 40 miles west of the city of Yakima, Washington. The Yakima Tieton Irrigation District and Tieton Hydropower seek to construct and operate a 13.6-megawatt run-of-the-river hydroelectric project at the base of Tieton Dam. Turbines would be driven by the head energy that is now released through the outlet works as a jet that sprays water up to 100 fps over the tailrace. Power production at the proposed project would redirect water from this outlet and be incidental to other project operations, such as irrigation, flood control, recreation, and fish and wildlife operations. Thus, flows in the river and annual reservoir drawdown would not be altered by this project. Hydropower generation would accompany all reservoir releases large enough to operate at least one of the two generators to be located within the powerhouse.

1.2 ESA Species

ESA-listed bull trout reproduce in the Tieton Basin above Rimrock Dam, and ESA-listed steelhead reproduce in the Tieton River below the dam.

2. DESCRIPTION OF THE PROPOSED ACTION

2.1 Construction Plan Overview

The proposed project is located on the Tieton River at the site of the existing USBR Tieton Dam approximately 40 miles west of the City of Yakima, WA. (Figure 1). The project would not modify that dam or the intake of the internal plumbing, but would be constructed below the dam to harness the energy from water exiting Rimrock Lake. Construction involves removal of an existing valvehouse at the tailrace and construction of a powerhouse, switchyard, and transmission line. No change in normal maximum surface area or normal maximum elevation of the impoundment will occur as the result of this project. The hydroelectric project would operate whenever release of sufficient flow is made from the impoundment. No change in the operating regime is proposed as an element of this hydroelectric project. The hydroelectric project will be operated as a run-of-the-reservoir facility relying on the releases made for irrigation, flood control, and other water uses. Operation of the hydroelectric project would not preclude modification of the flow regime by the USBR to meet future operational requirements.
The impoundment created by Tieton Dam has not established any wetland areas. The operating regime of the reservoir requires substantial fluctuation of the water surface.
elevation in a steep-sided valley to meet downstream irrigation requirements. The area at the toe of the dam where the powerhouse will be constructed does not support wetlands because of the turbulence caused by release through two 60-inch hollow jet valves into the stilling basin.

No new areas not previously affected by construction activity will be disturbed; water releases will continue to be made during construction and operation; and existing transmission line corridor will be used wherever possible to minimize new corridor construction.

The powerhouse will be located on the left abutment of the dam and would be of the “outdoor type” with the generators protected from the elements by weatherproof covers. The design involves replacing the existing outlet works and valvehouse with a powerhouse containing two vertical Francis turbines. The two existing dam outlet pipes would be connected to intake manifolds for the powerhouse. Water would then be discharged through the turbines or bypassed into and through the existing jet valves, which will be relocated to either side of the powerhouse (Figure 2).
Figure 2. View of proposed powerhouse showing position of relocated jet valves.
Rock splitting techniques will be employed to enlarge an area of sufficient area and for construction of the powerhouse foundation. Rock splitting is performed using a jackhammer type device mounted on an excavator and produces minimal dust and debris compared with conventional blasting. The powerhouse foundation will be structural concrete with a pre-manufactured metal building on top. Total excavation volume is estimated to be about 2400 cubic yards and total concrete fill is estimated to be about 400 cubic yards. The metal powerhouse building will contain a 30 ton bridge crane to access the turbine generators and the USBR flow jet valves.

A bypass system will be used to dewater the stilling basin during construction. A 48-inch bypass pipeline will reroute flow from the dam outlet pipes around the outlet works and into the existing concrete spillway (Figure 3). Rock splitting techniques will be employed to remove approximately 2600 cubic yards of rock from the hillside below the left dam abutment to make a path for the bypass line and for entry of equipment into the construction site. The bypass line will be connected to the two dam outlet pipes in an alternating fashion so that Tieton River flow is never interrupted. The bypass system will eliminate the need for a cofferdam.

Figure 3. Bird’s eye view of proposed project showing location of powerhouse and temporary bypass.
Once the bypass is operating, the stilling basin will be pumped dry so that construction can begin. Periodic pumping will be required during construction to eliminate seeping groundwater and dam leakage from the stilling basin. Flow can be returned to the relocated jet valves once powerhouse foundation work is complete. The remainder of construction can be completed with flow routed through either the bypass system or the jet valves, or both.

The turbine generators will deliver power via underground or overhead cable to a switchyard constructed on a small concrete pad near the powerhouse. The switchyard will contain equipment necessary to convert the input voltage to 115 kV. A 115 kV transmission line will be constructed from the switchyard to the Pacific Power and Light Tieton substation located 2 miles southeast of the city of Tieton, WA. Figure 4 shows the planned transmission line route. The alignment follows the existing Benton County Rural Electric Association (BCREA) right-of-way to a point near the upper limit of Weddle Canyon, then branches east toward the city of Tieton. Under an agreement between Tieton Hydropower and BCREA, BCREA will upgrade its existing line to accommodate 115 kV transmission, thus avoiding the need to expand the existing corridor. New impacts at river crossings and wetland crossings will be eliminated by using existing pole placements in these sensitive areas. Approximately 12 miles of new 115 kV transmission line will be constructed from the BCREA branch point to the city of Tieton. The alignment for the new construction follows an existing dirt road along a thinly timbered ridge for 5 miles and then follows section lines across open agricultural land to the city of Tieton. Figure 10 gives specifications for the planned power poles.
Figure 4. Planned transmission line route.
Figure 5. Tieton hydroelectric project transmission line river crossings 1-4.
Figure 6. Tieton hydroelectric project transmission line river crossings 5, 6.
Figure 7. Tieton hydroelectric project transmission line river crossing 7.
Figure 8. Tieton hydroelectric project transmission line river crossings 8, 9.
Figure 9. Tieton hydroelectric project transmission line gully crossings 10-12.
Figure 10. Specifications for Tieton hydroelectric project planned power poles.
Land use in the vicinity of the Tieton hydroelectric project varies. Recreational use occurs in the vicinity of Rimrock Lake and in the Tieton River downstream to Rimrock Retreat. The transmission line corridor from Rimrock Retreat to Divide Ridge occurs principally on private land in forest watershed and is subject to periodic logging. From Divide Ridge to the city of Tieton the transmission line corridor crosses private agricultural land. The final 3.5 miles of transmission line occurs within residential and rural transitional areas associated with the city of Tieton, along Hatton and Summitview roads. Existing service lines are located on the north side of Hatton Rd and the NE side of Summitview Rd. The proposed transmission line will be built on the south side of Hatton Rd and the SW side of Summitview Rd (Figure 11). The Tieton hydroelectric project is compatible with these various uses and with the purpose and intent of zoning ordinances and comprehensive plans because

- The project does not affect use of recreational facilities at Rimrock Lake or in the Tieton River.
- The transmission line follows an existing cleared corridor through all forest watershed areas.
- The transmission line occurs in remote sections of private agricultural lands and will not alter the use of these lands.
- The transmission line will parallel existing transmission line along existing right-of-way within and around the city of Tieton.
2.2 Construction Schedule

Construction will be staged to accommodate Bureau of Reclamation operations at Tieton Dam and to minimize environmental impacts. New transmission line construction (from existing BCREA line to Tieton substation) will be performed in late summer and early fall of 2003 and will be complete before winter. This will minimize impacts on deer and elk winter range.

Powerplant construction will commence with installation of the bypass pipeline during summer 2003. Approximately 2600 cubic yards of rock will be removed from the hillside below the left dam abutment to make a path for the bypass pipeline. A silt fence will be installed on the NW bank of the stilling basin to catch debris produced during excavation of the bypass corridor and access road. The bypass system will be operable by the end of flip-flop flow (approximately September 15, 2003) and will be capable of bypassing the maximum expected release from Tieton Dam during winter 2003–2004.

Following flip-flop, water in the stilling basin will be pumped downstream into the Tieton River or the spillway channel in order to dewater the stilling basin for foundation work. During drawdown, a fish salvage operation will be conducted in the stilling basin per WDFG and USFWS recommendations. Captured fish will be released into the Tieton River or into Rimrock Lake as directed by fishery agencies. All water pumped from the stilling basin during dewatering and construction of the powerhouse foundation will be passed through a filtration system such that it meets State of Washington water quality standards prior to reentering the Tieton River. Water will also be applied to construction roads as necessary to control dust during periods of high construction traffic. After completion of foundation work (approximately 2–4 months) the bypass will be shut down and water will be returned to the stilling basin as per normal Tieton Dam operations. The remainder of powerhouse construction will be completed by May 4, 2004.

The estimated project schedule is shown in Table 1 below.

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<td>2. Final Biological Assessment</td>
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<td>3. NFMS and USFWS Biological Opinion</td>
<td>7-Jul-02</td>
<td>1-Oct-02</td>
</tr>
<tr>
<td>4. Finish FERC Post licensing articles</td>
<td>1-Jul-02</td>
<td>1-Dec-02</td>
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<tr>
<td>5. FERC approval of articles</td>
<td>1-Aug-02</td>
<td>1-Jan-03</td>
</tr>
<tr>
<td>6. Obtain revised Water quality Certificate from WDOE</td>
<td>1-Oct-02</td>
<td>1-Nov-02</td>
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</table>
7. Obtain Corp of Engineers 404 permit 1-Oct-02 1-Jan-03
8. Obtain WDFW HPA permit 1-Oct-02 15-Nov-02
9. Finish Civil Design 1-Sep-02 15-Dec-02
11. FERC Approval of Civil Design 15-Jan-03 1-Apr-03
12. FERC authorization to break ground 1-Apr-03
13. Transmission Line Agreement with Benton REA 15-Dec-01 1-May-02
14. Forest Service Special Use permit for transmission line 1-May-01 1-Jul-02
15. Acquire private transmission line right of way 1-Oct-02 1-Jun-03
16. Transmission line construction 1-Aug-03 1-Nov-03
17. Powerplant construction
   17a. Bypass pipeline construction 1-Aug-03 1-May-04
   17b. Dewater stilling basin for foundation work* 1-Oct-03 15-Sep-03
   17c. Rewater stilling basin and complete construction 1-Dec-03 1-Dec-03
18. Online 1-May-04

* Following end of flip-flop flow

2.3 Water Quality Effects
Unavoidable short-term impacts to water quality would result from construction efforts.

Impacts on DO and temperature in the Tieton River are discussed in detail in later sections of this BA.

2.4 Mitigation Measures for ESA Species
Mitigative measures have already been incorporated into the proposed project as part of the development of the project concept to date. As noted earlier, the proposed project does not contemplate any changes in operation of Tieton Dam. Releases from Rimrock Lake will continue to be governed by irrigation, flood control, fish habitat and recreational considerations; hydropower production considerations will not influence the pattern of water release. Current operations include measures aimed at minimizing dewatering of spring chinook redds elsewhere in the Yakima basin. Rimrock Lake boasts one of the most abundant and robust populations of bull trout in the state under present operating conditions.

The proposed project includes a barrier rack on the turbine outlets to prevent fish from swimming into the outlets and ascending powerhouse draft tubes (Figure 12, Figure 13). Salmonid fishes are often attracted to point discharges where flows and velocities are relatively high. In some cases fish can ascend the turbine draft tubes during normal operation, and can be injured or killed when they swim up through the draft tubes and

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encounter the turbine runners or are battered against walls by draft tube turbulence (see NMFS 1993 and sources cited therein). Draft tubes environments can be very non-uniform, with areas of significantly higher than average flow and turbulence characteristics, which can result in vertebrae injuries from hydraulic shear, causing paralysis. Delayed mortality may also result from the onset of infection in areas of laceration or abrasions acquired from attempting to ascend turbine outlet structures.

Figure 12. Cross sectional diagram of proposed powerhouse, showing penstock, turbine, turbine outlet and barrier racks.
Figure 13. View of proposed powerhouse from the stilling basin, showing jet valve openings and turbine outlet, as well as barrier racks.

The structure of the turbine outlet of the proposed project is designed to allow velocities to dissipate to about 2 fps at the barrier rack, though water velocities across the rack will vary to some degree. Rack openings will be small enough to ensure that adult steelhead are prevented from entering the draft tubes and being injured. At the same time, rack openings will be large enough to allow juvenile fish entrained from the reservoir to pass through the screen rather than become impinged. Low water velocities at the barrier rack will allow these entrained fish to orient themselves in the water rather than being forced onto the rack bars.

The current barrier rack design is based on consultation from NMFS, USFWS and WDFW, and NMFS has indicated that 2 inch bar openings and a hinge mechanism to remove the racks from the river flow when steelhead are not present would be satisfactory. Openings of this size will prevent upstream movement of adult steelhead, and allow downstream passage of fish in the size classes of most fish observed in fyke nets (under 8 inches) during entrainment studies conducted by James (2001). Final size of barrier rack openings will be determined after further consultation with management agencies.
The plan for operating the racks will be based on the need to 1) prevent steelhead and bull trout from entering the turbines, and 2) the desire to provide downstream passage for juvenile fish that pass safely downstream through the turbines. The following general operating parameters were developed through consultation with NMFS:

- Rack to be installed during initial powerplant construction
- Rack can remain in the “up” position until such time that steelhead are reintroduced into the Tieton River
- After reintroduction, rack can remain in the “up” position except when spawning steelhead are in the river (approximately 1 month/year)
- If desirable for management of other resident fish, rack can remain in the “down” position as much as necessary

FERC Article 405 requires that the project proponent consult with fisheries agencies to determine a rack design that is acceptable to those agencies. Additional sampling will be completed by the USBR on fish passing through the dam outlet works in 2002, and this data may be considered in choosing an appropriate design of the fish exclusion rack. Before the fish exclusion rack is constructed, the USFWS will consult with NMFS, WDFW, Yakima Nation, USBR and the project proponent to choose the final design criteria.

It is conceivable, though not probable, that reduction of the jetted discharge may allow DO to drop below desirable levels for salmonids in the tailrace (<6 mg/L). If DO drops below this level some or all of the turbine flow will be diverted back through the jet valves as necessary to meet the 6 mg/L minimum.

It is also conceivable, though not probable, that reduction of jetted discharge may allow DO to drop below 9.5 mg/L in the Tieton River downstream of the stilling basin. (See detailed discussion on DO later in this BA). In order to mitigate for this possibility, the proposed project will build, as needed, rock weirs across the Tieton River in the quarter mile stretch downstream of the stilling basin (Figure 14, Figure 15). These weirs will only be constructed if post-project monitoring reveals that DO concentrations drop below 9.5 mg/L at the DO monitoring station 2300 feet downstream from the dam. Weirs would be constructed one at a time until their number is sufficient to achieve the 9.5 mg/L DO standard at the monitoring station. As discussed in other sections of this BA, data indicate that DO levels will not be reduced below threshold levels. Weirs, if implemented, would increase dissolved gas concentrations and increase availability of raw organic materials for chemosynthetic organisms, contributing to overall stream health.

The weirs will be a combination of concrete core and rock rubble construction to balance the need for efficient aeration and fish passage. Weirs would create a step
under 2 feet high at all but minimum flows. Concrete core sections would provide upstream passage for adult fish. Rock rubble sections will allow small fish to traverse the weir through large interstitial passages between boulders. Construction will be performed in two stages during minimum flow periods. Cofferdams will be used to dewater half the stream channel during construction of concrete core sections. All construction will be performed to Washington State water quality standards.
Figure 14. Diagram of project area showing positions of five proposed rock weirs spanning the Tieton River below Tieton Dam.
Figure 15. Cross sectional diagram of proposed structural (upper) and rock rubble (lower) weirs designed to increase DO levels in the Tieton River below Tieton Dam. Weirs would extend across the entire river flow.
2.5 Monitoring and Evaluation Plan

2.5.1 Dissolved Oxygen Monitoring

The project will operate under a water quality certificate issued by the State of Washington 3/84 and amended 10/01. The certificate specifies actions to be taken to assure that DO levels in the Tieton River are maintained at or above Washington State standards. Tieton River DO levels will be monitored in order to measure the effectiveness of compliance actions and to initiate additional actions under the certificate when necessary, as follows.

The primary monitoring station will be located 300 ft downstream from USGS gauging No. 12491500, which is located approximately 2000 ft below Tieton Dam (Figure 16). DO measurements will be made using a portable DO meter, which will be owned by the project proponent and maintained per manufacturer’s specifications. Measurement protocol has been developed in cooperation with WDE.

Monitoring will commence each year beginning on July 15 and will end on October 1, because this is the season when reduced DO is most likely to occur. Measurements will be conducted twice weekly. If the DO level falls below 9.5 mg/L ± 1.0 mg/L, project proponent will commence daily measurements to support calculation of a running 7 day mean. If the 7 day mean rises above 9.5 mg/L ± 1.0 mg/L, monitoring will return to twice weekly measurements.

The same schedule of DO monitoring will also be applied to the stilling basin where many fish reside. In the stilling basin, the minimum DO level that triggers additional monitoring and further mitigation actions is 6 mg/L. If DO drops below this level some or all of the turbine flow will be diverted back through the jet valve as necessary to meet the 6 mg/L minimum.

Figure 16. Map of project area showing locations of proposed powerhouse, stilling basin, DO monitoring station and USGS gauging station.
By October 31 of each year, project proponent will produce and deliver to FERC, WDE and USBR a summary report containing all DO measurement data for the subject year.

2.5.2 Entrainment Mortality Monitoring

Monitoring of entrainment mortality will require fish sampling. This can be accomplished by constructing or obtaining live box attachments for the existing fyke nets that were used by James during 2001 entrainment studies. Live boxes would enable more accurate estimates of entrainment mortality to be obtained than with existing equipment. If such attachments do no prove suitable for maintaining fish alive in the hydraulic setting that exists, the project proponent would purchase a rotary screw trap to be used in the Tieton River in place of one of the fyke nets. Daily monitoring of catches in the fyke nets or screw trap will be completed by USBR or its contractors as part of their ESA Section 7 permit for operating the Yakima Project, which includes Tieton Dam.

In either event, project proponent contemplates that entrainment mortality estimates would be derived from data collected (either by fyke net or screw trap) by the USBR bull trout monitoring efforts under the ESA Section 7 activities in connection with the Yakima Project as a whole.

3. DESCRIPTION OF THE ENVIRONMENTAL BASELINE

The environmental baseline for this action is the existing project operations, which are described in the following subsections of this BA.

3.1 General Description of the Locale

The proposed project is located on the Tieton River at the site of the existing Tieton Dam, which impounds Rimrock Lake (Figure 1). The dam creates a reservoir with a surface area of 2526 acres and a water surface elevation of 2926 feet. The 198,000 acre-feet of water stored in the reservoir are collected from the North Fork and South Fork Tieton River. No change in the operating regime of Tieton Dam is proposed as an element of this hydropower project.

The Climate in the project area is characterized by dry, hot summers and cold winters. Temperature averages 67 °F in the summer and 25 °F in the winter. Much of the water stored in Rimrock Lake derives from snowmelt in the Cascade Range to the West, where precipitation averages 80 inches annually. Total annual precipitation in the project area is 2 inches, most of which occurs in the winter and spring. Valleys in the project area are typically warmer and drier than the uplands.
The reservoir is located in a canyon created by the Tieton River. Elevations in the project area range from 2615 feet at the base of Tieton Dam to 5700 feet along Russel Ridge north of the impoundment. The Tieton River drains an area of 187 square miles above Tieton Dam.

3.2 Tieton Dam Operations

Rimrock Lake is part of the Yakima Project, which operates to provide irrigation water for agricultural production in the Yakima Valley. Missionaries first came to the Yakima Valley in 1848, which was the start of major changes in the area. By 1902, about 121,000 acres were irrigated in the Yakima River basin. This acreage was served by unregulated flows in the Yakima River and its tributaries. Irrigation diversions exceeded unregulated runoff during periods of low flow by the turn of the century. Early in 1906, the Reclamation Service started investigations of storage sites, including Rimrock Lake. By the late 1900s the USBR had constructed five major storage reservoirs and seven major irrigation diversions in the basin.

Construction of Tieton Dam began in 1917 and the structure was completed in 1925. It is an earthfill structure with a concrete core wall that extends from the crest to about 100 feet below the riverbed. The dam is 319 feet high and contains 2,049,000 cubic yards of material. Outlet capacity is 2760 cfs (USBR 2000). Rimrock Lake capacity is 198,000 acre-feet. No fish facilities exist at the dam.

The primary use of water stored in Rimrock Lake is irrigation. Secondary uses are flood control and recreation. Since 1981, a modified irrigation flow release schedule has been in effect at Tieton Dam in combination with modification to flow releases made at reservoirs in the upper Yakima River basin. The modified schedule, termed “flip flop," was designed to provide instream flows in the fall for Yakima River salmon spawning and incubation while minimizing demand on existing irrigation storage in the basin. Under the schedule, minimum flows are released from Tieton Dam in the early summer while flows from dams in the upper basin are increased to supply irrigation. This pattern is reversed starting September 10, so that flows in the Kachess, Cle Elum and Yakima Rivers can be dropped where spring chinook are spawning. Reducing flows at the time of spawning in those rivers ensures that eggs are deposited at river levels that can be sustained throughout the winter as reservoirs fill. At Tieton Dam, flows are sharply increased starting September 10 to deliver water for consumptive and nonconsumptive demands in the lower Yakima basin. Thus, increased releases from Rimrock Lake are designed to compensate for reduced releases from the upper Yakima basin reservoirs. Mean monthly flows for water years 1982 through 2001 are presented below (Figure 17).
At the end of the irrigation season in October, the outflow from Tieton Dam is reduced as the storage season begins. It is during this period that operations are influenced by flood control objectives. The informal flood control allocation curves require a minimum of 60,000 acre-feet of vacant capacity through the end of January, which is a 20% share of the 300,000 acre-feet required in the five Yakima Project reservoirs, combined. The requirement is then reduced in a straight line to 32,000 acre-feet on February 15, after which the required space is established by the forecast runoff above Parker gauging station. The goal of the flood control operation is to limit peak flow of the Yakima River near Parker gauging station to 12,000 cfs. Except for these flood control operations, all reservoir inflow is held in Rimrock Lake and released as required by irrigation demand. The Yakima Project Hydrology Section determines the amount of release required for daily project irrigation use. Prior to storing water in surcharge
space, approval must be granted by the regional office. Any water temporarily stored in surcharge to reduce a potentially hazardous situation downstream is released as soon as downstream conditions permit.

Water quality standards for WDE class AA exceptional water quality are met 300 feet below the stilling basin. The state standards for this rating are DO levels greater than or equal to 9.5 mg/l or 110% of saturation, and temperatures less than or equal to 16 °C. Dissolved Oxygen levels are discussed in more detail in the Project Effects section later in this BA.

3.3 Dissolved Oxygen and Temperature

Dissolved oxygen levels below 6 mg/L can impair egg development and growth of young fish, and affect swimming ability. Survival thresholds are around 3 mg/L, and metabolic and physiological processes are slowed at DO levels of 5 mg/L (Davis et al. 1963).

The Tieton River below Tieton Dam meets the Washington Department of Ecology Water Quality Program certification for a class AA stream. The state DO standards are for levels greater than or equal to 9.5 mg/l, and total DO levels less than or equal to 110% of saturation. Because saturation occurs at concentrations less than 9.5 mg/l at temperatures exceeding 13.3 °C (Table 2), WDE’s requirements for DO levels for the project when water temperature is greater than 13.3 °C is saturation rather than 9.5 mg/l (Tieton Hydro EA). The water quality certificate requires the state DO standards be met 300 feet downstream of the outlet of the stilling basin.

Table 2. Dissolved oxygen saturation levels at different temperatures.

<table>
<thead>
<tr>
<th>°C</th>
<th>°F</th>
<th>Dissolved Oxygen Saturation (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33.8</td>
<td>12.8</td>
</tr>
<tr>
<td>2</td>
<td>35.6</td>
<td>12.5</td>
</tr>
<tr>
<td>3</td>
<td>37.4</td>
<td>12.2</td>
</tr>
<tr>
<td>4</td>
<td>39.2</td>
<td>11.8</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
<td>11.6</td>
</tr>
<tr>
<td>6</td>
<td>42.8</td>
<td>11.3</td>
</tr>
<tr>
<td>7</td>
<td>44.6</td>
<td>11.0</td>
</tr>
<tr>
<td>8</td>
<td>46.4</td>
<td>10.7</td>
</tr>
<tr>
<td>9</td>
<td>48.2</td>
<td>10.5</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>10.2</td>
</tr>
<tr>
<td>11</td>
<td>51.8</td>
<td>10.0</td>
</tr>
<tr>
<td>12</td>
<td>53.6</td>
<td>9.8</td>
</tr>
<tr>
<td>13</td>
<td>55.4</td>
<td>9.6</td>
</tr>
<tr>
<td>13.3</td>
<td>55.94</td>
<td>9.5</td>
</tr>
<tr>
<td>14</td>
<td>57.2</td>
<td>9.4</td>
</tr>
</tbody>
</table>
WDE has conducted water quality monitoring on the Tieton River at Oak Creek (RM 2.1). Data was collected one day per month for a year starting October 1991 and continuing through September 1992. As Figure 18 shows, DO levels measured on those days met the state standard in every instance.

Figure 18. DO content in the Tieton River at Oak Creek (RM 2.1) in mg/L and saturation level. Measurements by WDE on twelve days in 1991, 1992.
Low DO in the outflow from the reservoir could only result if DO levels in the reservoir near the outlet depth were low. We can examine the possibility of that occurring by reviewing the DO versus depth profile in the reservoir forebay. Water quality sampling conducted in 1998 through 2001 show DO levels in the lake are generally at or above 90% saturation at 150 feet deep even in the late summer when lowest DO levels would be expected (Figure 19). The most recent DO measurements occurred in 2001, a drought year when Rimrock Lake dropped to 2812 feet – its lowest elevation in seven years and a level eclipsed only three times in the last 21 years (Figure 20). Even at this low level, DO profiling showed >80% saturation all the way to the reservoir bottom in September 2001.
Figure 19. DO concentrations in mg/L and % saturation measured in Rimrock Lake, 1998-2001. Reservoir elevations differed between sampling dates. USBR data. Location of monitoring station is in mid-channel, where reservoir bottom is evidently about 25 feet higher than elevation at the intake structure, which is located toward the north end of the dam (Steve Hiebert, USBR, personal communication, 2/25/02). Data presented are truncated to not include measurements taken while the probe rested on the reservoir bottom.
Under present conditions, water passing the outlet works is reaerated with jet valves as it is released into the Tieton River below the dam. The proposed project would divert up to 1200 cfs of discharge through the turbines; excess water would pass through the jet valves. Typical discharges during flip flop operations in late summer are in excess of turbine capacity between around September 5 to October 1 (Figure 21). Thus some level of reaeration of water exiting Rimrock Lake will take place during the late summer, when DO levels are at their lowest.
Thermal profiling conducted by the USBR shows that temperatures near the intake opening were between 10 and 14 °C in late summer (Figure 22). These profiles also show evidence of mixing in Rimrock Lake, because temperatures were well above 4 °C even at the bottom and showed only moderate stratification, and in some instances exhibited no stratification. All other storage reservoirs in the Yakima basin stratify thermally in summer with temperatures in the lower stratum at 4 °C. The higher temperatures in Rimrock Lake at depth indicate that vertical mixing occurs, and maintains the high levels of DO saturation. The unusual temperature regime in Rimrock Lake is probably due in part to the presence of Clear Lake on the North Fork Tieton River just upstream of Rimrock Lake. This body of water provides a large supply of cold water entering the reservoir, which tends to wedge under the warmer water it meets. This phenomenon, in concert with prevailing wind patterns in the Tieton basin results in the circulating of water in Rimrock Lake, which causes thermal mixing rather than
stratification, and keeps DO levels near saturation from surface to bottom (Steve Hiebert, personal communication).

While the jet valves in the Tieton Dam outlet works serve to re-aerate water destined for downstream reaches, the kinetic energy of the water ejected high pressure and velocity translates into thermal energy and causes water temperatures to increase by approximately one degree C in downstream reaches (Kim Sherwood, personal communication).

WDE temperature standards for class AA-exceptional streams is equal to or less than 16 °C. Temperature data for the Tieton River below the project area is limited. The only data we were able to find was water quality data collected by WDE in the Tieton River below Tieton Dam on 12 days in 1991 and 1992. Temperatures were measured as spot checks rather than over substantial periods of time, and therefore should be viewed as indexes estimates of mean temperatures. Index temperature exceeded 16 °C on only one of those days, and was below 15 °C on every other occasion (Figure 23). Index temperatures ranged between 8.9 and 15 °C for every day monitoring was conducted from March through October, and were 6 °C or below the other four months of the year.
3.4 Observations of Entrainment

The outlet of Rimrock Lake is a tower structure at the bottom of the lake near the dam. When fish are entrained, they are conveyed through a pipeline under the dam and exit at the existing jet valves.

Entrainment studies during the late summer of 2001 showed that entrainment of bull trout is low even at substantial reservoir drawdown, and entrainment rates of fish were related more to discharge rate than to reservoir level.
The USBR conducted entrainment studies in the Tieton River below Tieton Dam from late August to mid October 2001 (James 2001). Two large nets were fished on opposite sides of the stream approximately 400 m downstream from the stilling basin. The nets were fished at least 8 hours out of nearly every 24-hour period between August 27 and October 17. Four salmonid species were observed in the nets ( kokanee salmon, rainbow trout, bull trout and mountain whitefish) as well as dace, sculpin and sucker species. Because the nets were fished 400 m downstream of the stilling basin, it is possible that resident fish from the river below the dam may have been caught in the nets along with fish that passed through the dam outflow. Only kokanee, dace, rainbow trout and suckers were observed in numbers totaling over 25 individuals. Kokanee were by far the most abundant fish observed in the nets, accounting for nearly 97% of the 11290 fish caught (Table 3). Only four bull trout were caught in the traps during the 7-week duration of the study; all were subadults under 250 mm.

Table 3. Species and numbers of live and dead fish caught in fyke nets below Tieton Dam, August 27-October 17, 2001. USBR.

<table>
<thead>
<tr>
<th>Species</th>
<th>Alive</th>
<th>Dead</th>
<th>% dead</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bull Trout</td>
<td>0</td>
<td>4</td>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>Kokanee</td>
<td>2063</td>
<td>8880</td>
<td>81</td>
<td>10943</td>
</tr>
<tr>
<td>Dace Spp.</td>
<td>53</td>
<td>223</td>
<td>81</td>
<td>276</td>
</tr>
<tr>
<td>Mtn Whitefish</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Rainbow Trout</td>
<td>28</td>
<td>9</td>
<td>24</td>
<td>37</td>
</tr>
<tr>
<td>Sculpin Spp.</td>
<td>1</td>
<td>1</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>Bridgelip Sucker</td>
<td>11</td>
<td>16</td>
<td>59</td>
<td>27</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2157</strong></td>
<td><strong>9133</strong></td>
<td><strong>81</strong></td>
<td><strong>11290</strong></td>
</tr>
</tbody>
</table>

Because the number of hours fished each day was not constant it is more useful to look at catch per unit time than total numbers caught when examining the data. The plot of catch per hour versus flow shows that catch was generally higher at higher flow rates (Figure 24). Regression of catch per hour versus average daily outflow showed this relationship is highly significant (p < 0.00001), but daily flow accounted for only 39% of the variability in catch per hour.
Higher entrainment rates at higher flows are most likely related to higher water velocities near the intake valve during these times. Higgs and Kubitschek (2001) conducted modeling of the velocity field around Tieton Dam’s outlet structure at different discharge flows. They found that near field velocities are strongly dependent on outlet works discharge. Reservoir elevation, by contrast, had little influence on near field velocities. Modeling was conducted at three discharge levels: 2200, 800 and 300 cfs. Water velocities at the outlet exceeded maximum swimming speed of subadult kokanee and bull trout only for the highest discharge level modeled (Table 4) (Figure 25). We have found in our experience with numerous studies where we fish downstream migrant traps that velocities in excess of 6 fps are necessary to avoid size-related bias, even for fish no greater than 100 mm long. The velocity modeling showed that even at 800 cfs discharge, velocities were only 4 fps within 1 foot of the outlet, which would have allowed kokanee and bull trout to avoid being entrained.
Table 4. Tieton Dam outlet works near field water velocities at three different discharge levels (Higgs and Kubitschek 2001). Our experience indicates water velocities in excess of 6 fps are necessary for unbiased sampling of juvenile salmonids, even for fish no greater than 100 mm in length.

<table>
<thead>
<tr>
<th>Discharge (cfs)</th>
<th>Velocity within 1 foot of the outlet structure (fps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>1.5</td>
</tr>
<tr>
<td>800</td>
<td>4.0</td>
</tr>
<tr>
<td>2200</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Figure 25. Velocity contours in near field of outlet structure of Tieton Dam corresponding to discharge of 2200 cfs, as modeled by Higgs and Kubitschek (2001). Maximum velocities approaching 10 fps occur within 1 foot of the outlet structure. Velocity outputs of modeling at lower discharge levels were low enough for all but the smallest fish to avoid being entrained by swimming away from the outlet valve.
Current conditions without the proposed hydropower project at Tieton Dam cause high mortality of entrained fish. Eighty one percent of kokanee captured in the nets were dead, and many had eroded fins and/or were badly descaled. Those who sampled the nets said that injuries appeared to have been inflicted from the outlet jet rather than during capture in the net, but this could not be confirmed.

The proportion of dead fish of each species with over 30 observations was lowest for rainbow trout (24%). Rainbow trout exist in significant numbers below Tieton Dam, and in lower concentrations in Rimrock Lake. It is likely that a high proportion of rainbow captured were resident fish from the river environment downstream of the stilling basin. Other species with over 30 observations suffered at least 59% mortality.

Kokanee exist only in the reservoir, and therefore provide a good indicator of effects of passing through the dam outlet works. Eighty one percent of kokanee caught in the nets were dead. Certainly some fraction of entrained fish survive, and electrofish sampling in 1993 of the stilling basin and Wildcat Creek, which flows into the Tieton River ¼ mile below Tieton Dam, netted 25 kokanee (E. Anderson, personal communication). Kokanee have also been seen at the Sunnyside diversion screens in late October and early November (K. Puckett, personal communication).

It is possible that the nets themselves caused some mortality. Water velocity entering the nets averaged just under 5 fps (K. Puckett, personal communication). Fish pinned against the end of the net in this velocity at length would suffer adverse effects. No mark-recapture tests with live fish were performed in the nets, so the data are insufficient to directly estimate net mortality. If we assume as a worst case for net mortality, however, that all rainbow captured were of river origin, and were therefore alive when captured, we would estimate that net mortality was about 24% (the mortality rate observed for rainbow). This figure is likely artificially high since some number of entrained rainbow were probably captured as well. Even at this very liberal estimate of net mortality, it appears that significant mortality to entrained kokanee occurred as they passed the outlet works. A full 84% of the 10,943 kokanee recovered in the entrainment study were dead; leaving 60% of observed kokanee mortality attributable to passage through the outlet works.

Current mortality of fish passing through the outlet works is likely caused by a combination of physical stresses and sudden pressure differences. Under present conditions water released from Rimrock Lake is directed through a jet valve at the end of the outlet works. The jet is designed to re-aerate water exiting the reservoir, to supplement dissolved gas levels in downstream reaches. The valve forces water through a small opening then ejects the water horizontally into the air, where it plunges into the stilling basin (Figure 26, Photo 1). Tieton Dam is a high head facility and water
exiting the jet valves is expelled with great force. It is evident that passing through the concrete and steel jet valve causes physical stress to fish, which may strike these hard surfaces at considerable speed. Most of the small kokanee (<100mm) recovered from the nets were dead, and most kokanee in all size classes (both dead and alive) showed signs of descaling and seriously frayed dorsal and caudal fins. Some partial fish carcasses were also caught in the nets (K. Puckett, personal communication).

Figure 26. Schematic cross-sectional diagram of jet valve currently in place at Tieton Dam. The size of the opening through which water passes is determined by the vertical position of the gate stem, shown in the full open position in this diagram. In practice, operations at Tieton Dam call for water to be passed through the jet valve with the gate stem in a lowered position so that less than half the jet flow boundary is open (Nick Josten, personal communication).
The process of passing through the outlet works also results in entrained fish experiencing a great pressure differential as they pass the outlet works, because they enter the outlet works at depth and are suddenly ejected from the jet valve into the air, where the pressure is about 1 atmosphere -- far less than it was at the depth to which they were acclimatized. Because the valve works are maintained within a small range of settings, the effect of valve operations on pressure differential is negligible, and is rather related to reservoir elevation. Figure 27 shows the relationship between reservoir elevation and pressure difference experienced by fish, as well as water velocity in the outlet pipe. Note that the relationship between reservoir elevation and pressure differential is linear – thus pressure differential experienced is directly proportional to reservoir elevation. The pressure difference increases as reservoir elevation increases,
because higher reservoir elevations translate into greater depths at the dam intake, and thus higher pressures in the water column.

At higher reservoir levels fish in the outlet works pass through the jet valve at over 100 fps and experience a pressure difference of up to 80 psi over a very short period of time. At 1 atmosphere of pressure per every 14.7 psi, that is a pressure difference of over 5 atmospheres. A pressure difference of this magnitude would cause gas bubble trauma in fish passing through the Tieton Dam outlet works. Gas bubble disease is similar to the “bends” experienced by human divers who surface too quickly. It occurs when the dissolved gas in the fish's tissues are not in equilibrium with the surrounding water. At Tieton Dam, water exiting the regulating outlet can no longer hold the same amount of gas in solution at the ambient temperature and hydrostatic pressure as it did at depth in the reservoir. Because the water reaches equilibrium with its new conditions quite quickly, dissolved gas pressures in the blood and tissue of the fish are suddenly much higher than in the surrounding water, and the result is that gas bubbles form in the tissues and blood of the fish. These gas bubbles can block the flow of blood to the internal organs, causing significant damage.

Figure 27. Change in pressure at the jet valve and jet velocity in relationship to Rimrock Lake elevation.
The pressure differential experienced by fish entrained in the Tieton Dam outlet works can be estimated based on daily reservoir elevation. We also have daily values for mortality rates of entrained fish available to us from the entrainment study conducted by James (2001) recorded whether fish captured in the fyke nets during the study were recovered alive or dead. The purpose of the study was to quantify entrainment, not to report on the condition of entrained fish, so the condition information in that report should be viewed as an estimate. Simple regression analysis showed a strong relationship between the average daily pressure differential experienced by fish and the daily mortality rate ($p < 0.00001$) (Figure 28). We limited our analysis to kokanee, as these fish exist only in the lake and therefore are certain to represent entrained fish. We also only used data from days with at least 10 observations of kokanee in the nets. Fish condition data from one day of sampling was thrown out because it was of dubious accuracy. Pressure differential explained 56% of the variability in daily proportion of dead fish recovered from the fyke nets.

![Figure 28. Scatter plot of the daily proportion of kokanee observed in fyke nets that were dead versus change in pressure experienced by fish passing through the Tieton Dam outlet works, August 27 – October 17, 2001.](image-url)
The scatter plot of mortality rate versus change in pressure shows that daily mortality rate was at least 60% for each day that pressure differences was over 55 psi. Most of these days mortality rate exceeded 80%. Also, the regression indicates that mortality in the nets would drop to an average of 20% when the pressure change dropped to around 2 atmospheres (~30 psi). This is congruent with the observed 24% mortality rate of rainbow captured in the nets, most of which probably originated in the tailrace.

Even if we assume that the 24% mortality observed for rainbow trout in the fyke nets was exclusively due to net mortality, it is evident that a large proportion of fish passing through the outlet works at Tieton Dam – probably at least 60% (84%-20% = 60%) – are killed by physical stress and gas bubble disease caused by sudden pressure change as they exit the outlet works via the jet valve.

We conclude that mortality to entrained fish under present conditions without the hydro project is probably at least 60% and may be as high as 80%.

4. DESCRIPTION OF THE BIOLOGY OF THE LISTED FISH SPECIES AND THEIR USE OF THE PROJECT AREA

4.1 Bull Trout

Bull trout (*Salvelinus confluentus*), formerly known as Dolly Varden (*Salvelinus malma*) in many locations, was classified as a species separate from Dolly Varden in 1978. Members of the genus *Salvelinus* are known as char. Other members of this genus include brook trout (*S. fontinalis*), lake trout (*S. namaycush*), Dolly Varden and arctic char (*S. alpinus*) (Cavender 1978). Bull trout are native to the Yakima River basin.

On June 10, 1998 the USFWS listed the Columbia River population segment of bull trout as threatened. Columbia River bull trout populations have declined from historic levels and are generally considered to be isolated and remnant. An examination of 386 bull trout populations in the Columbia River population segment, which includes the Yakima River basin, indicated that 33 % were declining, 15 % were stable, 3 % were secure, and 2 % were increasing (USFWS 1997). The population status of the remaining 47 % in the Columbia River population segment within the United States was unknown. Because the USFWS considers that known, documented trends within a distinct population segment to be representative of the entire population segment, an overall declining trend of bull trout populations in the Columbia River Basin was evident based on the 1994 USFWS administrative record.

4.1.1 Life History and Distribution in the Yakima Basin

Bull trout live in cold water and are found in the upper basins of systems where they are present. Bull trout exhibit both migrant and resident life history strategies. After rearing
as juveniles for 2-4 years in their natal stream (Meehan and Bjornn 1991) migrant bull trout emigrate to larger rivers or lakes. Resident fish complete the entire life cycle within the natal stream. Spawning takes place in the fall. Table 5 and Table 6 summarize the life history of bull trout and present timing of upstream migration and spawning for bull trout streams feeding Rimrock Lake.

Table 5. Summary of the life history of the bull trout (from Knowles and Gumtow, 1996).

<table>
<thead>
<tr>
<th>Life conditions</th>
<th>Criteria/facts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at first reproduction</td>
<td>4-5 years</td>
</tr>
<tr>
<td>Number of eggs produced</td>
<td>1,300 to 9,000</td>
</tr>
<tr>
<td>Maximum size</td>
<td>Greater than 30 pounds and 36 inches</td>
</tr>
<tr>
<td>Life span</td>
<td>Up to 10 years</td>
</tr>
<tr>
<td>Food habits</td>
<td>Juveniles are insectivorous. Adults are piscivorous</td>
</tr>
<tr>
<td>Incubation success (%)</td>
<td>Critical Water temp (F)</td>
</tr>
<tr>
<td></td>
<td>32-36 F</td>
</tr>
<tr>
<td></td>
<td>0-2 C</td>
</tr>
<tr>
<td></td>
<td>% Success</td>
</tr>
<tr>
<td>Sediment size:</td>
<td>20 % fines</td>
</tr>
<tr>
<td>% success:</td>
<td>40%</td>
</tr>
<tr>
<td>Migration strategies</td>
<td>Resident, migrant (adfluvial, fluvial, and anadromous)</td>
</tr>
<tr>
<td>Closely related species</td>
<td>Dolly Varden, lake trout, and brook trout</td>
</tr>
<tr>
<td>Optimal and maximum water temperature</td>
<td>Juveniles = 39-48 F and 59 F</td>
</tr>
<tr>
<td>Spawning season</td>
<td>September through November</td>
</tr>
</tbody>
</table>
Table 6. Known spawning period for bull trout above Rimrock Lake.

<table>
<thead>
<tr>
<th>Migration to Spawning Areas</th>
<th>Spawning Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Fork Tieton</td>
<td>July - mid-Sept, mid Aug - mid Oct</td>
</tr>
<tr>
<td>Indian Creek</td>
<td>mid August - mid Sept, mid Aug - early Oct</td>
</tr>
</tbody>
</table>

The incubation period for bull trout is extremely long, owing to the cold water in which eggs are deposited, and young fry may take up to 225 days to emerge from the gravel (Craig 1997, USFWS 1998). Siltation, removal of stream cover, or changes in water flow or temperature affect the number of bull trout that hatch and their ability to survive to maturity (Knowles and Gumtow 1996).

In migratory populations of bull trout such as those in Rimrock Lake, juveniles rear in the natal stream for 1-3 years before migrating downstream to begin the piscivorous life stage. Ratliff (1992) found from sampling in the Metolius River basin that bull trout under 100 mm long were generally only found in the vicinity of spawning areas, and that fish over 100 mm were found downstream in larger channels and reservoirs. Downstream migration occurred principally in May and June. Buchanan et al. (1997) reported the results of downstream migrant trapping of juvenile bull trout in the Umatilla River that showed peak migration in April-May and again in October. Juvenile migrants in the Umatilla River were primarily 100-200 mm long in the spring and 200-300 mm long in October (Buchanan et al. 1997). Ratliff (1992) reported that most juveniles reached a size to migrate downstream at age 2, with some at ages 1 and 3. Pratt (1992) had similar findings for age at migration of juvenile bull trout from tributaries of the Flathead River.

Migrant forms of bull trout move downstream to a river or lake where they feed on other fish and grow to maturity. After entering the river or lake, juvenile bull trout grow rapidly, often reaching sizes over 20 inches and over 2 pounds by the time they are 5-6 years old. Migratory bull trout live several years in larger rivers or lakes, where they grow to a much larger size than resident forms before returning to tributaries to spawn. Growth differs little between 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). Resident and migratory forms may live together, but it is unknown if they represent a single population or separate populations (Rieman and McIntyre 1993).

Bull trout may spawn each year or in alternate years (Batt 1996), and survival is high between repeat spawning. Mark recapture studies of bull trout spawners from Rimrock Lake have shown that spawners each year include fish on up to their fifth spawning run (P. James, personal communication, Central Washington University, Ellensburg, Washington). Variation in the timing of out-migration and in the timing and frequency of
spawning also represents diversity in life history. The multiple life-history strategies found in bull trout populations represent important diversity (both spatial and genetic) that help these populations from environmental stochasticities and catastrophic events.

Temperatures above 15 °C (59 °F) are thought to limit bull trout distribution (Fraley and Shepard 1989, Batt 1996, Brown, 1992). Ratliff and Howell (1992) note that bull trout are the only fish present in many of the cold streams where spawn. Ratliff (1992) reported that four of the spawning streams for bull trout in the Metolius Basin had no other fish present, and the mean water temperature for July ranged from only 5.7 to 8.2 °C (42- 47 °F) in those streams. Buckman et al. (1992) found that stream temperatures averaged only 45 °F (7.2 °C) in streams where juvenile bull trout were found in the Malheur basin, and elevation of these streams was above 5000 feet.

The requirement for cold water during egg incubation has also limited 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 5000 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 5500 feet (Ziller 1992).

Underwood et al. (1995) studied the overlap of habitat use between bull trout and steelhead in three streams of southeastern Washington that have no barriers to fish passage. They found that “bull trout distribution was limited to the upper portion of each study stream.” Further, within the study reaches where bull trout were present, “bull trout were more abundant at the highest elevation sites, while O. mykiss were most abundant at the lowest elevation sites in each stream.” In the Tucannon River where both spring chinook and bull trout were present, the downstream limit of bull trout spawning started 5 km upstream from the upstream limit of spring chinook spawning. Elevations in the three streams ranged from 2,480 ft to 2,920 ft in Mill Creek (Walla Walla Basin), 3,480 ft to 3,880 ft in the Tucannon River, and 2,680 ft to 3,380 ft in Wolf Creek (Touchet River Basin). All of these elevations are near, or higher than, the elevation of the storage reservoirs in the Yakima Basin that support populations of adfluvial bull trout, including Rimrock Lake (Table 7), but are lower than elevations where bull trout are found further up the Snake River Basin or in the Klamath Basin.
Bull trout were likely more widely dispersed throughout the Yakima River drainage than is the case today. In the Yakima Basin, several bull trout populations were isolated, or nearly isolated, once the storage dams were built.

Rieman et al. (1997) suggest that, even historically, bull trout distributions would have been patchy because of natural passage barriers, thermal barriers, stringent habitat requirements, and by some life history factors discussed below. Summarizing existing knowledge of bull trout distribution within the interior Columbia River basin in Oregon, Washington, Idaho, Montana, and Nevada and of the Klamath River basin in Oregon, Rieman et al. (1997) concluded that bull trout are most likely to occur and to be strong in colder, higher-elevation, low- to mid-order watersheds with low road density. Elevation has been found to be correlated to fish distribution in the Yakima River (Pearsons and Martin 1993) and elsewhere (Rieman and McIntyre 1995). Elevation is likely associated with temperature, stream order, and other variables and has been used as an assumed proxy for temperature to define habitat patches for bull trout (Reiman and McIntyre 1995).

The final determination to list bull trout stated, “Bull trout in the mid-Columbia River area are most abundant in Rimrock Lake of the Yakima River basin and Lake Wenatchee of the Wenatchee River basin. Both subpopulations are considered ‘strong’ and increasing or stable” (63 FR 31650). The two major spawning tributaries to Rimrock Lake are South Fork Tieton River and Indian Creek. The South Fork Tieton River has substantially greater catchment above 5,000 ft and greater length of spawning area than
any other stream surveyed above reservoirs (Table 8); which means it is the largest
stream with the most rearing area. Further, Indian Creek was largely spring fed with
highly stable temperatures at about 8°C. Thus, the high abundance of bull trout in
Rimrock Lake is associated with the largest amount of desirable spawning habitat for
bull trout above any lake in the Yakima Basin. Possible spawning areas are far more
confined above Bumping Lake (Deep Creek only), Keechelus Lake (Gold Creek only),
and Kachess Lake (Box Canyon Creek only) than they are above Rimrock Lake. Thus,
the limited availability of spawning and rearing habitat dictates that healthy populations
of bull trout in Bumping, Keechelus and Kachess Lakes will not be as large as those in
Rimrock Lake. Little is known about the bull trout population above Cle Elum Lake, but
the large and remote watershed above that lake leaves open the possibility that a
substantial bull trout population may exist there.

Table 8. Stream Characteristics and Redd Counts in Bull Trout Streams in the Yakima River
basin. American River includes Union and Kettle Creeks. Redd Counts from WDFW, Yakima.

<table>
<thead>
<tr>
<th>Stream</th>
<th>Above Dam</th>
<th>1996-99 Mean Count</th>
<th>Length of Spawning Reach (km)</th>
<th>96-99 Redds Per km</th>
<th>Catchment Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.Fk.Teanaway, DeRoux Crk</td>
<td>N</td>
<td>1</td>
<td>3.0</td>
<td>0.2</td>
<td>5.0</td>
</tr>
<tr>
<td>MF Ahtanum Creek</td>
<td>N</td>
<td>6</td>
<td>7.6</td>
<td>0.8</td>
<td>44.8</td>
</tr>
<tr>
<td>NF Ahtanum Creek</td>
<td>N</td>
<td>28</td>
<td>13.8</td>
<td>2.0</td>
<td>145.2</td>
</tr>
<tr>
<td>American River</td>
<td>N</td>
<td>45</td>
<td>9.1</td>
<td>5.0</td>
<td>85.6</td>
</tr>
<tr>
<td>Rattlesnake Creek</td>
<td>Y</td>
<td>13</td>
<td>2.5</td>
<td>5.1</td>
<td>31.6</td>
</tr>
<tr>
<td>Box Canyon Creek</td>
<td>Y</td>
<td>40</td>
<td>6.4</td>
<td>6.2</td>
<td>35.3</td>
</tr>
<tr>
<td>Gold Creek</td>
<td>Y</td>
<td>94</td>
<td>8.4</td>
<td>11.2</td>
<td>64.2</td>
</tr>
<tr>
<td>Deep Creek</td>
<td>Y</td>
<td>178</td>
<td>9.7</td>
<td>18.4</td>
<td>137.1</td>
</tr>
<tr>
<td>SF Tieton River</td>
<td>Y</td>
<td>201</td>
<td>9.2</td>
<td>21.9</td>
<td>41.5</td>
</tr>
</tbody>
</table>

There are several possible mechanisms through which reservoirs might provide
an advantage to production of bull trout, including: (1) expanded rearing capacity for
juveniles, (2) higher survival rate from age 2 to maturity, (3) opportunity for growth to
large size and high fecundity, and (4) refuge area from catastrophic events. We have
not found data to verify any of these mechanisms, except growth to large size. There is
suggestive evidence that the expanded rearing and refuge mechanisms may be
important. Reiser et al. (1997) demonstrated in the Cedar River, Washington, that
some juvenile bull trout emigrated to Chester Morse Lake as emergent fry. If fry can
successfully rear in the reservoir, then rearing capacity would be substantially greater
than that in only the natal stream. McPhail and Murray (1979) confirmed from analysis
of otoliths that 15% of maturing bull trout in MacKenzie Creek (tributary to Upper Arrow Lake), showed no period of stream rearing in the juvenile life.

It is likely that the reservoirs in the Yakima basin (and the natural lakes that pre-existed there) have served as refuges where bull trout can survive through the low water years when spawning and rearing in marginal spawning streams is prevented. It is a common life history for bull trout to spawn at several different ages, and to skip years between repeat spawning. Repeat and alternate year spawners constituted 40% and 8.4% of spawners during 1996 and 1997 in the Wigwam River, British Columbia (Baxter and Westover 1999), which is similar to findings by Fraley and Shepard 1989 in the Flathead River. This trait would enable bull trout populations to survive in Yakima Project reservoirs through several years of complete spawning failure, as was the case in Keechelus and Kachess lakes when no successful spawning occurred in Gold and Box Canyon creeks, respectively, for several years. Bull trout are able to perpetuate the population by successfully spawning in years when water conditions are satisfactory. Dams may also create refuges by blocking invading species. Baxter et al. (1999) note that Bigfork Dam has protected Swan Lake from invasion by lake trout, and this may explain why the Swan Basin populations of bull trout have not experienced the decline that has been true in other tributaries to Flathead Lake.

The four factors considered by NMFS and FWS when making a determination whether to list a given species are presented in Table 9, along with how those factors play out with respect to Rimrock Lake bull trout. The answers to the questions presented in Table 9 highlight the abundant and robust nature of bull trout above Tieton Dam.

| Functionally/geographically isolated? | Restricted to areas above Rimrock Lake |
| Limited to single spawning area? | No |
| <5000 individuals or <500 spawners? | No |
| Life history forms lost? | Retains migratory form |

### 4.1.2 Uses of Rimrock Lake

The construction of Rimrock Lake isolated the populations of bull trout in the basin from migrating below the dam during their life. Bull trout spawn in Indian Creek and the South Fork of the Tieton River. Central Washington University, Reclamation, USFS, and WDFW are conducting bull trout studies in this area. Redd counts in the late 1990s appear to be stable in Indian Creek and more variable in the South Fork Tieton River (Table 10), but higher than in the 1980s. James et al. (1998a) reported recent population estimates based on mark-recapture studies as 600-700+ in Indian Creek and 875 to 2000+ in the South Fork Tieton River. Indian Creek bull trout appear to be
slightly larger than those captured in Deep Creek and bull trout in the South Fork Tieton River are even larger. Bull trout enter their spawning streams from July to mid-September and spawn from mid-August through early October (WDFW 1998a). James et al. (1998b) concluded from tagging data and differences in body size and adult migration timing that Indian Creek and South Fork Tieton River fish may represent two reproductively isolated sub-populations. James (1999) estimated bull trout populations in Indian Creek and South Fork Tieton River based on mark and recapture studies (Table 11).

Table 10. Bull trout redd counts in Yakima River basin Index Areas (Data from WDFW)

<table>
<thead>
<tr>
<th>Year</th>
<th>N. Ahtanum</th>
<th>Rattlesnake</th>
<th>S.Fk. Tieton</th>
<th>Indian</th>
<th>Deep Cr.</th>
<th>Box Canyon Cr.</th>
<th>Gold Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>29</td>
<td>5</td>
<td>2</td>
<td>69</td>
<td>3</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>1985</td>
<td>69</td>
<td>4</td>
<td>2</td>
<td>16</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>1986</td>
<td>35</td>
<td>0</td>
<td>17</td>
<td>25</td>
<td>0</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>1987</td>
<td>39</td>
<td>17</td>
<td>0</td>
<td>69</td>
<td>15</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>1988</td>
<td>2</td>
<td>32</td>
<td>69</td>
<td>123</td>
<td>84</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>1989</td>
<td>142</td>
<td>78</td>
<td>32</td>
<td>142</td>
<td>78</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>1990</td>
<td>9</td>
<td>38</td>
<td>140</td>
<td>140</td>
<td>45</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>1991</td>
<td>14</td>
<td>4</td>
<td>167</td>
<td>167</td>
<td>12</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>1992</td>
<td>6</td>
<td>26</td>
<td>95</td>
<td>95</td>
<td>201</td>
<td>101</td>
<td>16</td>
</tr>
<tr>
<td>1993</td>
<td>5</td>
<td>38</td>
<td>233</td>
<td>233</td>
<td>193</td>
<td>46</td>
<td>8</td>
</tr>
<tr>
<td>1994</td>
<td>7</td>
<td>46</td>
<td>177</td>
<td>177</td>
<td>193</td>
<td>126</td>
<td>10</td>
</tr>
<tr>
<td>1995</td>
<td>5</td>
<td>53</td>
<td>142</td>
<td>142</td>
<td>212</td>
<td>98</td>
<td>16</td>
</tr>
<tr>
<td>1996</td>
<td>7</td>
<td>44</td>
<td>161</td>
<td>161</td>
<td>205</td>
<td>107</td>
<td>17</td>
</tr>
<tr>
<td>1997</td>
<td>11</td>
<td>45</td>
<td>144</td>
<td>144</td>
<td>226</td>
<td>147</td>
<td>10</td>
</tr>
<tr>
<td>1998</td>
<td>20</td>
<td>57</td>
<td>158</td>
<td>158</td>
<td>117</td>
<td>51</td>
<td>14</td>
</tr>
<tr>
<td>1999</td>
<td>9</td>
<td>47</td>
<td>169</td>
<td>169</td>
<td>96</td>
<td>13</td>
<td>32</td>
</tr>
</tbody>
</table>

Table 11. Adult Bull Trout Population Estimate (95% Confidence Interval Range)

<table>
<thead>
<tr>
<th>Year</th>
<th>Indian Creek</th>
<th>South Fork Tieton</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>(456-860)</td>
<td>(875-2066)</td>
</tr>
<tr>
<td>1996</td>
<td>(633 -1103)</td>
<td>(554 - 903)</td>
</tr>
<tr>
<td>1997</td>
<td>(600 -717)</td>
<td>(756 -1379)</td>
</tr>
<tr>
<td>1998</td>
<td>(756 -1379)</td>
<td>(541 -1059)</td>
</tr>
<tr>
<td>1999</td>
<td>(541 -1059)</td>
<td>(876 -2452)</td>
</tr>
</tbody>
</table>
4.1.3 Limitations to Production Below Rimrock Lake

Though bull trout are known to exist in the Tieton River below the project area, this stretch of stream offers less than ideal conditions for bull trout distribution and abundance. Elevation is 2615 at the base of Tieton Dam. This is lower than elevations at which bull trout are known to be adapted. Spawning areas for bull trout in the Yakima basin typically are between 2500 and 5000 feet (see Table 7). Because bull trout require cold water, especially during egg incubation, distribution is typically limited to higher elevations where summer air temperatures remain cool.

Temperatures in the Tieton River below Rimrock Lake limit the suitability of this habitat to bull trout. Bull trout are fall spawners, with peak spawning typically occurring in September. Spawning may occur anytime from late July to November, however. Temperatures in the Tieton River between the mouth and Tieton Dam are substantially higher than optimal spawning temperatures during this time. WDE temperature data measured on 12 days (one per calendar month) in 1991 and 1992 show that in no instance did temperature approach the optimum incubation temperature for bull trout of 0-2 °C (Figure 23). In fact, temperatures during bull trout spawning season ranged from 12.0 to 14.8 °C in every month except November, when a temperature of 6 °C was recorded. While these temperatures were only spot checks and therefore should be viewed only as index estimates of temperature, they indicate that temperatures in the lower Tieton River for July through October are well above the lethal limit for incubating eggs and embryos, and approach the limiting temperature for adult bull trout (15 C).

It should be noted that although the EPA standard for juvenile bull trout is 10 °C (40 CFR 131 (1997)), several published reports indicate that juvenile bull trout are often found in habitats with water temperature in the 12 to 14 degree C range (Thurow 1987, Adams 1994, Saffer and Scarnecchia 1995, Thurow and Schill 1996). The temperature regime in the Tieton River below the project area may be suitable for successful rearing of bull trout. Temperature requirements of bull trout eggs are more limiting, however, and are lower than index temperatures measured by WDE in 8 months of the year. While index temperatures measured in November through February were in the range in which successful bull trout incubation may be achieved, the long incubation period of bull trout (up to 225 days) means that eggs in the gravel in the lower Tieton River would be exposed to temperatures above lethal limits regardless of when during the range of bull trout spawn timing they were deposited. It is unlikely that the lower reaches of the Tieton River have ever supported bull trout spawning, although it may have provided opportunities for subadult and adult rearing.

The lower Tieton basin is an area of higher human influence than the upper watershed. Irrigation wastewater increases water turbidity and introduces agricultural chemicals into the river. Moreover, low releases from Tieton Dam during the storage season keep flow in the lower Tieton at levels of 30-60 cfs, decreasing the available habitat and making
the stream more susceptible to increased water temperatures, as smaller bodies of water have less thermal inertia.

Bull trout existing in the Tieton River below Rimrock Lake encounter competition from several other fish species, both native and exotic. Rainbow trout, kokanee of Rimrock Lake origin, juvenile spring chinook, whitefish, exotic bass species and crappie inhabit the lower river (E. Anderson, personal communication). Environmental conditions in this part of the river favor these species over bull trout.

All of these factors limit the suitability of the lower Tieton River to bull trout, which have stringent habitat requirements.

4.1.4 Factors Contributing to Species Decline
Impacts on bull trout generally occur from three areas of resource management practices: land, water, and fisheries. Current recognized threats to bull trout are discussed in the following sections. For a complete list of factors affecting bull trout stocks in the Yakima Basin, see WDFW (1998).

Harvest

Abundance of spawning bull trout in the Rimrock basin has increased 5-10 fold since the 1980s and has stabilized since legal sport fishing was eliminated. Since the mid-1980s a variety of angling restrictions have been implemented to protect bull trout populations in the Yakima basin (WDFW, 1998). The initial conservation measures involved establishment of minimum size limits and reduced daily catch limits, as well as a seasonal closure on bull trout angling during the spawning period. A total prohibition on angling for bull trout in the Yakima basin was implemented in 1992. In addition, total fishing season closures for major bull trout spawning areas and streams in the Yakima Basin was implemented.

Because migratory bull trout are voracious predators, they are perhaps the most vulnerable to anglers of any salmonid. Wherever fishing pressure is moderate, numbers of bull trout are quickly reduced by anglers. An excellent example of the impacts from overharvest has been illustrated in the bull trout populations of the Metolius River Basin in Oregon (Buchanan et. al 1997). Prior to 1980, the bull trout bag limit was 10 fish per day. Starting in 1983, all bull trout had to be released in the Metolius River, and angling was closed in spawning tributaries. By 1994, redd counts in the system had increased to 330 redds, up tenfold from the count of 27 redds in 1986.

James (personal communication, 2-8-00) noted that poaching occurs in Indian Creek. Illegal harvest of bull trout may continue to be a problem in the Yakima Basin as discussed by Watson and Toth (1995 p. 35):

Adfluvial spawners in small streams in remote areas are particularly vulnerable to poaching because of their large size. Bull trout poaching
has been documented in Gold Creek, Deep Creek, Box Canyon Creek and the South Fork Tieton River. Some level of poaching and incidental harvest of bull trout has occurred in virtually all systems.

**Passage Barriers and Stream Diversions**

Construction of Tieton Dam eliminated the opportunity for free migration of bull trout in the Tieton basin. Operation of the dam has modified entrained some bull trout and affected bull trout forage bases. Draw down in drought years reduces production of phytoplankton, zooplankton and aquatic insects, but there is no clear evidence that growth rates of adult bull trout decline in the reservoir during years of substantial draw down. Entrainment research in 2001 indicated that bull trout entrainment rates were low (James 2001).

**Habitat Degradation**

Many bull trout spawning strongholds are associated with undisturbed watersheds at high elevation where streams are in near pristine condition in downstream areas where migrants may have traveled. Agriculture, road building, diking, grazing, development in the floodplain, timber harvest, recreation, gravel mining, increased population pressure, and other factors have been cited as affecting habitat for bull trout in other areas of the Columbia basin, but such factors are absent or nominal in the South Fork Tieton and Indian Creek basins.

**Competition With Exotic Species, Especially Brook Trout**

Brook trout were introduced to Washington in the early 1900s. The species has been stocked quite widely in the Yakima Basin. Though stocking of brook trout has ceased, self-sustaining populations have become established in the Tieton River (WDFW 1998).

Brook trout not only directly compete with juvenile bull trout for food but also are genetically close enough to the bull trout to permit hybridization. The hybrids are sterile and represent a dead end for bull trout genes. The danger is especially acute when there are few bull trout and the hybrids cannot contribute to the bull trout population. Only one bull trout/brook trout hybrid has been documented in the Yakima River Basin to date (E. Anderson, WDFW 1999, personal communication). It is not known what effect hybridization has had on the resident bull trout population.

Other introduced species that provide forage and have different habitat preferences, such as kokanee (O. nerka), may benefit bull trout.

**Catastrophic Events**

Wildfire and floods can affect bull trout populations by altering the channel, sediment, water quality, water temperature, woody debris, bank vegetation, and stream flow characteristics. Drought results in reduced summer stream flows (and reduced
reservoir elevations) and increased water temperature and will predictably reduce spawning success and survival of bull trout (Knowles and Gumtow, 1996).

Environmental stochasticity or the effect of a catastrophic event may influence the probability of bull trout extinction when population size is small (Rieman and McIntyre, 1993). Lakes and reservoirs may serve as refuges during catastrophic events in streams.

4.2 Steelhead Trout

4.2.1 Life History and Distribution in the Yakima Basin

Details of the life history, habitat requirements, and genetics of Washington’s steelhead (Oncorhynchus mykiss) and other salmonids has been widely studied (e.g., Wydoski and Whitney 1979; Bjornn and Reiser 1991; Behnke 1992; Burgner et al. 1992; Busby et al. 1996) and will not be repeated here. The purpose of this section is to provide a brief overview pertinent to the anadromous form of O. mykiss in the Yakima basin and Tieton River.

The Yakima steelhead are classified as a stream maturing or summer steelhead, which enter the Columbia River in the spring and summer in a sexually immature condition. They require several months to mature prior to spawning. Hockersmith et al. (1995a) identified three distinct phases of adult steelhead migration into the Yakima basin corresponding to river entry, winter holding, and spawning. Although numerous distinct spawning populations (locations) were identified, all populations were mixed together during the river entry and winter holding phases. Run-timing into the Yakima River was generally from September through May, with peaks of movement at Prosser Dam generally occurring in October and February-March. Most overwintering was below Sunnyside Dam, with about 60% of fish holding between Prosser and Sunnyside, and another 25% holding below Prosser (Hockersmith et al. 1995a).

Upstream movement of adult steelhead ceased at water temperatures below 3 °C (Hockersmith et al. 1995a). Spawning is generally from mid-February through May, and peaks during the last two weeks of April and the first week of May (YIN et al. 1990). Hockersmith et al. (1995a) found that both the departure from winter holding areas and spawning occurred earlier among steelhead destined for lower elevation tributaries. Spawning peaked earliest in Status Creek, followed 4 weeks later in Toppenish Creek, and 6 weeks later in the Naches River.

The mean adult age structure for Yakima summer steelhead, based on a sample of 171 fish from the 1984-1990 broods (predominantly female broodstock), was 55 % 1-ocean, 45 % 2-ocean, and 2 % 3-ocean years (Hymer et al. 1992). Age-specific mean fork lengths in the sample were 60 cm for 1-ocean fish and 71.5 cm for 2-ocean fish. Only one 3-ocean fish, 86.4 cm long, was in the sample. No age-weight data exists, but
Yakama Nation field biologists estimate Yakima steelhead weigh 4-12 pounds in the Yakima River. Females comprise a major portion (63 - 73 %) of the adult run (YIN et al. 1990). Mean observed fecundity for 1-ocean and 2-ocean fish was, respectively, 4,858 and 7,119 eggs per female. Applying age-specific fecundities to the above age structure gives an estimated overall fecundity of 5,963 eggs per female.

Substrate composition, cover, water quality, and water quantity are important habitat elements for steelhead before and after spawning. Steelhead spawn in clear, cool, well-oxygenated streams with suitable gravel and water velocities. Adult fish waiting to spawn or in the process of spawning are vulnerable to disturbance and predation in areas without suitable cover. Cover types include overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, deep water, and turbulence. Spawning occurred earlier in areas of lower elevation and where water temperature was warmer than in areas of higher elevation and cooler water temperature (BPA 1995). Spawning occurs from January through May. Through the interaction studies conducted by WDFW, (BPA 1993), the spawn timing in the upper Yakima River basin was positively correlated to elevation. The interaction studies concluded that because spawn timing is related to stream temperature (Thurow and King 1994), elevation may be a surrogate for stream temperature.

Female steelhead bury their eggs at a depth of 2 to 12 inches in redds that occupy up to 60 square feet. More than one redd may be constructed by each female in a season. Spawning sites typically require gravel (0.5 - 4.5 inch diameter) and well-aerated flow. Adult steelhead, unlike salmon, do not necessarily die after spawning but return to the ocean. Repeat spawning is not common, however, among steelhead migrating several hundred miles or more upstream from the ocean.

Steelhead eggs hatch in 35 to 50 days depending on water temperature. Following hatching, alevins remain in the gravel 2 to 3 weeks until the yolk sac is absorbed. Fry emergence occurs from May through June in the lower Yakima River basin and from June through August in the upper basin (YIN et al. 1990). Following emergence, fry usually move into shallow and slow-moving margins of the stream. As they grow, they adopt areas with deeper water, a wider range of velocities, and larger substrate. Although most steelhead juveniles overwinter in tributaries, some move downriver past Prosser Dam in the winter.

Smolt outmigration in the lower Yakima River at Prosser begins in April and essentially ends by mid-June. The midpoint of the outmigration generally occurs in the first week of May (figure 4-7) (Fast et al. 1986). The mean proportion of age-I+, age-II+ and age-III+ smolts has been estimated at 41 %, 56 %, and 4 %, respectively (Busack et al. 1991). It should be noted that these figures describe the aggregate age composition for smolts originating from all parts of the Basin. Figure 4-8 shows the age composition observed in each major population. Scale analysis of returning adult steelhead at Prosser Dam indicated that a much lower proportion (8.3 %) had migrated seaward as age 1+ smolts, and that most (81.2 %) had migrated at age 2+. Busack et al. (1991) attributed this
difference in freshwater ages of smolt and adult samples to either interannual variation in age composition or a higher relative smolt-to-adult survival of age 2+ smolts. The Independent Science Group (ISG) (1996) reviewed juvenile salmon migration behavior and concluded that downstream migrant fish may stop to feed periodically during the migration. It is not known to what extent steelhead are feeding as they leave the Yakima River.

Survival rates are roughly estimated at 8 % from egg to headwater smolt and about 2 % from headwater smolt to adult (1983 and 1984 brood years) (YIN et al. 1990).

4.2.1 Uses of Rimrock Lake

Tieton Dam blocks access of Rimrock Lake to upstream migrants. Steelhead have not been observed to spawn in the Tieton River. While it is possible, though unlikely, that anadromous *O. mykiss* may have traveled upstream of the project area before construction of Tieton Dam, the dearth of spawners in the Tieton River downstream of the project area compared to higher concentrations in Yakima tributaries lower in the basin indicates this is not an important piece of habitat for steelhead production in the Yakima basin. Catchable sized hatchery plants of rainbow trout are stocked in Rimrock Lake and in the Tieton River below the lake by WDFW. The population of resident rainbow trout in these habitats appears robust.

4.2.2 Limitations to Production Below Rimrock Reservoir

*O. mykiss* in the Yakima River basin is present in two forms: resident rainbow trout and anadromous steelhead (Pearsons et al 1998). Steelhead represent less than 1 % of the *O. mykiss* spawners in the upper Yakima River above Roza Dam (Pearsons et al. 1998), but nearly 100 % of the *O. mykiss* found in Satus and Toppenish creeks in the lower basin (Hubble 1992). The proportion of steelhead that spawn in the Naches River subbasin may be intermediate between Satus/Toppenish and the upper Yakima River. Whether the resident or anadromous form of *O. mykiss* dominates in a particular stream reach may be due to both genetic and environmental factors.

Although detectable genetic differences exist among *O. mykiss* from Yakima River subbasins, recent studies indicate that resident and anadromous forms of *O. mykiss* interbreed and share a common gene pool in the Yakima River basin. Pearsons et al. (1998) collected ecological and genetic evidence in the upper Yakima River basin to determine the potential for gene flow between resident and anadromous *O. mykiss*. They documented interbreeding between steelhead and rainbow trout, and concluded that naturally-produced rainbow trout were genetically indistinguishable from naturally-produced steelhead when collected together in the river. Steelhead spawning was found to be less widely distributed than rainbow trout, but was entirely within the geographic range of rainbow trout spawning. The spawning time of rainbow trout and
steelhead was related to elevation, and no differences in timing were detected between resident and anadromous forms.

The intermixing of resident and anadromous forms of *O. mykiss* was acknowledged in the final rule by NMFS to list Mid Columbia steelhead as threatened under the ESA. The choice to list anadromous *O. mykiss* and exclude resident *O. mykiss* was apparently motivated by administrative rather than biological reasons. The final rule states,

> While conclusive evidence does not yet exist regarding the relationship of resident and anadromous *O. mykiss*, NMFS believes available evidence suggests that resident rainbow trout should be included in listed steelhead ESUs in certain cases. Such cases include (1) where resident *O. mykiss* have the opportunity to interbreed with anadromous fish below natural or man-made barriers, or (2) where resident fish of native lineage once had the ability to interbreed with anadromous fish but no longer do because they are currently above human-made barriers, and they are considered essential for recovery of the ESU. (64 FR 14521)

Under certain conditions, anadromous and resident *O. mykiss* are apparently capable not only of interbreeding, but also of having offspring that express the alternate life history form; that is, anadromous fish can produce resident offspring, and vice versa (Shapovalov and Taft 1954; Burgner et al. 1992).” (64 FR 14521)

NMFS believes resident fish can help buffer extinction risks to an anadromous population by mitigating dispensatory effects in spawning populations, by providing offspring that migrate to the ocean and enter the breeding population of steelhead, and by providing a “reserve” gene pool in freshwater that may persist through times of unfavorable conditions for anadromous fish. (64 FR 14521)

NMFS believes available data suggest that resident rainbow trout are, in many cases, part of steelhead ESUs. However, FWS, which has ESA authority for resident fish, maintains that behavioral forms can be regarded as separate DPSs (e.g., as when the agency listed coastal, but not interior, populations of the western snowy plover). (64 FR 14521) The FWS concludes that only the anadromous forms of *O. mykiss* should be included in the listed steelhead ESUs at this time (Department of the Interior, 1997; FWS, 1997). (64 FR 14521)

There is evidence to suggest that the low percentage of anadromy among *O. mykiss* in the upper Yakima River may be the result of environmental factors. The year-around dependable water supply from mountain runoff, and the cool water temperatures that seldom approach stressful levels, create a freshwater habitat in the upper basin that enables high growth and survival rates of rainbow trout that spend their entire life in freshwater. Average temperatures of the Yakima River from Sunnyside to Cle Elum are generally in the high 50s to low 60s Fahrenheit during July and August. The resident
rainbow trout fishery in the upper Yakima River is regarded by WDFW as the best in the state. Because growth rates are relatively high, rainbow in the upper basin can achieve large body size, accompanied by moderate fecundity, without migrating to sea. In contrast, this may not be true of the lower elevation subbasins of Satus Creek, Toppenish Creek, and the lower Naches River mainstem, where anadromy is the dominant life history. In those streams, summer temperatures are frequently stressful to resident trout, as are temperatures in the lower Yakima River where those streams enter. Average temperatures in the Yakima River near Prosser typically exceed 70 °F from mid-July to mid-August. Water quantity and quality in the lower portion of Satus Creek and in the Yakima River below its confluence ranks among the poorest in the entire Basin. A survey of water temperatures throughout the Yakima River basin in 1988 found that temperatures in all tributaries, except the lower portions of Satus Creek and Toppenish Creek, were well within the acceptable range for summer rearing of salmonids (YIN et al. 1990). Under the conditions in lower Satus and Toppenish Creeks, fish remaining through the summer would experience high mortality and low growth rate. The anadromous life history, however, enables rainbow trout to leave restricted rearing areas when they are still young, grow rapidly in the ocean, and return with a high fecundity that compensates for the added mortality that fish experience during the long migration.

The distribution of anadromy among Yakima subbasins, relative to the altitude of subbasin catchment, appears congruent with this hypothesis. GIS analysis was used to estimate the watershed area at increments of 500 feet elevation in six subbasins: Satus, Toppenish, Ahtanum, Rattlesnake, Little Naches, and Teanaway River. Each basin was chosen because access to its headwaters is not blocked by a dam, and it supports steelhead spawning. Satus and Toppenish Creeks, which radio-tracking indicated to support a major portion (57 %) of Yakima steelhead spawning (Hockersmith et al. 1995a), are low elevation watersheds with 39 % and 35 % of the area, respectively, above 3000 feet elevation (Figure 29). In the other subbasins examined, which collectively attracted 3.7 % of radio-tagged steelhead in the above study, a much higher proportion of the watershed (55 - 96 %) is situated above 3000 feet (Figure 30). Rattlesnake Creek and Little Naches River, where only 2 of 108 radio-tagged steelhead spawned (Hockersmith et al. 1995a), are large Naches River tributaries that would have afforded relatively easy, unobstructed access to steelhead spawners. These differences in steelhead use of tributary streams appear to be related to watershed elevation and its effect on stream temperature. Studies of upper Columbia River steelhead populations in the Wenatchee, Entiat, and Methow rivers (Mullan et al. 1992) indicate that higher elevation tributaries are too cold to support growth rates required for _O. mykiss_ to reach steelhead smolt size in the normal 2 or 3 years of rearing (Peven et al. 1994). On the subject of _O. mykiss_ juveniles in tributary streams, Mullan et al. (1992) concluded “--- Most fish that do not emigrate downstream early in life from the coldest environments are thermally-fated to a resident (rainbow trout) life history regardless of whether they were the progeny of anadromous or resident parents.”
Figure 29. Elevation profiles and locations of confirmed spawning for radio-tagged steelhead in the Yakima basin. Spawning locations from Hockersmith et al. (1995).
Figure 30. Elevation profiles and spawning elevations for steelhead and bull trout in Yakima basin streams where both species spawn and dams do not block migration. Steelhead spawning locations are for individual fish determined from radio tracking by Hockersmith et al. (1995). Bull trout spawning reaches determined from E. Anderson, WDFW, Yakima. Elevation determined from GIS analysis of 10m digital elevation model.

GIS analysis was also used to determine elevations at the specific locations where radio-tagged Yakima steelhead were reported to spawn (Hockersmith et al. 1995a). Most steelhead spawned at elevations of 1000 feet to 2500 feet (Table 12), which generally occurred in the lower to middle portion of the accessible reaches of spawning streams (Figure 29, Figure 30). The elevation band for most concentrated spawning within Satus Creek was also confirmed by Fast et al. (1989) who counted 404 steelhead
redds in Satus Creek and its tributaries, and found the highest concentration of redds between km 52 and km 63, at an elevation of 1500 - 2000 feet. The highest elevation at which steelhead spawning was confirmed for radio-tagged fish during 1989-1992 was a single fish at about 3330 feet in Dry Creek, a tributary to Satus Creek. Spawning elevations for steelhead are substantially lower than those for bull trout in the streams without dams blocking upstream migration (Figure 30).


<table>
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<tr>
<th>Stream</th>
<th>20th %ile</th>
<th>Median</th>
<th>80th %ile</th>
<th>Spawner Count</th>
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<td>1,314</td>
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<td>Dry</td>
<td>1,259</td>
<td>1,701</td>
<td>2,181</td>
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<tr>
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<td>2,060</td>
<td>82</td>
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</tbody>
</table>

Cuffney et al. (1997) sampled fish, invertebrates and algae communities at 25 sites in the Yakima Basin during 1990. Results showed that, “elevation was the dominant factor accounting for the distribution of biota in the Yakima River Basin: agricultural intensity and stream size were of secondary importance.”

Radio tracking studies examining *O. mykiss* migration in the Yakima basin lend credence to the theory that environmental variables determine life history form in rainbow/steelhead. Most *O. mykiss* in the Yakima River basin are migratory to some degree, either migrating downstream to larger channels with favorable conditions through the summer, or migrating downstream all of the way to the ocean. In the basin above Sunnyside, *O. mykiss* that migrate downstream out of the tributaries will encounter favorable rearing conditions through the summer in the mainstem Yakima River, but trout entering the Yakima River below Sunnyside will find stressful to lethal temperatures during summer. Hockersmith et al. (1995b) also radio-tracked 52 wild adult rainbow trout that had been tagged in the mainstem Yakima River, half in the lower canyon and half in the upper canyon. These fish migrated 0.3 km - 87.2 km to spawn, with 71 % migrating under 15 km to spawn. Fish spawned in the mainstem
Yakima River from km 211.1 to km 298.8, and in three tributaries (Umtanum Creek, Cherry Creek, and Teanaway River). The tributary spawning locations indicate that juveniles must have migrated from these tributaries to the mainstem where the fish were tagged. The high rate of residualism and low passage rate of steelhead smolts released into the upper Yakima River basin provide further evidence that environmental cues are causing *O. mykiss* to have a predominantly resident life history in the upper basin.

WDFW studied interactions of hatchery steelhead smolts with wild *O. mykiss* in two treatment and two control streams in the Teanaway River subbasin during 1991-1994. The hatchery steelhead were progeny of adult steelhead collected in the lower Yakima River. Investigators found that 26 - 39 % of the smolts released did not emigrate even from the Teanaway River study area during the first month after release (McMichael et al. 1999b). Further, only 1.9 % to 2.6 % were estimated to have passed Prosser Dam (234 km downstream) in 3 of the 4 years studied, while a high of 24.9 % passed Prosser Dam in 1993.

Snorkel observations revealed that stocked steelhead behaviorally dominated and often displaced typically smaller wild rainbow trout. Low stream temperatures, which in some years did not exceed 8 °C until June 1, may have suppressed migratory tendencies (McMichael et al. 1999b).

The occurrence of both resident and anadromous populations of *O. mykiss* in the same river basin is not unique to the Yakima River basin. Two notable examples with large populations of each type are the Deschutes and Willamette rivers in Oregon. In the Deschutes River Basin, steelhead and resident rainbow are generally reproductively isolated due to different spawning times and locations (Zimmerman and Reeves 1999). Steelhead and resident rainbow trout spawning begins about the same time, but the spawning period is shorter for steelhead than it is for resident rainbow trout. Steelhead redds were significantly larger, were in deeper water, and had larger substrate than rainbow trout redds (Zimmerman and Reeves 1999). The *O. mykiss* found in tributaries on the east side of the Deschutes River (low elevation watersheds) are predominantly steelhead, while those in west side tributaries that drain from the Cascade mountains support resident rainbow.

In the Willamette River Basin, resident rainbow trout are abundant and steelhead absent in the two uppermost tributaries that drain from the Cascade mountains, the McKenzie River and the Middle Fork Willamette River. These streams support renowned wild trout fisheries and are natal areas for spring chinook. Although there is no migration barrier between the McKenzie River and the next two Cascade tributaries that enter the Willamette River downstream, the *O. mykiss* in those tributaries, the Calapooia and Santiam rivers, are predominantly steelhead. As in the Yakima River, the resident rainbow populations of the upper Willamette Basin migrate within the basin, but without migrating to the ocean (Howell et al. 1988). NMFS concluded in their final rule for steelhead listings, that because (1) rainbow trout in the McKenzie and Middle Fork Willamette were genetically distinct from steelhead, and (2) ODFW has been unable to achieve success in their attempts to establish steelhead populations upstream
of the Calapooia River, “these factors combine to give credence to the theory that, for some unidentified reason, the upper reaches of the Willamette River Basin are not suitable to support steelhead populations, although resident trout and chinook salmon have been successful there” (64 FR 14521).

Steelhead spawning is uncommon in the Tieton River. Environmental conditions in the river downstream of the project area favor residency over anadromy. Temperatures remain below 18 °C year round, and thus O. mykiss in the Tieton River below Rimrock Lake seldom experience stressful summer temperatures that would provide environmental cues tending toward anadromy. Though river flows are greatly reduced during the winter months, releases from Rimrock Lake, along with accretion flows and contributions from tributary streams provide for available habitat during the summer months such that the needs of adult resident rainbow trout could be satisfied. The cool water temperatures and year-around dependable water supply create a freshwater habitat in the Tieton River below the proposed project area that likely enable rainbow trout that spend their entire life in freshwater to achieve survival rates greater than those that would be achieved by anadromous forms. Larger resident rainbow in this stretch of stream would have a competitive advantage over juvenile fish of the anadromous life history form, and thus would tend to displace anadromous fish when they did occur. While it is possible that anadromous forms of O. mykiss could use the Tieton River below Tieton Dam to spawn, a substantial body of scientific experiments and compiled environmental data indicate that the resident life history form of O. mykiss is more suited to that stretch of stream than is the anadromous form.

4.2.5 Factors Contributing to Species Decline

The factors affecting the decline of the steelhead in the Yakima River Basin are human induced factors that have been compounded by natural events in ocean survival conditions in recent times. With the development of the Yakima River basin starting in the late 1800s, the productivity of the river ecosystem and access to the river system itself for steelhead has been adversely altered for anadromous steelhead population in the basin. No single human induced factor is solely responsible for the decline of steelhead, but each factor incrementally contributes in varying degrees to a less productive river basin for steelhead.

*Development of Irrigated Agriculture*

The Yakima River system has been modified by a complex array of reservoirs, diversion dams, canals, and drains used to store and convey water. The development of irrigated agriculture has not only added physical constraints to the system but also modified the timing, quantity, and quality of water in the river and its tributaries.

The Yakima River and many of its tributaries have impassable diversion or storage dams that block steelhead access. Early diversion structures on the river mainstem did not have adequate passage facilities or did not have passage facilities at all and caused
migration delays and, at times, total blockages. One such example is the Roza Diversion Dam built in 1939 with an improper fish ladder that allowed fish passage only when the pool behind the diversion dam was full. When the pool behind the diversion dam was lowered for maintenance or winter operations the ladder did not provide passage. There is also speculation that prior to 1983 ladder maintenance during the winter months was inadequate and passage was compromised.

The screen facilities on the diversion canals caused injury and mortality due to improper design and operations. Since 1984, when the Phase I passage program started, the majority of fish passage facilities in the Yakima River basin have been rebuilt to the correct criteria to protect both adult upstream and juvenile downstream passage.

Nearly all of the significant tributary streams in the agricultural lowlands of the Yakima basin are completely developed for use as irrigation channels. Many of these streams have numerous, possibly hundreds, of private irrigation diversion dams, turnouts, unscreened diversions, and siphons. Many private facilities were developed prior to the Yakima Project and are generally a fair distance upstream in the tributaries they intersect. Water management of these tributaries is complicated by multiple water-users with levels of organization and resources ranging from individual farmers with priority water rights to major irrigation districts.

Irrigation diversion withdrawals affect instream flows and flow fluctuations below diversion dams. The reduced and fluctuating flows have diminished and degraded habitat available to steelhead below diversion dams. Since 1994 the USBR has instituted target minimum flows below Sunnyside and Prosser dams, and has entered informal agreements with irrigators, management agencies and the YIN to manage the flows below other diversion and storage dams.

At their confluence with the Yakima River, some irrigation return flow facilities may also produce a false attraction for steelhead on their way to spawning areas. False attractions occur when adult or juvenile fish migrate from the river into a man-made irrigation return flow facility such as a drain or a wasteway where suitable habitat does not exist. This issue has been detailed by Romey and Cramer (2001).

There is strong evidence that aquatic pollution from agricultural sources has reduced the quality of habitat available for salmonids including steelhead. The USGS investigated the water quality conditions of the Yakima River basin, including long-term trends in water quality, historical conditions, and trends associated with natural and human induced factors. USGS reported that state standards were not met for stream temperature, pH, and fecal-coliform bacteria in most tributaries to the lower Yakima River during the irrigation season. Additionally, they reported phosphorus and nitrogen (nitrite-plus-nitrate) concentrations and turbidity were commonly detected at levels making them of concern to eutrophication and aquatic plant growth (Rinella et al. 1992). Overall, suspended-sediment, turbidity, nutrient, biological, and pesticide contamination have been attributed to the impairment of beneficial uses (domestic water supply,
primary and secondary contact recreation, aesthetic enjoyment, and support of fish and wildlife. The quality of water returning to the Yakima River mainstem and its tributaries from agricultural return flows has not always been supportive of these beneficial uses.

The irrigation districts have implemented measures aimed at bringing return flows into compliance with current water quality standards. The water quality program has resulted in significant improvements in the quality of water being returned to the Yakima River. In Granger Drain, turbidities have been reduced 50% from historic levels, and progress has been observed in Sulphur Creek. As water quality conditions of return flows to the Yakima River improve due to these efforts, adverse effects to aquatic resources will diminish.

High water temperature in the lower Yakima River has been widely recognized as adversely affecting anadromous salmonids. High temperatures at the mouth of the Yakima River may delay adult steelhead migrations. Water temperature is a particularly difficult variable to change. Vaccaro (1986) modeled water temperature in the Yakima River with four scenarios: (1) 1981 operations; (2) 1981 estimated-unregulated or "natural" stream flows without storage or diversions; (3) reductions in irrigation diversions and irrigation return flows over the entire basin; or (4) similar reductions, but limited to the Yakima River below Parker. Vaccaro's model estimated that reducing return flows and subsequently leaving such flows instream would actually increase water temperatures at Prosser during the high water temperature period because, in late summer, major irrigation return flows are generally cooler than the Yakima River at the point of return. Although the model indicated reducing return flows during the spring months could also help reduce water temperatures (because return flows in spring tended to be warmer than the river), spring temperatures did not exceed steelhead tolerances. Most irrigation return flow facilities collect and discharge both surface and subsurface water, which tends to be cooler than river water in summer (Vaccaro 1986). Reducing irrigation return flow volume is therefore unlikely to produce a measurable change in thermal dynamics of the Yakima River during summer, although other improvements in water quality may be expected. Relatively cool irrigation return flows may, however, create localized pockets of lower temperature where the flows enter the main river.

**Land Use Activities and Urbanization**

Land use activities associated with logging, road construction, urban development, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality and have contributed to the decline of steelhead populations in the Yakima River basin. Associated impacts of these activities include the following: alteration of stream bank and channel morphology; alteration of ambient stream temperatures; degradation of water quality; degradation of spawning and rearing habitat, fragmentation of available habitats; elimination of downstream recruitment of spawning gravels and large woody debris; and removal of riparian vegetation that protects stream banks from erosion.
Some of the most dramatic impacts to the river ecosystem have been: altered water quality through agriculture return water; overgrazing of the riparian vegetation; flood control through diking; and development of the flood plain. Of particular importance has been the loss of habitat complexity, including connectivity between off-channel and mainstem habitats, which directly relate to the ability of the ecosystem to support steelhead populations. Flood control dikes and levees and railroad and highway construction have disrupted the lateral connectivity between wetted areas that occurred historically. This deprivation of lateral connectivity has resulted in loss of habitat, reduced vertical connectivity, loss of or changes in nutrient flux, and reduction in the tempering affect of groundwater on stream temperature. These changes can exert a significant influence on stream productivity.

Adult Harvest

The peak years of the sport and tribal fishery in the Yakima River occurred in the mid-1960s when total harvest averaged over 2,000 steelhead (YIN et al. 1990). Since 1979 the sport fishery has been the only terminal fishery to target steelhead. Exploitation rates in that fishery were estimated to be relatively high (66 - 69 %) in the early 1980s. Sportfishery harvest in the Yakima River basin was consequently limited to hatchery fish only in 1986 (WDFW et al. 1993), and the entire sport fishery was closed in 1994.

Tribal subsistence dip net fisheries in the Yakima River are not selective with respect to species. Although steelhead are not a target of the tribal fishery, small numbers of the species may be caught incidentally in dip net fisheries for fall chinook, coho and spring chinook that migrate coincidentally with the fall and spring segments of the steelhead run (Howell et al. 1985).

Yakima River and Columbia River summer steelhead do not contribute significantly to ocean fisheries. Yakima and other Columbia River summer steelhead stocks have been harvested, however, in Columbia River mainstem fisheries. Though commercial non-Indian harvest of summer steelhead has been prohibited since 1975, a treaty Indian harvest continues in Zone 6, upstream of Bonneville Dam (WDFW/ODFW 1999). Since 1984 the Zone 6 fishery has harvested between 2.7 % and 19.4 % (average 9.7 %) of wild steelhead in Group, A which would include the Yakima population. Sport harvest of summer steelhead in the Columbia mainstem has, since 1984, been limited to marked hatchery fish.

Juvenile Mortality Related to Angling

The trout sport fishery in streams of the Yakima River basin may, in the past, have been a significant source of mortality for juvenile steelhead. Although most juvenile steelhead caught by anglers were probably released, there would still have been high mortality of fish after release, and many juveniles may have been caught multiple times before
emigration from the basin. Stream trout fishing has attracted a high number of participants who, in the past, were encouraged by the stocking of catchable trout in many basin streams.

WDFW has taken measures to reduce the impact of the resident trout fishery on juvenile steelhead. Since the early 1990s, angling in the upper Yakima River above Roza Dam has been restricted to catch-and-release with single barbless hook, and there has been a ban on the use of bait. In 1998 the use of bait and barbed treble hooks was prohibited in the upper Yakima River tributaries and the Naches River and tributaries (WDFW 1998). Daily trout catch limits were reduced to 2 fish per day with minimum size limits of 12 inches in the Naches River and 8 inches in tributaries of the Naches River and upper Yakima River (E. Anderson, WDFW, personal communication). Stocking of catchable-size hatchery rainbow trout, which was common in Yakima River basin streams in the 1960s to early 1990s, has been discontinued in most tributaries to avoid potential impacts on wild salmonids. Stocking still occurs in the Tieton River below Tieton Dam and Wide Hollow Creek near Yakima, however (J. Cummins, WDFW, personal communication).

**Influence of Introduced Species**

Patten et al. (1970) reported that 10 introduced fish species had become established in the Yakima River basin, including two salmonid species: brook trout and brown trout. In addition, eight warmwater species were established: largemouth bass, smallmouth bass, pumpkinseed, bluegill, black crappie, carp, black bullhead and yellow perch. Subsequent to Patten’s survey in the 1950s, four other introduced species have been documented: channel catfish, mosquitofish, brown bullhead, and walleye. With the exception of carp, which are present in the Yakima River from the mouth to near Ellensburg, the warm water introduced fishes are generally restricted to the lower river downstream of Sunnyside Dam. Several introduced species, especially smallmouth bass and channel catfish, pose a predation threat to steelhead (McMichael et al. 1999a). These introduced species may also compete with the steelhead for food and habitat. The Yakima Project and land use activities have altered river environments in ways that favor introduced fishes over native fishes, compounding the effects of species introductions (Stanford et al. 1996). The altered flow regime, presence of irrigation dams that provide slack water habitat for predatory fish, and elevated stream temperatures and water quality all contribute to modifications to the natural habitat template that tend to create environments that favor exotic species over native steelhead in some areas of the basin.
5. EFFECTS OF THE ACTION ON LISTED FISH SPECIES

5.1 Direct Effects

Because the project will not alter the operation of Rimrock Lake, the direct effects of the proposed project on federally listed fish species would be limited to (1) altering the current mortality rate of entrained bull trout, and (2) reducing the DO levels in the Tieton River downstream of the project site.

5.1.1 Change in Entrainment Mortality

The proposed project would likely decrease entrainment mortality, because fish passing through the Francis turbines would have a better chance of surviving than those that pass through the existing jet valve. A conservative estimate of present entrainment mortality would place that value at 60% to 80% (see BA section 3.4, Observations of Entrainment). As we describe next, studies at similar hydro projects suggest that mortality rates for fish entrained into Francis turbines is substantially less than the present mortality rate of fish passing through the existing jet valves.

Hardin (2001) examined mortality rates of fish entrained into Francis Turbines of the type proposed to be used at Tieton Dam. He states that fish mortality in turbines is related to the following variables: head, turbine speed (rpm), peripheral runner velocity, runner diameter, and runner elevation above tailwater. Table 13 shows how the values of the proposed project for these variables compare to those from other existing projects.


<table>
<thead>
<tr>
<th>Plant</th>
<th>Head (ft)</th>
<th>RPM</th>
<th>Peripheral Runner Velocity (fps)</th>
<th>Runner Diameter (ft)</th>
<th>Runner Elevation Above Tailwater (ft)</th>
<th>Average % Estimated Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cushman</td>
<td>450</td>
<td>300</td>
<td>108</td>
<td>6.9</td>
<td>11.0</td>
<td>41</td>
</tr>
<tr>
<td>Elwha</td>
<td>104</td>
<td>300</td>
<td>59</td>
<td>4.9</td>
<td>14.0</td>
<td>10</td>
</tr>
<tr>
<td>Faraday</td>
<td>120</td>
<td>360</td>
<td>62</td>
<td>3.3</td>
<td>10.0</td>
<td>4</td>
</tr>
<tr>
<td>Leaburg</td>
<td>89</td>
<td>225</td>
<td>88</td>
<td>7.5</td>
<td>11.9</td>
<td>17</td>
</tr>
<tr>
<td>North Fork</td>
<td>136</td>
<td>139</td>
<td>82</td>
<td>9.7</td>
<td>5.0</td>
<td>26</td>
</tr>
<tr>
<td>Publishers</td>
<td>42</td>
<td>300</td>
<td>47</td>
<td>3.0</td>
<td>23.0</td>
<td>13</td>
</tr>
<tr>
<td>Puntledge</td>
<td>340</td>
<td>277</td>
<td>103</td>
<td>7.1</td>
<td>1.0</td>
<td>33</td>
</tr>
<tr>
<td>Ruskin</td>
<td>124</td>
<td>120</td>
<td>78</td>
<td>12.4</td>
<td>10.0</td>
<td>10</td>
</tr>
<tr>
<td>Seton Cr.</td>
<td>142</td>
<td>120</td>
<td>95</td>
<td>12.0</td>
<td>16.0</td>
<td>9</td>
</tr>
<tr>
<td>Shasta</td>
<td>410</td>
<td>138</td>
<td>111</td>
<td>1.0</td>
<td>1.0</td>
<td>39</td>
</tr>
<tr>
<td>Sullivan</td>
<td>42</td>
<td>240</td>
<td>64</td>
<td>6.2</td>
<td>23.0</td>
<td>20</td>
</tr>
</tbody>
</table>
The relationship of these variables to each other and to mortality is a complex one. However, fish strike by the turbine blades is presumed to be the major cause of injury and mortality in turbines such as the ones proposed for this project (Hardin 2001). Low pressure pockets caused by localized cavitation has also been recognized as an important factor influencing mortality, but this variable is very difficult to predict and is highly correlated with other variables and turbine operations.

Electric Power Research Institute (1987) reviewed 64 studies of turbine mortality and concluded that, of the variables listed above, peripheral runner velocity was the most critical factor contributing to fish mortality rates, particularly for Francis turbines:

Comparisons of turbine operational and design characteristics with mortalities in prototypes found few good cause-effect relationships. The best linkage with mortality was that of peripheral runner speed in the case of Francis units.

Hardin regressed estimates of fish mortality against peripheral runner velocity from 14 studies, and found a significant relationship ($p = 0.0014$) (Figure 31). Runner velocity explained 58% of the variability in estimated mortality. The simple regression equation predicts that turbine mortality at the proposed project on the Tieton Dam outlet would be 28%. This prediction is comparable to direct estimates of juvenile salmon mortality passing dams with similar head and peripheral runner velocity.
The best indication of mortality that is likely for the size and species of fish that will pass through the turbines can be obtained by examining mortality of similar sized fish in similar projects elsewhere. Projects with similar turbines, head, and runner speed, where there has also been studies to determine survival of juvenile salmonids passing through the project, are Baker and Glines Canyon dams. At Baker Dam, studies used fin-marked coho and sockeye smolts (Hamilton et al. 1954). Mortality through the Francis turbines (250 ft head, 80 ft/sec peripheral runner velocity) was estimate at 34% for sockeye smolts and 28% for coho smolts (Hamilton et al. 1954). At Glines Canyon Dam on the Elwha River, studies were conducted in 1953 (Shoeneman and Junge 1954) with yearling coho, and again in 1983 (Wunderlich 1983) with yearling coho (14.4 cm). Mortality through the turbines (194 ft head, 86 ft/sec peripheral runner velocity) was estimated to be 33% in 1953 and 38% in 1983. These findings, coupled with those from the regression in Figure 31, indicate that turbine mortality to yearling salmonids from the proposed project will be in the neighborhood of 35%.
Data from entrainment studies at Tieton Dam and comparisons with other similar projects lead to the conclusion that the proposed project would reduce mortality of entrained fish from around 60% (minimum estimate) to around 35%.

Of the federally listed fish species in the project area, only bull trout are subject to entrainment mortality. Steelhead are not found in Rimrock Lake. Entrainment studies by James (2001) suggest that bull trout are not entrained in large numbers. Only four bull trout were captured in fyke nets fished below the stilling basin over 79 days of sampling. Estimated total entrainment of bull trout over this time was between 46 and 87 fish (James 2001). All bull trout recovered from the nets were dead, but it is unclear whether bull trout mortality was caused by passing the outlet works or occurred in the nets themselves.

The four bull trout observed during entrainment studies were all sub-adults between 100 and 200 mm in total length, and this would likely be the vulnerable size in other years during flip flop operations as well. Flip flop releases occur in September and October when mature bull trout are in or near their spawning areas. Given that entrainment is related to flow, and flow is highest during flip flop releases, adult bull trout are unlikely to vulnerable to entrainment.

5.1.2 Effects of Dissolved Oxygen on Growth and Survival
Redirection of outflows through turbines rather than through the jet valve is likely to result in similar DO levels in the tailrace during most of the year, and possible reductions of 1-2 mg/L below present levels in August through and the first part of September. If such reduction occurs, the project includes measures to ensure that DO is restored to 9.5 mg/L within 300 ft below the stilling basin. DO concentrations less than 6 mg/L have not been detected near the intake structure during 4 years of sampling in Rimrock Lake, so tailrace levels should always remain above 6 mg/L.

While much effort has been applied to determining optimal DO concentrations at early life stages in connection with artificial propagation, little study has been conducted regarding the relationship between DO levels and growth or survival of salmonids, except at the earliest life stages. Much of the published research dealing with DO levels is aimed at identifying lower lethal limits for various species at various temperatures. Some study has also focused on the effects of low DO concentrations on swimming performance.

The optimum range of DO concentrations is different for different species of salmonids and changes depending on life history stage. The United States EPA has determined that 6 mg/L is the acceptable standard for DO concentrations for adult salmonids.

Analysis of the effects of low DO on salmonids is difficult due to highly variable data derived in the absence of standardized analytical methods. The low oxygen threshold at which some reaction first becomes apparent is usually termed the critical level. At this level the fish must adjust its available energy to counteract the effects of hypoxia.
When this type of stress is chronic, it could have a detrimental effect on growth and long-term survival.

Avoidance behavior of salmonids to habitats of low oxygen concentration has been reported by Whitmore et al. (1960), McGreer and Vigers (1983), and Birtwell (1989). Spoor (1990) offered brook trout juveniles the choice of 16 different DO concentrations between 1 and 8.9 mg/L. The fish did not occupy water with concentrations below 4 mg/L with statistical significance, but no significant preference for particular DO concentrations equal to or greater than 5 mg/L was observed.

Swimming performance is affected by DO, with negative impacts at lower concentrations. Davis et al. (1963) tested the effect of DO concentration on sustained swimming speed of juvenile coho and chinook salmon. Fish were placed in a tubular swimming chamber at temperatures ranging from 10 to 20 °C, and failing speed was noted for different combinations of temperature and DO. The authors found that variation in DO concentration had little effect on swimming performance when concentrations were near saturation, though results were variable (Figure 32). Observed failing speeds were progressively lower with lower DO concentrations below saturation. Graham (1949) found that the cruising speed of brook trout at 8 °C was appreciably reduced only when DO was lowered to levels below 6 mg/L -- about 50% of saturation. Jones (1971) subjected juvenile *O. mykiss* to increasing water velocities in an experiment similar to that of Davis et al. (1963). Two temperature regimes were examined (14.1 and 22.4 °C) and DO was held at 50% saturation (5.2 and 3.9 mg/L, respectively). A decline in sustained swimming speed of 43% was observed for the low temperature group, and the high temperature group’s performance dipped by 30%. Similar reductions in swimming performance at lower DO concentrations has been reported by Dahlberg et al. (1968) for coho and Bushnell et al. (1984) for rainbow trout.
Figure 32. Water velocities at which swimming failures occurred in hatchery-reared and pond-reared yearling coho salmon, in relation to DO concentration. Saturation at 12 °C is 9.8 mg/L; at 15 °C it is 9.2 mg/L. Reproduced from Davis et al. (1963).

The significance of impaired swimming ability due to low DO levels is difficult to assess, but the intuitive conclusion to be drawn is that impaired swimming ability would adversely affect such essential functions as feeding, reproduction, escape from predation, interspecific competition and migration.

The detrimental effects of low oxygen concentration during the earliest life stages is widely reported (Silver et al. 1963, Alderdice et al. 1958). Siefert and Spoor (1974) documented reduced growth in brook trout and coho salmon at DO concentrations under 6 mg/L. Similarly, Warren et al. (1973) and Chapman (1969) found that steelhead embryos exhibited reduced size at hatch at oxygen levels below 6 mg/L.

Low DO has been postulated to impair growth rate of young fish (Doudoroff and Shumway 1970). Larger size in juveniles typically translates into greater survival; as fish attain larger sizes they are able to exploit habitats and food items that are not available to smaller fish, and gape-limited predators are fewer. Attainment of a threshold size is also vital to the smolting process of anadromous salmonids. It is unclear whether lower oxygen levels necessarily translates into slower growth, however.
Thatcher (1974) observed similar growth rates but reduced activity of juvenile coho held at DO concentrations of 5 mg/L compared to those kept at 8 mg/L. The author attributed the difference to the fact that the fish were kept in artificial conditions, in which normal activities such as finding food and defending territory were not necessary, and postulated that if the experiment could have been conducted under more natural conditions where these activities had to be addressed the difference in DO would have translated into differential growth rates. Leppink and Valentine (1989) raised rainbow trout in hatchery ponds under three different DO levels: 5.1, 7.5 and 8.4 mg/L. He found that fish length was 32% lower for the low DO group, but found no statistically significant difference between the two higher DO groups. This drop in growth below 6 mg/L has been noted by the EPA, which reviewed data collected by several researchers when adopting its standard (see Hermann et al. 1962, Fisher 1963, Adelman and Smith 1972, Warren et al. 1973, Brett et al. 1981).

DO levels necessary for normal function of fish present in the stilling basin could be influenced by temperatures and water velocities there. Temperature profiles in the reservoir and spot temperatures in the tailrace indicate that temperatures in the tailrace will be 10-14 °C during August and September. Habitat in the stilling basin is highly heterogeneous with respect to water velocity, with calm water areas, shear zones and areas of high velocity and turbulence. Ample low-energy areas exist where fish can find refuge from high water velocities to which they may periodically venture. Data indicate that DO concentrations in the stilling basin will meet EPA standards for salmonids. DO profiles in Rimrock Lake in 2001 show that DO concentrations are in excess of 6 mg/L and 90% saturation from surface to bottom even in late summer of extreme low pool drought years. In short, all available data indicate that post-project oxygen concentrations below Tieton Dam will not be problematic to growth, activity or survival of salmonids.

5.1.3 Effect of Project on Future Options for Fish Passage

We determined from discussions with Dennis Hudson (fish passage engineer, USBoR, Boise), chairman of Yakima Dams Fish Passage Work Group, that turbines installed on the outlet works of Tieton Dam would have no effect on installation or operation of fish passage options being considered for Tieton Dam. The Yakima Dams Fish Passage Work Group is a the technical committee presently reviewing fish passage options for all dams in the Yakima Basin. The committee includes representatives from USFWS, USBR, WDFW. According to Dennis Hudson, the unique problems posed by a high head dam that has extensive annual drawdown severely limit the types of fish passage strategies that might be successful. Hudson believed that a trap and haul arrangement was the only likely option for passing adult fish upstream of the project. Options they will consider for downstream passage include (1) a surface collection device in the dam’s forebay, (2) an Eicher screen in the pipe carrying water out of the dam, and (3) a collection devise in the spillway that could operate when the reservoir was full. Hudson sees no reason why any of the options would be impaired by the proposed hydro project.
5.2 **Interdependent and Interrelated Effects**

It is conceivable that availability of power produced from the proposed project could lead to future development in the project area. Any future development must comply with land use regulations designed to protect natural resources, including listed species, and would be subject to separate review. Interdependent and interrelated effects are negligible.

5.3 **Cumulative Effects**

Cumulative effects are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within project area. Though little development presently exists in the project area, the Yakima basin as a whole is an area of population growth, and it is probable that increased use of the project area will occur in the future. Along with growth comes pressure on natural resources, as increasing populations make for increases in demands on water and recreational uses of rivers and reservoirs. The Tieton River is a popular late season white-water destination during flip flop operations, and this use in particular is likely to increase as Yakima basin population increases.

5.4 **Conclusion**

We conclude that the project will have no measurable effect on steelhead, and may increase the survival of bull trout entrained in the dam’s outflow. These additional bull trout that survive passage through the turbines are highly unlikely to spawn successfully, because no suitable temperatures exist below the dam for bull trout spawning. Accordingly, these bull trout will survive, but not reproduce. The bull trout will prey on other fishes in the river. However, this should be no different than the situation that existed historically.

**Literature Cited**


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Shapovalov, L., and A. C. Taft. 1954 The life histories of the steelhead rainbow trout (Salmo gairdneri gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California, and recommendations regarding their management. Pages 375p. State of California Department of Fish and Game Fish Bulletin No. 98, Sacramento.


6. Other ESA species

This BA section addresses non-fish species in the project area. The following list of endangered, threatened and candidate non-fish species within a broad region surrounding the project area was obtained through consultation with USFWS and NMFS:

**Endangered**

- Gray wolf, *Canis lupus*

**Threatened**

- Bald eagle, *Haliaeetus leucocephalus*
- Canada lynx, *Lynx canadensis*
- Grizzly bear, *Ursus arctos horribilis*
- Marbled murrelet, *Brachyramphus marmoratus marmoratus*
- Northern spotted owl, *Strix occidentalis caurina*
- Ute ladies'-tresses, *Spiranthes diluvialis*

6.1 Gray Wolf

Status of the Species in the Action Area

The gray wolf (*Canis lupus*), currently listed as endangered, was historically present throughout much of the region. WDFW's Heritage Database lists thirteen records of gray wolf in the Yakima basin in the 1990s and 5 records in the 1980s (FWS 1999).

Gray wolves depend more on the availability of suitable prey than any specific type of habitat. Their primary prey would be big game such as deer and elk. Populations of big game occur throughout the Yakima basin but are mainly restricted to the forest and rangeland areas and upper elevations of the western and northern portions of the basin. Deer and elk winter ranges occur at lower elevations along the slopes of the Cascades, generally above the irrigated agricultural lands. There are some deer that come down to lower elevations to frequent fruit orchards, but this is sporadic and mainly occurs in the fall and winter months.
Effects of the Proposed Action

Gray wolves, if present, depend upon the availability of suitable prey rather than any specific type of habitat. Construction activities and the increased noise and human activities associated with it would disturb wildlife, causing deer and elk to temporarily avoid the powerhouse and transmission line construction areas. All disturbed areas will be revegetated in order to speed the restoration of vegetative cover and minimize habitat loss. Project structures would permanently displace less than 0.25 acres of habitat. Although gray wolf and prey may occasionally visit areas within the hydroelectric project boundary, project operations and maintenance are not expected to affect gray wolves or their habitat.

References

FWS. 1999. Memorandum dated October 14, 1999 to USBR on Draft Biological Assessment for Yakima Project operations.
6.2 Bald Eagle

The bald eagle (Haliaeetus leucocephalus) is currently listed as threatened in all lower 48 contiguous states. Historically, the bald eagle could be found nesting throughout most of the continent. However, reproduction in North America declined dramatically between 1947 and 1970, largely due to intake of organochloride pesticides (FWS 1986). Habitat degradation, illegal harassment and disturbance, poisoning, and a reduced food base contributed to the decline. By 1978, the bald eagle was federally listed as a threatened species in 5 of the lower 48 states and as an endangered species in the remaining lower 43 states.

In establishing a recovery program for the species in the mid-1970s, the FWS divided the bald eagles of the lower 48 states into five recovery regions. A recovery plan was prepared for each region by separate recovery teams composed of species experts in each geographic area. The teams set forth goals for recovery and identified tasks to achieve those goals. The Tieton River basin lies within the Pacific recovery region that includes the states of Idaho, Oregon, Washington, Montana, Wyoming, California, and Nevada. The bald eagle recovery plan for the Pacific region was approved in 1986.

In the 17 years since it was listed throughout the lower 48 states, the bald eagle population has clearly increased in number and expanded in range. The improvement is a direct result of bans on DDT and other persistent organochlorides, habitat protection, a growing public awareness of the bald eagles' plight, and other measures. Due to the overall population increase, the bald eagle was reclassified from endangered to threatened in all of the lower 48 states in 1995 (FWS 1995).

In 1990, bald eagles nested in all but 5 of the 50 states. However, most bald eagle nesting occurs in the Pacific Northwest, Alaska, Canada, the Great Lake states, Chesapeake Bay, Arizona, and Florida. Oregon and Washington have been strongholds for bald eagles, with more than two-thirds of the nesting population and one-half of the wintering population of the Pacific recovery area (FWS 1994). Occupied breeding territories surveyed in Oregon and the Washington portion of the Columbia River recovery zone have increased from less than 100 in 1979, to 3300 in 1997 (Isaacs and Anthony 1997). On July 6, 1999 a proposed rule to delist the bald eagle was published in the Federal Register (FR Doc. 99-16924).

Delisting requirements under the Pacific Bald Eagle Recovery Plan (PBERP) include:

- A minimum of 800 nesting pairs
- An average reproductive rate of 1.0 fledged young per pair with an average success rate per occupied site of not less than 65 %
Wintering Habitat

More than 25% of the wintering bald eagles in the lower 48 States are present in the Pacific Northwest (FWS 1986). Bald eagles winter in the Northwest from approximately November through March and are primarily associated with open water near concentrated food sources. An important habitat feature is perch trees that provide an unobstructed view of the surrounding area near foraging sites (FWS 1986). Ponderosa pine and cottonwood snags are preferred perches in some areas, probably due to their open structure and height. Bald eagles may also use communal night roost sites in winter for protection from inclement weather. Characteristics of communal winter roost sites differ considerably from those of diurnal perch sites (FWS 1986), although both are invariably located near concentrated food sources, such as anadromous fish runs or high concentrations of waterfowl. Roost sites tend to provide more protection from weather than diurnal perch sites. Communal roosts in the Pacific Northwest tend to be located in uneven-aged forest stands with some degree of old-growth forest structure. Conifers might provide a more thermally favorable microenvironment than dead or deciduous trees, which might explain their high use by wintering eagles. In eastern Washington, bald eagles have been observed roosting in mixed stands of Douglas-fir and ponderosa pine and in stands of black locust and black cottonwood.

Foraging Habitat

Bald eagles are opportunistic foragers throughout their range. In the Pacific Northwest bald eagles consume a range of food including a variety of fish, waterfowl, jackrabbits, and mammalian carrion (FWS 1994). Game and non-game fish tend to be the preferred food, but diet is dependent on prey availability. Winter-killed mammals can be important on big game winter ranges, while waterfowl are important where concentrations are significant. Fish are also taken as carrion, especially spawned out kokanee (FWS 1986).

Factors Contributing to Species Decline

Habitat loss and increasing human population will continue to be the greatest long-term threats to recovery of the bald eagle. Breeding, wintering, and foraging areas continue to be degraded by urban and recreational development and resource extraction activities. Shootings continue to be a problem for bald eagles. Electrocution is also an ongoing problem where power lines do not conform to standards for raptor protection. Nesting habitat quality below dams may decline over the long term if flow releases do not permit perpetuation of forest riparian stands or if fisheries are negatively affected.
Contamination of waterways from point and non-point source pollution is also a potential problem. Contaminants may affect the survival as well as the reproductive success and health of bald eagles. The abundance, and - potentially more important - the quality of prey may be seriously affected by environmental contamination. Although many compounds implicated in reduced reproductive rates and direct mortality are no longer used, contaminants continue to be a major problem in some areas. Pesticides in recent times have not affected the bald eagle on a population level; however, individual poisonings still occur.

Reservoir drawdowns, low winter flows, or high ramping rates that reduce fish populations impact bald eagle food supplies. Low winter flows that result in increased ice cover can affect the availability of fish because of increased ice cover and may be a factor in heavily used areas. Reservoir open water areas may not be available to bald eagles during the late winter because of ice conditions.

**Site-Specific Status of Bald Eagle in the Yakima River basin**

Bald eagles occur in the Yakima River basin along the shores of lakes, reservoirs, and streams. Suitable habitat includes areas that are close to water and provide a suitable food resource, such as anadromous or resident fish, waterfowl, or carrion.

In the Pacific Northwest, bald eagles typically nest in multi-layered, coniferous forest stands with old growth trees that are located within 1 mile of large bodies of water. Factors such as relative tree height, diameter, species, form, position on the surrounding topography, distance from the water, and distance from disturbance appear to influence nest site selection. Bald eagles usually nest in the same territories each year and often use the same nest repeatedly. Availability of suitable trees for nesting and perching is critical for maintaining bald eagle populations. One bald eagle nest occurs in the vicinity of the hydroelectric project at Rimrock Lake, about 7 – 8 miles from the Tieton dam. WDFW monitored this nest from 1983 – 1989, during which it produced an annual average of 1.6 young. All major perch sites and roost trees are located around the nest; none are near the proposed project (Yakima-Tieton Irrigation District 1989a).

Wintering sites typically occur in the vicinity of concentrated food resources such as anadromous fish spawning areas, waterfowl concentration areas, or sources of mammalian carrion like ungulate winter ranges. Other important wintering habitat features include perch sites and communal roost sites. The birds do not arrive until late in December, or, more typically, in early January. Mid-winter bald eagle surveys were conducted in Washington from the winter of 1981-82, through the winter of 1988-89 (Rees 1989). Rimrock Lake and the Tieton River were included in these surveys. From the winter of 1981-82, to the last survey in 1988-89, the counts on the Yakima River varied from a high of 39 to a low of 3 with a mean of 23.9 (Rees 1989). Up to six bald
Eagles were observed to winter along the Tieton River in the project area (Yakima-Tieton Irrigation District 1989b).

WDFW has observed eagles feeding on fish at the base of the Tieton dam in late summer or early fall when the reservoir is drawn down because of drought (Yakima-Tieton Irrigation District 1989a). WDFW believes that the eagles feeding on spilled fish are the breeding pair and their young. WDFW has also seen bald eagles scavenging dead elk in the elk wintering areas near the proposed transmission line corridor.

**Effects of the Proposed Action**

Nesting bald eagle pairs are quite limited within the project area. This may partly be due to a shortage of trees appropriate for nesting; in this basin old growth Ponderosa Pine is probably preferred. Tree removal for transmission line construction will be planned to avoid removal of prime eagle nesting or roosting trees.

A majority of the bald eagles wintering in central and eastern Washington are winter migrants (Fielder 1992). Wintering bald eagles are expected to occur in and around the area that could be impacted by routine construction, operation and maintenance of the Tieton hydroelectric project. Bald eagles would be expected to feed on carrion during the winter, including deer and elk using winter range along portions of the transmission line corridor. Construction activities would cause eagles to temporarily avoid the powerhouse and transmission line construction areas. The transmission line would be constructed over a 3- to 4-month period some time between March and October, after wintering eagles have left the project area. The transmission line will be designed to reduce the potential for raptor collision according to the recommendations contained in *Suggested Practices for Raptor Protection of Powerlines* (Raptor Research Foundation).

The hydroelectric project would not influence Rimrock Lake drawdown or flows in the Tieton River and would therefore have no effect on eagle forage opportunities related to these features of the river basin.
6.3 **Canada Lynx**

**Status of Species in the Action Area**

In the United States, the distribution of lynx is associated with the southern boreal forest, which in the western part of the county consists of subalpine coniferous forest. FWS (2000) describes general lynx distribution in the Northern Rocky Mountain/Cascade Region and indicates that lynx occur mostly in the moist coniferous forest types at elevations of around 4,900 to 6,600 feet. This includes habitats in the Cascades of Washington where lynx are known to occur and reproduce. The FWS (2000) reports that the lynx in the contiguous United States are part of a larger metapopulation; the core of this metapopulation is located in the northern boreal forest of central Canada.

In 1993 the WDFW identified 6 zones which covered the lynx range in Washington (WDFW 1993). The 6 zones occurred primarily in the northern tier of counties from the Cascade crest east to the Idaho-Washington line. The westernmost zone extends south along the crest of the Cascades through Okanogan and into Chelan County but does include lands in Yakima County where forest habitat occurs in the Project area. The Forest Service and FWS reported lynx observations south of the zone in Okanogan/Chelan County but the observations where not in the area of the Tieton River and Rimrock Lake (USFS 1995).

Lynx occurrence is strongly associated with snowshoe hare occurrence, which is the primary prey species. Habitat conditions that are good for snowshoe hares generally benefit lynx. In the Okanogan region of Washington, on the east slopes of the Cascades, lynx used dense stands of early successional aged lodgepole pine for a variety of activities including foraging, escape, hiding and thermal protection. These stands also provided the primary habitat for snowshoe hares in the area. Lynx denning in Washington is associated with more mature forests where there is abundant down woody material (WDW 1993).

**Effects of the Action**

Potential Canada lynx habitat occurs within the upper 10 miles of the hydroelectric project's proposed transmission line corridor but core lynx populations have not been identified in the Project area. All of the identified lynx core zones are well north of the Project area, to large extent along the Washington-Canada border. Along the east slopes of the Cascades lynx have been found in highest numbers in early successional lodgepole pine forests where snowshoe hares are abundant and in late successional forests where lynx den. The proposed transmission line corridor coincides with an existing power line right-of-way and crosses only Forest Service lands managed as Matrix forest. No Late Successional or Managed Late Successional lands occur within
the proposed corridor. The hydroelectric project will not require construction of any new roads. The proposed action would have no affect on Canada lynx.
6.5 **Grizzly Bear**

**Status of the Species in the Action Area**

Grizzly bear (**Ursus arctos horribilis**), currently listed as threatened, is one of North America’s largest bears and is easily recognized by the distinct hump at the shoulders and slightly concave facial profile. The grizzly bear's historic range covered much of North America from the plains, westward to California and from central Mexico north through Canada and Alaska. Today, the grizzly is found only in about 2 % of its original range in the lower 48 States.

Grizzly bear habitat needs differ seasonally. After emerging from the den in early spring, the bears move quickly to low elevation areas and feed on new growth and winter killed ungulates, such as deer. Later in spring, bears generally feed on emerging grasses, forbs, and budding shrubs. In the late summer and fall bears use berry fields for a source of food, and in the winter they den in higher elevations. Most of the Project area lacks high quality foraging and denning habitat for grizzly bear (WDG, 1986). Currently there is a grizzly bear recovery zone delineated for an area in the North Cascades, both east and west of the crest, that extends from just north of Interstate Highway 90 into Canada (FWS, 1994). This recovery zone does not extend into Yakima County, where project forest lands occur.

**Effects of the Proposed Action**

Potential grizzly bear habitat occurs in the forested portions of the upper Tieton River basin including the upper 10 miles of the hydroelectric project’s proposed transmission line corridor; however, no core populations have been identified in the Project area. All of the identified grizzly bear core recovery zones are well north of the Project area in the Northern Cascades. The proposed transmission line corridor coincides with an existing power line right-of-way and crosses only Forest Service lands managed as Matrix forest. No Late Successional or Managed Late Successional lands occur within the proposed corridor. Construction and operation of the hydroelectric project will not require construction of any new roads. The proposed action would have no affect on grizzly bear.

**References**


6.6 **Marbled Murrelet**

**Status of the Species in the Action Area**

Marbled murrelet (*Brachyramphus marmoratus marmoratus*), currently listed as threatened, is mainly a marine bird but nests in inland old-growth forests. Marbled murrelets prefer old growth forest for nesting. Horizontal branching length is a determining factor to murrelet use, mainly for nesting habitat. Marbled murrelet habitat, as identified in the Northwest Forest Plan, occurs along the Washington Pacific coast inland to about the crest of the Cascades, but does not extend into the hydroelectric project area (USFS 1994).

**Effects of the Proposed Action**

The proposed action should have no affect on marbled murrelets since the construction and operation of the hydroelectric project, including the transmission line corridor, will not include activities which would remove, impair, or degrade any marbled murrelet habitat.

**References**

USFS. 1994. Final Supplemental Environmental Impact Statement on management of habitat for late-successional and old-growth forest related species within the range of the spotted owl. USFS and BLM, Portland, Oregon.
6.7 **Northern Spotted Owl**

Northern spotted owls (*Strix occidentalis caurina*) are currently listed as threatened. Their habitat occurs on the western fringes of the Project area (USFS 1994). Spotted owls prefer stands of mature old growth forests, multi-layered canopies/structures, and the presence of snags and down woody debris in relatively contiguous blocks of habitat (FWS 1992, USFS 1994). Several critical habitat units have been designated for northern spotted owls near the Tieton River and Rimrock Reservoir. These are critical habitat units W-12 and W-13.

**Effects of the Proposed Action**

The hydroelectric project transmission line corridor follows an existing powerline right-of-way that passes through USFS Matrix lands. No late successional or managed late successional lands occur within the project boundary. Therefore, construction and operation of the hydroelectric project is not expected to remove or degrade existing old-growth forest or existing multi-layered canopies upon which the spotted owl depends. The project is also not likely to remove or degrade dispersal habitat or alter critical habitat units. Consequently, the proposed action would have no affect on the northern spotted owl.

**References**


USFS. 1994. Final supplemental Environmental Impact Statement on management of habitat for late- successional and old-growth forest related species within the range of the spotted owl. USFS and BLM, Portland, Oregon.
6.8 Ute Ladies’-tresses

Status of the Species in the Action Area

Ute ladies' tresses (*Spiranthes diluvialis*) is a member of the orchid family and is found in wetland, riparian areas, spring habitats, mesic to wet meadows, river meanders, and floodplains. The plant occurs between an elevation range of 1,500 to 7,000 feet and at lower elevations in the western part of its range. The orchid generally occurs below montane forests, in open areas of shrub or grassland, or in transitional zones. It is considered a lowland species, typically occurring beside or near moderate gradient - medium to large streams and rivers. The plant is not found on steep mountainous parts of a watershed, nor out in the flats along slow meandering streams. This species tends to occupy grass, rush, sedge and willow sapling dominated openings.

Ute ladies'-tresses orchid was named in 1984 and federally listed as threatened on January 17, 1992 under the ESA. The species occurs near the base of the eastern slope of the Rocky Mountains in southeast Wyoming and north-central and central Colorado; in the upper Colorado River Basin; and along the Wasatch Front and westward in the eastern Great Basin in north-central and western Utah and extreme eastern Nevada (historical). In 1994, the range was expanded north by discoveries in central Wyoming and western Montana, and in 1996, along the South Fork of the Snake River in southeast Idaho. In 1997 the range was extended to include north-central Washington.

*S. diluvialis* is endemic to moist soils at relatively low-elevation riparian, spring, and lakeside wetland meadows. The elevation range of known habitat is 1,500 to 7,000 feet. Most of the occurrences are along riparian edges, gravel bars, old oxbows, and moist-to-wet meadows along perennial streams and rivers, although some localities are near freshwater lakes or springs. *S. diluvialis* appears to be well adapted to disturbances caused by water movement through flood plains over time. It often grows on point bars and other recently created riparian habitat. The orchid appears to require permanent sub-irrigation, with the water table holding steady throughout the growing season and into late summer and early autumn. *S. diluvialis* occurs primarily in areas where the vegetation is relatively open and not very dense.

Effects of the Proposed Action

This orchid was first found in Okanogan County, Washington in 1997 so it could occur in suitable habitats within the Project area. The required habitat is most likely to occur in wetlands along the Tieton River. The hydroelectric project transmission line corridor will follow an existing powerline right-of-way along the Tieton River. Powerpole locations and construction activities have been planned to avoid all wetland habitat. On this basis we conclude that the proposed action is not likely to adversely affect Ute ladies tresses.