# 2009 YAKIMA STEELHEAD RECOVERY PLAN

Extracted from the

## 2005 Yakima Subbasin Salmon Recovery Plan

With Updates

Final
August 2009

Prepared by
the Yakima Basin Fish & Wildlife Recovery Board

# Yakima Steelhead Recovery Plan

Extracted from the 2005 Yakima Subbasin Salmon Recovery Plan

with Updates

**September 30th, 2009**


Compiled by:

Alex Conley, Yakima Basin Fish & Wildlife Recovery Board

Joel Freudenthal, Yakima County

David Lind, Yakama Nation

Phil Mees, Benton County

Richard Visser, Washington Department of Fish and Wildlife


***Cover photo by Ken Bevis, WDFW***


**Yakima Basin Fish & Wildlife Recovery Board**

**http://www.ybfwrb.org/**

Contact: info@ybfwrb.org or (509) 453-4104

# EXECUTIVE SUMMARY

## Introduction

The federal Endangered Species Act (ESA) requires listing species that have declined to the point that they are threatened with extinction and sets up regulations to protect these species. Recovering a listed species to the point that it no longer needs protection under the ESA is an important goal, both for people with a direct interest in the health of that species and for the individuals and groups who may be negatively affected by regulations put into place to protect a listed species. The ESA requires development of recovery plans that review a listed species' status, set recovery goals, and identify actions required to recover it and remove it from the list. Recovery plans are non-regulatory documents that provide guidance on how to recover a species; they do not create any binding commitments or legal mandates.

In 1999, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) classified Middle Columbia River Steelhead as a threatened species under the ESA. In 2006, NOAA Fisheries revised its listing to apply only to the anadromous (ocean-going) form *of Oncorhynchus mykiss*, commonly known as steelhead.[1] This listing applies to steelhead that spawn in a large portion of central and eastern Washington and Oregon (See Figure 1.1). This document, the Yakima Steelhead Recovery Plan, is a recovery plan for those listed Middle Columbia Steelhead that spawn in the Yakima Basin and are collectively referred to as the Yakima Major Population Group (MPG).

This document is an updated version of the steelhead portion of the 2005 Yakima Subbasin Salmon Recovery Plan, which NOAA Fisheries approved as an interim recovery plan for Yakima Basin populations of the Middle Columbia Steelhead River Distinct Population Segment (DPS) in May 2006. This 2007 Yakima Steelhead Recovery Plan will be incorporated into NOAA Fisheries' Middle Columbia Steelhead Recovery Plan, which will be released in final form in the fall of 2009.

The Yakima Basin Fish & Wildlife Recovery Board developed this plan to guide steelhead recovery efforts in the Yakima Basin. The Board is a locally based organization governed by representatives of Yakima, Benton, and Kittitas counties, the Yakama Nation, and cities in the basin. The Board's mission is to "to restore sustainable and harvestable populations of salmon, steelhead, bull trout, and other at-risk fish and wildlife species through the collaborative, economically sensitive efforts, combined resources, and wise resource management of the Yakima River Basin." It is recognized by the State of Washington as one of the regional organizations at the heart of the state's salmon recovery efforts.

The Board and its partners followed guidance from NOAA Fisheries, Washington Department of Fish and Wildlife (WDFW) and the Washington Governor's Salmon

---

[1] The freshwater-resident form of *O. mykiss* (commonly known as rainbow trout) is not listed, and falls under the jurisdiction of the U.S. Fish and Wildlife Service.

Recovery Office (GSRO) in developing this plan. Local planners also provided information and feedback to the Interior Columbia Technical Recovery Team (ICTRT) that NOAA Fisheries convened to develop science-based viability criteria and assessments of the status of steelhead populations. The ICTRT stock status assessments for Yakima Basin steelhead populations are incorporated into this document by reference.

This plan is built on the belief that healthy steelhead populations can be rebuilt in a manner that coexists with vibrant human communities and the local economies that support them. This plan emphasizes that steelhead recovery should build on existing fish and wildlife recovery programs and should rely on voluntary, non-regulatory approaches to habitat improvement. While this plan focuses on recovery efforts in the Yakima Basin, it acknowledges the need for ongoing recovery actions in the Columbia River, its estuary, and the Pacific Ocean. These are further addressed in NOAA Fisheries' Middle Columbia Steelhead Recovery Plan.

Recovery of steelhead in the Yakima Basin will not occur in a vacuum. In addition to steelhead, the basin once supported large populations of Chinook, coho, and sockeye salmon, oceangoing lamprey, and migratory bull trout. While only bull trout and steelhead are listed under the ESA, all of these species have declined significantly over the last 150 years. Recovering steelhead is just one objective of ongoing efforts to restore conditions that allow all of these species to thrive.

Chapter 1 provides more detail on the planning process and its broader context.

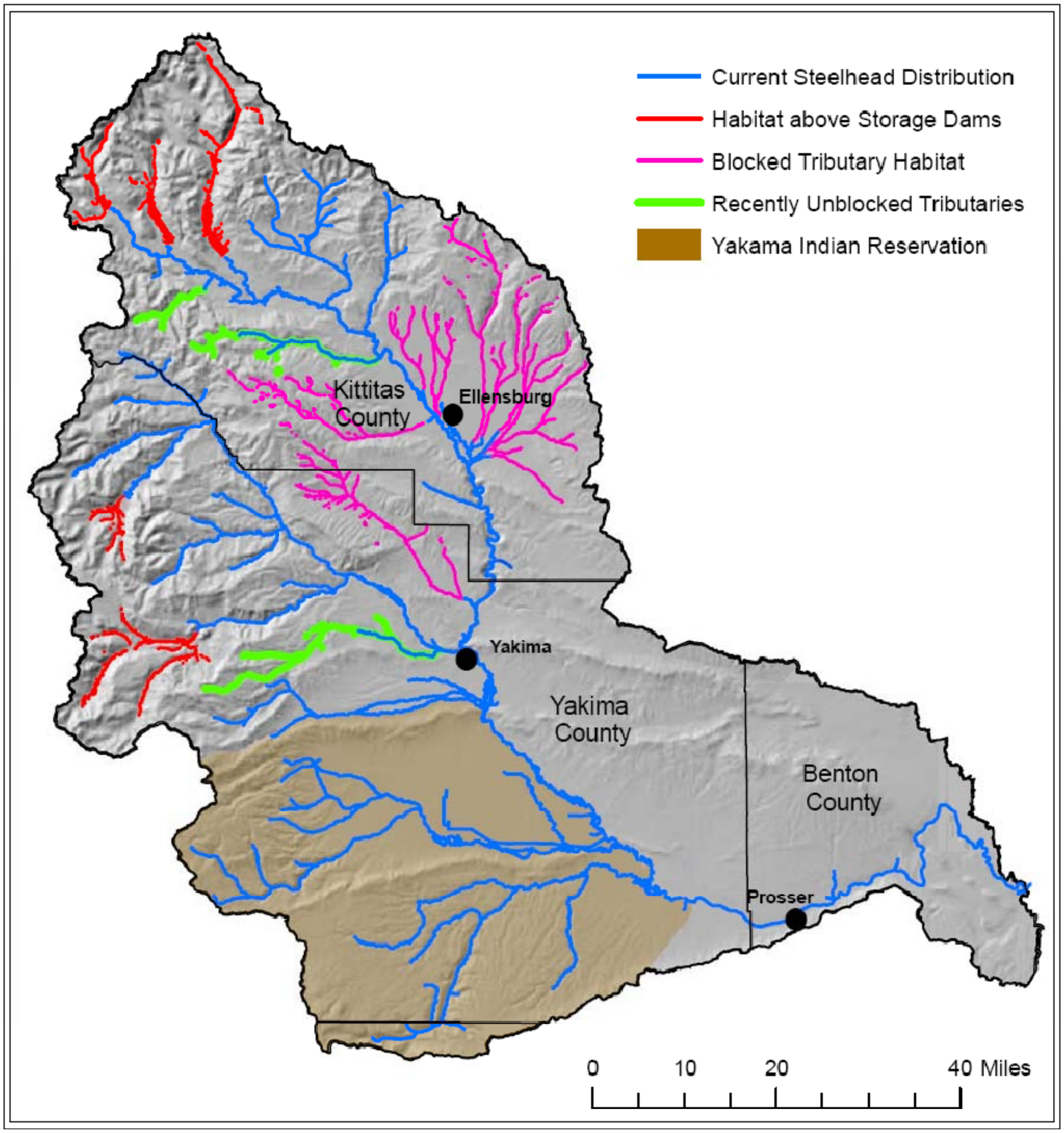
**Species Status**

Chapter 2 presents detailed empirical data about the status, distribution, characteristics, and life histories of Yakima Basin steelhead. Steelhead in the Yakima Basin are divided into four populations: the Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River populations. The NOAA ICTRT identifies the Satus Creek population as steelhead that spawn in the Satus Creek drainage on the Yakama Indian Reservation, the mainstem Yakima River below Satus Creek, and tributaries to the lower mainstem. For management purposes, local planners have subdivided the Satus population into the Satus block, which spawns in the Satus Creek drainage, and a mainstem block, whose current and historic status is uncertain. The Toppenish population consists of steelhead that spawn in Toppenish Creek, its tributaries and the short stretch of the mainstem between Toppenish and Satus creeks, and is entirely on the Yakama Reservation. The Naches population includes steelhead spawning in the Naches River and its tributaries (including the Tieton, Little Naches, American, and Bumping rivers and Cowiche, Rattlesnake and Nile creeks), the mainstem Yakima from the Naches confluence to the Toppenish Creek confluence and the tributaries to that reach of the Yakima, including Ahtanum Creek. The Upper Yakima population consists of all steelhead that spawn in the Yakima River and its tributaries upstream of the Naches confluence. Together these four populations make up the Yakima MPG.

Estimates of the number of adult steelhead returning to the Yakima Basin prior to European settlement range from 20,800 to 100,000. In contrast, the number of adults passing fish counting facilities at Prosser Dam (on the mainstem Yakima downstream of virtually all current spawning locations) between 1985 and 2006 has ranged from 450 to

4,491 with an average of 1,764. The ICTRT estimated the 10-year (1996-2005) geometric average by population as 379 for the Satus population, 322 for the Toppenish population, 472 for the Naches population, and 85 for the Upper Yakima.

**Map A: Basin overview and status of steelhead habitat**




The ICTRT modeled the extent of historically available steelhead habitat. This plan reviews that model, presents local planners revisions to the model, and compares that to current steelhead distribution (see Map A). Steelhead spawning is widely distributed throughout the areas accessible to them, except in the lower Yakima River and its tributaries (below the Satus Creek confluence). The extent and distribution of spawning in the mainstem from the Columbia to Roza Dam is uncertain. Steelhead currently cannot access the watersheds above Tieton, Bumping, Cle Elum, Kachess, and Keechelus dams[2] and a number of significant tributaries (e.g., Wenas, Manastash, and Naneum creeks in the Upper Yakima population area, and until just last year, Cowiche Creek in the Naches population area).

The Yakama Nation and WDFW have emphasized maintaining the natural genetic composition of Yakima Basin steelhead stocks. The last release of hatchery-origin juvenile steelhead in the Yakima Basin occurred in 1993. Stray hatchery-origin fish from other basins made up only 3% of the run from 1999 to 2005.

Instead of dying immediately after spawning like most salmon, steelhead can survive, return to the ocean, and spawn again. The Yakama Nation is currently capturing post-spawning steelhead at Prosser Dam and reconditioning them in hatchery facilities to increase the number that survive to spawn again.

Our knowledge of steelhead status in the upper portions of the basin is complicated by the fact that steelhead and rainbow trout are different forms of the same biological species that can interbreed. Better understanding the historic, current, and future potential for steelhead production in these areas will require determining how habitat conditions, genetics, and survival rates for oceangoing smolts interact to affect the balance between resident and anadromous life histories.

The ICTRT assessed the viability of Yakima Basin steelhead populations and concluded that none currently meet its standards for viability. The Satus population comes nearest to meeting the ICTRT’s standard, while the Upper Yakima population is farthest from the standard. The ICTRT analysis is based on NOAA Fisheries’ Viable Salmonid Population (VSP) framework, which calls for managing salmon and steelhead populations based on an understanding of their abundance, productivity, spatial structure, and diversity.

## Factors for Decline

Chapter 3 reviews the factors that led to the order of magnitude decline in abundance of steelhead in the Yakima Basin over the last 150 years. This decline parallels that of salmon throughout the Columbia Basin and is a function of both in-basin habitat changes, major impacts in the Columbia River and the Pacific Ocean associated with extensive harvest in fisheries, development of the Columbia River hydropower dams—Yakima steelhead must pass four on migrations to and from the sea—and management of hatchery programs in a manner that adversely affected wild populations.

Major in-basin factors for decline include:

1) Alteration of stream flows due to development of irrigation systems, including both the dewatering of lower reaches in many tributaries and the high and low flows in the mainstem Yakima and Naches rivers associated with water storage and delivery from upstream reservoirs

[2] The Bureau of Reclamation is currently evaluating passage options at the five storage dams.

2) Creation of passage barriers associated with both small and large diversion dams, road crossings, and Bureau of Reclamation (BOR) storage dams
3) Reductions in floodplain function due to diking, channel simplification, and floodplain development for agricultural and urban uses
4) Impacts to riparian areas and upland hydrology due to past and, to a lesser extent, current, grazing, and forestry practices
5) Changed ecological dynamics, including reduction in beaver populations, reductions in delivery of oceanic nutrients to headwaters by salmon, introduction of exotic species, and increased predation by native species

Significant progress has been made to address many of these threats, even as other threats have intensified because of changes in socio-economic conditions. Chapter 3 details the past and current status of these factors for each of the four populations (Satus, Toppenish, Naches, and Upper Yakima) and links them to the limiting factors framework used by NOAA Fisheries in the Middle Columbia Steelhead Recovery Plan.

**Recovery Goals, Criteria, and Strategies**

Chapter 4 identifies three different recovery thresholds for the Yakima MPG:

- An ESA de-listing threshold based on the ICTRT's framework that calls for one population to be viable, one to be highly viable, and two to be at "maintained status" or better
- A short-term recovery threshold that is based on the ICTRT framework, but emphasizes bringing all four Yakima populations to viable status
- A long-term recovery threshold that calls for restoring access to all historic habitat that can be restored consistent with the Board's commitment to sustaining local traditions and economies and improving abundance to levels that support broad ecological and harvest goals

The Board sees these three thresholds as points on a continuum. The Board concurs with NOAA Fisheries and the ICTRT that when the delisting threshold is met for the Yakima MPG and all other MPGs in the Middle Columbia River Steelhead DPS, it will be appropriate to consider removing the ESA listing. The Board expects recovery actions to continue after that point, even without the immediate motivation of the ESA. The long-term goals are less definite, but are meant to affirm that the Board and its partners believe that long-term recovery to significantly higher abundance levels is both feasible and desirable.

The abundance and productivity criteria associated with each of these thresholds are presented below. The delisting and short-term recovery criteria are drawn from the ICTRT viability analysis. Chapter 4 also sets out specific criteria for spatial distribution and diversity.

**Abundance and Productivity Criteria**

| | Delisting Threshold | | Short-Term Recovery | | Long-term Recovery | |
|---|---|---|---|---|---|---|
| **Population** | **Avg. #** | **Prod.** | **Avg. #** | **Prod.** | **Avg. #** | **Prod.** |
| **Satus:**<br>Satus Watershed<br>Mainstem Block* | <br>500<br>500 | <br>2.00<br>1.56 | <br>500<br>500 | <br>1.56<br>1.56 | 2,000 | <br>1.2<br>1.2 |
| **Toppenish** | 250 | 1.2 | 500 | 1.56 | 1,500 | 1.2 |
| **Naches** | 1,500 | 1.26 | 1,500 | 1.26 | 5,400 | 1.2 |
| **Upper Yakima** | 500 | 1.2 | 1,500 | 1.26 | 7,700 | 1.2 |
| ***Total*** | ***3,250*** | | ***4,500*** | | ***16,600*** | |

*Either spawners in the lower mainstem, or additional spawners above targets in other population areas, as described in Chapter 4

Achieving recovery goals for the Satus Population will require implementing these strategies:

1) Continuing efforts to protect existing functional habitat
2) Continuing ongoing efforts by the Yakama Nation to improve watershed and riparian conditions within the Satus drainage
3) Restoring floodplain function and channel complexity in lower Satus Creek
4) Improving migration conditions in the mainstem Yakima River

Achieving recovery goals for the Toppenish Population will require implementing these strategies:

1) Continuing efforts to protect existing functional habitat
2) Significantly improving passage, flows, and riparian conditions in Toppenish Creek and its tributaries
3) Restoring floodplain function in lower Toppenish Creek
4) Improving migration conditions in the mainstem Yakima River

Achieving recovery goals for the Naches Population will require implementing these strategies:

1) Continuing efforts to protect existing functional habitat
2) Significantly protecting and improving passage, flows, and instream and riparian conditions in tributaries (Ahtanum, Bumping, Cowiche, Rattlesnake, Nile, and Little Naches watersheds)

3) Addressing the effects on steelhead of reservoir operations and irrigation withdrawals in the Tieton, lower Bumping, and lower Naches rivers
4) Improving floodplain function and conditions in the mainstem Naches River
5) Improving migration conditions in the mainstem Yakima River

Achieving recovery goals for the Upper Yakima Population will require implementing these strategies:

1) Continuing efforts to protect existing functional habitat
2) Providing unimpeded passage for steelhead in key tributaries (Manastash, Taneum and, if feasible, Naneum and Cle Elum)
3) Improving outmigration conditions at Roza Dam
4) Addressing the effects of reservoir and irrigation system operations on winter/spring/fall low flows and summer high flows in the lower Cle Elum and mainstem Yakima rivers
5) Protecting and enhancing floodplain conditions along the mainstem Yakima
6) Improving flows and instream and riparian conditions in tributaries and side channels
7) Improving migration conditions in the lower mainstem Yakima River

**Recovery Actions**

Chapter 5 identifies 94 steelhead recovery actions. These are broken into basinwide actions (16), Lower Mainstem Yakima actions (9), Satus Creek actions (8), Toppenish Creek actions (10), Naches actions (32), and Upper Yakima actions (21). These actions implement the strategies described above.

Implementing some or all of the set of actions presented here should significantly improve the abundance, productivity, spatial structure, and diversity of steelhead in the Yakima Basin. Recovery planners anticipate that the full suite of actions presented here, if combined with expected improvements outside of the Yakima Basin, will be more than sufficient to meet de-listing and short-term recovery goals, but that additional actions may be needed to reach long-term broad sense recovery goals.

The scope and level of detail of specific actions varies considerably. The Yakima Basin Fish & Wildlife Recovery Board is committed to working with partners who will implement recovery actions to refine action descriptions and develop a more specific implementation schedule.

Initial cost estimates for implementing all of the actions identified in this plan over 15 years total $1,168.3 million, with $269.3 million of that cost directly attributed to steelhead recovery. The remaining portion of the total cost is attributed to other sources based on anticipated benefits to agricultural producers (e.g. irrigation system improvements), flood control, open space, other fish and wildlife species, etc. This is a simple and very preliminary estimate of actual implementation costs for actions. It is not a cost-benefit analysis of the proposed actions and does not include indirect costs such as opportunity and compliance costs associated with recovery efforts. It should not be taken as the total cost of recovery, as achieving delisting goals may require only implementing some of the actions included in this plan, while long-term recovery may require additional actions not included in the plan.

**Plan Implementation**

This plan is a beginning, not an end. Chapter 6 describes how this plan will be implemented. Achieving recovery goals will require sustained long-term efforts by a wide range of stakeholders. Salmon recovery is not a new pursuit in the Yakima Basin. Fish screening efforts began in the early 20th century, and intensive recovery efforts have been ongoing since the 1980s. The steelhead recovery actions proposed in this plan are a natural extension of this work.

Key recovery partners include the Yakama Nation, WDFW, BOR, USFS, NOAA Fisheries, USFWS, the Washington Department of Ecology, county and municipal governments, local Conservation Districts, non-profit organizations, and other landowners and managers throughout the basin. Developing collaborative partnerships between existing organizations should take precedence over the creation of new organizations and programs unless there is a clear need for a new structure.

This plan focuses on voluntary, non-regulatory approaches to implementing recovery actions. While it does call on decision-makers to effectively implement existing regulatory programs, it does not mandate specific regulatory actions or call for new regulatory programs.

Coordinating diverse recovery efforts and ensuring that limited funding is used effectively requires ongoing collaboration between in-basin stakeholders and state and federal agencies. The Yakima Basin Fish & Wildlife Recovery Board has committed to working with recovery partners to 1) develop a regularly updated implementation schedule that prioritizes future recovery actions, 2) track completion of recovery actions, 3) promote effective use of existing funding[3], 4) work with partners to develop new sources of support for recovery actions, and 5) ensure Yakima Basin recovery efforts are coordinated with recovery efforts across the range of the Middle Columbia River Steelhead DPS.

[3] Current funding sources include the Washington Salmon Recovery Funding Board (which distributes both federal Pacific Coast Salmon Recovery Fund dollars and state funds), the BPA/NPCC Fish and Wildlife Program, the Bureau of Reclamation’s Yakima River Basin Water Enhancement Project, and the Washington Department of Ecology’s Columbia River Initiative.

### Research Monitoring and Evaluation

Our understanding of steelhead biology and the factors that affect steelhead habitat and survival is continually improving. Chapter 7 reviews key uncertainties and the research, monitoring, and evaluation actions that will answer them. While the extent of empirical data about Yakima Basin steelhead populations is much greater than for most other populations of the Middle Columbia River Steelhead DPS, successfully implementing this plan will require additional data collection and analyses. Targeted empirical research is needed to increase our ability to effectively and efficiently implement recovery actions. Tracking the response of steelhead to specific actions and broad habitat trends and evaluating progress towards meeting quantifiable recovery goals will require a robust monitoring and evaluation program. This research and monitoring will build on the extensive research capacity built by the Yakima/Klickitat Fisheries Program and others. Chapter 7 reviews the need for research and monitoring and identifies key uncertainties that will need to be addressed as part of implementing this recovery plan. The Yakima Basin Fish & Wildlife Recovery Board will develop a Research, Monitoring and Evaluation Plan that builds on Chapter 7 of this plan to identify critical research and monitoring needs and assess how they can be incorporated into an effective and practical adaptive management framework.

### Public Education and Outreach

Chapter 8 reviews outreach and education needs and presents some initial proposals for future actions. Effectively implementing the recovery actions identified in this plan will require outreach and education activities that: 1) build support for steelhead recovery actions among decision makers, land managers, and the public at large, and 2) increase public understanding of how individual actions affect steelhead and their habitat. Outreach activities are often forgotten in the push to implement on-the-ground recovery actions, yet they are vital to sustaining the political and financial support that achieving recovery will require. The Yakima Basin Fish & Wildlife Recovery Board is committed to working with partners throughout the basin to support and expand education and outreach programs.

# TABLE OF CONTENTS

# LIST OF TABLES

## LIST OF FIGURES

# ACRONYMS

| | |
|---|---|
| BIA | BUREAU OF INDIAN AFFAIRS |
| BKD | BACTERIAL KIDNEY DISEASE |
| BOR | UNITED STATES BUREAU OF RECLAMATION (also Reclamation) |
| BPA | BONNEVILLE POWER ADMINISTRATION |
| BW | BASINWIDE |
| CAG | CONSERVATION ADVISORY GROUP |
| CFHMP | COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN |
| cfs | CUBIC FEET PER SECOND |
| CREP | CONSERVATION RESERVE ENHANCEMENT PRORAM |
| CWT | CODED WIRE TAG |
| DPS | DISTINCT POPULATION SEGMENT |
| DOE | UNITED STATES DEPARTMENT OF ENERGY |
| EDT | ECOSYSTEM DIAGNOSIS AND TREATMENT |
| EIS | ENVIRONMENTAL IMPACT STATEMENT |
| EPA | UNITED STATES ENVIRONMENTAL PROTECTION AGENCY |
| ESU | EVOLUTIONARILY SIGNIFICANT UNIT |
| FTE | FULL-TIME EMPLOYEE |
| FPS | FISH PASSAGE CENTER |
| GMA | GROWTH MANAGEMENT ACT |
| GSRO | GOVERNOR’S SALMON RECOVERY OFFICE |
| ICTRT | INTERIOR COLUMBIA TECHNICAL RECOVERY TEAM |
| ID | IRRIGATION DISTRICT |
| KCT | KITTITAS CONSERVATION TRUST |
| KID | KENNEWICK IRRIGATION DISTRICT |
| LM | LOWER YAKIMA RIVER MAINSTEM |
| LWD | LARGE WOODY DEBRIS |
| MF | MIDDLE FORK |
| MPG | MAJOR POPULATION GROUP |
| MSA | MAJOR SPAWNING AREA (DEFINED BY ICTRT) |
| MiSA | MINOR SPAWNING AREA |
| N | NACHES RIVER |
| NF | NORTH FORK |
| NOAA | NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION |
| NMFS | NATIONAL MARINE FISHERIES SERVICE (A DIVISION OF NOAA ALSO REFERRED TO AS NOAA FISHERIES) |
| NPCC | NORTHWEST POWER AND CONSERVATION COUNCIL |
| NPPC | NORTHWEST POWER PLANNING COUNCIL (NOW NPCC, SEE ABOVE) |
| NRCS | NATURAL RESOURCES CONSERVATION SERVICE |
| PCSRF | PACIFIC COAST SALMON RECOVERY FUND |
| PIT | PASSIVE INTEGRATED TRANSPONDER |
| RC & D | RESOURCE CONSERVATION AND DEVELOPMENT |
| RFEG | REGIONAL FISHERIES ENHANCEMENT GROUP |
| RM | RIVER MILE |

| | |
|---|---|
| RME | RESEARCH, MONITORING, AND EVALUATION |
| S | SATUS CREEK |
| SAR | SMOLT ADULT RATIO |
| SF | SOUTH FORK |
| SMA | SHORELINES MANAGEMENT ACT |
| SOAC | SYSTEMS OPERATIONS ADVISORY COMMITTEE (BOR YAKIMA PROJECT) |
| SR | STATE ROAD |
| SRFB | SALMON RECOVERY FUNDING BOARD |
| SVID | SUNNYSIDE VALLEY IRRIGATION DISTRICT |
| T | TOPPENISH CREEK |
| TLC | TOPPENISH LATERAL CANAL |
| TMDL | TOTAL MAXIMUM DAILY LOAD |
| U | UPPER YAKIMA RIVER |
| USDA | UNITED STATES DEPARTMENT OF AGRICULTURE |
| USFS | UNITED STATES FOREST SERVICE |
| USGS | UNITED STATES GEOLOGICAL SURVEY |
| USFWS | UNITED STATES FISH AND WILDLIFE SERVICE |
| VSP | VIABLE SALMONID POPULATION |
| WDFW | WASHINGTON DEPARTMENT OF FISH AND WILDLIFE |
| WDNR | WASHINGTON DEPARTMENT OF NATURAL RESOURCES |
| WDOE | WASHINGTON DEPARTMENT OF ECOLOGY |
| WIP | WAPATO IRRIGATION PROJECT |
| WRIA | WATERSHED RESOURCE INVENTORY AREA |
| WSDOT | WASHINGTON STATE DEPARTMENT OF TRANSPORTATION |
| WSU | WASHINGTON STATE UNIVERSITY |
| YBFWRB | YAKIMA BASIN FISH & WILDLIFE RECOVERY BOARD (ALSO THE BOARD) |
| YFO | YAKIMA FIELD OFFICE (OF BOR) |
| YKFP | YAKIMA/KLICKITAT FISHERIES PROJECT |
| YN | YAKAMA NATION |
| YRBWEP | YAKIMA RIVER BASIN WATER ENHANCEMENT PROJECT |
| YSPB | YAKIMA SUBBASIN FISH AND WILDLIFE PLANNING BOARD |
| YTAHP | YAKIMA TRIBUTARY ACCESS AND HABITAT PROGRAM |

# 1 Introduction



## 1.1 Overview of Recovery Planning

### 1.1.1 Listing of Yakima Basin Steelhead

Anadromous steelhead (*Oncorhynchus mykiss*) have declined significantly in abundance and geographic extent in the last one and a half centuries, but are still found across a broad geographic area. The National Oceanographic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) is responsible for applying the Endangered Species Act (ESA) to anadromous salmon and steelhead. NOAA Fisheries has divided habitat areas with salmon in Washington, Oregon, Idaho, and California into Evolutionarily Significant Units (ESUs), while dividing habitat areas with steelhead in those states into Distinct Population Segments (DPSs). Yakima Basin steelhead were first listed under the ESA as part of the Middle Columbia River Steelhead ESU, which NOAA Fisheries first designated as threatened on March 25, 1999 [4]. The Middle Columbia River Steelhead ESU (later DPS) included the Columbia River and its tributaries from above the Wind River in Washington and the Hood River in Oregon, upstream to, and including, the Yakima River, in Washington. Snake River basin steelhead are not included (see Figure 1.1).

In 2005-6, NOAA Fisheries revised its species determinations for West Coast steelhead under the ESA, delineating steelhead-only "distinct population segments" (DPS) in place of the earlier ESUs. NMFS listed the Middle Columbia River Steelhead DPS as threatened on January 5, 2006 [5]. The area occupied by the Middle Columbia River Steelhead DPS remained the same as the area originally designated as an ESU. The steelhead DPS does not include rainbow trout, the non-anadromous freshwater form of *Oncorhynchus mykiss*, which are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS).[6]

[4] See the Federal Register, Volume 64, p. 14517.
[5] See the Federal Register, Volume 71, p. 834.
[6] For a good overview of the history of the listing and the reasoning underlying NOAA's decision to list only the anadromous form of *O. mykiss* as a DPS, see the January 5, 2006 Federal Register notice (Volume 71, p. 834).

**Figure 1.1: Location of Yakima MPG within Middle Columbia River DPS**

### 1.1.2 Requirements for a Recovery Plan

Section 4(f) of the ESA calls for the development of recovery plans. The following are the key provisions:

- 4(f)(1) – Recovery plans shall be developed and implemented for listed species unless the Secretary "…finds that such a plan will not promote the conservation of the species."
- 4(f)(1)(A) – Priority is to be given, to the maximum extent practicable, to "…species, without regard to taxonomic classification, that are most likely to benefit from such plans, particularly those species that are, or may be, in conflict with construction or other forms of economic activity."
- 4(f)(1)(B) – Each plan must include, to the maximum extent practicable, "(i) a description of site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species; (ii) objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list; and, (iii) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal."

A recovery plan is a guidance document, or "road map" that describes the current status of a species and the actions that the federal agencies administering the ESA (NOAA Fisheries and the USFWS) have determined will lead to recovery of the listed species and its associated habitats. Recovery requires reversing the decline of a listed species and removing the threats to the long-term survival of a species that led to its listing under the ESA. When this is accomplished a species may be removed from the ESA list, or "delisted." Recovery, as defined by NOAA Fisheries, requires restoring listed species so that they become viable components of their ecosystem.[7] This document addresses the status and recovery needs of the portion of the Middle Columbia River Steelhead DPS that utilize the Yakima Basin. The Yakima Basin Fish & Wildlife Recovery Board is providing it to NOAA Fisheries in order to assist in its efforts to develop a federal recovery plan for the Middle Columbia River Steelhead DPS.

### 1.1.3 Development of the Yakima Subbasin Salmon Recovery Plan

This document is builds upon the Yakima Subbasin Salmon Recovery Plan, which was prepared by the Yakima Basin Fish & Wildlife Recovery Board (YBFWRB, also the Board), and its predecessor organization, the Yakima Subbasin Fish and Wildlife Planning Board (YSPB). These Boards developed this plan in response to the Washington State Salmon Recovery Act (RCW 77.85), which encourages the creation of regional recovery plans that address the needs of ESA-listed salmonid species. The

[7] A "viable" population is defined by NOAA Fisheries as an independent population that has negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (ICTRT 2004b).

Yakima Subbasin Salmon Recovery Plan addressed the recovery needs of both of the ESA-listed fish species found in the Yakima Basin: steelhead and bull trout. The Salmon Recovery Act states that the fish and wildlife resources of the state are currently managed by state resource agencies, and that it is in the interest of the citizens of the State of Washington to retain management responsibility for these resources. Accordingly, local organizations, in cooperation with state, tribal, and federal governments, are developing recovery plans. This approach accelerates the required recovery planning process and ensures that NOAA Fisheries and USFWS consider local expertise and concerns in the preparation and approval of recovery plans.

In order to implement the Salmon Recovery Act, the Washington Salmon Recovery Funding Board and the Office of the Interagency Committee (known as the Recreation and Conservation Office) contracted with the Yakima Subbasin Fish and Wildlife Planning Board to develop a local salmon recovery plan based on guidance from the Washington Department of Fish and Wildlife (WDFW) and the Governor's Salmon Recovery Office (GSRO). The YSPB was originally convened to develop the Yakima Subbasin Plan for the Northwest Power and Conservation Council, and consisted of representatives from local governments in the Yakima Basin.[8] The YSPB worked with local partners and stakeholders to develop and review the initial draft of Yakima Subbasin Salmon Recovery Plan.

The draft plan was approved by the state and forwarded to NOAA Fisheries and the USFWS on October 26th, 2005. NOAA Fisheries subsequently reviewed the draft plan and developed a response entitled "Supplement to the Draft Yakima Subbasin Salmon Recovery Plan" (NMFS Northwest Region 2006). NOAA Fisheries announced the availability of the draft plan and the agency's supplement in the Federal Register on May 3, 2006 [9], with a formal comment period that extended until July 3, 2006.

In April 2006, in an effort to consolidate salmon recovery efforts, the Planning Board was dissolved and its duties taken on by a new organization, the Yakima Basin Fish & Wildlife Recovery Board. The new Board also took on the role of Lead Entity from the Yakima River Salmon Recovery Board, a separate Board that was also dissolved. The YBFWRB assumed responsibility for the Yakima Subbasin Salmon Recovery Plan.[10]

Since the formation of the Yakima Basin Fish & Wildlife Recovery Board, the original October 2005 draft has been revised to incorporate new information, improve clarity, and address issues identified in the NOAA Fisheries' supplement and comments received in response to publication in the Federal Register. In order to ensure clarity and facilitate incorporation into NOAA Fisheries' Middle Columbia River Steelhead Recovery Plan,

---

[8] Membership in the Yakima Subbasin Planning Board included the Yakama Nation, Benton County, Yakima County, the cities of Benton, Ellensburg, Granger, Kennewick, Prosser, Richland, Roslyn, Selah, Sunnyside, West Richland, Union Gap, and Yakima, and WDFW.

[9] See the Federal Register, Volume 71, p. 26052.

[10] Membership in the Yakima Basin Fish & Wildlife Recovery Board includes the Yakama Nation, Benton, Kittitas, and Yakima counties and 18 of the 24 municipalities in the Yakima Basin. Its work is overseen by a Board of Directors and conducted through a non-profit organization that reports to the Board. For more information see http://www.ybfwrb.org.

this steelhead-specific plan was compiled from the Yakima Subbasin Salmon Recovery Plan. The Yakima Basin Fish & Wildlife Recovery Board has followed existing statutory and policy guidance to develop what we believe is an effective and practical recovery plan for steelhead in the Yakima Basin.

## 1.2 Vision and Guiding Principles for Local Planning

### 1.2.1 Vision

The recovery plan built upon the Yakima Subbasin Fish and Wildlife Planning Board's (YSPB) Vision 2020 (Yakima Subbasin Fish and Wildlife Planning Board 2005). Vision 2020 describes in general terms the desired future conditions of fish and wildlife habitats and populations in the Yakima Basin. It states:

> Yakima River basin communities have restored the Yakima River basin sufficiently to support self-sustaining and harvestable populations of indigenous fish and wildlife while enhancing the existing customs, cultures, and economies in the basin. Decisions that continuously improve the river basin ecosystem are made in an open and cooperative process that respects different points of view and varied statutory responsibilities and benefits current and future generations.

### 1.2.2 Guiding Principles

The Guiding Principles set the direction for the recovery plan by taking into account local economic and social conditions and concerns, generally accepted biological assumptions, treaty rights, and other applicable laws and policies. The Guiding Principles developed by the YSPB for the subbasin planning process are:

- The natural environment, including its fish and wildlife resources, is the common heritage of our diverse human community. The underlying premise of the Vision is to prepare and implement a balanced plan of action that plays a key role in the long-term sustainability of this common cultural and biological heritage in the Yakima Basin.
- The quality of water and a near natural timing and quantity of water flow (normative hydrograph) are principal indicators of a healthy river ecosystem. These indicators must be improved and monitored.
- The continued exercise of the Yakama Nation treaty-reserved and aboriginal rights to religious, subsistence, commercial, and recreational use of natural resources is recognized.
- Planning and implementation is based on voluntary actions and incentives.
- The processes of plan preparation, implementation, and amendment are open and equitable.

- The costs of plan actions are estimated in relation to benefits. Alternatives that achieve the highest benefit relative to costs are preferred. Costs of habitat and species restoration should be mitigated and distributed equitably.
- Programs and actions must be monitored and evaluated for effectiveness and may be altered as necessary.
- Balanced sustainable resource management recognizes these basic precepts:
  - The physical and biological environments are functionally interdependent relative to productivity.
  - At any level of function, productivity is finite.
  - Without actions to restore degraded functions, and to protect, avoid, and mitigate impacts to the physical and biological environment, the increasing demands of human population growth could reduce productivity to zero, with unacceptable costs to the cultures and economies of the Yakima subbasin.

The primary focus of this plan is "recovery" of listed species to levels that no longer require those species to be listed under the Endangered Species Act. However, both the mission of the Yakima Basin Fish & Wildlife Recovery Board and the specific goals identified in Chapter 4 go beyond just delisting of these species, and include maintaining population levels that support sustained harvest and diverse ecological functions. In order to reach these goals, recovery to the point where delisting is possible is a necessary first step, but not the end point. Meeting the long-term population and harvest goals of the Board will require ongoing actions even after the initial goal of delisting is met.

### 1.2.3 Non-Regulatory Nature of Recovery Plans

The NOAA Fisheries Recovery Plan for Middle Columbia River Steelhead and the Yakima Subbasin Salmon Recovery Plan are not regulatory documents. They lay out recommended actions, but do not require anyone to implement those actions. The intent of the plans is to provide information and guidance to those looking for ways to recover listed species. The recommendations made in the plans can only become binding commitments if decision makers subsequently incorporate them into requirements established by other governmental entities or programs according to their regular processes. The plans themselves create no obligations.

Both local and NOAA Fisheries recovery planners have repeatedly assured basin citizens and stakeholders that these recovery plans are not a regulatory mechanism, and that their implementation will not usurp or diminish the existing authority under state law or federal treaty, of any government or special district. The Board envisions that implementation of the plan will be inclusive, transparent, collaborative, cooperative, and voluntary. This approach is essential in order to build the long-term social and political support required for successful steelhead recovery. While the science, metrics and overall recovery strategy of the Yakima Subbasin Salmon Recovery Plan must guide what actions should be taken to increase steelhead productivity, there will often be additional considerations that will determine the sequence of actions that are taken, and how the actions should best be implemented so that recovery goals can be achieved in an atmosphere of trust and cooperation. The organizations that promote implementation of these recovery plans must be flexible and innovative in using their resources so that broad understanding, support, involvement, and enthusiasm for salmon recovery is nurtured.

## 1.3 Process Used to Develop the Plan

### 1.3.1 Drafting of the Plan

In the initial 2005 draft of the Yakima Subbasin Salmon Recovery Plan, the limiting factors and actions were developed based on consideration of both bull trout and steelhead. The plan took a watershed-based approach that focused on protecting existing habitat and supporting natural habitat-forming processes. In this updated steelhead version, we have extracted the steelhead-specific information for ease of reference and incorporation into NOAA Fisheries' Middle Columbia River Steelhead Recovery Plan. We will update the bull trout section of the 2005 plan in conjunction with the USFWS's development of a bull trout recovery plan.

This plan was developed as follows:

- The Interior Columbia Technical Recovery Team (ICTRT) identified "Independent" populations for steelhead (ICTRT 2003; ICTRT 2005c). See Section 2.2 for definition of these populations.
- Current and historical conditions of each population were described, with emphasis on four general Viable Salmonid Population (VSP) parameters: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000).
- Limiting factors that led to the decline of each population in the Yakima Basin were identified. Limiting factors were identified in the Yakima Subbasin Plan based on Ecosystem Diagnosis and Treatment (EDT) model runs specific to steelhead, other watershed assessment documents and plans, the species management programs by the Yakama Nation (YN) and WDFW, NOAA Fisheries' Draft Guidelines for Limiting Factors and Threats Assessments, and recent research on habitat conditions and populations.
- Specific recovery actions were selected from those listed in the subbasin plan, and additional actions were identified consistent with "An Outline for Salmon Recovery Plans" (WDFW 2003). The plan also includes actions to respond to extinction risks consistent with the Interior Columbia Technical Recovery Team's guidelines (ICTRT 2004a; ICTRT 2004b), actions based on threats identified by stakeholders, and actions stakeholders identified for the first time during this planning process.
- The benefits, practicability, and relative cost of actions for each population were assessed.
- A suite of actions that could be implemented, were reasonable, and should provide the greatest benefit to the listed and other species was selected.

Planners believe that the proposed actions are sound. The actions identified in the plan address the range of threats to steelhead as they are understood at this time. However, outcomes are uncertain because of the lack of comprehensive knowledge about the ecological and social processes that affect fish. Unpredictable events will continue to affect recovery efforts. In order to ensure that the recovery strategy effectively incorporates improved knowledge and changing conditions, the plan calls for monitoring and evaluation efforts that assess the outcomes of recovery efforts and the response of target fish populations. Participants will take this information and updated cost estimates and use them to re-evaluate proposed actions and their priorities and update the plan.

### 1.3.2 Public Involvement

The public participation process for the preparation of Yakima Subbasin Salmon Recovery Plan was a continuation of the process carried out for the Yakima Subbasin Fish and Wildlife Plan. The contact list developed during the subbasin planning process was used and updated to keep interested parties informed and involved in the progression of the draft salmon recovery plan. The Yakima Subbasin Fish and Wildlife Planning Board's website remained active and updated, the media were kept informed, and there was a public comment period on each agenda of the advertised Board meetings. Board staff continued to give presentations and updates to various interested groups. During the preparation of the Salmon Recovery Plan, however, public participation activities emphasized involving stakeholders—the agencies, special districts, non-profits, economic interests, local government departments, and others that are daily engaged in consumptive use, management, or acquisition of resources that directly or indirectly affect salmon and salmon habitat. These entities include irrigation districts, conservation districts, state and federal agencies (e.g., BOR, USFS, and Washington Department of Transportation), greenways and land trusts, and local government planning and public works departments. These stakeholders funding, abilities, constraints, legal authorities, constituent interests, and internal policies will determine whether or not they can commit to the changes in their operations and programs identified in the draft Recovery Plan as necessary to restore salmon habitat.

Within the salmon recovery planning process, the interaction with stakeholders is called the Policy Forum. Board staff consulted with stakeholders during the months of March, April, and early May, beginning with a well-attended workshop held at the Yakima Convention Center on March 2, 2005. The list of Policy Forum stakeholders is shown in Appendix D. Additional outreach efforts were made throughout the planning process, as described in Appendix D, and changes were made in response to comments made during the September to December 2008 NOAA Fisheries comment period on the Middle Columbia River Steelhead Recovery Plan.

Chapter 8 of this document discusses information and outreach needs associated with recovery efforts.

### 1.3.3 Incorporating the Local Plan into NOAA's Recovery Plan

NOAA Fisheries is currently preparing its recovery plan for the Middle Columbia River Steelhead DPS, as mandated by the ESA. The geographic area of the DPS encompasses much of north-central Oregon and south-central Washington. The Yakima MPG is one of four MPGs in the Middle Columbia River Steelhead DPS. It contains 20% of the acreage and four of the 18 extant steelhead populations in the DPS (see Figure 1.1). It is the intent of both NOAA Fisheries and the YBFWRB that the Yakima Subbasin Salmon Recovery Plan be the basis for the Yakima MPG portion of NOAA Fisheries' Mid-Columbia Steelhead Recovery Plan.

This excerpt includes the portion of the updated version of the Yakima Subbasin Salmon Recovery Plan that address the recovery needs of the Middle Columbia Steelhead DPS. It has been prepared specifically for reference by NOAA Fisheries in preparation of the formal federal recovery plan for Middle Columbia River Steelhead, and this excerpt is expected to be included by NOAA Fisheries as an Appendix in its final recovery plan. For the sake of brevity and clarity, this excerpt does not include those portions of the Yakima Subbasin Salmon Recovery Plan that focus solely on bull trout. Where bull trout recovery needs influence and/or overlap recovery needs for steelhead, this is noted in the excerpt.

The steelhead that spawn in the Yakima Basin spend their first years in the basins streams and rivers, and then migrate out the Columbia to the Pacific ocean before turning around and, as adult fish, migrating up the Columbia and Yakima rivers to their spawning grounds. Recovering Yakima steelhead will require taking actions that improve survival rates for steelhead in the Yakima Basin, the Columbia River, its estuary, and the ocean. The Yakima Subbasin Salmon Recovery Plan and this steelhead excerpt focus on the factors that affect steelhead during the portions of their lives spent in the Yakima Basin. The NOAA Fisheries Recovery Plan for the Middle Columbia River Steelhead DPS will combine this within-basin information with an assessment of the many factors that affect steelhead during their time outside of the Yakima Basin. These include passage through the mainstem Columbia hydropower system, conditions in the Columbia River and its estuary, harvest by both fisheries and predators, and ocean conditions. The NOAA Fisheries recovery plan will incorporate proposed actions that address these out of basin impacts.

## 1.4 Relationship to Other Recovery Activities

### 1.4.1 Relationship to Other Planning Efforts

The Yakima Subbasin Salmon Recovery Plan draws from several related planning efforts undertaken in the basin in recent years. In 2000, the Northwest Power and Conservation Council (formerly the Northwest Power Planning Council) adopted a revised Columbia River Basin Fish and Wildlife Program with the intent that the program will be more comprehensive than, but complementary to, regional, state, county, and tribal efforts. Their revised program called for an ecosystem-based approach for planning and implementing mitigation of impacts to fish and wildlife from the Columbia Basin hydroelectric system. To provide specific recommendations for the Yakima Basin, the Northwest Power and Conservation Council (NPCC) contracted with the Yakima Subbasin Fish & Wildlife Planning Board to develop the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005), which was completed in 2004 and is the basis of much of the information contained in this recovery plan. While the Yakima Subbasin Salmon Recovery Plan focuses more narrowly on steelhead and bull trout, other resident and anadromous fish species should also benefit from the actions it identifies.

The Washington State Conservation Commission drafted a Limiting Factors Analysis of fish habitat in the Yakima Basin (Haring 2001) as part the Washington State Salmon Recovery Strategy laid out in House Bill 2496 in 1998. It provides a detailed stream-by-stream discussion of habitat conditions in the basin.

The Yakima River Basin Watershed Management Plan was developed as part of the state-wide watershed planning process under House Bill 2514. The draft plan was completed in November 2005, and addresses water supply, water quality, and fish habitat issues. Yakima, Benton, and Klickitat counties have adopted the plan, but neither Kittitas County nor the Yakima Nation have approved it. The Yakima Basin Water Resources Agency has developed a Detailed Implementation Plan for the Watershed Plan and is coordinating its implementation. It is our hope that implementation of the Yakima Subbasin Salmon Recovery Plan can be closely coordinated with efforts to implement the Watershed Plan.

### 1.4.2 Relationship to Ongoing On-the-Ground Recovery Efforts

WDFW and the Yakama Nation work together as co-managers to manage the basin's fish resources. These co-managers and numerous partners (including federal agencies, local governments, non-profit organizations, Conservation Districts, and local landowners and managers) have a strong history of working together to improve habitat and recovery salmon and steelhead in the Yakima Basin. Fish management programs in the basin are described in Appendix A and include fisheries enhancement projects funded by the Bonneville Power Administration's Fish & Wildlife Program, salmon restoration projects funded by the Washington Salmon Recovery Funding Board via the Lead Entity system developed by HB 2496, the Bureau of Reclamation's Yakima River Basin Water Enhancement Project, restoration projects conducted by the Wenatchee National Forest, local comprehensive and shoreline management plans and their respective regulatory programs, and numerous voluntary efforts by private individuals and organizations. The recovery strategy described in the Yakima Subbasin Salmon Recovery Plan is built on continuing and enhancing these fish restoration efforts. Meeting the recovery goals for ESA-listed fish populations within the Yakima Basin will likely require sustained efforts over the course of several decades. The estimated cost attributed to steelhead recovery for all actions identified in this plan is $269.3 million. Local budgets and economies within the basin cannot fund such expenditures on their own, and success in salmon recovery will depend on the ongoing support of state and federal governments. This support needs to be sufficient, reliable, and consistent over time.

Successfully delisting steelhead in the Yakima Basin will also require coordinating efforts with other areas within the Middle Columbia River DPS. NOAA Fisheries will only delist the Yakima steelhead Major Population Group (MPG) if delisting is deemed to be appropriate for the entire DPS. This is dependent on progress towards recovery in other MPGs in the DPS (the John Day, Walla Walla/Umatilla, and East Cascades Major Population Groups). This means that local communities in different basins that cross local and state boundaries are dependent upon each other for success in meeting de-listing goals, and will need to work together to insure that their shared goals are met.

# 2 Species Status



This section describes the Yakima Basin, its steelhead populations, and their population structure, distribution, abundance, characteristics, and life histories. It then reviews existing viability assessments of Yakima Basin steelhead populations. In this document, steelhead refers to the anadromous component of *O. mykiss* in the Yakima Basin, as described in Chapter 1, the Introduction.

## 2.1 Regional Setting

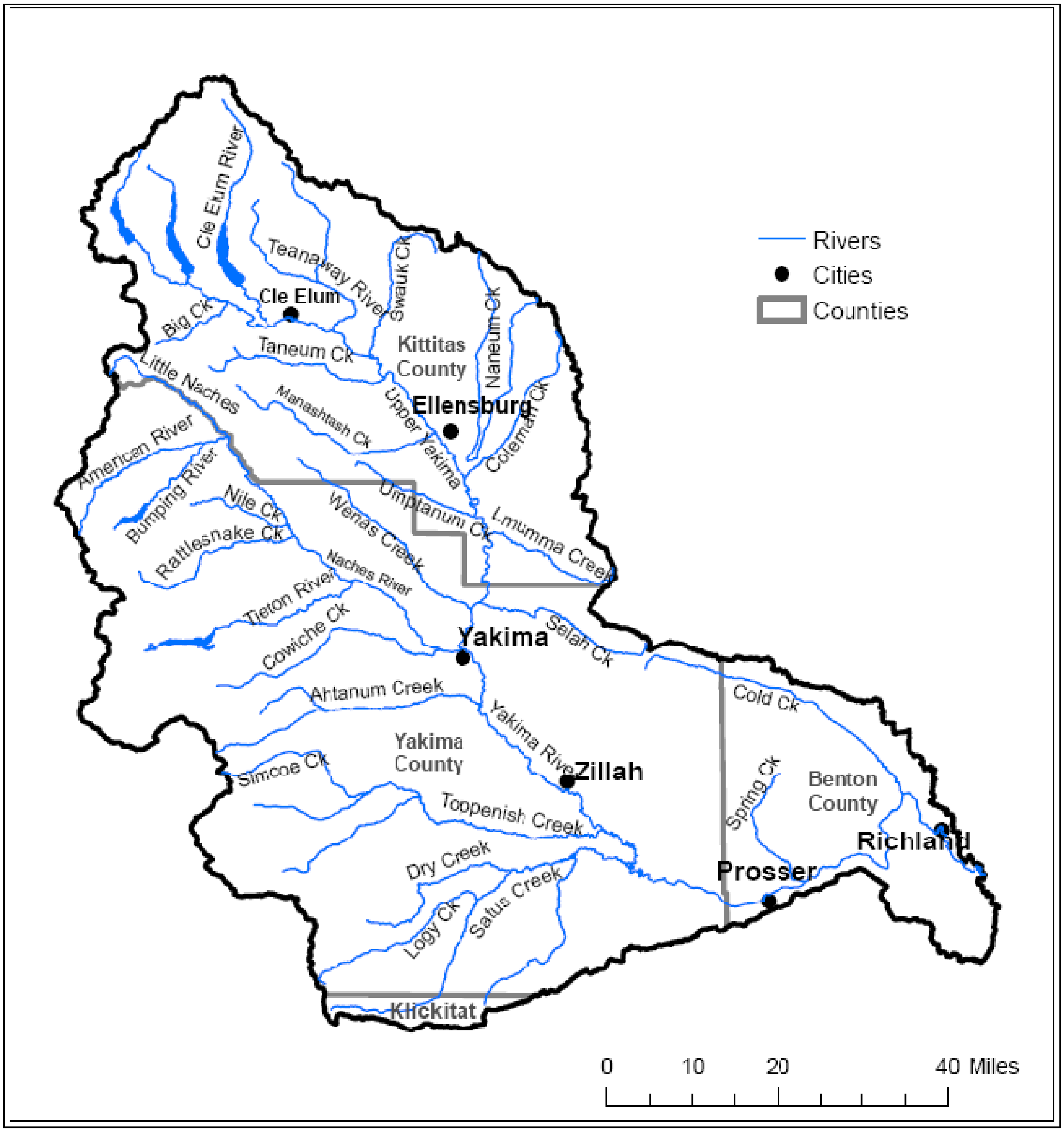
### 2.1.1 Geographic Setting[11]

The 214-mile Yakima River and its tributaries drain a 6,150 square mile watershed that runs from the crest of the Cascade Mountains (over 8,000 feet in elevation) to the Columbia River 333 miles upstream of the Pacific Ocean (340 feet in elevation). The Yakima River and its tributaries run through landscapes that range from the forested, mountainous terrain of the Cascades to the dry, shrub-steppe hills of the Columbia Basin. The Yakima Basin occupies two physiographic provinces (the Columbia Plateau and Cascade Mountains), and three major ecoregions, Cascades, Eastern Cascades Slopes and Foothills, and Columbia Basin (Omernik 1987). Climate, topography, precipitation, and vegetative cover are highly variable across the basin. Precipitation in the basin ranges from over 120 inches in the mountains to 7 inches in the lower Yakima Valley. Figure 2.1 shows the major rivers and streams in the Yakima Basin discussed in this recovery plan.

Basin geology dictates the form of the river valleys in the Yakima Basin. At the highest elevations of the Naches and Upper Yakima systems, streams flow through wide glacially carved valleys and glacial lakes that have been converted to serve as storage reservoirs. At lower elevations, and in other tributaries, stream channels have incised narrow canyons into the basalt and other bedrock. Valley floors near the towns of Ellensburg, Selah, Yakima, and Wapato contain deep alluvial floodplains composed of glacial outwash materials separated by geologic nickpoints consisting of bedrock outcroppings or anticlinal basalt ridges (e.g., Manastash, Umtanum, Yakima, and Ahtanum ridges). In the lower Yakima Valley, the Yakima River assumes a meandering planform atop broad floodplains composed of wind-blown soils and lacustrine silts from the Missoula Floods of the late Pleistocene (Bretz 1969).

[11] Unless otherwise noted, information for this section comes from the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005).

**Figure 2.1: Yakima Basin**




The longitudinal profiles of anadromous salmonid streams in the Yakima Basin respond to these physiographic and geologic factors, with stream gradients ranging from greater than 15% in the upper reaches of tributaries to the Naches River to less than 0.1% in meandering reaches of the Lower Yakima River. In many areas, the floodplains that once contained a complex network of braided channels covered by dense riparian forests have been reduced to simplified channels confined by transportation infrastructure and levees.

The basin includes parts of four counties (Kittitas, Yakima, Klickitat, and Benton) and has a population of about 300,000 people. The largest towns in the basin are Ellensburg, Yakima, and part of two of the Tri-Cities (Richland and Kennewick). Table 2.1 and Figure 2.2 summarize land ownership in the basin.

**Table 2.1: Land ownership in the Yakima Basin**

| OWNERSHIP | ACRES | % |
|---|---|---|
| | | |
| **Private** | **1,246,818** | **31%** |
| | | |
| **Yakama Nation** | **889,786** | **22%** |
| | | |
| **Federal** | **1,303,297** | **33%** |
| Forest Service | 892,509 | 22% |
| Bureau of Land Management | 48,893 | 1% |
| Department of Defense | 199,099 | 5% |
| Department of Energy | 160,098 | 4% |
| Other Federal | 2,698 | 0% |
| | | |
| **State** | **361,403** | **9%** |
| Department of Fish & Wildlife | 156,712 | 4% |
| Department of Natural Resources | 203,085 | 5% |
| Other State | 1,606 | 0% |
| | | |
| **Other/Unknown** | **168,870** | **4%** |
| | | |
| **TOTAL** | **3,970,174** | |
| | | |
| Compiled from the Yakima Subbasin Plan (YSPB 2005) | | |

Forests and rangelands each cover 40% of the basin. From an economic perspective, the primary land uses in the basin include irrigated agriculture (1,000 square miles or 16% of land area), commercial and residential development (60 square miles or 1% of land area), and transportation. Figure 2.3 shows irrigated acreage and major dams in the basin. Secondary land uses include recreation, forestry, floodplain gravel mining, and grazing. For a more detailed description of the Yakima Subbasin, see Chapter 1 of the Yakima Subbasin Salmon Recovery Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005). Overviews of each population area's geography are given below; population area boundaries are shown in Figure 2.4.

**Figure 2.2: Yakima Basin land ownership**

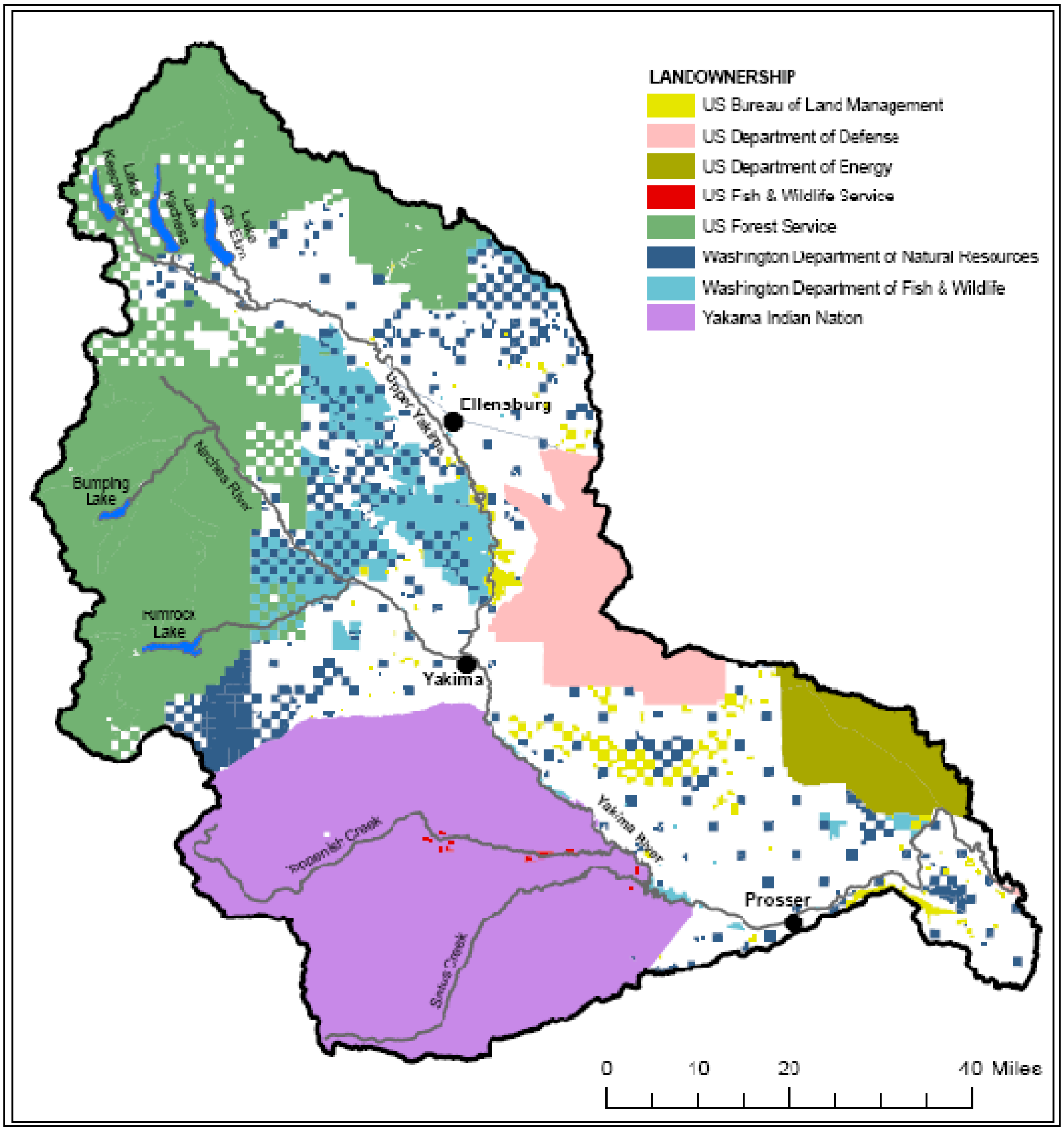
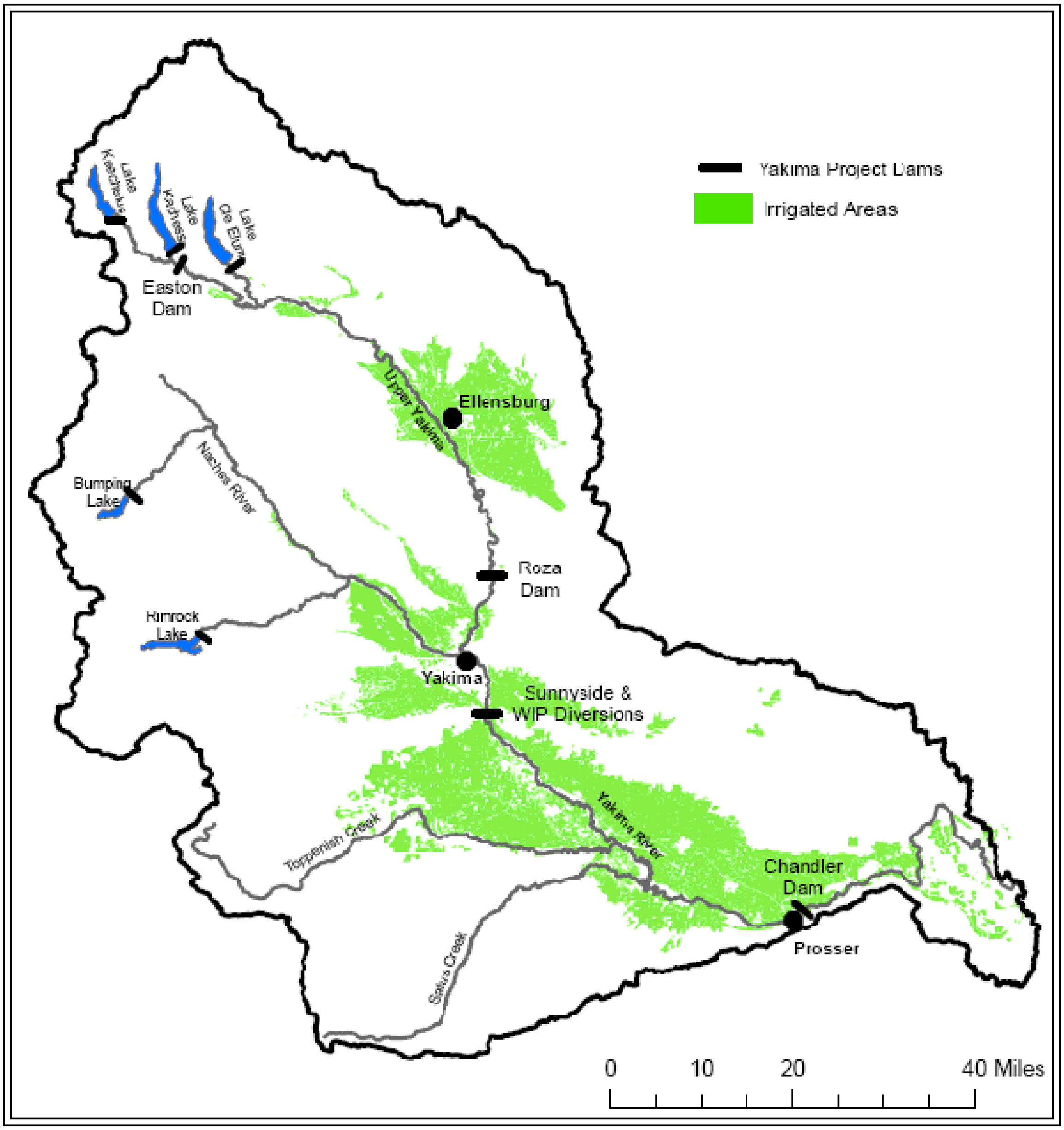


**Figure 2.3: Irrigated areas and major storage & diversion dams**




## Satus Creek

With a drainage area of 612 square miles, Satus Creek comprises 10% of the Yakima Basin area. Many of the headwater streams in the Satus Creek watershed flow across plateaus bordered by wet meadows. As they flow generally eastward the headwater streams cascade through narrow canyons toward the relatively broad Satus Creek canyon. Satus Creek exits the canyon at RM 12.5 and flows eastward across the Yakima River floodplain to the confluence with the Yakima River. Most of the Satus Creek watershed is undeveloped and is not exposed to agricultural, industrial, or domestic effluents, but because of riparian conditions and low flow, maximum weekly average temperatures can exceed 26$^{o}$ C in the reach of Satus Creek between Logy Creek and Wilson Charley Creek (RM 39.3). Logy Creek cools Satus Creek for a few miles downstream from their confluence. Water quality suffers, although water quantity increases as Satus Creek flows through the Wapato Irrigation Project (WIP) in its lower eight miles. The relatively young and rapid steelhead out-migration from Satus Creek appears to be a population response to harsh historic and current summer conditions.

**Toppenish Creek**

The Toppenish Creek watershed, at 625 square miles, is similar in size to the Satus Creek watershed. Upper Toppenish Creek consists of three forks along with several smaller tributaries draining the Cascade foothills between Toppenish and Ahtanum ridges. These are all high gradient streams in narrow basalt canyons. Anadromous access is limited by steadily increasing gradient and coarsening substrates, not the distinct waterfalls typical in the Satus Creek system. Agency and Wahtum creeks flow into Simcoe Creek, which joins Toppenish Creek at low elevation. A few miles downstream of the Simcoe Creek confluence, the Toppenish Creek channel historically assumed a branched appearance and flowed through an extensive network of wetlands for nearly 30 miles to the Yakima River. This network has a gradient of less than 0.1%. The complexity of this network has been significantly reduced.

**Naches River**

The Naches River drains some of the highest and wettest terrain in the Yakima Basin. The Naches and Tieton rivers are considerably steeper and naturally more confined than the most of the Upper Yakima River. Nevertheless, the predevelopment floodplain reaches of the mainstem Naches River and its tributaries provided a labyrinth of channels surrounded by extensive riparian forests that maintained cool summer temperatures and habitat complexity for all life stages of salmon and steelhead (Kinnison and Sceva 1963; Snyder and Stanford 2001; Stanford et al. 2002). In an unregulated condition, the flow of the Naches River would be characteristic of snowmelt-dominated systems where discharge peaks between May and June concurrent with melting snow and reaches base flow in August and September. Late autumn rainfall and minor snowmelt would augment summer base flow, with occasional winter high water events under the influence of Chinook winds. Above the confluence with the highly regulated Tieton River, the Naches River and its tributaries have some of the most natural flow regimes in the Yakima Basin. Below the Tieton confluence, the Naches River floodplain widens, although a highway and other structures have isolated the river from part of the active floodplain. Rimrock Reservoir blocks passage to upstream habitat and has a major effect on flows in the Tieton River and lower Naches mainstem.

**Upper Yakima River**

The Yakima River above the Naches confluence is nearly 100 miles long and drains nearly twice as much area as the Naches drainage. Much of the mainstem of the Upper Yakima has relatively low gradient with extensive floodplains that once contained multiple channels and large areas of spawning and rearing habitat for salmonids, as around the towns of Easton, Cle Elum, Ellensburg, and Selah. Other reaches run through large bedrock canyons between Cle Elum and Ellensburg and Ellensburg and Selah. The mainstem Yakima, Teanaway River, and Swauk Creek support most of the current steelhead use in the Upper Yakima population area. A number of other tributaries to the Upper Yakima River (e.g., Wilson, Naneum, Big, Little, Taneum, Manastash, Tucker, Cooke, Caribou, Coleman, and Reecer creeks) are likely to have historically supported steelhead, but impassable dams, dry reaches below dams and unscreened diversions have greatly reduced or eliminated steelhead use of these tributaries. The upper watershed contains three natural glacial lakes that now serve as storage reservoirs; historically accessible habitat above Cle Elum, Kachess, and Keechelus dams has been unavailable to steelhead since the early 20th century.

### 2.1.2 Ecological Setting

Steelhead use a wide range of aquatic habitats in the Yakima Basin, ranging from small intermittent streams to large multi-channel floodplains. Steelhead share the aquatic environment with at least 46 other fish species in the Yakima Basin (Fast and Berg 2001). Other species of importance include spring and fall Chinook salmon, reintroduced coho salmon, bull trout, Pacific lamprey (*Lampetra tridentata*), and westslope cutthroat trout (*O. clarki lewisi*). Sockeye are extinct in the basin, but kokanee (*O. nerka*) exist in five upper-basin storage reservoirs, and four of the populations may be descended in part from sockeye salmon present before dam construction. Summer Chinook were historically present but are now extinct in the basin. Anadromous salmon runs are thought to have once reached half a million fish or more; in recent decades combined numbers for all anadromous species have ranged from less than 3,000 in the early 1990s to more than 40,000 in 2001.[12]

Active conservation-oriented hatchery programs exist for Chinook and coho salmon. Bull trout are listed as threatened under the ESA and are under the jurisdiction of the USFWS; they are addressed in detail in the Yakima Subbasin Salmon Recovery Plan. Bull trout and steelhead distributions in the Yakima Basin currently overlap in the Naches, Ahtanum, and Upper Yakima systems. Historically bull trout would have been present across much of the current steelhead distribution, and steelhead would have been present in areas now blocked by storage dams. Currently, Pacific lamprey, and westslope cutthroat are designated as species of concern by USFWS. Steelhead recovery actions identified in this plan should benefit all these species.

There are also potential negative interactions between steelhead and other fish species. Three salmonid species (brook trout, *Salvelinus fontinalis*; lake trout *S. namaycush*; brown trout, *Salmo trutta*) have been introduced in the basin and may compete with or prey on juvenile steelhead, along with a variety of exotic sunfish, perch, catfish, and minnow species. Smallmouth bass are established in the lower river. Before the introduction of exotics, northern pikeminnow (*Ptychocheilus oregonensis*), sculpin

---

[12] Data compiled from Prosser Dam fish counts available online at http://www.cbr.washington.edu/dart/

(*Cottus* spp.), bull trout, rainbow trout, cutthroat trout, and burbot (*Lota lota*) were the primary piscivores in the basin.

## 2.2 Identification of Populations

NOAA Fisheries classified Yakima Basin steelhead as summer run steelhead within the Middle Columbia River ESU when the 1999 Endangered Species Act listing was completed.[13] Yakima Basin steelhead are the upstream-most part of the Middle Columbia River DPS. NOAA Fisheries considered including them as part of the Upper Columbia ESU but they were ultimately included in the Middle Columbia ESU due to their genetic similarity to Klickitat steelhead and the similarity of their life histories and habitat types to other Middle Columbia populations (Busby et al. 1996). Genetic analyses of Yakima Steelhead include Loxterman et al. (2003) and Phelps (2000). The ICTRT has classified Yakima Basin steelhead as one of the four Major Population Groups (MPGs) within what is now the Middle Columbia River Steelhead DPS. (The others are the East Cascades, Umatilla/Walla Walla, and John Day MPGs.) The ICTRT has further subdivided the Yakima MPG into the Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River populations (ICTRT 2003; ICTRT 2005c). The population level is the basic unit used in this plan for developing recovery goals, strategies, and actions. Figure 2.4 shows the ICTRT's boundaries for the spawning areas for each of the four populations.

The Toppenish and Upper Yakima population boundaries correspond well to the informal population designations used by fish managers in the basin. The ICTRT has included the Yakima River and its tributaries from the confluence of Satus Creek to the Columbia River in the Satus Creek Population area, while fish managers in the basin generally consider the Satus Creek steelhead to include only steelhead that spawn in the Satus Creek drainage. While currently almost all the spawning in the ICTRT Satus population area occurs within the Satus drainage itself, the large extent and uncertain historic habitat value of the lower mainstem and its tributaries do affect assessments of historic potential and current viability of this ICTRT population area. Local planners have addressed this by dividing the Satus population into two parts: the Satus Creek block, which spawns within the Satus Creek watershed, and the mainstem block, which spawns in the lower mainstem and its tributaries below Satus Creek. While the Satus Creek block represents an area with known and wide spread spawning, the current and historic status of the mainstem block is uncertain. This issue is addressed in more detail in Sections 2.3.1 and 4.1.1.

The ICTRT has also included the Yakima River from Selah Gap to the mouth of Toppenish Creek and the Ahtanum Creek drainage in the Naches River population area, while fish managers in the basin have generally considered the Naches population to include only steelhead that spawn in the Naches River and its tributaries. The current and historic level of steelhead use of this portion of the mainstem Yakima is not well understood. While Ahtanum Creek steelhead may be genetically distinct from other Naches Basin populations (Small et al. 2006), the similarity in habitat and geographic

[13] See the Federal Register, Volume 64, p.14517.

proximity of Ahtanum Creek makes its inclusion as part of the ICTRT Naches population appropriate. The Naches population would still rank as a large population even if mainstem area were excluded, so no there is no separate “mainstem block.”

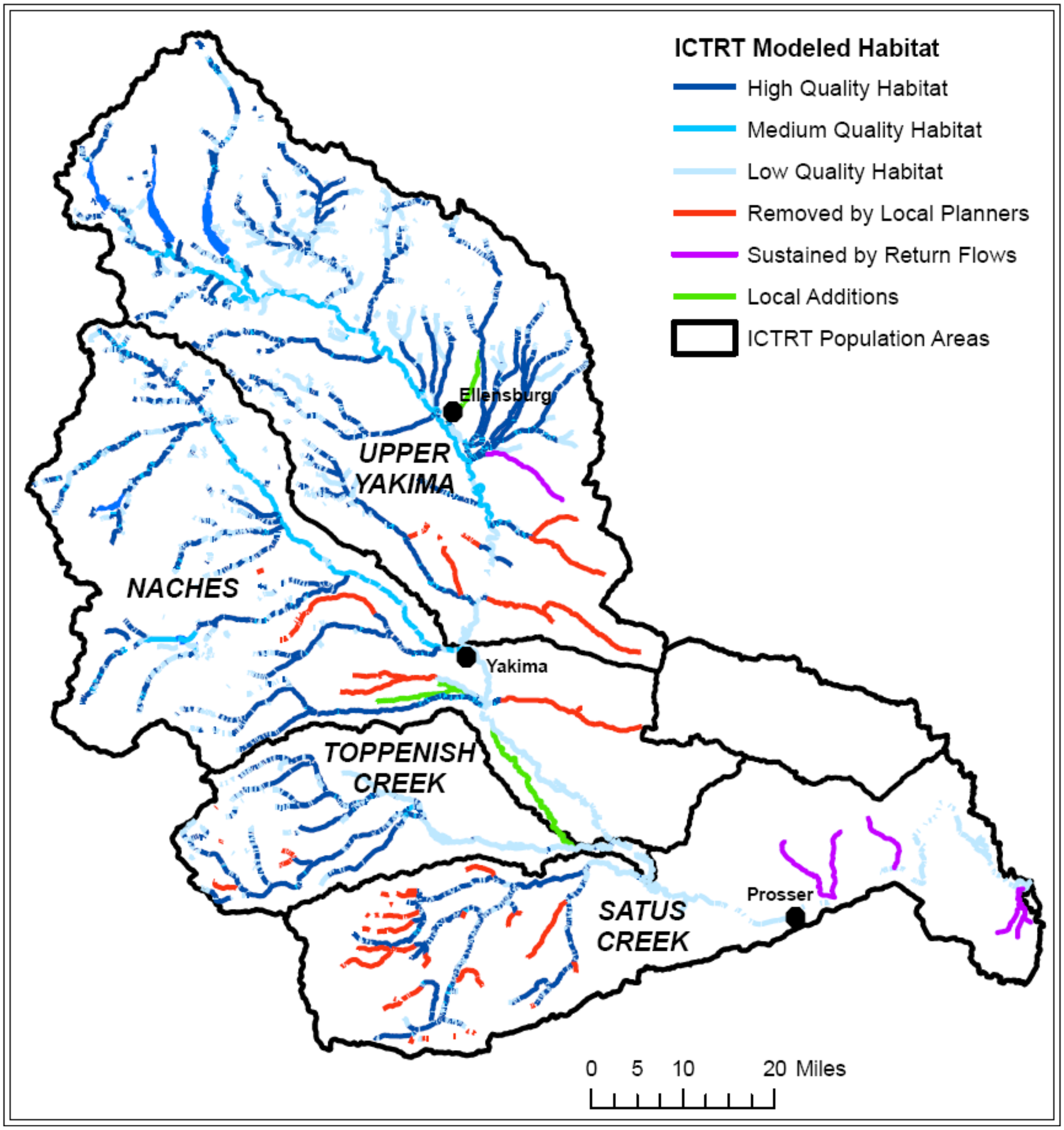
## 2.3 Steelhead Distribution

Steelhead are the most widespread anadromous fish in the Yakima Basin. They range from intermittent streams in semi-arid watersheds to headwaters high in the Cascades. A consensus of local managers on the current distribution of steelhead for the Yakima Basin is represented in WDFW’s SalmonScape online mapping system (included as orange symbol in Figure 2.4).[14] The USFS and the Yakama Nation maintain more detailed estimates of distribution for specific areas. The overlap between anadromous and resident forms of *O. mykiss* can make determining the exact distribution of steelhead in the Naches and Upper Yakima populations challenging. Redd surveys and radio-tracking data (Hockersmith et al. 1995; Karp et al. 2003; Karp et al. 2005) provide the most definitive information on areas used by anadromous spawners in recent years.

Numerous qualitative efforts have been made to estimate the historic and/or potential distribution of steelhead in the Yakima Basin (Haring 2001; Tuck 1995; Yakima Subbasin Fish and Wildlife Planning Board 2005). The ICTRT developed its Historic Intrinsic Potential Analysis to enable comparisons between modeled estimates of historic steelhead distribution and abundance and current steelhead distribution and abundance. These comparisons play a key role in the ICTRT’s efforts to assess the current status and potential viability thresholds for individual steelhead populations. The ICTRT has described its viability assessment procedure (ICTRT 2007b) and the Historic Intrinsic Potential Analysis (Cooney and Holzer 2006). The model estimates the amount of historically available steelhead habitat using defined decision rules and quantitative data captured in a Geographic Information System (GIS). The model focuses on identification of spawning and early rearing habitat within the Columbia Basin. It uses stream widths to calculate habitat areas in addition to simple linear stream lengths. The ICTRT model also gives a relative habitat value (high, medium, or low) to all areas identified as potential habitat, which is used to develop estimates of habitat area weighted by relative value. Model results are intended to estimate the potential habitat accessible to steelhead in the Yakima Basin using readily available measurements and consistent rules. They should not be used to classify specific areas and their current habitat values and/or potential.

[14] http://wdfw.wa.gov/mapping/salmonscape

**Figure 2.4: ICTRT Intrinsic Potential Analysis & population areas in the Yakima**




Local recovery planners worked closely with the ICTRT to review the results of the preliminary ICTRT Intrinsic Potential Analysis, provide additional information for inclusion into the GIS (e.g., locations of natural barriers to steelhead access), note discrepancies between results of the ICTRT analysis and previous historic/potential analyses, and propose adjustments to the decision rules that would reduce the discrepancies. To assure the integrity of their model, the ICTRT did not adjust specific model outputs to correspond with local reviews. The ICTRT adjusted the model by making changes to decision rules based on documented rationales and then applying the revised rules to the entire regional database. In general, the most current iteration of the ICTRT model takes into account these local assessments of habitat potential, but continues to overestimate the extent of potential habitat in arid areas. Figure 2.4 shows the potential habitat identified by the model and the locations where local planners did not concur with the model results.

The model consistently assigned habitat potential to streams in semi-arid portions of the Basin that the review team identified as not generating enough flow to support steelhead. Correcting this may require refining the model's approach to predicating flow in semi-arid (under 16") precipitation regimes. The ICTRT has acknowledged this limitation and is exploring ways to build a decision rule that would better model arid watersheds. Inclusion of streams with watersheds that do not have the precipitation and/or watershed area to generate any sustained base flows was primarily an issue in the Satus Creek watershed and the lowest elevations in the Upper Yakima and Naches watersheds. These areas are marked in red in Figure 2.4. In a few cases, streams that are unlikely to have had sufficient flow to support steelhead under historic conditions now have flows that are enhanced by surface and subsurface irrigation return flows (purple on Figure 2.4) (Smith et al. 2006).

In areas with over 16" annual precipitation, model results largely matched local surveys and expert opinion. The model consistently extended lower quality habitat higher up small tributaries and headwater reaches than locally derived maps, but these differences do not make significant differences in overall population-level weighted habitat area and were considered as feasibly within historic potential by local reviewers.

The model also failed to include a few streams considered by the review team to be potential/historic habitat. In all of these cases, the streams were either distributary channels connected to other streams at both upstream and downstream ends or small spring-fed creeks in floodplains. The ICTRT has acknowledged that their model either does not recognize these streams as having sufficient watershed area to generate flow or routes flows down a single channel where channels diverged. These streams are colored green in Figure 2.4. For a more detailed description of remaining divergences between the ICTRT model and recovery planners' assessments, see Appendix A. In this plan, the locally corrected model results are used as the basis for determining potential steelhead distribution. The weighted habitat areas identified by the ICTRT model and the locally adjusted model output are listed in Table 2.2. The table shows the habitat area cited in the most recent draft of the ICTRT stock status reports; the area indicated in the updated GIS coverage of the model results provided by NOAA Fisheries; and the area remaining after local edits to the model were made. In general, the ICTRT reports include more estimated habitat area than either the updated GIS-data or the locally edited model results.

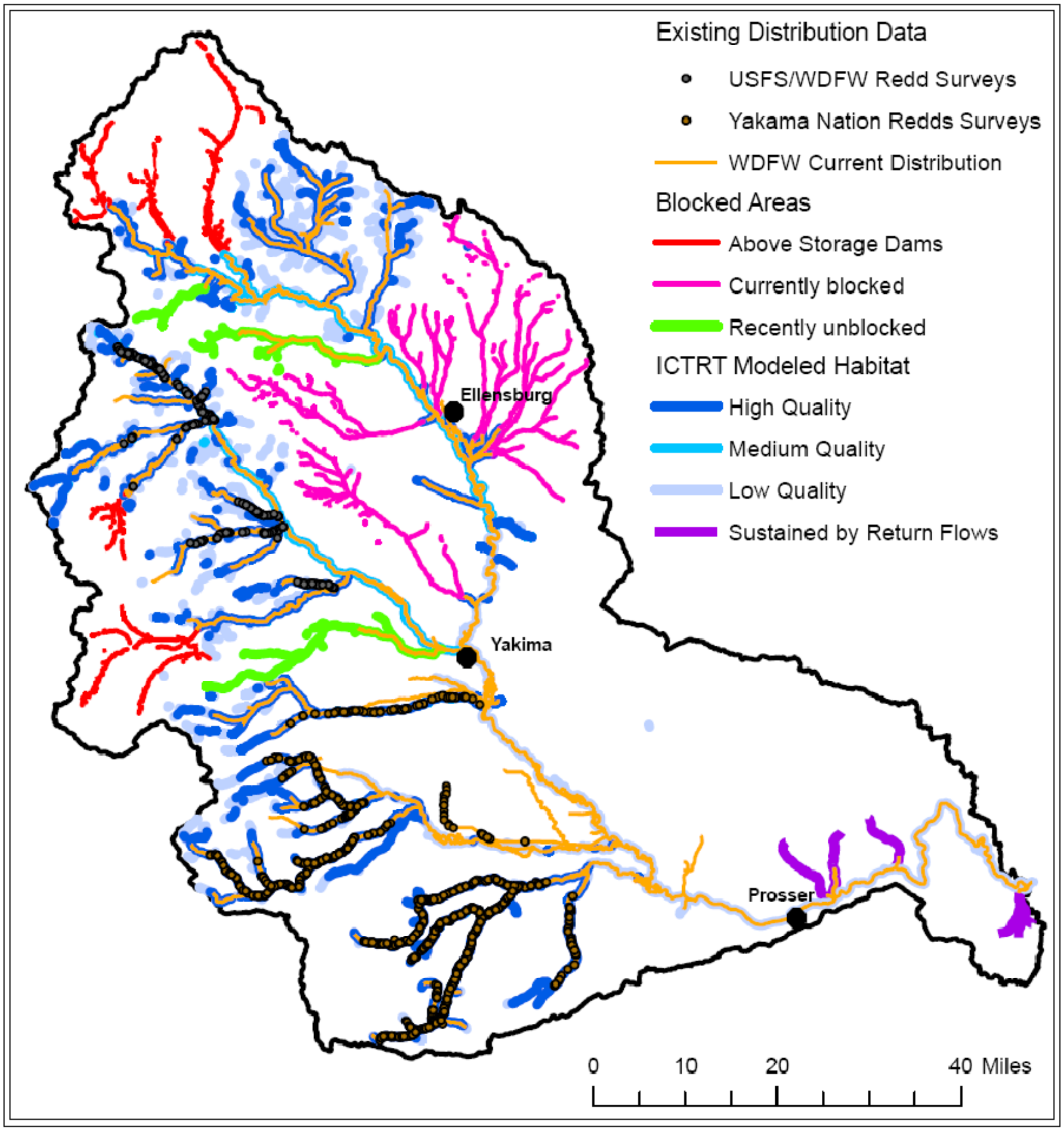
**Table 2.2: Intrinsic Potential Analysis modeled habitat areas**

| | | Total stream area weighted by intrinsic potential ($m^2$) | Total stream area weighted by intrinsic potential, temp limited ($m^2$) | Branched stream area weighted by intrinsic potential ($m^2$) | Branched stream area (weighted and temp. limited, $m^2$) |
|---|---|---|---|---|---|
| **Satus** | | | | | |
| | ICTRT Stock Status Report 7/07 | 4.111 | 1.28 | 1.7 | 0.992 |
| | ICTRT GIS 7/07 | 2.981 | 1.053 | 1.447 | 0.802 |
| | As Locally Adjusted | 2.487 | 0.847 | 1.06 | 0.655 |
| **Toppenish** | | | | | |
| | ICTRT Stock Status Report 7/07 | 1.909 | 1.171 | 1.17 | 0.803 |
| | ICTRT GIS 7/07 | 1.802 | 1.101 | 1.136 | 0.769 |
| | As Locally Adjusted | 1.735 | 1.043 | 1.12 | 0.753 |
| **Naches** | | | | | |
| | ICTRT Stock Status Report 7/07 | 7.207 | 5.849 | 5.088 | 4.495 |
| | ICTRT GIS 7/07 | 7.033 | 5.724 | 5.021 | 4.422 |
| | As Locally Adjusted | 6.31 | 5.163 | 4.661 | 4.153 |
| **Upper Yakima** | | | | | |
| | ICTRT Stock Status Report 7/07 | 9.038 | 8.795 | 7.531 | 7.456 |
| | ICTRT GIS 7/07 | 8.818 | 8.591 | 7.422 | 7.347 |
| | As Locally Adjusted | 7.945 | 7.74 | 6.851 | 6.764 |

Figure 2.5 shows current spawning and distribution data from Yakama Nation redd surveys in the Satus, Toppenish, and Ahtanum watersheds, USFS/WDFW redd surveys in selected Naches Population tributaries, and the WDFW SalmonScape database. Redd survey data are for varying spans of years and survey intensities; they show areas where spawning is confirmed to occur but should not be used as indicators of relative spawning densities. Redd surveys have not been done in most of the mainstem Naches and Tieton

rivers[15] or in the Upper Yakima population area. Radio-tracked fish have been located in and are presumed to have spawned in all the habitat areas above Roza identified in the WDFW SalmonScape distribution (orange line) except for the Upper Yakima River above Easton Dam (Karp et al. 2003; Karp et al. 2005). Figure 2.5 also shows currently accessible habitat, blocked habitat, and recently re-opened habitat. It indicates that the locally adjusted Intrinsic Habitat Potential map of high quality habitat corresponds well with current distribution and spawning for accessible areas.

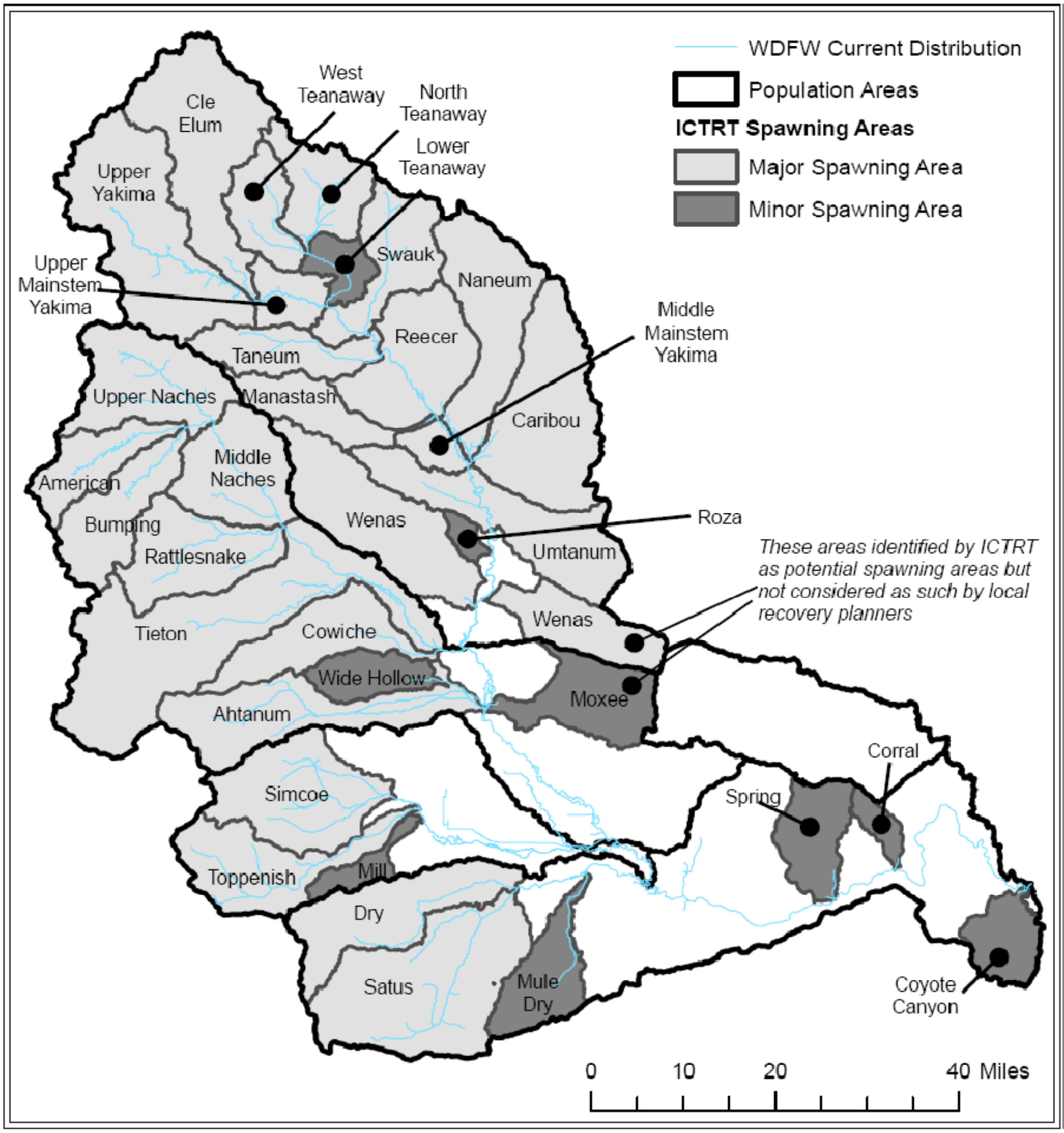
**Figure 2.5: Available habitat, current distribution, and blocked areas**




15 A redd survey was conducted from RM 38 to RM 27 on the Naches River by Pat Monk on 4/20/05. No redds were observed.

The ICTRT Intrinsic Potential Model (Cooney and Holzer 2006; ICTRT 2007b; ICTRT 2008) was used to designate major spawning areas (MSAs) and minor spawning areas (MiSAs) within each population area. Local recovery planners have used this as the basic unit for assessing spatial distribution in this plan. Figure 2.6 shows the ICTRT's MSAs and MiSAs overlaid with WDFW's current steelhead distribution map.

**Figure 2.6: ICTRT spawning areas and WDFW steelhead distribution**



### 2.3.1 Satus Population

The ICTRT assigned two MSAs and four MiSAs to the Satus Creek steelhead population, based on historical intrinsic potential analysis (Figure 2.6). Both MSAs and one of the MiSAs are within the Satus Creek drainage itself. The remaining three minor spawning concentrations are associated with small tributary drainages of the mainstem Yakima River.

Spawning is known to occur throughout the Satus and Dry Creek MSAs, as well as in Mule-Dry Creek MiSA. Spawning is also attributed to the Corral Creek MiSAs in WDFW's SalmonScape online mapping system. Surveys of Snipes Creek and its tributary Spring Creek have revealed small numbers of *O. mykiss* (Monk 2001) and an adult steelhead was identified 0.5 miles up Spring Creek by WDFW in 2007 (Bartand, communication, 2007). Habitat surveys in 2001 revealed that, of the left-bank drains with suitable spawning substrate, only Spring Creek had sufficient flow in the non-irrigation season to provide adult steelhead access (Romey and Cramer 2001). *O. mykiss* presence during the summer was documented in Amon Wasteway (in the Coyote Canyon MiSA) during WDFW electroshock sampling by Paul Hoffarth in 2005 and during snorkel surveys by Dr. David Smith of the University of Idaho in 2002. A planned 2007 steelhead spawning ground survey was thwarted by high flow (P. LaRiviere, WDFW, communication, 2007).[16]

For the Satus Population, the local review team was generally agreed with the ICTRT model results for the Satus Creek watershed itself, with the exception of a few tributaries indicated on Figure 2.5 that were not believed to have the flows needed to support steelhead. The habitat area within the Satus Creek drainage itself would (both with and without the tributaries in question) classify as a Basic population under the ICTRT framework, with a minimum viable abundance target of 500 returning adults. When the mainstem and tributaries to the lower mainstem were included in the Satus population, it was classified as an Intermediate population, with an abundance threshold of 1,000 spawners. The local review team felt most comfortable addressing management of these two portions of the Satus population area separately, with a threshold of 500 fish for Satus Creek watershed and another 500 for the mainstem component of the ICTRT population area; this is discussed in more detail in Section 4.3.9.

### 2.3.2 Toppenish Population

The ICTRT assigned two MSAs and one MiSA to the Toppenish Creek steelhead population, based on historical intrinsic potential analysis (Figure 2.6). All are within the Toppenish Creek drainage itself. Spawning is known to occur throughout the Simcoe

---

[16] Spring, Corral, and Snipes creeks, and Amon Wasteway are referred to by the names used on the USGS 7.5 minute topographic maps. The first three are referred to as drainageways by local irrigation districts, while Amon Wasteway is often referred to as Amon Creek. The use of these names in this document is in no way meant to indicate any conclusions regarding ongoing disputes about the legal status of these waterways.

Creek and Toppenish Creek MSAs but WDFW's SalmonScape online mapping system does not include the Mill Creek MiSA in its spawning or rearing databases. Resident *O. mykiss* were recently found in a perennial upper reach of Mill Creek (T. Resseguie, YN, communication, 2007), indicating that steelhead have used the intermittent Toppenish Creek tributary. Conversely, steelhead are shown to be present in Medicine Creek, a channel tributary to Simcoe Creek, in SalmonScape, but the ICTRT does not designate Medicine Creek as a spawning area. Medicine Creek is an abandoned distributary channel of Simcoe Creek that carried irrigation returns prior to 2003 (B. Rogers, YN, communication, 2007).

Steelhead spawning has also been documented in Marion and Harrah drains, which join near the confluence of Toppenish and Simcoe creeks. Marion Drain then flows east and enters the Yakima River 3 km upstream of Toppenish Creek (B. Rogers, YN, communication, 2007). Both drains were excavated in the 1920s to carry return flows from the Wapato Irrigation Project to the Yakima River.

### 2.3.3 Naches Population

The ICTRT has identified eight major historical MSAs and two MiSAs associated with the Naches River steelhead population (Figure 2.6). Seven of the MSAs are in the Naches River drainage. The remaining MSA, Ahtanum Creek, is a major tributary to the Yakima River mainstem, entering just downstream of the Naches River confluence. Impassable storage dams block the upper portions of the Tieton and Bumping watersheds. Their MSA sizes are based on modeled historic (pre-dam) habitat area. The MSA identified by the ICTRT as "Upper Naches" is actually the Little Naches River and its tributaries. The two MiSAs are small tributaries to the Yakima River between the Naches River and Ahtanum Creek. Wide Hollow Creek begins in the dry foothills west of Yakima and becomes perennial upon reaching the irrigated agricultural area surrounding Yakima. Before irrigation development, springs may have kept lower reaches of the creek perennial. Because of significant groundwater inputs, Wide Hollow Creek has received some passage and habitat funding during the past 20 years. Moxee Drain is an excavated channel draining the Roza and Selah-Moxee irrigation districts east of Yakima and receives ephemeral runoff from the arid upper Moxee Valley. Monk (2001), along with Romey and Cramer (2001), concluded that Moxee Drain was not suitable for spawning or rearing salmonids. The lower reach of Moxee drain in the Yakima River floodplain has perennial flows and provides suitable juvenile habitat. Steelhead spawning is known to occur in all eight MSAs. WDFW's SalmonScape online mapping system also includes Wide Hollow Creek and the lower end of Moxee Drain in its "documented presence" database.

### 2.3.4 Upper Yakima Population

The ICTRT has identified fourteen major historical MSAs and two MiSAs associated with the Upper Yakima River steelhead population (Figure 2.6). Of these, the ICTRT identifies seven as currently occupied (in both upper and lower portions) and another four as occupied in their lower extent only (See Figure 2.6).[17] Impassable storage dams block the Cle Elum and Kachess rivers and the uppermost reach of the Yakima River. The Upper Yakima and Cle Elum MSA sizes are based on modeled historic (pre-dam) habitat area. The lower Teanaway River is designated a MiSA, probably because of the ICTRT model's branching algorithm that separated the North and West Teanaway MSAs from this lower section. The Roza Creek MiSA includes Burbank Creek which is on the other side of the Yakima River; Roza and Burbank creeks drain small, semi-arid watersheds.

## 2.4 Steelhead Abundance

### 2.4.1 Estimates of Historic Abundance

Published estimates of the size of the annual return of adult steelhead to the Yakima Basin prior to European settlement range from 20,800 (Kreeger and McNeil 1993) to "less than 50,000" (Cramer et al. 2003) to 80,000 (Howell et al. 1985) to 100,000 (Smoker 1956, as cited in WDF(1993, Appendix 3); although Cramer et al. (2003) note this is a misinterpretation of Smoker's assessment).

Table 2.3 shows estimates of "historic" abundance of anadromous spawners identified by EDT model runs conducted in development of the Yakima Subbasin Plan (see Appendix B). This estimate is based on historic conditions in the Yakima Basin coupled with current Columbia River and ocean conditions, and is not equivalent to a true historic scenario; it also does not fully address the interactions between resident and anadromous *O. mykiss* presumed to occur in the Upper Yakima and parts of the Naches basin. The population boundaries referenced here are similar, but not identical, to the updated ICTRT population designations used in this plan.

**Table 2.3: EDT estimates of "historic" abundance**

| Population | EDT Abundance |
|---|---|
| Satus | 5,761 |
| Toppenish | 4,639 |
| Naches | 14,542 |
| Upper Yakima | 21,152 |
| TOTAL | 46,094 |

The ICTRT used the Historic Intrinsic Potential analysis described in Section 2.4 to classify populations according to relative historic size, with Toppenish classified as a Basic population, Satus Creek as an Intermediate, and the Naches and Upper Yakima as Large populations (ICTRT In press). Table 2.4 goes a step further and uses the results of the Intrinsic Potential Analysis to extrapolate historic spawner abundance based on two calculations.

[17] See Section 4.2.3 for the ICTRT definition of "occupancy."

**Table 2.4: Historic abundance estimates derived from Intrinsic Potential Analysis**

| | | Spawner Abundance | |
|---|---|---|---|
| **Population** | **Locally Adjusted ICTRT Weighted & Branched Area in km2** | **at 2000/km2** | **at 0.1 smolt/m2 and 4% SAR** |
| Satus | 1.06 | 2,120 | 4,240 |
| Toppenish | 1.120 | 2,240 | 4,480 |
| Naches | 4.661 | 9,322 | 18,644 |
| Upper Yakima | 6.851 | 13,702 | 27,404 |
| **Total** | **13.692** | **27,384** | **54,768** |

The first calculation is based on densities of spawning adults and multiples the estimated branched and weighted habitat area (see Figure 2.4 and Table 2.2) by an estimate of spawners per unit area. The value of 2000 spawners per $km^2$ is equivalent to 500 spawners per 250,000 $m^2$, which is the potential density of spawners used by the ICTRT to designate Major Spawning Areas based on branched habitat area (Cooney and Holzer 2006). This corresponds to 20 spawners in a hypothetical high quality stream reach 1 km long and 10m wide, or, using conversions of 1.75 spawners/redd and 1.609 km/mile, 18 redds per mile. This compares to rates of 5-10 redds per mile observed in portions of Satus Creek after an average or better steelhead run and up to 30 to 100 spawners per mile in some other areas (Rock Creek in Klickitat County at 34 to 45 redds per mile (NPPC 2004) and a range of 33 to 109 on the Middle Rogue River (ODFW 2005, p. 325). At the 2000/$km^2$ rate, the basin would produce about 31,000 spawners. Using 540 spawners/$km^2$ (which converts as above to about five redds/mile) results in approximately 8,400 fish. The second calculation is based on smolt production per unit area set at 0.1/$m^2$ and a smolt to adult survival rate of 4% (versus 2% generally assumed under current conditions) and results in ~62,000 spawners. Neither calculation models the impacts of resident/anadromous interactions on anadromous abundance. Note that when run with a smolt density of 0.01 smolts/$m^2$ and a SAR of 2% and limited to currently utilized habitat (both estimates based on empirical data from the Yakima Basin under current conditions), this simple model gives estimated abundances in line with current abundances. This admittedly simple model may serve as a useful thought tool with results that correspond with other estimates of historic abundance; its results should not be treated as definitive.

While precise estimates of historic abundance are impossible to generate, it seems reasonable to conclude that historic spawners abundances were between 25,000 and 75,000 per year. Major areas of uncertainty that affect our estimates of historic spawner abundance include:

- The extent of historic use by steelhead of the mainstem Yakima and its side channels
- The outcomes of interactions between steelhead and other salmonid species also estimated to be far more numerous under pre-European conditions, including positive relationships (enhanced supply of nutrients in headwaters) and negative relationships (increased interspecific competition)
- The nature of interaction between resident and anadromous *O. mykiss*
- The range of year-to-year variability in run size under pre-European conditions

### 2.4.2 Current Abundance and Productivity

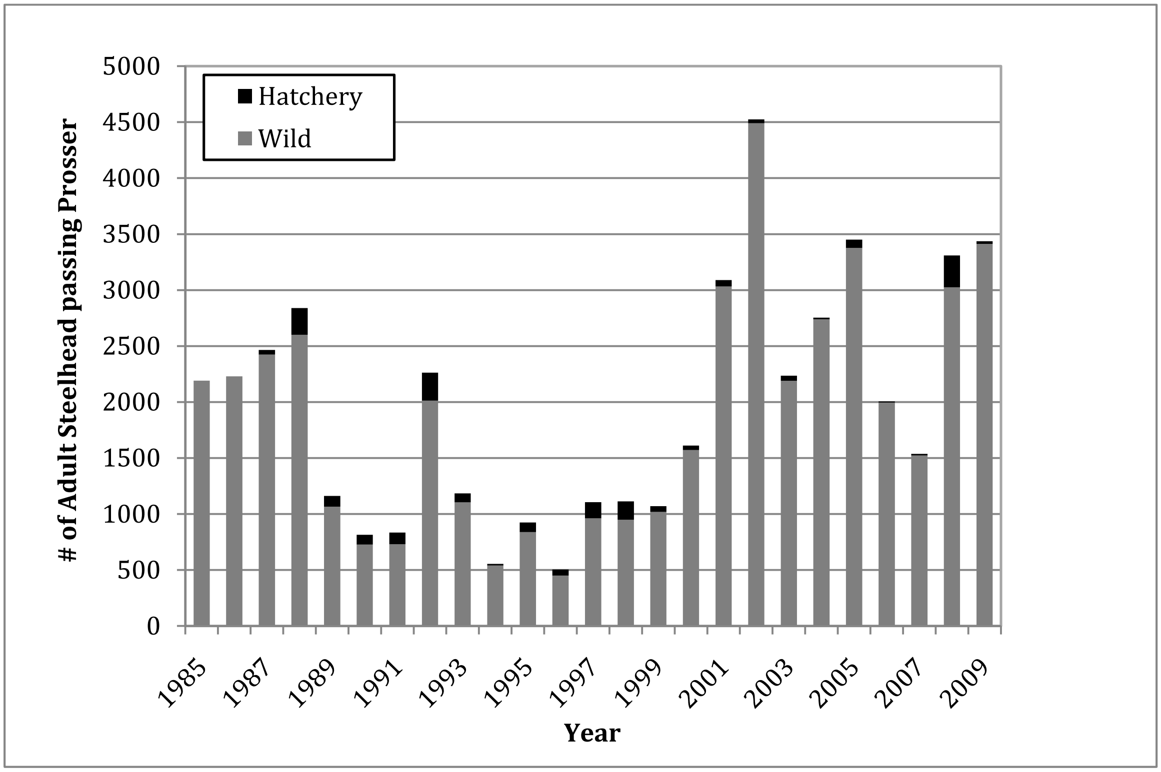
**Overall Abundance in the Yakima Basin**

Returning adult steelhead are counted and classified as wild or hatchery as they pass the fish ladders at Prosser Dam downstream from all major spawning areas.[18] Since records began in 1985, estimated returns have ranged from a low of 450 in 1996 to a high of 4,491 in 2002, with an average of 1,764. The run is dominated by wild fish, with a hatchery component of 8% over the period of record and 3% between 1999 and 2007.

Figure 2.7 gives an indication of the variability of recent steelhead returns. At the time of listing (1999), the 10-year average abundance for wild steelhead was 933, the majority of which was being produced in a single tributary drainage (Satus Creek). Since then abundance has increased, with the current 10-year average at 2,269. Upstream dam, redd, and smolt trap counts have also revealed a somewhat wider distribution of steelhead in the Yakima Basin than was recognized in 1999. However, even the more recent estimates of steelhead abundance are at least an order of magnitude less than even the low to middle range of estimates of historic abundance.

[18] Very limited spawning has been observed in the Yakima River and its tributaries below Prosser, but whether or not offspring survive is unknown.

**Figure 2.7: Yakima Basin steelhead abundance**




## Abundance by Population

While the Prosser Dam counts provide excellent abundance estimates for the Yakima Basin MPG as a whole, determining the abundance of each of the four component populations is more challenging. The ICTRT's current approach apportions the total Prosser count based on a combination of 1990-92 radio-tracking data (Hockersmith et al. 1995), redd counts from Satus and Toppenish creeks and counts at the Roza Dam fish ladder. Table 2.5 summarizes available data from Yakima/Klickitat Fisheries Project dam counts, Yakama Nation Fisheries redd counts for Satus, Toppenish, and Ahtanum watersheds, and USFS/WDFW led redd counts for selected Naches tributaries.

**Table 2.5: Available dam count and redd data**

| | Ladder Counts (July 1 to June 30) | | | | Redd Counts | | | |
|---|---|---|---|---|---|---|---|---|
| Year Ending | Prosser Wild | Prosser Hatchery | Roza Wild | Roza Hatchery | Satus | Toppenish | Ahtanum | Naches Tribs |
| **1985** | 2191 | 0 | 6 | 0 | * | * | * | * |
| **1986** | 2230 | 0 | 3 | 0 | * | * | * | * |
| **1987** | 2424 | 41 | 0 | 0 | * | * | * | * |
| **1988** | 2601 | 239 | 0 | 0 | 445 | * | * | * |
| **1989** | 1066 | 96 | 0 | 0 | 404 | 45 | * | * |
| **1990** | 727 | 87 | 0 | 0 | 289 | 26 | * | * |
| **1991** | 730 | 104 | 0 | 0 | 125 | * (32) | * | * |
| **1992** | 2012 | 251 | 107 | 9 | *(121) | *(38) | * | * |
| **1993** | 1104 | 80 | 15 | 0 | 73**(118) | *(43) | * | * |
| **1994** | 540 | 14 | 28 | 0 | 114 | *(49) | * | * |
| **1995** | 838 | 87 | 22 | 1 | 85***(131) | *(55) | * | * |
| **1996** | 450 | 54 | 90 | 2 | 148 | *(61) | * | * |
| **1997** | 961 | 145 | 22 | 0 | 76 | 5**(66) | * | * |
| **1998** | 948 | 165 | 51 | 0 | 190 | 13**(71) | * | * |
| **1999** | 1018 | 52 | 14 | 0 | 130 | 78 | * | * |
| **2000** | 1571 | 40 | 14 | 0 | 169 | 185 | 11 | * |
| **2001** | 3032 | 57 | 133 | 7 | 252 | 355 | 8 | * |
| **2002** | 4491 | 34 | 236 | 2 | 298 | 111***(291) | 13*** | * |
| **2003** | 2190 | 45 | 128 | 6 | 319 | 161***(227) | 16*** | * |
| **2004** | 2739 | 15 | 211 | 2 | 117 | 56***(163) | 12*** | 94** |
| **2005** | 3377 | 74 | 224 | 3 | 110 | 99 | 14 | 140 |
| **2006** | 1995 | 10 | 121 | 2 | 60 | 21*** | 1*** | 19** |
| **2007** | 1523 | 14 | 60 | 0 | 87 | 44*** | 4*** | 44** |
| **2008** | 3025 | 285 | 171 | 5 | 110 | 68*** | 8*** | 11** |
| **2009** | 3412 | 24 | 204 | 0 | 119 | 79*** | 3*** | 29** |

* No survey; ** Partial survey; *** Survey affected by poor redd visibility; (#) Interpolation used by ICTRT
Dam count data from www.ykfp.org; redd data from Yakama Nation staff except for USFS data for Naches data from USFS.

Given that we do not have direct counts for all populations, the best existing population-specific abundance estimates are from the ICTRT stock status reviews (ICTRT In press) and are summarized in Table 2.6; Table 2.7 shows how Prosser counts were apportioned to derive these estimates. The ICTRT adjusted aggregate annual Prosser counts to account for estimated losses between Prosser Dam and tributary spawning by applying 11% average loss rates from the 1990 to 1991 radio-tracking studies (losses directly associated with tagging were excluded). Prior to 1995, an additional 2% of the returns passing Prosser were attributed to harvest (directed harvest was closed after 1994). Population-specific abundance estimates for return years 1985-1989 were generated by applying the average distribution from the 1990 to 1992 radio tagging studies to the Prosser Dam count adjusted for pre-spawning mortality (Table 2.13). For those return years where radio tag-based distribution estimates were available (1990-92), the aggregate count over Prosser Dam was allocated among populations based on the relative distribution of radio tagged steelhead during the spring spawning time window.

For each of the return years, 1993-2004, an estimate of the aggregate number of spawners in Satus and Toppenish creeks was generated by subtracting the Roza Dam count and the

Naches River abundance estimates from the Prosser count adjusted for prespawning losses. The resulting composite estimate was allocated to Satus Creek and Toppenish Creek based on the annual ratios of expanded redd counts for the two populations. Redd counts provide the only current index to adult abundance, and redd counting conditions are more favorable in these two watersheds than in the upper basin. Redd counts in the Naches River and its higher-elevation tributaries are not a reliable index of spawner abundance, and the lower Naches River lacks an impassable dam and counting facility similar to Roza Dam in the Yakima River above the Naches confluence. This leaves managers with 15-year-old radio-tracking data for allocating Prosser adults, after subtracting upper Yakima River returns, to the Naches River and a Satus-Toppenish composite. Genetic sampling of adults at Prosser and/or new radio-tracking studies would greatly improve population specific abundance and productivity estimates.

For run years 1993-2004, Roza Dam counts were incorporated into abundance estimates for the Upper Yakima population. During the Hockersmith study, some radio tagged steelhead were tracked to the mainstem Yakima River below Roza Dam but above the confluence with the Naches River. To account for possible spawning below Roza Dam, the year-specific counts at Roza Dam were averaged with corresponding estimates based on the 1990-92 radio telemetry proportion returning to the Upper Yakima.

Hatchery releases of steelhead into the Yakima system ceased after 1993 (Fast and Berg 2001); the proportion of returning spawners at Prosser Dam that are of natural origin has averaged 94% since 1985 (99% for the most recent five years). The ICTRT assumed that hatchery strays were not disproportionately present in any specific populations.

**Table 2.6: Natural-origin spawner abundance by population, 1995-2004**

| Population | Low (year) | High (year) | 1995 to 2004 Geomean |
|---|---|---|---|
| **Satus** | 138 (1998) | 1,000 (2002) | 379 |
| **Toppenish** | 44 (1990) | 1,252 (2002) | 322 |
| **Naches** | 142 (1996) | 1,454 (2002) | 472 |
| **Upper Yakima** | 34 (1994) | 283 (2002) | 85 |

**Table 2.7: ICTRT extrapolation from Prosser to population-specific abundance**

| | | | | Satus | | Toppenish | | Naches | | Upper Yakima | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Prosser # | Mortality | Spawners | % total | # | % total | # | % total | # | % total | # |
| 1985 | 2191 | 13% | 1901 | 45% | 849 | 12% | 222 | 36% | 691 | 7% | 139 |
| 1986 | 2230 | 13% | 1935 | 45% | 864 | 12% | 226 | 36% | 703 | 7% | 142 |
| 1987 | 2465 | 13% | 2138 | 45% | 955 | 12% | 249 | 36% | 777 | 7% | 157 |
| 1988 | 2840 | 13% | 2464 | 45% | 1101 | 12% | 287 | 36% | 895 | 7% | 181 |
| 1989 | 1162 | 13% | 1008 | 45% | 450 | 12% | 118 | 36% | 366 | 7% | 74 |
| 1990 | 814 | 13% | 706 | 43% | 304 | 7% | 49 | 43% | 304 | 7% | 49 |
| 1991 | 834 | 13% | 723 | 37% | 268 | 13% | 94 | 40% | 289 | 10% | 72 |
| 1992 | 2263 | 13% | 1963 | 54% | 1060 | 15% | 294 | 26% | 510 | 5% | 107 |
| 1993 | 1184 | 13% | 1027 | 43% | 446 | 16% | 163 | 36% | 373 | 4% | 45 |
| 1994 | 554 | 11% | 493 | 40% | 197 | 17% | 85 | 36% | 179 | 7% | 32 |
| 1995 | 925 | 11% | 824 | 41% | 340 | 17% | 143 | 36% | 299 | 5% | 42 |
| 1996 | 504 | 11% | 449 | 35% | 158 | 15% | 65 | 36% | 163 | 14% | 62 |
| 1997 | 1106 | 11% | 985 | 32% | 310 | 27% | 270 | 36% | 358 | 5% | 47 |
| 1998 | 1113 | 11% | 991 | 42% | 413 | 16% | 156 | 36% | 360 | 6% | 62 |
| 1999 | 1070 | 11% | 953 | 37% | 353 | 22% | 212 | 36% | 346 | 4% | 42 |
| 2000 | 1611 | 11% | 1435 | 28% | 408 | 31% | 446 | 36% | 521 | 4% | 60 |
| 2001 | 3089 | 11% | 2753 | 13% | 353 | 45% | 1229 | 36% | 1000 | 6% | 171 |
| 2002 | 4525 | 11% | 4032 | 26% | 1040 | 31% | 1261 | 36% | 1465 | 7% | 267 |
| 2003 | 2235 | 11% | 1991 | 33% | 659 | 24% | 469 | 36% | 723 | 7% | 140 |
| 2004 | 2755 | 11% | 2455 | 20% | 496 | 35% | 870 | 36% | 892 | 8% | 197 |

| | | | | | |
|---|---|---|---|---|---|
| *1995-2004 geomean all spawners* | *1389* | *405* | *344* | *505* | *87* |

Prosser # = Prosser wild plus Prosser Hatchery from Table 2.5
Presumed 11% mortality from Prosser to spawning from Hockersmith plus 2% in-basin harvest prior to 1994
1990 to 1992 run approtionment done using Hockersmith data for those years;
1985 to 1989 done using average run portion data from the Hockersmith study;
1993 on:
Hockersmith average used for Naches (36%)
Avg of Hockersmith average & annual proportion of Roza to Prosser count used for Upper Yakima;
Remainder of Prosser count attributed to Satus and Toppenish; divided between the two based on the relative redd numbers (gaps in redd data interpolated linearly)

## Productivity by Population

The ICTRT used the adult age structure from the 1990-92 radio tagging study to calculate returns per spawner. To estimate intrinsic productivity (the rate at which the population rebuilds when depressed to low numbers), the ICTRT calculated geometric means of spawner/return ratios for those data pairs where parent spawner abundance was less than 75% of the abundance target for the population. This approach is designed to minimize density dependant effects that may influence the average productivity value. The ICTRT then applied a further adjustment to compensate for annual basinwide fluctuations in marine survival. Table 2.8 shows the results.

**Table 2.8: Spawner/return ratios for the brood years 1985-1999**

| Population | Low (year) | High (year) | 15-yr Adjusted* |
|---|---|---|---|
| **Satus** | 0.19 (1992) | 2.36 (1996) | 1.40 |
| **Toppenish** | 0.30 (1985) | 14.48 (1996) | 1.60 |
| **Naches** | 0.37 (1986) | 5.03 (1996) | 1.12 |
| **Upper Yakima** | 0.35 (1988) | 4.87 (1997) | 1.12 |

*Median delimited and adjusted based on marine survival, as per text and ICTRT (2007b)

## 2.5 Population Characteristics and Life Histories

### 2.5.1 Adult Upstream Migration

**Timing of Upstream Migration**

All Yakima Basin steelhead are classified as summer steelhead based on the timing of their return from the ocean to the Columbia River. Table 2.9 shows the seasonal progression of upstream migrants from Bonneville into the Yakima. Adult steelhead that were tagged with passive integrated transponders (PIT tags) in Satus, Toppenish, and Ahtanum creeks as juveniles have migrated upstream past Bonneville Dam from May through October, with 90% passing Bonneville in July (62%) and August (28%). About a third of the run then moves relatively rapidly up the Columbia past McNary in July (19%) and Aug (9%). The majority of the run holds in the Columbia between Bonneville and McNary into the fall, with Yakima steelhead presumably forming part of the large concentrations of steelhead found holding in the cool waters at the mouths of tributaries such as the White Salmon and Klickitat rivers. In September and October, 64% of the run continues past McNary, while in November and December the last 8% passes. Timing of movements through the Columbia may differ for steelhead from other parts of the Yakima Basin. Assessing this requires additional PIT-tag data from the Naches and Upper Yakima populations.

**Table 2.9: Timing of dam passage by adult steelheads**

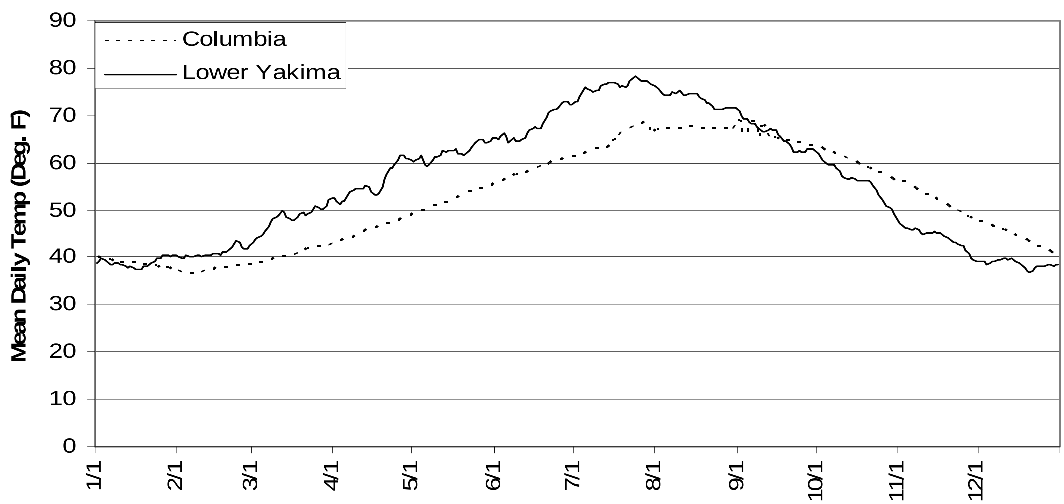
| | Bonneville | McNary | Prosser | Roza |
|---|---|---|---|---|
| | n=58 | n=47 | n=19332 | n=1088 |
| June | 3% | 0% | 0% | 0% |
| July | 62% | 19% | 0% | 0% |
| August | 28% | 9% | 0% | 0% |
| September | 3% | 38% | 12% | 2% |
| Oct | 2% | 26% | 32% | 3% |
| Nov | 0% | 2% | 19% | 1% |
| Dec | 0% | 6% | 8% | 0% |
| January | 0% | 0% | 10% | 2% |
| February | 0% | 0% | 7% | 4% |
| March | 0% | 0% | 6% | 34% |
| April | 0% | 0% | 4% | 49% |
| May | 2% | 0% | 1% | 5% |
| Bonneville & McNary data from PIT-tagged adults tagged as juveniles in Satus, Toppenish, and Ahtanum creeks, 2004 to 2006 | | | | |
| Prosser and Roza data from dam counts of adults, 2000 to 2006 | | | | |

Most (63% of dam counts from 2000 to 2006) of the run continues from McNary relatively rapidly past Prosser in September, October and November. However about one third of the run holds between McNary and Prosser until December through April before passing Prosser. These fish may be using habitat in both the McNary Pool of the Columbia (where temperatures are lower through the summer) and the lower Yakima River, which cools off faster than the McNary Pool after September 1 (Figure 2.8). Where and how fish use the McNary Pool and the Lower Yakima and how that is affected by habitat conditions is noted as a key knowledge gap in Chapter 7.

While limited numbers of PIT tags make any conclusions preliminary, existing data suggest that a significant percentage of Yakima-origin steelhead overshoot the mouth of the Yakima and continue up the Columbia, with some ascending as many as four more dams on the Columbia before turning downstream to return to the Yakima. The main source of evidence is from adult steelhead tagged in the trap at Priest Rapids dam. Of the 3,890 adult steelhead tagged there between 7/12/06 and 10/16/08, 72 were subsequently detected at Prosser, with no returns from Prosser to the Upper Columbia noted so far. Of the 72 tagged steelhead, 2 were also detected at Ice Harbor after release from Priest Rapids: 1 before detection at Prosser and 1 after detection at Prosser. There were 6 Priest Rapids-tagged adults that reached Wells Dam before falling back and ascending Prosser Dam. One of them later ascended Roza Dam.

Returns of adult steelhead PIT tagged as juveniles in the Yakima Basin also indicate some Yakima steelhead pass the Yakima to ascend farther up the Columbia. Fifty-one adult steelhead tagged as juveniles in the 2006-07 outmigration and earlier were detected ascending Prosser ladders from 5/28/05 through the 2008-9 adult migration. The nine adults that were tagged as juveniles in the Yakima Basin during the 2006-07 outmigration have been detected as adults at Priest Rapids Dam as of October 2008. Of these nine Priest Rapids detections of Yakima steelhead, four returned to Prosser. The need to better understand the rates of overshot by returning adults, its causes, and the implications for survival and condition of returning spawners is highlighted as a key uncertainty in Section 7.2.5.

**Figure 2.8: Lower Yakima River and McNary Pool temperatures**




Columbia temperature calculated from USGS data at Richland for the period of record, 10/1/75 to 3/2/95.
Low er Yakima temperature calculated from the USGS gage at Kiona for the period of recod, 7/17/01 to 9/13/07

While at least some adult steelhead movement into the Yakima Basin and past Prosser Dam has been documented in every month of the year, the main migration past Prosser Dam occurs from September through April. Passage from the McNary Pool and/or Lower Yakima River past Prosser Dam appears to be driven by flow and temperature cues, with fish generally moving rapidly following increased flow and moderating water temperatures.

In the two years between 1999 and 2007 when spring high flows (>2000 cfs) and lower river temperatures (< 68 ºF at Kiona) continued into July, a portion of the run passed Prosser in July (28 in 1999 and 10 in 2002). In the only other year (2004) where mean daily temperatures in July were below 68ºF at Kiona, flows remained lower (<1000 cfs) and no steelhead passed Prosser.[19] Prior to regulation of flows in the Yakima and Columbia rivers, the high flows and lower temperatures of spring runoff would have prevailed longer into the summer. It is likely that historically, some portion of the steelhead run would have traveled rapidly from the ocean into the Yakima system during the summer, but that high temperatures in the Columbia and lower Yakima rivers now limit that run timing.

---

[19] Analyses based on passage data accessed via DART http://www.cbr.washington.edu/dart/dart.html; Prosser flow and temperature data at http://www.usbr.gov/pn/hydromet/yakima/yakwebarcread.html.

In those years when more than two steelhead passed Prosser in August (2000, 2003, 2004 and 2007), there appears to be a significant correlation between fish movements and periods when flows increase and temperatures drop below 70ºF. The typical September beginning of the upstream run past Prosser occurs when river temperatures at Kiona consistently drop below 70ºF (in 2001, when low flows and high temperatures persisted through most of September, steelhead movement past Prosser began in late September). Throughout the fall and winter run, fish tend to move in response to increased flows, though low water temperatures can limit the influence of a midwinter flow increase, and a midwinter rise in temperature can stimulate movement even when flow remains relatively constant.

Most steelhead that pass Prosser in the fall overwinter in the Yakima River between Prosser and Sunnyside dams in reaches with deep pools and low velocity (Hockersmith et al. 1995). The final migration from holding areas to the spawning grounds begins between January and May, with fish that will spawn in lower elevation tributaries generally beginning to move earlier. Eighty-eight % of steelhead passage past Roza into the Upper Yakima occurs in March, April and May with the remaining 12% scattered from September through February. Radio tracking in 2002 through 2004 found that upstream movements above Roza towards spawning areas peaked in mid-March, but could occur anytime between November and late June (Karp et al. 2003; Karp et al. 2005).

Currently the range of run timings for specific populations cannot be accurately determined; all information presented here (except for Roza passage) is for the Yakima MPG as a whole. Developing the ability to identify steelhead to population at Prosser and increasing the number of PIT tags for the Naches and Upper Yakima populations would facilitate determining if there are significant differences in run timing between the four populations.

### Age and Sex Distribution of Upstream Migrants

From 2000 to 2006, an average of 75% of the returning adult steelhead handled at the Prosser Denil and Roza Trap were females, as shown in Table 2.10 over the three years of the Hockersmith study (1990-92), radio-tagged fish were 73%, 78%, and 64% female (Hockersmith et al. 1995). Currently the only population-specific sex ratio that can be determined is for the Upper Yakima Population, which is slightly higher than the aggregate rate. With improvements to our ability to assign fish to population at Prosser, we will be able to determine if sex ratios are similar across all four populations and their subpopulations, or if they differ (perhaps based on degree of overlap with resident fish).

**Table 2.10: Sex ratios of returning steelhead**

| | | Prosser | | | | Roza | |
|---|---|---|---|---|---|---|---|
| | **Total** | **Female** | **%** | | **Total** | **Female** | **%** |
| **2001-2** | 472 | 329 | 70% | | 210 | 153 | 73% |
| **2002-3** | 169 | 143 | 85% | | 126 | 110 | 87% |
| **2003-4** | 575 | 389 | 68% | | 207 | 154 | 74% |
| **2004-5** | 985 | 629 | 64% | | 201 | 167 | 83% |
| **Totals** | 2201 | 1490 | 68% | | 744 | 584 | 78% |

Yakima Basin steelhead cover a wide range of combinations of freshwater and ocean ages with residence in freshwater ages ranging from one to four years followed by one to three years of saltwater residence (the saltwater age does not include the winter spent by adults in freshwater prior to spawning).

Table 2.11 shows the combinations of fresh and saltwater ages determined through scale analysis of steelhead handled in the Prosser Denil for the 2002-3 to 2004-5 return years (this sample is representative of steelhead passing Prosser in September to December, but does not include fish passing after December).[20] The bulk of the run consists of age 2.1 and 2.2 fish (with a combined total of between 63% and 80% all years). The age structure of the run can vary significantly from year to year, as indicated by the range separating minimum and maximum percentages for each age class. On average, males return at younger freshwater and ocean ages (1.1 fish make up 15% of males, versus 8% of females, and for fish of freshwater age two, males return proportionally more often as one ocean fish). Based on summary tables in Hockersmith et al. (1995), there is also a weak inverse correlation between freshwater age and saltwater age for the sample as a whole (i.e., younger smolts returned at slightly older average ocean age).

**Table 2.11: Prosser Denil age structures, 2002-3 to 2004-5 return years**

**Ages from scale analysis; n = 1729**

| Age | Min % | Max % | Total % | % Males | % Females |
|---|---|---|---|---|---|
| **1.1** | 1.2% | 25.5% | 9.4% | 14.6% | 7.8% |
| **1.2** | 0.5% | 11.2% | 4.4% | 3.7% | 5.0% |
| **2.1** | 36.7% | 77.0% | 53.3% | 64.0% | 51.9% |
| **2.2** | 3.1% | 28.4% | 16.8% | 8.7% | 21.2% |
| **2.3** | 0.0% | 0.2% | 0.1% | 0.2% | 0.1% |
| **3.1** | 1.2% | 15.5% | 7.5% | 7.5% | 7.9% |
| **3.2** | 0.2% | 3.0% | 1.5% | 0.4% | 2.1% |
| **4.1** | 0.0% | 1.2% | 0.5% | 0.1% | 0.6% |
| **Rs** | 2.3% | 17.2% | 6.5% | 0.8% | 3.4% |

[20] Ages are given as (# of freshwater winters) and (# of saltwater winters), so a 2.3 age fish would have had two winters in freshwater as a juvenile followed by three winters at sea. Rs = repeat spawner.

Age distribution appeared to differ somewhat among populations. Table 2.12 shows the age distribution of the steelhead sampled at Roza Dam, which comprise most of the Upper Yakima population for the 2002-3 to 2004-5 returns. When compared to the aggregate run at Prosser, Upper Yakima fish are weighted towards older fish freshwater and ocean ages: one freshwater fish represent 4% of returns vs. 14% for the aggregate sample, while two ocean fish represent 52% of the Roza return vs. only 23% at Prosser.

**Table 2.12: Roza Dam age structures, 2002-3 to 2004-5 return years**

Ages from scale analysis; n = 534

| Age | Min % | Max % | Total % | % of males | % of females |
|---|---|---|---|---|---|
| **1.1** | 0.0% | 3.3% | 1.1% | 2.3% | 0.8% |
| **1.2** | 0.5% | 5.6% | 3.2% | 1.2% | 3.7% |
| **2.1** | 5.6% | 69.6% | 34.4% | 58.3% | 28.2% |
| **2.2** | 3.9% | 72.6% | 42.2% | 33.7% | 44.4% |
| **2.3** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **3.1** | 0.5% | 19.3% | 7.5% | 2.3% | 8.9% |
| **3.2** | 1.0% | 11.0% | 7.0% | 0.6% | 8.6% |
| **4.1** | 0.0% | 0.5% | 0.1% | 0.0% | 0.1% |
| **4.2** | 0.0% | 0.8% | 0.3% | 0.0% | 0.4% |
| **Rs** | 2.0% | 7.1% | 4.2% | 1.6% | 4.9% |

In contrast, data on the 70 of the 99 known-age adults that were tracked to spawning locations in the Hockersmith (1995) radio-tracking study (Table 2.13) found that known-age Satus spawners had younger freshwater ages than the other three groups and younger saltwater ages than the Naches and Toppenish groups.

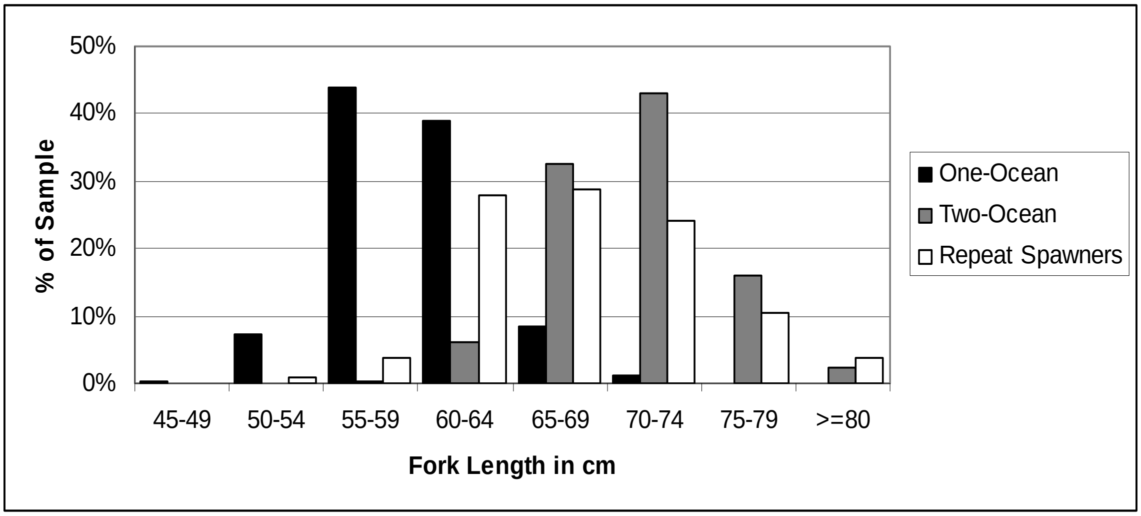
**Table 2.13: Spawning locations of known-age steelhead by population, 1990-92**

| Total Age | Satus Spawners | | Naches Spawners | | Toppenish Spawners | | Yakima Spawners | | Total Aged Fish | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % | No. | % |
| **1.1** | 3 | 7.9 | | 0.0 | | 0.0 | | 0.0 | 5 | 5.1 |
| **1.2** | 10 | 26.3 | 2 | 10.5 | | 0.0 | 1 | 20.0 | 24 | 24.2 |
| **1.3** | | 0.0 | | 0.0 | | 0.0 | | 0.0 | 1 | 1.0 |
| **2.1** | 10 | 26.3 | 4 | 21.1 | 1 | 12.5 | 2 | 40.0 | 20 | 20.2 |
| **2.2** | 15 | 39.5 | 11 | 57.9 | 6 | 75.0 | 2 | 40.0 | 45 | 45.5 |
| **2.3** | | 0.0 | 2 | 10.5 | 1 | 12.5 | | 0.0 | 3 | 3.0 |
| **4.1** | | 0.0 | | 0.0 | | 0.0 | | 0.0 | 1 | 1.0 |
| **Totals** | 38 | 100 | 19 | 100 | 8 | 100 | 5 | 100 | 99 | 100 |

## Size of Returning Adults

Fork lengths of returning steelhead measured at the Prosser Denil and Roza Trap from 2001 to 2006 ranged from 49 cm to 88 cm. Length is associated with ocean age, with an average of 60 cm for fish that have passed one winter at sea, 71 cm for fish that have passed two winters at sea, and 68 cm for repeat spawners. Figure 2.9 shows the distribution of spawners by ocean age.

**Figure 2.9: Size class by ocean age**




## Survival Rates of Upstream Migrants

The only Yakima-population specific data on survival during the upstream migration comes from a very limited number of PIT tag detections.[21] For the period spanning the 2003-04 to 2006-07 return years, 60 of 75 Yakima-origin PIT-tagged adult steelhead (80%) that were detected moving upstream past Bonneville were subsequently detected at McNary Dam. Three of those 60 strayed to the Snake or Upper Columbia, for a total of 57 of the 75 (76%) known to have survived from Bonneville to above McNary and presumed to have entered the Yakima River.

PIT tag detectors have been in place on all three fish ladders at Prosser Dam since August 30, 2005. Of the 16 Yakima-origin adults detected at McNary between August 2005 and June 2007, 13 (81%) were detected at Prosser and 1 at Priest Rapids (6%). Two (12%) were not detected again above McNary.

According to this very preliminary analysis, 80% of tagged fish passing Bonneville are known to have survived to above McNary and 20% died, strayed into other tributaries between Bonneville and McNary, or passed upstream or back downstream undetected. Of those PIT-tagged Yakima origin fish passing McNary, 81% passed Prosser into the Yakima Basin, 6% are known to have strayed into upstream areas, and 12% died, strayed into other tributaries to the McNary Pool, passed upstream undetected, or entered the Lower Yakima River but did not pass Prosser. Multiplying the 80% confirmed passage from Bonneville to McNary by the 81% confirmed passage from McNary to Prosser gives an estimated rate of confirmed passage from Bonneville to Prosser of 65%.

A portion of the losses is attributable to harvest in tribal fisheries and incidental mortality in recreational fisheries in the Columbia River above Bonneville. NOAA Fisheries estimates that overall harvest rates of Middle Columbia steelhead in tribal fisheries average of 4.8% of the run (NMFS 2008, Sec. 6.3.7). Detection failure may account for

---

[21] Analysis based on data from the DART database http://www.cbr.washington.edu/dart/dart.html

some, but not all, of the remaining loss between Bonneville and McNary. Of 57 fish detected at McNary in all return years, 4 had not been detected at Bonneville, a 7% detection failure. However, all of the 19 adults detected at Prosser since the first ladder went on line had been detected at McNary, indicating that detection rates at McNary are high.

These preliminary survival estimates differ significantly from the estimate of 90% survival from Bonneville to tributaries commonly used. While the analysis presented here relies on a small and short-term dataset and should be considered preliminary at best, the results highlight the need for empirical population-specific estimates of survival rates for the upstream migration of both specific populations and the Middle Columbia River Steelhead DPS as a whole.

Our only estimates of pre-spawning mortality of returning adults within the Yakima Basin come from radio-tracking studies. Of the 194 fish tracked by Hockersmith, 3.6% were confirmed to have died during migration and winter holding, 4% were harvested, and 9% were lost due to either harvest or failed transmitters prior to spawning (Hockersmith et al. 1995). Karp notes that 5 of 93 fish (5%) tagged at Roza in 2002-3 were lost to anglers and 7 of 105 fish (7%) tagged at Roza in 2003-4 were presumed lost to anglers or otters (Karp et al. 2003; Karp et al. 2005). Yakama Nation redd survey teams have also observed otter kills on Satus Creek. These studies support manager's estimates of approximately 10% mortality between passage at Prosser and spawning.

### 2.5.2 Spawning

**Distribution of Spawning**

Steelhead spawn across a broad seasonal and geographic range in the Yakima Basin, although based on intrinsic potential analysis and on planners' professional judgments, the current spatial distribution is significantly decreased from historic conditions. Spawning locations include intermittent streams, mainstems, and side-channels of larger rivers, and perennial streams up to relatively steep gradients (Hockersmith et al. 1995; Pearsons et al. 1996). Most Yakima steelhead are tributary spawners, although the distribution of redds throughout the basin is highly variable from year to year and significant amounts of mainstem spawning are known to occur.

Table 2.14 shows spawning locations identified in the Hockersmith radio-tracking study in the early 1990s. At that time 10 spawning areas (Satus Creek, Toppenish Creek, Marion Drain, Naches River, the mainstem Yakima River below Roza Dam, the mainstem Yakima River in the Roza Canyon, Taneum Creek, Swauk Creek, the upper Yakima River [above Ellensburg], and the Teanaway River) were identified.

**Table 2.14: Known spawning locations from 1990 to 1992 radio tracking**

| **Location** | | | **Number** | **Percent** |
|---|---|---|---|---|
| Satus Creek | | | | |
| | Satus Creek | | 30 | 28% |
| | Logy Creek | | 8 | 7% |
| | Dry Creek | | 11 | 10% |
| | Wilson-Charlie Creek | | 1 | 1% |
| | | **Total** | *50* | 46% |
| Toppenish Creek | | | | |
| | Marion Drain | | 2 | 2% |
| | Toppenish Mainstem | | 12 | 11% |
| | | **Total** | *14* | 13% |
| Naches | | | | |
| | Naches Mainstem | | 29 | 27% |
| | Little Naches | | 1 | 1% |
| | Bumping River | | 3 | 3% |
| | Rattlesnake Creek | | 1 | 1% |
| | Mainstem Yakima | | 5 | 5% |
| | | **Total** | *39* | 36% |
| Upper Yakima | | | | |
| | Mainstem in Roza Canyon | | 3 | 3% |
| | Teanaway | | 2 | 2% |
| | Upper Yakima Mainstem | | 1 | 1% |
| | | **Total** | *6* | 6% |
| | | **TOTAL** | 109 | 100% |

Population-specific spawning location information comes from a variety of sources. For the Satus Creek watershed, the Yakama Nation has surveyed accessible reaches since 1988. No surveys of mainstem spawning outside of the Satus Creek drainage have been conducted; there are anecdotal accounts of limited spawning in mainstem and lower sections of Spring and Corral creeks and Amon Wasteway.[22] For the Toppenish Creek Population, redd counts initiated in 1989 by the Yakama Nation give a detailed picture of spawning distribution.

For the Naches Population, the Yakama Nation has conducted redd surveys in Ahtanum Creek since 2000. Since 2004, the USFS, WDFW, USFWS, the Yakama Nation, and others have worked together to survey portions of the Naches drainage (Table 2.15). This information has greatly improved our understanding of spawning distribution in the Naches basin, but inconsistent survey conditions due to high flows and poor visibilities (especially in 2006) limit their use in estimating abundance. No surveys have been conducted in the lower mainstem of the Naches and the associated reaches of the mainstem Yakima. Figure 2.5 shows surveyed redd locations for recent years.

**Table 2.15: Naches redd survey results**

| | **2004** | **2005** | **2006*** | **2007** | **2008** | **2009** |
|---|---|---|---|---|---|---|
| Little Naches River | 27 | 70 | 4 | 16 | Ns | Ns |
| Bumping River | 2 | 16 | 11 | Ns | Ns | Ns |
| Nile Creek | 33 | 20 | 2 | 13 | 8 | 20 |
| Rattlesnake Ck & Tribs | 14 | 26 | 1 | Ns | Ns | Ns |
| Oak Creek | 18 | 2 | 1 | 15 | 3 | 9 |
| American River | Ns | 4 | 0 | Ns | Ns | Ns |
| Cowiche Creek | Ns | 2 | Ns | Ns | Ns | Ns |
| **Total** | **94** | **138** | **19** | **44** | **11** | **29** |

*Poor survey conditions

Our primary source of information on spawning locations for the Upper Yakima population comes from 2002 to 2006 radio-tracking surveys (Karp et al. 2003; Karp et al. 2005; Karp et al. 2009). Spawning locations are given in Table 2.16. The high proportion of mainstem spawners (87 of 183 spawners, or 48% for 2002-2004) is striking. The Teanaway system and Swauk Creek are the most consistently used tributary spawning areas.

[22] Spring, Corral, and Snipes creeks and Amon Wasteway are referred to by the names used on the USGS 7.5 minute topographic maps. The first three are referred to as drainageways by local irrigation districts, while Amon Wasteway is often referred to as Amon Creek. The use of these names in this document is in no way meant to indicate any conclusions regarding ongoing disputes about the legal status of these waterways.

**Table 2.16: Presumed spawning locations of steelhead tracked by Karp et al. (2009)**

| Location of Presumed Spawning | Number of Radio-tagged Steelhead |
|---|---|
| Mainstem Yakima River1 | 133 (37.7%) |
| Teanaway River | 137 (38.8%) |
| Swauk Creek | 46 (13.0%) |
| Taneum Creek | 17 (4.8%) |
| Cle Elum River | 12 (3.4%) |
| Lower Naches River, Umtanum, Cherry, Naneum, and Wilson creeks | 8 (2.3%) |
| *Total tributary* | 220 (62.3%) |
| Total | 353 |

### Timing of Spawning

Based on radio tagging and redd surveys, most spawning is completed between late January and mid-May. Figure 2.10 shows spawning dates by tributary for the 86 steelhead tracked to spawning in 1990-1992 (Hockersmith et al. 1995). In Satus Creek and its tributaries, the median spawning date was more than a month earlier than in any of the other tributaries, with spawning beginning in late January and predominantly occurring in February and March. In Toppenish Creek and the Naches spawning occurred mostly in March and April, while spawning in higher elevation tributaries occurred in late April and May.

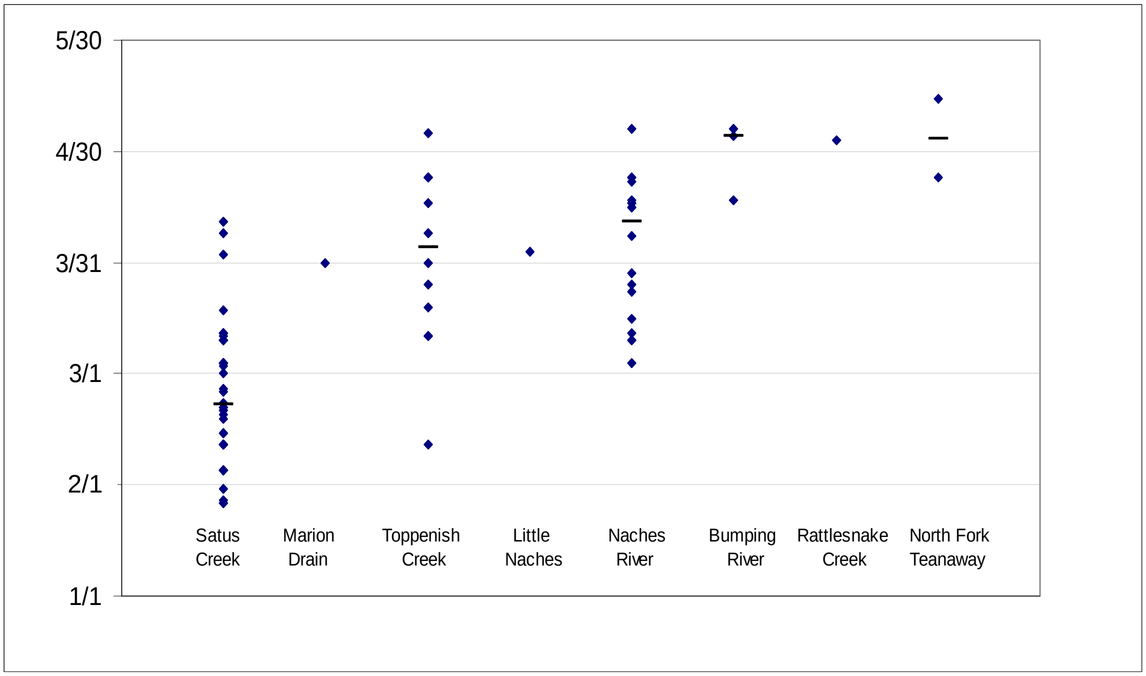
### Fecundity

Yakima steelhead have a relatively high fecundity in spite of their small size. Broodstock collected for species interaction experiments in brood years from 1986 to 1993 carried an average of 5,100 eggs (Fast and Berg 2001).[23]

---

[23] A length/fecundity relationship of # eggs = 189.28 x Fork Length in cm—6449 was calculated based on data from broodstock collected from the 1988-89 return (Chris Fredrickson, Yakama Nation, personal communication).

**Figure 2.10: Individual and median dates for spawning initiation 1990-1992**




## 2.5.3 Role of Kelts

Steelhead can return to the ocean after spawning and return to spawn again. During their return to the ocean they are called kelts. In spawning areas near the ocean, rates of repeat spawning can be as high as 79%. Natural rates of repeat spawning for Interior Columbia steelhead populations are unknown. Recent rates range include 17% for the Kalama River, 4.6% for the Hood River, 2-9% in the Walla Walla, and 1.5% in the Upper Columbia River (Branstetter et al. 2005). Natural repeat spawning by Yakima Basin steelhead is extremely limited; scale analysis in 1990-1992 indicated that 1.6% of returning adults were repeat spawners in the 1990-1992 brood years (Hockersmith et al. 1995). It is hypothesized that the development of the mainstem Columbia hydropower system and the associated passage impediments, reduced spring flows, and increased temperatures have reduced kelt survival rates.

Kelts typically migrate downstream from spawning areas in March through June. Kelts have been observed at the Chandler Juvenile Enumeration Facility (RM 47.1) into the middle of July, but water temperature approaches lethal levels by that time even in normal water years. Temperatures do not return to safe levels until early autumn (Fast and Berg 2001). Out-migration of kelts from the upper basin may be especially hazardous because later spawning dates combine with increased travel distance as the Yakima and Columbia rivers warm and their flow declines.

To increase the contribution of repeat spawners to steelhead productivity in the basin, the Yakima-Klickitat Fisheries Project initiated kelt reconditioning experiments in 2000 with funding from BPA. Post-spawning steelhead are captured as they pass through the Chandler Juvenile Facility at Prosser Dam on their downstream migration. From 2000 to 2006, between 15 and 37% of the upstream adult count were captured (the remaining fish either pass over Prosser Dam or it ladders without entering the juvenile facility or do not migrate downstream) (Table 2.17). Over 90% of collected kelts are female.

**Table 2.17: Numbers of kelts**[24]

| Year | Collected | % of run | In-river | No-term | Reconditioned | Short-term | Long-term | Mortalities |
|---|---|---|---|---|---|---|---|---|
| 2000 | 512 | 37% | 0 | 0 | 512 | 0 | 91 | 421 |
| 2001 | 551 | 19% | 0 | 0 | 551 | 0 | 108 | 443 |
| 2002 | 1113 | 25% | 0 | 0 | 899 | 334 | 140 | 425 |
| 2003 | 826 | 37% | 0 | 0 | 690 | 187 | 298 | 205 |
| 2004 | 966 | 35% | 0 | 64 | 779 | 83 | 216 | 480 |
| 2005 | 808 | 23% | 67 | 96 | 541 | 96 | 65 | 380 |
| 2006 | 520 | 26% | 53 | 49 | 348 | 50 | 85 | 213 |
| 2007 | 567 | 37% | 53 | 38 | 465 | 38 | 221 | 206 |
| 2008 | 855 | 26% | 88 | 100 | 600 | 100 | 266 | 234 |

Captured kelts are put into one of four groups: in-river, no-term, short-term, and long-term. In-river kelts are tagged and returned directly to the Yakima River to continue their downstream voyage. This treatment was established in 2005 to develop better estimates of current rates of natural repeat spawning (Branstetter et al. 2005). No-term kelts are tagged and immediately transported to release sites below Bonneville Dam. Short-term kelts are held and fed in the hatchery for three to five weeks prior to being released below Bonneville, while long-term kelts are held and fed for six to nine months prior to being released in the lower Yakima River prior to the next spawning season.

The program is currently the only hatchery program for Yakima steelhead stocks. It is estimated to have increased the number of spawning steelhead in the Yakima Basin by 7% (David Lind, Yakama Nation, personal communication, 2008.). The basin's most famous kelt was captured and PIT-tagged as an adult headed above Roza Dam in 2002, then recaptured in 2003 and radio tracked to spawning in Swauk Creek. She then traveled downstream to Chandler where she was reconditioned, and after release, was tracked back to the same reach of Swauk Creek (Karp et al. 2003; Karp et al. 2005). That is over 1,500 miles of in-river migration by a single fish!

Efforts to evaluate the reproductive success of reconditioned kelts began in 2004 (Branstetter et al. 2005). The effects of the kelt reconditioning program on the steelhead populations' genetic and life history diversity are unknown, but thought to be minor due to the natural origin of the fish themselves and the volitional release strategy that allows the reconditioned kelts to naturally select spawning sites. This issue is being investigated using genetic sampling and radio tracking of reconditioned adults.

### 2.5.4 Incubation and Emergence

Unlike other species in the *Oncorhynchus* genus, steelhead eggs incubate as temperatures increase. Hatching time varies with water temperature, region, habitat, and season (Bjornn and Reiser 1991). The timing of steelhead fry emergence in the Yakima Basin is poorly understood. Field studies indicate that 50% of steelhead trout in a redd will have

---

[24] Based on annual reports from BPA Project # 200001700 (Branstetter et al. 2005)

emerged when roughly 1,300 cumulative temperature units have been acquired. [25] Based on this relationship, fry emergence would occurs as follows (Yakima Subbasin Fish and Wildlife Planning Board 2005):

- Satus Creek: early May to early June
- Toppenish Creek: late May through early July
- Lower Naches and Cowiche: early June through mid-July
- Upper Naches: mid June through mid-July
- Upper Naches tributaries: late June through late July
- Middle Yakima and tributaries: early June through early July
- Mainstem in Yakima Canyon (including tributaries): early June through early July
- Upper Yakima mainstem above the Yakima Canyon: mid June through late July
- Upper Yakima tributaries: late June through early August

### 2.5.5 Juvenile Rearing

Juvenile steelhead spend from one to three years in fresh water before migrating to the Pacific Ocean. Juveniles use tributary and mainstem reaches throughout the Yakima Basin as rearing habitat, until they begin to smolt and leave the basin. Some juveniles leave their natal areas and may spend considerable time from fall to spring rearing in areas that may have been inhospitable in the summer.

Juvenile rearing conditions significantly affect the size and condition of outmigrating smolts. For example, Yakama Nation smolt trap data indicate that steelhead from Ahtanum Creek were substantially larger than those in Satus and Toppenish creeks in each age class in both seasons sampled. This higher growth rate may be related to lower rearing density and more favorable discharge and temperature for growth in late summer.

Data from Toppenish Creek smolt traps demonstrate the value of seasonal rearing habitat. Five juveniles that were tagged prior to March 1 in a section of Toppenish Creek not hospitable to summer rearing were recaptured an average of 85 days later only 28 km downstream, and had tripled their average weight, indicating the potential significance of lower Toppenish Creek for pre-smolt rearing, despite substrate too fine for spawning and water temperatures that preclude summer use.

Cramer et al. (2003; 2004) have used stock-recruit relationships to argue that Yakima Basin steelhead production is limited by juvenile capacity, assuming habitat capacity above Roza Dam is naturally predisposed to produce resident *O. mykiss*. (See below.)

---

[25] Cumulative temperature units are calculated by summing the daily average degrees Celsius over the number of days from spawning to emergence.

### 2.5.6 Resident/Anadromous Interactions

Offspring of steelhead can residualize in tributaries and never migrate to sea, thereby becoming resident rainbow trout. Conversely, progeny of resident rainbow trout can migrate to the sea and thereby become steelhead. This dynamic expression of life-history characteristic makes *O. mykiss* very challenging to understand and manage. For an overview of the current understanding of the range of interactions between resident and anadromous *O. mykiss*, see Chapter 2 of WDFW's recent draft assessment of steelhead status (Scott and Gill 2006) and NOAA Fisheries' Salmon Recovery Science Review Panel Report on the topic (Salmon Recovery Science Review Panel 2004). Generally, the anadromous form of *O. mykiss* dominates the Satus and Toppenish populations, while the resident form currently dominates the Upper Yakima. In the Naches population, both anadromous and resident forms are geographically widespread.

Steelhead/resident pairing during spawning has not been noted at any significant levels during Satus and Toppenish Creek redd surveys (Tim Resseguie, Yakama Nation Fisheries, personal communication, 2007) but has been observed repeatedly during redd surveys in the Naches drainage (Gary Torretta, USFS, personal communication, 2007). Pearsons et al. (1998) concluded that ecological and genetic evidence indicated that rainbow and steelhead trout in the upper Yakima interbreed when in sympatry, and document several cases of observed resident/steelhead matings. However during 2004 radio tracking in the Upper Yakima, no resident/anadromous pairs were observed; all 15 observed pairings were between male and female steelhead, and occurred in tributaries (Teanaway, Taneum, and Swauk creeks) (Karp et al. 2005).

Cramer et al. (2003; 2004) assert that the Upper Yakima and portions of the Naches drainage would naturally primarily support the resident form of *O. mykiss*. Many others have asserted that the Upper Yakima would once have been a major producer of anadromous steelhead, and that changes in habitat conditions and introduction of non-native hatchery rainbow trout have greatly reduced the expression of anadromy. Factors hypothesized to contribute to this shift include:

- Reduction in survival rates for outmigrating smolts and returning adults associated with changed flow, predation, and passage conditions in the mainstem Yakima and Columbia that reduces the fitness of the anadromous life history relative to residents
- Reduction in temperatures and increases in flow in mainstem habitat reaches associated with irrigation delivery flows increasing the relative benefits of residency
- Loss of access to tributary habitat with conditions that promote anadromy
- Reduction of mainstem habitat quality for year-0 juveniles due to simplified channels, high summer velocities associated with irrigation delivery flows and rapid changes in flows associated with flip-flop
- Possible introgression of genes from non-anadromous hatchery trout and steelhead introductions

Genetic analysis indicates that in specific Upper Yakima tributaries, the anadromous and resident forms of *O. mykiss* are genetically more similar to each other than to the same life history in other tributaries, while the trout population in the mainstem is both genetically distinct from tributary *O. mykiss* and shows signs of introgression from hatchery stocks (Pearsons et al. 2007).

Based on the goal built into NOAA Fisheries' policy of conserving the anadromous component of *O. mykiss* as a Distinct Population Segment, interactions between resident and anadromous *O. mykiss* can have both positive and negative outcomes. The ICTRT viability framework identifies a significant shift by a predominantly anadromous population to increased residency as a factor that increases the extinction risk of the anadromous portion of the population.

The ability of resident males to successfully breed with anadromous females and produce anadromous offspring can significantly increase the effective population size of the anadromous population, especially when spawner abundance is low, and can increase the resilience and persistence of the population.

The ability of resident-resident pairings to produce anadromous offspring can also allow for re-establishment of an anadromous run in the absence of anadromous spawners. While this is known to occur, and may be an important survival mechanism for temporarily isolated populations, the persistence of this trait after many generations without anadromous returns contributing to the gene pool is unknown (Salmon Recovery Science Review Panel 2004; Scott and Gill 2006). Thrower (2004) found, however, that a resident population continued to produce smolts despite 70 years of isolation from anadromous adults. Thrower's results indicate that the correlation between smoltification and other traits associated with fitness in the freshwater environment provide a mechanism to explain how a low level of smoltification could persist despite the loss of all smolts from the isolated population. However, this example is only 70 years old, which is fairly short from an evolutionary perspective. If the ability is retained, it is likely that interim absence of selection for traits favorable to anadromy may result in loss of these traits (Thrower 2004).

The impacts of competitive interactions between larger resident individuals and juvenile anadromous *O. mykiss* may also reduce the production of smolts, especially where habitat conditions have shifted to promote residency.

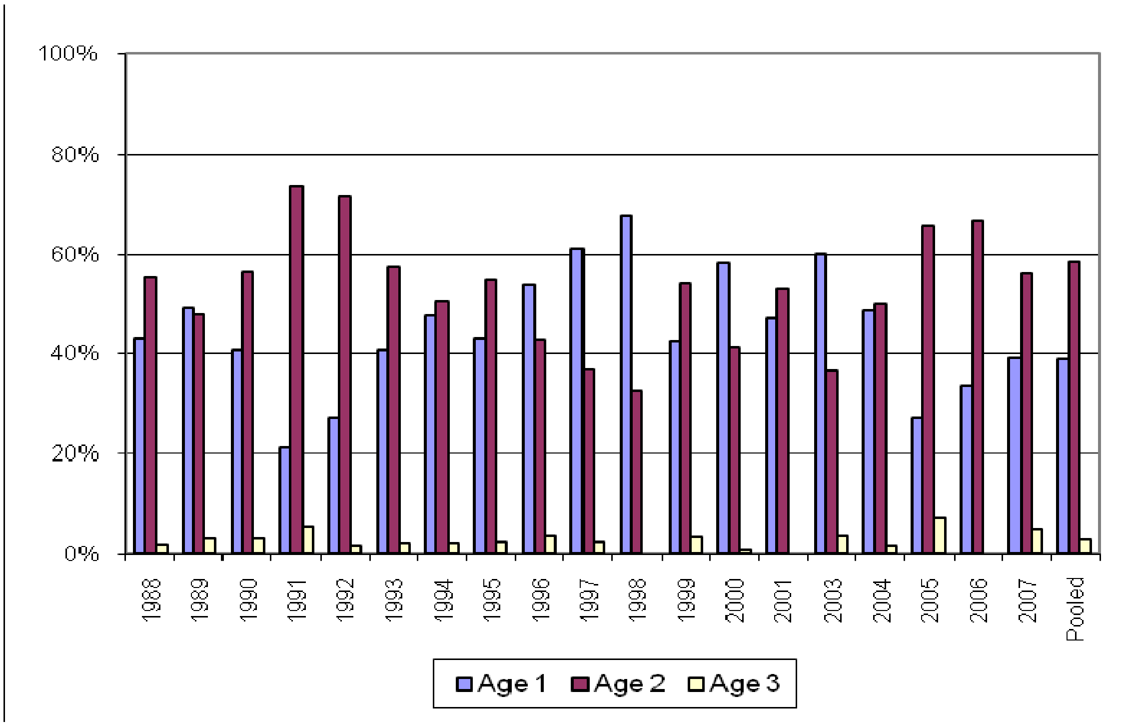
The nature of the relationship between resident and anadromous forms is inherently complex. Setting realistic goals for steelhead production in different parts of the Upper Yakima and Naches systems will require an improved understanding of the range of interactions between resident and anadromous life histories. This is identified as a key knowledge gap in Chapter 7.

### 2.5.7 Smolt Outmigration

**Age and Size at Outmigration**

Steelhead smolt ages at Prosser Dam are shown in Figure 2.11 below, which is derived from more than 9,000 age determinations from 1988 through 2004. Overall, 39% of the sample was age one, 58% was age two and 3% was age three. The percentage of age one steelhead smolts passing Prosser Dam (Fig. 2.1) is unusually high for an interior population (Peven et al. 1994). The age distribution of outmigrating smolts differs from the freshwater age distribution of returning adults (15% age one, 75% age two and 10% age three (calculated from Figure 2.11 and excluding repeat spawners), indicating significantly better survival from smolt to returning adult for older smolts. (Some of the difference could also be explained by smolts spending another winter in freshwater below Prosser Dam; however, this is not a known life history for Yakima Basin steelhead.)

**Figure 2.11: Steelhead smolt ages at Prosser Dam**




Very little data exist to estimate age at outmigration for specific populations. Based on scale samples from juvenile steelhead trapped by the Yakama Nation in Satus, Toppenish, and Ahtanum creeks during the 2001-02 and 2003-04 out-migration seasons, age one smolts appeared to be more prevalent than age two in Satus and Toppenish creeks, and age three smolts were uncommon in all three creeks. Table 2.18 shows the average size by smolt age for outgoing smolts sampled at the Chandler juvenile facility at Prosser.

**Table 2.18: Size in millimeters for outmigrating smolts at Prosser by age class**

| Year | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **1988** | 147 | 187 | 210 | |
| **1989** | 155 | 189 | 217 | |
| **1990** | 133 | 179 | 220 | |
| **1991** | 148 | 179 | 210 | 300 |
| **1992** | 160 | 190 | 232 | |
| **1993** | 137 | 183 | 216 | |
| **1994** | 127 | 170 | 235 | |
| **1995** | 151 | 179 | 209 | |
| **1996** | 136 | 181 | 226 | |
| **1997** | 152 | 189 | 208 | |
| **1998** | 131 | 173 | | |
| **1999** | 137 | 178 | 247 | |
| **2000** | 162 | 183 | 255 | |
| **2001** | 174 | 198 | | |
| **2003** | 132 | 194 | 243 | |
| **2004** | 136 | 186 | 195 | |
| **2005** | 179 | 195 | 206 | |
| **2006** | 139 | 204 | | |
| **2007** | 160 | 202 | 236 | |
| **Average** | **147** | **186** | **223** | |

## Abundance of Outmigrants

Prosser Dam is located downstream of almost all steelhead spawning areas in the Yakima Basin. A juvenile fish counting facility is built into the fish screen bypass system, enabling both PIT tag detections and manual counts of entrained fish. Steelhead mark-and-recapture studies have not been conducted at Prosser Dam since before the June 23, 1999 listing of Middle Columbia River steelhead. Instead, steelhead passage is estimated by applying entrainment, canal mortality, and sampling rate coefficients established for spring Chinook to manual counts of steelhead at the Prosser Juvenile Facility. The degree of bias introduced by this substitution is not known, but may be significant. For this reason, annual steelhead smolt counts are not considered reliable enough for year-to-year comparisons of the number of outmigrants. Estimates of the number of steelhead smolts passing Prosser Dam have ranged between 25,000 and 50,000 smolts between 1999 and 2005 (2006 counts were hampered by high flows).

## Timing of Outmigration

As noted in Section 2.5.4, some juveniles leave their natal areas and may spend considerable amounts in the fall through spring rearing in areas that may have been inhospitable in the summer. Others move fairly rapidly from their initial rearing areas towards the Columbia. Juvenile outmigration through the lower Yakima River and past Prosser Dam begins in November and peaks between mid-April and May. The timing of the overall steelhead outmigration at McNary and Bonneville dams parallels the timing at Prosser, and runs from early April through the end of June. Steelhead smolts have been observed passing Prosser into the middle of July, but the Lower Yakima has warmed to lethal temperatures by that time even in normal water years and typically does not cool again to safe levels until early autumn (Fast and Berg 2001). Little information is currently available to determine if the timing of outmigration differs by population. Steelhead tagged in Satus Creek in the 2003-04 and 2004-05 seasons arrived earlier at Prosser Dam than smolts tagged in Toppenish Creek or Ahtanum Creek (Table 2.19).

**Table 2.19: Steelhead travel times from tributary tagging locations to Prosser Dam**

| | | Mean Dates | |
|---|---|---|---|
| **Release Year** | **Trap Location** | **Release** | **Prosser** |
| 2003-04 | Toppenish | 2/10/04 | 4/24/04 |
| 2003-04 | Ahtanum | 4/8/04 | 5/8/04 |
| 2003-04 | Satus | 3/25/04 | 4/20/04 |
| 2004-05 | Toppenish | 3/12/05 | 4/25/05 |
| 2004-05 | Ahtanum | 3/25/05 | 5/5/05 |
| 2004-05 | Satus | 2/27/05 | 4/7/05 |

## Survival Rates for Outmigrants

A series of PIT tag groups used for entrainment rate studies at Prosser Dam in the relatively high-flow year of 1999 were used to estimate juvenile steelhead survival rate of 0.798 to McNary Dam by Williams et al. (2005). Subsequent years' survival estimates to McNary Dam by the authors were lower, (0.314 in 2002 and 0.394 in 2003), and were likely derived from the 2001-02 and 2002-03 Toppenish Creek releases described below, thus having a point of origin well upstream from Prosser Dam.

The Yakama Nation operates screw traps in Satus, Toppenish, and Ahtanum creeks, but widely fluctuating flows and heavy debris loads during the out-migration period hamper passage estimation at these locations. Toppenish Creek steelhead have been PIT tagged since the 2001-02 out-migration season, giving an opportunity to estimate downstream survival and return rates of tag groups. PIT tagging at the Ahtanum and Satus creek traps began in the 2003-04 season.

Downstream survival rate of PIT-tagged juvenile steelhead to Prosser Dam can be estimated by dividing Prosser detections by Prosser entrainment rate on the date of each detection (using the aforementioned diversion-entrainment relationship) and also by using PIT tag detections at the McNary Dam juvenile bypass to calculate the Prosser entrainment rate. Table 2.20 shows tagging data and estimated survival rates. Calculated survival rates from tributaries to Prosser range from 14% to 74%.

Table 2.20 supports the hypothesis that steelhead smolt survival rate to Prosser is related to travel distance. Fish from the Satus Creek trap, which is closest to Prosser Dam, survived best, while estimated survival rates from the Toppenish and Ahtanum creek traps were both lower, and much lower from Toppenish Creek in the drought year of 2005. Within Toppenish Creek, survival rates were lower for upstream releases, especially in the 2001-02 outmigration period. There is a strong tendency for later outmigrants to travel faster downriver. Better understanding of the relationship between flows, habitat conditions, and outmigration timing and survival is identified as a key knowledge gap in Chapter 7.

**Table 2.20: Survival rates of steelhead smolts from selected tributaries**

| | | | | | | | | | | Adult Return Rate (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Km To | Tagging Dates | | | Juvenile Survival Rate to McNary (%)[1] | | Adult Returns to McNary | | Tributary Smolt To McNary Adult | | | McNary Smolt to McNary Adult[2] | | |
| Outmi-gration Season | Stream | McNary Dam | Begin | End | Number Tagged | Survival Rate | Standard Error, +/- | Age 1 | Age 2 | Age 1 | Age 2 | Total | Age 1 | Age 2 | Total |
| 2002 | Toppenish | 247 | 12/5/01 | 5/22/09 | 955 | 29 | 7 | 9 | 2 | 0.94 | 0.21 | 1.15 | 3.29 | 0.73 | 4.02 |
| 2002 | Toppenish | 219 | 2/21/02 | 5/24/02 | 292 | 58 | 22 | 9 | 2 | 3.08 | 0.68 | 3.77 | 5.29 | 1.18 | 6.47 |
| 2003 | Toppenish | 247 | 11/12/02 | 3/3/03 | 575 | 40 | 11 | 11 | 2 | 1.91 | 0.35 | 2.26 | 4.78 | 0.87 | 5.65 |
| 2003 | Toppenish | 219 | 3/30/03 | 5/19/03 | 196 | 28 | 8 | 4 | 1 | 2.04 | 0.51 | 2.55 | 7.38 | 1.85 | 9.23 |
| 2004 | Toppenish | 247 | 12/10/03 | 5/5/04 | 467 | 28 | 11 | 3 | 0 | 0.64 | 0.00 | 0.64 | 2.33 | 0.00 | 2.33 |
| 2004 | Toppenish | 219 | 12/24/03 | 5/2/04 | 671 | 20 | 6 | 4 | 1 | 0.60 | 0.15 | 0.75 | 2.95 | 0.74 | 3.68 |
| 2004 | Ahtanum | 246 | 1/16/04 | 5/5/04 | 247 | 43 | 26 | 1 | 0 | 0.40 | 0.00 | 0.40 | 0.95 | 0.00 | 0.95 |
| 2004 | Satus | 183 | 1/13/04 | 5/5/04 | 61 | 47 | 25 | 1 | 0 | 1.64 | 0.00 | 1.64 | 3.51 | 0.00 | 3.51 |
| 2005 | Toppenish | 247 | 12/13/04 | 5/26/05 | 1420 | 14 | 6 | 9 | 2 | 0.63 | 0.14 | 0.77 | 4.69 | 1.04 | 5.73 |
| 2005 | Ahtanum | 246 | 12/14/04 | 5/21/05 | 386 | 10 | 3 | 0 | 1 | 0.00 | 0.26 | 0.26 | 0.00 | 2.60 | 2.60 |
| 2005 | Satus | 183 | 12/17/04 | 4/24/05 | 160 | 20 | 8 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2006 | Toppenish | 247 | 12/24/05 | 5/30/06 | 685 | 30 | 5 | 9 | 0 | 1.31 | 0.00 | 1.31 | 4.40 | 0.00 | 4.40 |
| 2006 | Ahtanum | 246 | 1/13/06 | 6/6/06 | 95 | 48 | 19 | 1 | 0 | 1.05 | 0.00 | 1.05 | 2.18 | 0.00 | 2.18 |
| 2006 | Satus | 183 | 12/27/05 | 5/25/06 | 176 | 68 | 14 | 2 | 1 | 1.14 | 0.57 | 1.70 | 1.66 | 0.83 | 2.49 |

[1]Calculated by PitPro 4 (PitTag Processor), Columbia Basin Research, University of Washington

[2]McNary smolts estimated from total releases multiplied by survival rate estimates to McNary

[3]released from two locations on Snake Creek, a lower Toppenish Creek distributary

## 2.5.8 Ocean Residence

Yakima Basin steelhead typically spend between one and three years in the ocean before returning to natal streams to spawn, as detailed in the discussion of age structures in Section 2.5.1.2. Variability in estuary and ocean conditions is a major driver of year-to-year survival and growth of adult steelhead. Variation occurs because of changing climatic conditions, fisheries impacts (presumed minimal for the Middle Columbia Steelhead DPS), possible density-dependant competitive interactions with other salmon species and hatchery fish, and variability of prey and predator abundance. NOAA Fisheries' Middle Columbia Steelhead Recovery Plan will address ocean and estuary effects on the Middle Columbia River Steelhead DPS as a whole. The only specific data about ocean survival rates of Yakima Basin steelhead comes from analysis of return rates of PIT-tagged smolts detected during their downstream and subsequent upstream migrations. Preliminary estimates show McNary smolt to McNary adult return rates of 2.5% to 6.3%; general experience with PIT tag returns shows that they typically underestimate smolt to adult survival rates for the untagged portion of the run (FPC (Fish Passage Center) and Comparative Survival Study Oversight Committee 2006). Future efforts to assess the impacts of size, age, and condition of outmigrating smolts on ocean survival rates will help guide efforts to manage conditions within the Yakima Basin in a manner that improves ocean survival of outgoing smolts.

## 2.6 Viability Assessments for Yakima Basin Steelhead

Several efforts have been made to assess the current status of steelhead in both the Yakima Basin and the Middle Columbia DPS as a whole. At the time of the initial listing under the ESA in 1999 (64FR14517 and Busby (1996)), habitat degradation, low abundance, declining productivity, and the threat of hatchery practices to genetics of native stocks were identified as the primary factors justifying listing.

Cramer et al. (2003; 2004) have emphasized that Yakima Basin steelhead are minimally affected by intermixing with hatchery spawners, that abundance and productivity trends improved significantly between the mid-1990s and 2004, and that steelhead production from parts of the basin may be limited by conditions that promote residency. They assert that steelhead are fully seeding currently available habitat and that the availability of rearing habitat is limits production. They do not address the degree to which improvements in existing habitat and increased access to currently inaccessible habitat could increase juvenile habitat capacity nor do they address how improvements in survival rates in migratory life stages (smolt and adult) could change the adult abundance supported by a given smolt production capacity.

This plan incorporates the viability assessments developed by the ICTRT in 2004 through 2007 based on the Viable Salmonid Population conceptual framework (McElhany et al. 2000). The ICTRT Stock Status Assessments for the Yakima Basin (ICTRT In press) were prepared in accordance with ICTRT guidelines (ICTRT 2004a; 2004b; 2005a; 2005b; 2007b). Supporting data were drawn from multiple sources, including previous drafts of this recovery plan. These analyses are based on the best information available. While this information is at times limited, the stock status assessments represent a solid effort to utilize existing data to evaluate viability. As noted in Chapter 7, these assessments should be updated as our ability to determine population-specific VSP parameter improves.

Table 2.21 shows the results of the ICTRT analysis: the Satus and Toppenish populations were each assigned an abundance/productivity risk of moderate and a Spatial Structure/Diversity risk of moderate. The Naches population was assigned a high abundance/productivity risk and a Spatial Structure/Diversity risk of moderate. The Upper Yakima was ranked high for both risk classes. The rest of this section reviews the ICTRT’s basis for these assignments.

**Table 2.21: ICTRT risk ratings for Yakima steelhead populations**

| | | Spatial Structure/Diversity Risk | | | |
|---|---|---|---|---|---|
| | | **Very Low** | **Low** | **Moderate** | **High** |
| **Abundance/ Productivity Risk** | **Very Low** (<1%) | **HV** | **HV** | **V** | **M** |
| | **Low** (1–5%) | **V** | **V** | **V** | **M** |
| | **Moderate** (6–25%) | M | M | M **Satus/ Toppenish** | |
| | **High** (>25%) | | | **Naches** | **Upper Yakima** |

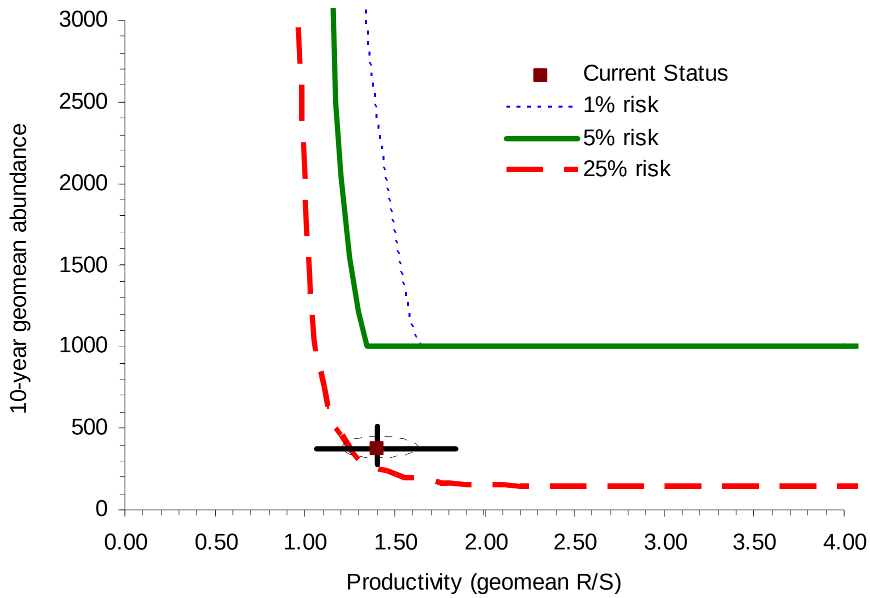
Viability Key: HV = Highly Viable; V = Viable; M = Not Viable, Candidate for Maintained Status

### 2.6.1 Satus Creek

#### Abundance and Productivity

The ICTRT classified the Satus Creek steelhead population as “Intermediate” in size based on historical habitat potential analysis (ICTRT 2007). This classification requires a minimum abundance threshold of 1,000 wild spawners with sufficient productivity (greater than 1.35 returns per spawner at the abundance threshold) to avoid a 5% extinction risk on the ICTRT’s viability curve. With a 10-year (1996-2005) geomean abundance of 379 and a delimited/adjusted productivity value of 1.40 returns per spawner, the Satus Creek steelhead population is deemed to be at moderate risk of extinction, i.e., between the 5% and 25% risk lines for an intermediate-size population (Figure 2.12).

**Figure 2.12: Satus abundance & productivity compared to the viability curve**




Curve is for an intermediate-sized population. The point estimate includes a 1 standard error ellipse and 95% confidence intervals (1.81 x SE for both productivity and abundance estimates).

## Spatial Structure and Diversity

Both MSAs and the MiSA in the Satus Creek drainage are rated as occupied.[26] Table 2.22 summarizes spatial structure and diversity risk assessment scores. The ICTRT placed the Satus Creek steelhead population at low risk for Goal A, which covers spatial structure factors, and moderate risk for Goal B, which covers genetic and phenotypic diversity. The three metrics contributing to the risk rating under Goal B were phenotypic variation due to constraints on migration timing, distribution across habitat types because of habitat loss in lower Satus Creek, and selective impacts related to migration timing constraints. Using the lower score for the two goals gives the population an overall spatial structure and diversity risk rating of moderate.

According to the ICTRT the population status relative to Goal B could be improved by addressing B.1.b (phenotypic variation). The first step in addressing this component should be a more detailed evaluation of spawning and rearing timing. That assessment should be designed to evaluate the relative change in phenotypic characteristics for the population and the factors driving the shifts. If further analysis confirms a significant shift in phenotypic characteristics relative to the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting, restoration actions should be initiated. Based on this scoring system, this metric must be addressed in order for the status of goal B to improve to low risk.

---

[26] See Section 4.2.3 for the ICTRT definition of "occupancy."

**Table 2.22: ICTRT spatial structure & diversity ratings for the Satus population**

| Metric | Risk Assessment Scores | | | | |
|---|---|---|---|---|---|
| | *Metric* | *Factor* | *Mechanism* | *Goal* | *Population* |
| A.1.a Number and spatial arrangement of spawning areas | L (1) | L (1) | Low Risk (Mean = 0.66) | Low Risk | **Moderate Risk** |
| A.l.b. Spatial extent or range of population | L (1) | L (1) | | | |
| A.1.c. Increase or decrease in gaps or continuities between spawning areas | M (0) | M (0) | | | |
| B.1.a. Major life history strategies | L (1) | L (1) | Moderate Risk | Moderate Risk | |
| B.1.b. Phenotypic variation | M (0) | M (0) | | | |
| B.1.c. Genetic variation | VL (2) | VL (2) | | | |
| B.2.a. (1) Out-of-DPS spawners | L (1) | Low Risk | Low Risk | | |
| B.2.a. (2) Out-of-MPG spawners | L (1) | | | | |
| B.2.a. (3) Out-of-Population spawners | VL (2) | | | | |
| B.2.a. (4) Within-population hatchery spawners | L (1) | | | | |
| B.3.a. Distribution of population across habitat types | M (0) | M (0) | M (0) | | |
| B.4.a. Selective change in natural processes or selective impacts | M (0) | M (0) | M (0) | | |

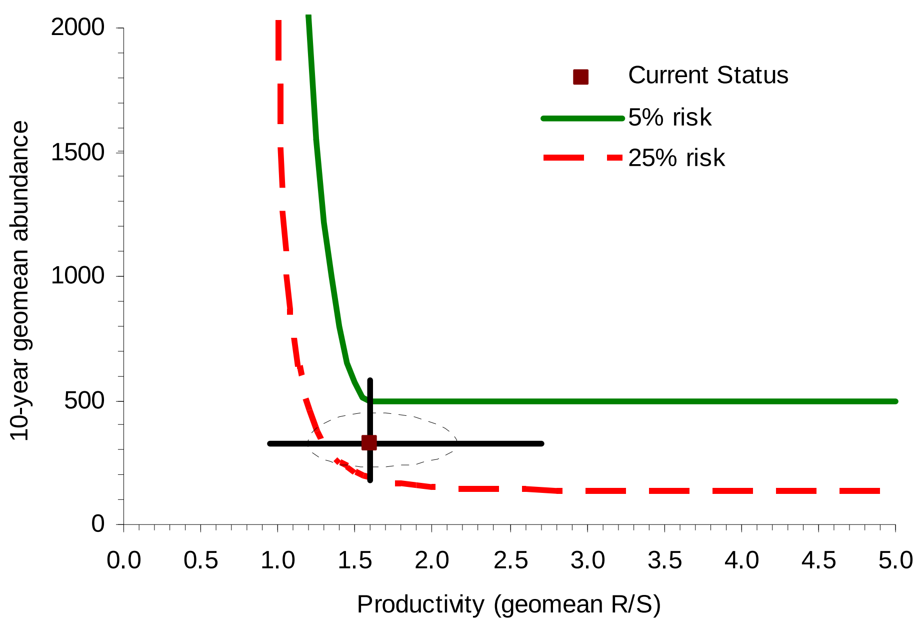
Overall, the Satus Creek steelhead population is not considered viable under the ICTRT guidelines—both abundance/productivity and spatial structure/diversity elements indicate moderate risk. To achieve viable status, the Satus Creek population must exceed the minimum threshold escapement of 1,000. To achieve very low risk status (high viability) the improvement in abundance would need to be accompanied by an increase in productivity and the changes in spatial structure and diversity described above.

### 2.6.2 Toppenish Population

**Abundance and Productivity**

The ICTRT classified the Toppenish Creek steelhead population as "Basic" in size based on historical habitat potential analysis (ICTRT 2007). This classification requires a minimum abundance threshold of 500 wild spawners with sufficient productivity (greater than 1.56 returns per spawner) to avoid a 5% extinction risk on the ICTRT's viability curve. With a 10-year (1996-2005) geomean abundance of 322 and a delimited/adjusted productivity value of 1.60 returns per spawner, the Toppenish Creek steelhead population is deemed to be at moderate risk of extinction, i.e., between the 5% and 25% risk lines for a basic-size population (Figure 2.13).

**Figure 2.13: Toppenish abundance & productivity compared to the viability curve**




Curve is for a basic-sized population. The point estimate includes a one standard error ellipse and 95% confidence intervals (1.81 x SE for both parameters).

**Spatial Structure and Diversity**

The ICTRT classifies both MSAs as occupied. Table 2.23 summarizes spatial structure and diversity risk assessment scores. The ICTRT placed the Toppenish Creek steelhead population at low risk for Goal A, which covers spatial structure factors and moderate risk for Goal B, which covers genetic and phenotypic diversity. Using the lower score for the two goals gives the population an overall spatial structure and diversity risk rating of moderate.

**Table 2.23: ICTRT spatial structure & diversity ratings for the Toppenish population**

| Metric | Risk Assessment Scores | | | | |
|---|---|---|---|---|---|
| | Metric | Factor | Mechanism | Goal | Population |
| A.1.a Number and spatial arrangement of spawning areas | L (1) | L (1) | Low Risk Mean = 0.66 | Low Risk | |
| A.l.b. Spatial extent or range of population | M (0) | M (0) | | | |
| A.1.c. Increase or decrease in gaps or continuities between spawning areas | L (1) | L (1) | | | |
| B.1.a. Major life history strategies | M (0) | M (0) | Moderate Risk | Moderate Risk | |
| B.1.b. Phenotypic variation | M (0) | M (0) | | | |
| B.1.c. Genetic variation | M (0) | M (0) | | | |
| B.2.a. (1) Out-of-DPS spawners | L (1) | Low Risk (1) | Low Risk (1) | | |
| B.2.a. (2) Out-of-MPG spawners | L (1) | | | | |
| B.2.a. (3) Out-of-Population spawners | VL (2) | | | | |
| B.2.a. (4) Within-population hatchery spawners | L (1) | | | | |
| B.3.a. Distribution of population across habitat types | L (1) | L (1) | L (1) | | |
| B.4.a. Selective change in natural processes or selective impacts | M (0) | M (0) | M (0) | | |

Since listing of the DPS in 1999, problems with adult passage, juvenile entrainment, and instream flow have been addressed in part through several restoration projects and flow regulation in the agricultural portion of the Toppenish Creek watershed. However, seepage losses (which may be partly of human origin) combine in dry years with agricultural diversions to restrict passage to and from the most important spawning and rearing areas. Summer rearing is also precluded in lower Toppenish and Simcoe creeks. Eggs and fry in Marion and Harrah drains, a new spawning area, are unlikely to survive due to poor habitat and to irrigation spills during the emergence period. This ostensible increase in range may actually increase extinction risk, hence the moderate risk rating under the spatial extent metric.

Under Goal B, risk is elevated with respect to life history strategies given rearing conditions in the lower creek, phenotypic variation because of constraints on adult migration timing, and in genetic variation due to low levels of heterozygosity that may be related to earlier passage bottlenecks. Migration timing constraints and loss of rearing habitat in the lower creek result in moderate risk with respect to the selective impacts metric.

According to the ICTRT, at least two major components of the spatial structure/diversity criteria must be addressed to move this population to a low risk rating. Expansion of the current range into historically utilized rearing areas in the lower reaches of Toppenish Creek would increase the range of life history patterns towards historical levels. The status relative to goal B could be improved by addressing B.1.b (phenotypic variation). The first step in addressing this component should be a more detailed evaluation of spawning and rearing timing. That assessment should be designed to evaluate the relative change in phenotypic characteristics for the population and the factors driving the shifts. If further analysis confirms a significant shift in phenotypic characteristics relative to the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting, restorations actions should be initiated. Based on the ICTRT scoring system, this metric must be addressed in order for the status of goal B to improve to low risk.

Overall, the Toppenish Creek steelhead population is not considered viable under the ICTRT guidelines—both abundance/productivity and spatial structure/diversity elements indicate moderate risk. To achieve viable status, the abundance of the population must be increased sufficiently to maintain the population above the minimum threshold escapement of 500 spawners. To achieve very low risk status (high viability) those improvements in abundance would need to be accompanied by the changes in spatial structure and diversity described above.

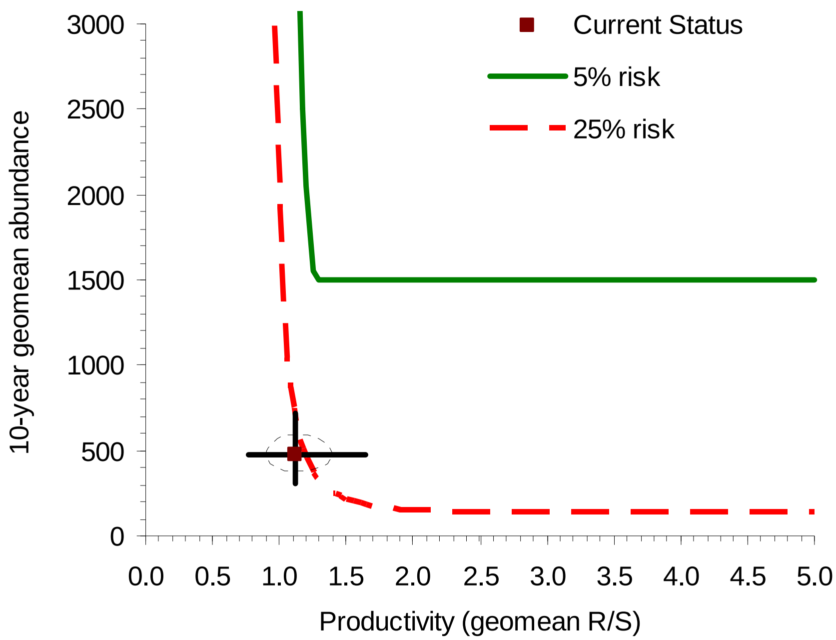
### 2.6.3 Naches Population

**Abundance and Productivity**

The ICTRT classified the Naches River steelhead population as “Large” in size based on historical habitat potential analysis (ICTRT 2007). This classification requires a minimum abundance threshold of 1500 wild spawners with sufficient productivity (greater than 1.26 returns per spawner at the abundance threshold) to avoid a 5%

extinction risk on the ICTRT's viability curve. With a 10-year (1996 to 2005) geomean abundance of 472 and a delimited/adjusted productivity value of 1.12 returns per spawner, the Naches River steelhead population is deemed to be at high risk of extinction, i.e., below the 25% risk line for a large-size population (Figure 2.14).

**Figure 2.14: Naches abundance & productivity compared to the viability curve**




Curve is for a large-sized population. The point estimate includes a 1 standard error ellipse and 95% confidence intervals (1.81 x SE for both productivity and abundance estimates).

## Spatial Structure and Diversity

The ICTRT classified seven of eight MSAs in the Naches Population area as occupied (the Cowiche MSA was rated as unoccupied). Table 2.24 summarizes spatial structure and diversity risk assessment scores. The ICTRT placed the Naches River steelhead population at low risk for Goal A, which covers spatial structure factors, and moderate risk for Goal B, which covers genetic and phenotypic diversity. Using the lower score for the two goals gives the population an overall spatial structure and diversity risk rating of moderate.

**Table 2.24: ICTRT spatial structure & diversity ratings for the Naches population**

| Metric | Risk Assessment Scores | | | | |
|---|---|---|---|---|---|
| | Metric | Factor | Mechanism | Goal | Population |
| A.1.a Number and spatial arrangement of spawning areas | VL (2) | L (2) | Low Risk Mean = 1.33 | | |
| A.l.b. Spatial extent or range of population | L (1) | L (1) | | | |
| A.1.c. Increase or decrease in gaps or continuities between spawning areas | L (1) | L (1) | | | |
| B.1.a. Major life history strategies | M (0) | M (0) | Moderate Risk | | |
| B.1.b. Phenotypic variation | M (0) | M (0) | | | |
| B.1.c. Genetic variation | L (1) | L (1) | | | |
| B.2.a. (1) Out-of-DPS spawners | L (1) | Low Risk (1) | Low Risk (1) | | |
| B.2.a. (2) Out-of-MPG spawners | L (1) | | | | |
| B.2.a. (3) Out-of-Population spawners | VL (2) | | | | |
| B.2.a. (4) Within-population hatchery spawners | L (1) | | | | |
| B.3.a. Distribution of population across habitat types | L (1) | L (1) | L (1) | | |
| B.4.a. Selective change in natural processes or selective impacts | H (-1) | H (-1) | H (-1) | | |

Under Goal B, risk is elevated with respect to life history strategies and phenotypic variation, because of flow regulation, including the “flip-flop” water management strategy, affecting rearing conditions in the main stem below the Tieton River. Migration timing constraints in the lower Naches and the lower Yakima, and the aforementioned loss of rearing habitat in the lower Naches, both hamper mainstem rearing strategies and result in high risk with respect to the selective impacts metric.

The status relative to goal B could be improved by addressing phenotypic variation, beginning with a more detailed evaluation of spawning and rearing timing to evaluate the relative change in phenotypic characteristics for the population and the factors driving the shifts. If further analysis confirms a significant shift in phenotypic characteristics relative to the assumed historical condition or with comparable unaltered reference populations, restoration actions should be initiated. The status rating could also be improved by evaluating detrimental selective impacts of activities affecting within-basin passage, and reducing those impacts if warranted. Based on the ICTRT scoring system, this metric must be addressed in order for the status of goal B to improve to low risk.

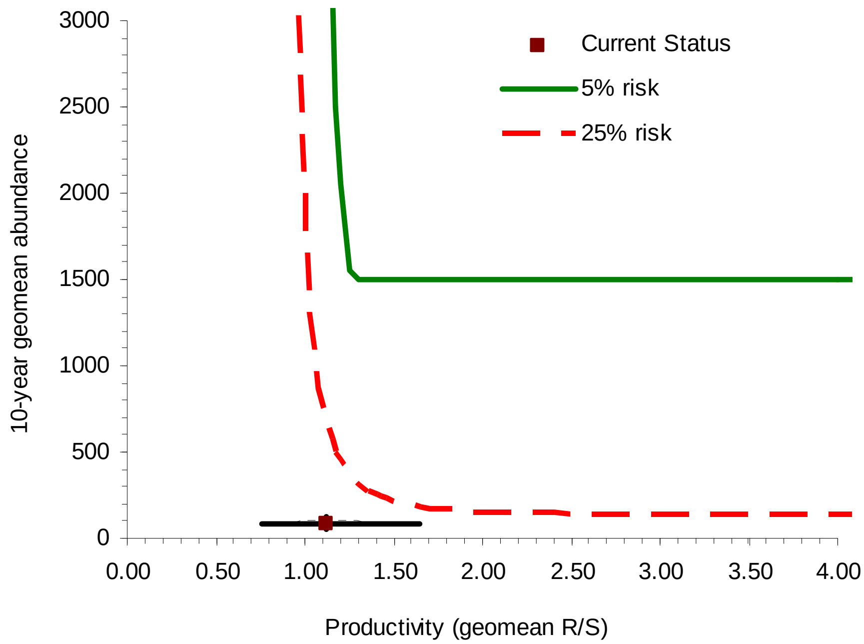
Overall, the Naches River steelhead population is not considered viable under the ICTRT guidelines—both abundance/productivity and spatial structure/diversity elements indicate moderate risk. To achieve viable status, the abundance of the population must be increased sufficiently to maintain the population above the minimum threshold escapement of 1500 spawners. To achieve very low risk status (high viability) those improvements in abundance would need to be accompanied by the changes in spatial structure and diversity described above.

### 2.6.4 Upper Yakima Population

**Abundance and Productivity**

The ICTRT classified the Upper Yakima River steelhead population as “Large” in size based on historical habitat potential analysis (ICTRT 2007). This classification requires a minimum abundance threshold of 1500 wild spawners with sufficient productivity (greater than 1.26 returns per spawner at the abundance threshold) to avoid a 5% extinction risk on the ICTRT’s viability curve. With a 10-year (1996 to 2005) geomean abundance of 85 and a delimited/adjusted productivity value of 1.12 returns per spawner, the Upper Yakima River steelhead population is deemed to be at high risk of extinction, i.e., below the 25% risk line for a large-size population (Figure 2.15).

**Figure 2.15: Upper Yakima abundance & productivity compared to viability curve**




Curve is for a large-sized population. The point estimate includes a 1 standard error ellipse and 95% confidence intervals (1.81 x SE for both productivity and abundance estimates).

## Spatial Structure and Diversity

Table 2.25 summarizes spatial structure and diversity risk assessment scores. The ICTRT placed the Upper Yakima River steelhead population at moderate risk for Goal A, which covers spatial structure factors, and high risk for Goal B, which covers genetic and phenotypic diversity. Using the lower score for the two goals gives the population an overall spatial structure and diversity risk rating of high.

**Table 2.25: ICTRT spatial structure & diversity ratings for Upper Yakima population**

| Metric | Risk Assessment Scores | | | | |
|---|---|---|---|---|---|
| | Metric | Factor | Mechanism | Goal | Population |
| A.1.a Number and spatial arrangement of spawning areas | L (1) | L (1) | Moderate Risk (Mean = 0) | Moderate Risk | High Risk |
| A.l.b. Spatial extent or range of population | M (0) | M (0) | | | |
| A.1.c. Increase or decrease in gaps or continuities between spawning areas | H (-1) | H (-1) | | | |
| B.1.a. Major life history strategies | H (-1) | H (-1) | High Risk | High Risk | |
| B.1.b. Phenotypic variation | M (0) | M (0) | | | |
| B.1.c. Genetic variation | H (-1) | H (-1) | | | |
| B.2.a. (1) Out-of-DPS spawners | NA | Low Risk | Low Risk | | |
| B.2.a. (2) Out-of-MPG spawners | NA | | | | |
| B.2.a. (3) Out-of-Population spawners | NA | | | | |
| B.2.a. (4) Within-population hatchery spawners | VL (2) | | | | |
| B.3.a. Distribution of population across habitat types | L (1) | L (1) | L (1) | | |
| B.4.a. Selective change in natural processes or selective impacts | H (-1) | H (-1) | H (-1) | | |

Under Goal A, extinction risk is elevated with respect to spatial extent or range and increase in gaps between spawning areas. Of the 14 MSAs, only seven are judged to have steelhead spawning in both their upper and lower portions (the ICTRT standard for occupancy). Another four MSAs are occupied in their lower portions only, and significant gaps exist between spawning areas.

Under Goal B, risk is elevated with respect to life history strategies and phenotypic variation, because of flow regulation, including the “flip-flop” water management strategy, affecting rearing conditions in the mainstem and because of curtailment of presmolt migration within and between tributaries. Migration timing constraints in the lower Yakima, long migration distances coupled with past and present constraints on passage at Roza Dam, and the aforementioned loss of rearing habitat in the mainstem both hamper mainstem rearing strategies and result in high risk with respect to the selective impacts metric.

Overall, the Upper Yakima River steelhead population is not considered viable under the ICTRT guidelines—both abundance/productivity and spatial structure/diversity elements indicate high risk of extinction. The ICTRT concludes that improving the overall rating to Viable will require substantial improvements in current abundance and productivity relative to the recent base period. Improved passage at Roza Dam and into Taneum and Big creeks was only recently restored (post 1988), and further improvements in survival and in habitat availability (including provision of access into currently blocked areas) will likely be required to meet overall abundance and productivity objectives for this population. Key improvements in spatial/structure and diversity (described above) will also be required.

# 3 Factors for Decline



## 3.1 Introduction

This chapter gives an overview of the factors that have contributed to the decline in steelhead populations identified in Chapter 2. To provide a context for the actions presented in Chapter 5, this chapter discusses the threats and limiting factors currently affecting the four steelhead populations in the Yakima Basin. Chapter 3 does not give a reach-by-reach assessment of habitat conditions and limiting factors for Yakima Basin steelhead habitat. More detailed reach-specific assessments can be found in the habitat assessment portions of the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005) and the Limiting Factors Analysis conducted for the Washington State Conservation Commission (Haring 2001); numerous other watershed assessments give information for specific geographic areas. These more detailed assessments will be incorporated into the implementation scheduling process described in Chapter 6.

### 3.1.1 General Overview of Steelhead Population Decline

Salmon, and trout recolonized and expanded their range in the Columbia River Basin after the most recent Ice Age (10,000-15,000 years ago). Native Americans had access to an abundant fish resource comprised of coho, chum, and sockeye salmon, spring, summer, and fall runs of Chinook, steelhead, bull trout, cutthroat trout, Pacific lamprey, and white sturgeon. Their cultures were formed around the availability of anadromous fish (Craig and Hacker 1940), with catches increasing as their populations rose and fishing techniques developed. Estimates of pre-development (late 1700s) abundance of Columbia River salmon and steelhead ranged from about 8 million (Chapman 1986) to 14 million (NPPC 1986) fish.[27] While questions exist about the degree of cyclic variations in freshwater and ocean habitat conditions, it is quite certain that salmon and steelhead have declined to a small fraction of their former abundance and distribution (NRC 1996, Figure 3-2). In recent decades, the total run of all salmon and steelhead has ranged from one to two million fish, with about three-quarters of the recent spring Chinook and summer steelhead runs consisting of fish cultured to smolt size in hatcheries. The overall decline of anadromous fish runs in the Columbia Basin has been reviewed extensively (Busby et al. 1996; Lichatowich 1999; Nehlsen et al. 1991; NPPC 1986; NRC 1996).

---

[27] Estimates of pre-development salmon and steelhead numbers are based on multiplying the maximum catches in the latter part of the 1800s (which reached 3-4 million salmon and steelhead) with the assumed catch rates by all fishing gear.

The decline of salmon and steelhead in the Yakima Basin occurred in two major phases. During the first phase, between 1850 and roughly 1900, Yakima runs declined about 90% from historical values (Davidson 1953; Lichatowich 1999; Tuck 1995). Initial causes of decline include diversion of instream flows into unscreened watercourses for irrigation (Lichatowich 1999; Tuck 1995) and over-harvest in early mainstem fisheries. In the second phase, covering the years 1900 to the present, native sockeye (*O. nerka*), coho (*O. kisutch*), and summer Chinook were extirpated and the abundance of the other stocks fell to small fractions of historical values. The construction of dams to convert natural glacial lakes into storage reservoirs early in the twentieth century blocked off many miles of spawning and rearing habitat and, along with reduced flows and increased temperatures in the lower Yakima, led to the extinction of native sockeye salmon. Reservoir and diversion operations cut off access to headwater streams and significantly changed flow and temperature regimes downstream, resulting in reductions in spawning, rearing, and migratory habitat quality and quantity. Unscreened diversions are known to have stranded large numbers of fish. While a long history of fish screening programs has greatly reduced extent of such stranding, many unscreened diversions remain. Irrigation diversions reduced flows, sometimes to the point of drying out specific stream reaches. Irrigation drains have severely impacted water quality in some tributaries and in the lower Yakima River, (although recently many components of some irrigation effluents have been reduced).

Development of the Columbia River dams also had a large impact on anadromous fish runs by reducing survival rates for upstream and downstream migrants. Steelhead are able to return to the sea after spawning and then travel upstream to spawn again. The degree to which repeat spawners contributed to the productivity of Yakima Basin steelhead populations prior to European settlement is unknown, but is presumed depressed from historic levels due to general changes in habitat and the development and operation of the Columbia River hydropower system. Early hatcheries constructed to mitigate for fish loss at mainstem dams were operated without a clear understanding of population genetics. Although hatcheries were increasing the abundance of depleted stocks, they were probably also decreasing the diversity of the native populations with which they overlapped.

Human population growth and associated land uses within the basin (agriculture, mining, timber harvest, transportation systems, and urban and rural development) have significantly affected salmon and trout spawning and rearing habitat. The National Research Council Committee on Protection and Management of Pacific Northwest Anadromous Salmonids identified habitat problems as a primary cause of declines in wild salmon runs (ISAB 1996; ISAB 2000; NRC 1996). They identified the fragmentation and loss of available spawning and rearing habitat, migration delays, degradation of water quality, removal of riparian vegetation, decline of habitat complexity, alteration of stream flows and stream bank and channel morphology, alteration of ambient stream water temperatures, sedimentation, and loss of spawning gravel, pool habitat and large woody debris.

Floodplain development has degraded floodplain and channel function. Portions of the Yakima River and its tributaries have been detached from their historical floodplains, impairing floodplain function, reducing access to off-channel habitats, and reducing flow and elevating temperatures. Urbanization (especially in alluvial floodplains) and livestock grazing practices have altered riparian habitat (Busby et al. 1996; NMFS 1996; Washington Department of Fisheries et al. 1993; West Coast Steelhead Biological Review Team 1999). Exotic species introductions have directly and indirectly affected steelhead. All these activities (harvest, hydropower, hatcheries, and habitat, both within and outside of the Yakima Basin) acted in concert to decrease the abundance, productivity, spatial structure, and diversity of steelhead populations in the Yakima Basin.

The 2004 Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005) and the Yakima River Habitat Limiting Factors Analysis for the Yakima (Haring 2001) describe, in some detail, the array of habitat modifications that currently affect the quantity and quality of salmonid habitat within the Yakima Basin. Although land and water management practices have typically improved in recent decades, factors such as storage dams, diversions, roads and railways, agriculture (including livestock grazing), residential development, and forest management all continue to affect steelhead and their habitat in the Yakima Basin.

### 3.1.2 Ongoing Efforts to Address the Decline of Steelhead

Changing land-use practices have reduced some threats to steelhead and increased others. Many activities that address threats and reverse the long-term decline of steelhead in the Yakima Basin have been initiated at the federal, state, and local levels (e.g., restrictive harvest regulations, habitat improvement projects, adoption of various land management rules, and development of conservation strategies and plans). Appendix C gives an overview of some of the major fish restoration programs in the Yakima Basin. While these efforts are important to the conservation and recovery of ESA-listed species, additional work is needed to minimize current threats to recovery. Chapter 5 proposes specific actions to be taken to recover steelhead populations. The remainder of Chapter 3 addresses the threats and limiting factors that currently affect steelhead populations in the Yakima Basin. This provides a context for understanding the purpose for actions proposed in Chapter 5.

## 3.2 Definition of Threats and Limiting Factors

### 3.2.1 Threats

Section 4(a) (1) of the Endangered Species Act of 1973 lists five sets of threats to consider when determining species status under the ESA. These listing factors are: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) over-utilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. Historical and current human activities associated with these five factors—especially habitat-related factors—have negatively affected steelhead in the Yakima Basin to the point that they were listed under the ESA, as described in Chapter 1. The National Marine Fisheries Service (1996) listed a number of habitat-related factors affecting the Middle Columbia River Steelhead

ESU and the Yakima Basin that led to the 1999 listing. They included water withdrawal, conveyance, and storage, flood control, logging, agriculture, mining, road building, and urbanization. Their list closely corresponds to the definition of threats used in this document.

The ESA describes the human and naturally induced actions that have resulted in the decline of steelhead populations as threats. According to NMFS' Draft Guidelines for Limiting Factors and Threats Assessment (2005):

> Threats are the human actions or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, and volcanoes) that cause or contribute to limiting factors. Threats may be caused by the continuing results of past events and actions as well as by present and anticipated future events and actions.

While the term "threats" carries a negative connotation, it does not mean that activities identified as threats are inherently undesirable. They are typically legitimate and necessary human activities that may at times have unintended negative consequences on fish populations—and that can also be managed in a manner that minimizes or eliminates these negative impacts.

### 3.2.2 Limiting Factors

Limiting factors are the specific changes in conditions through which threats affect the abundance, productivity, spatial distribution, and diversity of the species of concern (NMFS 2005). Limiting factors are characterized in relation to the biological needs of the species. According to NMFS' Draft Guidelines for Limiting Factors and Threats Assessment (2005):

> Limiting factors are the physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish at the population, intermediate (e.g., stratum or major population grouping), or ESU-levels that result in reductions in VSP parameters (abundance, productivity, spatial structure, and diversity) at any life stage. Key limiting factors are those with the greatest impacts on a population's ability to reach its desired status.

Table 3.1, Table 3.2, Table 3.3, Table 3.4, Table 3.5 and Table 3.6 list the threats and associated limiting factors identified by recovery planners in the Yakima Basin. Sections 3.3.1 thru 3.3.6 describe these in more detail for each population area. NOAA Fisheries has identified 12 basic limiting factors that affect the viability of Middle Columbia Steelhead populations, as described below:

1) **Degraded floodplain connectivity and function:** The loss, impairment, or degradation of floodplain connectivity; access to previously available habitats (seasonal wetlands, off-channel habitat, side channels); and a connected and functional hyporheic zone.

2) **Degraded channel structure and complexity:** The loss, impairment, or degradation of channels; a suitable distribution of riffles and functional pools; functional amounts and sizes of large woody debris or other channel structure.

3) **Degraded riparian areas and LWD recruitment:** Factor includes loss, degradation or impairment of riparian conditions important for production of food organisms and organic material, shading, bank stabilizing by roots, nutrient and chemical mediation, control of surface erosion, and production of large-sized woody material.

4) **Altered hydrology:** Changes in the hydrograph that alter the natural pattern of flows over the seasons, causing inadequate flow, scouring flow, or other flow conditions that inhibit the development and survival of salmonids.

5) **Degraded water quality:** Degraded or impaired water quality due to abnormal temperature, or levels of suspended fine sediment, dissolved oxygen, nutrients, heavy metals, pesticides, herbicides and other contaminants (toxics).

6) **Altered sediment routing:** Altered sediment routing leading to an overabundance of fine-grained sediments, excess of course-grained sediments, inadequate course-grained sediments, and/or contaminated sediment.

7) **Impaired fish passage:** The total or partial human-caused blockage to previously accessible habitat that eliminates or decreases migration ability or alters the range of conditions under which migration is possible. This may include seasonal or periodic total migration blockage.

8) **Hatchery-related adverse effects:** Any hatchery-related adverse effects on natural-origin salmonid population survival and productivity.

9) **Harvest-related adverse effects:** Any harvest-related adverse effects on survival.

10) **Predation/Competition/Disease:** Predation or competition levels that have been elevated above likely rates in a normative system due to human actions.

11) **Degraded estuarine and nearshore marine habitat:** The loss, impairment or degradation of intertidal, salt marsh, and other functional estuarine and marine vegetation; altered amounts, quality, distribution, and timing of freshwater inflows; loss of estuary complexity; access to previously available habitats; and inadequate large woody debris.

12) **Mainstem Columbia River hydropower-related adverse effects:** Any adverse effects caused by the operation of hydroelectric dams in the mainstem Columbia and Snake rivers.

Table 3.1, Table 3.2, Table 3.3, Table 3.4, Table 3.5 and Table 3.6 show the correspondence between the limiting factors used in this plan and these more general limiting factors from NOAA Fisheries. For more details on NOAA Fisheries' limiting factors and their application to the Middle Columbia River Steelhead DPS, see the Middle Columbia Steelhead Recovery Plan (to be released in 2009).

**Table 3.1: Basinwide threats and limiting factors**

| ***Basinwide Threats and Limiting Factors*** | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Regulation of stream flow for irrigation storage and flood control | 1 | Inadequate migration flow because of irrigation storage or flood control headspace targets | Flow | 4) Altered hydrology | BW1,3,4,5 |
| | 2 | Altered hydrograph affects riparian and submerged vegetation | Flow | 4) Altered hydrology<br>3) Degraded riparian area & LWD recruitment | BW1,3,4,<br>5,12 |
| Water storage and diversion structures | 3 | Entrainment, injury or delay of downstream migrants at diversions | Withdrawals (entrainment), Obstructions | 7) Impaired fish passage | BW2,6 |
| Forest harvest practices, road construction and fire suppression | 4 | Increased risk and severity of forest disease, pests and land-scape scale fire | Sediment load, Flow | 4) Altered hydrology<br>6) Altered sediment routing | BW13 |
| Climate variation and trends | 5 | Drought worsens effects of other threats on adult spawning success and juvenile survival | Flow, Temperature, Key habitat quantity | 4) Altered hydrology<br>5) Degraded water quality | |
| In-basin Harvest | 6 | Incidental take in legal fisheries | Harassment | 9) Harvest-related adverse effects | BW14 |
| | 7 | Illegal harvest of steelhead | Harassment | 9) Harvest-related adverse effects | BW14 |

| Basinwide Threats and Limiting Factors | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Ecological Legacy | 8 | Slow recolonization of reopened habitats by small populations | NONE | NONE | BW6,7 |
| | 9 | Lack of nutrients in rearing areas | Food | 5) Degraded water quality | BW8,15 |
| | 10 | Reduction of beaver activity | Channel stability, Flow | 4) Altered hydrology<br>2) Degraded channel structure & complexity | BW11 |

**Table 3.2: Lower mainstem Yakima threats and limiting factors**

| *Lower Mainstem Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limited Factors** | **Actions** |
| Withdrawal of stream flow for irrigation and hydropower | 1 | Inadequate migration flow below diversions | Flow | Altered hydrology | LM2,5,7 |
| | 2 | Loss of habitat quantity and diversity below diversions | Flow | Altered hydrology | LM2,5,7 |
| | 3 | Increased summer water temperature below diversions | Temperature | Degraded water quality | LM7 |
| Conveyance of irrigation deliveries and return flow in streams | 4 | High temperature, sediment and other pollutants in summer flow | Temperature, Sediment load, Chemicals | Degraded water quality<br>Altered sediment routing | LM2,9 |
| | 5 | False attraction due to high flow and/or mixing of sources | Flow | Altered hydrology | LM2,9 |
| Water storage and diversion structures | 6 | Entrainment, injury or delay of downstream migrants at diversions | Withdrawals (entrainment), Obstructions | Impaired fish passage | LM3 |
| Floodplain constriction and development | 7 | High water temperature, low flow in summer due to floodplain storage loss | Temperature, Flow | Altered hydrology<br>Degraded water quality | LM7 |
| | 8 | Degraded riparian vegetation needed for shade, bank stability and food | Habitat diversity | Degraded riparian area & LWD recruitment | LM6,7 |

| Lower Mainstem Threats and Limiting Factors | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limited Factors** | **Actions** |
| | 9 | Reduced availability of woody debris in the channel and floodplain | Key habitat quantity | Degraded riparian area & LWD recruitment | LM6,7 |
| | 10 | Simplified, degraded, and/or unstable stream channels | Channel stability, Key habitat quantity | Degraded channel structure & complexity | LM6 |
| | 11 | Reduced quantity and/or quality of side channel habitat | Habitat diversity, Key habitat quantity | Degraded floodplain connectivity & function | LM6,7 |
| Management of Gravel Pits | 12 | Increased habitat for predatory and exotic fish | Predation, Competition (with other species) | Predation/Competition/Disease | BW10 |
| | 13 | River capture creating channel instability and raising water temperature | Channel stability, Temperature | Degraded channel structure & complexity<br>Degraded water quality<br>Altered sediment routing | BW10 |
| Non-native fish species | 14 | Predation by bass and catfish | Predation | Predation/Competition/Disease | LM3,7, BW16 |
| Native predatory fish species | 15 | Increased predation by northern pikeminnow | Predation | Predation/Competition/Disease | LM3,7, BW16 |
| Predatory birds and mammals | 16 | Increased predation by gulls and pelicans, especially at inriver structures | Predation | Predation/Competition/Disease | LM3,7 |

**Table 3.3: Satus population area threats and limiting factors**

| ***Satus Threats and Limiting Factors*** | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Conveyance of irrigation deliveries and return flow in streams | 1 | High temperature, sediment and other pollutants in summer flow | Temperature, Sediment load, Chemicals | Degraded water quality<br>Altered sediment routing | S3,4 |
| Water storage and diversion structures | 2 | Upstream migration blockages or delays at diversions | Obstructions | Impaired fish passage | S5 |
| Floodplain constriction and development | 3 | High water temperature, low flow in summer due to floodplain storage loss | Temperature, Flow | Altered hydrology<br>Degraded water quality | S1 |
| | 4 | Simplified, degraded, and/or unstable stream channels | Channel stability, Key habitat quantity | Degraded channel structure & complexity | S1 |
| | 5 | Reduced quantity and/or quality of side channel habitat | Habitat diversity, Key habitat quantity | Degraded floodplain connectivity & function | S1 |
| Forest harvest practices, road construction and fire suppression | 6 | Impassable and/or unstable stream crossings | Obstructions, Channel stability | Impaired fish passage<br>Degraded channel structure & complexity | S6 |

| ***Satus Threats and Limiting Factors*** | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| | 7 | Loss of riparian, floodplain and wetland function due to tree harvest and road building | Habitat diversity, Flow | Altered hydrology<br>Degraded riparian area & LWD recruitment | S7 |
| | 8 | Acceleration and degradation of runoff (sediment, high summer temperature) by road and skid trail drainage | Sediment load, Temperature | Altered sediment routing<br>Degraded water quality | S7 |
| Grazing Impacts | 9 | Damage to stream channels, banks and riparian zones | Channel stability, Habitat diversity | Degraded channel structure & complexity<br>Degraded riparian area & LWD recruitment | S2 |
| | 10 | Sedimentation of streams | Sediment load | Altered sediment routing | S2 |
| | 11 | High water temperature, low flow in summer due to wet meadow storage loss | Temperature, Flow | Altered hydrology<br>Degraded water quality | S8 |

**Table 3.4: Toppenish population area threats and limiting factors**

| ***Toppenish Threats and Limiting Factors*** | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Withdrawal of stream flow for irrigation and hydropower | 1 | Loss of habitat quantity and diversity below diversions | Flow | Altered hydrology | T5 |
| | 2 | Increased summer water temperature below diversions | Temperature | Degraded water quality | T5 |
| Conveyance of irrigation deliveries and return flow in streams | 3 | High temperature, sediment and other pollutants in summer flow | Temperature, Sediment load, Chemicals | Degraded water quality<br>Altered sediment routing | T2,6 |
| | 4 | False attraction due to high flow and/or mixing of sources | Flow | Altered hydrology | T6 |
| | 5 | Stream channel modifications to convey irrigation or return flow | Channel stability, Habitat diversity, Key habitat quantity | Degraded channel structure & complexity | T1,6 |
| Water storage and diversion structures | 6 | Entrainment, injury or delay of downstream migrants at diversions | Withdrawals (entrainment), Obstructions | Impaired fish passage | T4 |
| Floodplain constriction and development | 7 | High water temperature, low flow in summer due to floodplain storage loss | Temperature, Flow | Altered hydrology<br>Degraded water quality | T1,2 |
| | 8 | Degraded riparian vegetation needed for shade, bank stability and food | Habitat diversity | Degraded riparian area & LWD recruitment | T7 |

| *Toppenish Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| | 9 | Reduced availability of woody debris in the channel and floodplain | Key habitat quantity | Degraded riparian area & LWD recruitment | T1 |
| | 10 | Simplified, degraded, and/or unstable stream channels | Channel stability, Key habitat quantity | Degraded channel structure & complexity | T1 |
| | 11 | Reduced quantity and/or quality of side channel habitat | Habitat diversity, Key habitat quantity | Degraded floodplain connectivity & function | T1 |
| Forest harvest practices, road construction and fire suppression | 12 | Impassable and/or unstable stream crossings | Obstructions, Channel stability | Impaired fish passage<br>Degraded channel structure & complexity | T3,4 |
| | 13 | Loss of riparian, floodplain and wetland function due to tree harvest and road building | Habitat diversity, Flow | Degraded riparian area & LWD recruitment<br>Degraded floodplain connectivity & function | T8 |
| | 14 | Acceleration and degradation of runoff (sediment, high summer temperature) by road and skid trail drainage | Sediment load, Temperature | Degraded water quality<br>Altered sediment routing | T8 |
| Livestock grazing | 15 | Damage to stream channels, banks and riparian zones | Channel stability, Habitat diversity | Degraded channel structure & complexity<br>Degraded riparian area & LWD recruitment | T10 |

| ***Toppenish Threats and Limiting Factors*** | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| | 16 | Sedimentation of streams | Sediment load | Altered sediment routing | T9 |
| | 17 | High water temperature, low flow in summer due to wet meadow storage loss | Temperature, Flow | Altered hydrology Degraded water quality | T10 |
| | 18 | Stock water diversions during low stream flow periods | Flow, Temperature | Altered hydrology Degraded water quality | T5 |

**Table 3.5: Naches population area threats and limiting factors**

| *Naches Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Regulation of stream flow for irrigation storage and flood control | 1 | Inadequate migration flow below reservoirs because of irrigation storage or flood control headspace targets | Flow | Altered hydrology | N30, BW1 |
| | 2 | Low June-August and high Sept-Oct flows below reservoirs | Flow | Altered hydrology | N4 |
| Withdrawal of stream flow for irrigation and hydropower | 3 | Loss of habitat quantity and diversity below diversions | Flow | Altered hydrology | N1,2,3,4,15,17,21,24,25,26, BW5 |
| | 4 | Increased summer water temperature below diversions | Temperature | Degraded water quality | N1,2,3,4,15,17,21,24,25,26, BW5 |
| Conveyance of irrigation deliveries and return flow in streams | 5 | Stream channel modifications to convey irrigation or return flow | Channel stability, Habitat diversity, Key habitat quantity | Degraded channel structure & complexity | |
| Water storage and diversion structures | 6 | Migration blockages at storage dams | Obstructions | Impaired fish passage | N9 |
| | 7 | Upstream migration blockages or delays at diversions | Obstructions | Impaired fish passage | N16 |

| *Naches Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| | 8 | Coarse sediment deficiency below storage dams | Key habitat quantity | Altered sediment routing | |
| Floodplain constriction and development | 9 | High water temperature, low flow in summer due to floodplain storage loss | Temperature, Flow | Altered hydrology Degraded water quality | N5,10,11,12, 19,20,28 |
| | 10 | Simplified, degraded, and/or unstable stream channels | Channel stability, Key habitat quantity | Degraded channel structure & complexity | N10,11,12,14, 20,27,28 |
| | 11 | Reduced quantity and/or quality of side channel habitat | Habitat diversity, Key habitat quantity | Degraded floodplain connectivity & function | N5,10,11,12, 19,20, 27,28 |
| | 12 | Channel aggradation upstream from constrictions | Obstructions | Impaired fish passage | N6,18,20 |
| | 13 | Impassable and/or unstable stream crossings | Obstructions, Channel stability | Impaired fish passage Degraded channel structure & complexity | |

| *Naches Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Forest harvest practices, road construction and fire suppression | 14 | Loss of riparian, floodplain and wetland function due to tree harvest and road building | Habitat diversity, Flow | Degraded riparian area & LWD recruitment Degraded floodplain connectivity & function | N7,8,14,22,23 |
| | 15 | Acceleration and degradation of runoff (sediment, high summer temperature) by road and skid trail drainage | Sediment load, Temperature | Altered sediment routing Degraded water quality | N8 |
| | 16 | Loss of forest cover needed to moderate snowmelt | Flow | Altered hydrology | BW10,13 |
| | 17 | Increased risk and severity of forest disease, pests and landscape-scale fire | Sediment load, Flow | Altered hydrology Altered sediment routing | N23, BW10,13 |
| Livestock grazing | 18 | Damage to stream channels, banks and riparian zones | Channel stability, Habitat diversity | Degraded channel structure & complexity Degraded riparian area & LWD recruitment | N22,29 |

| ***Naches Threats and Limiting Factors*** | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| | 19 | Sedimentation of streams | Sediment load | Altered sediment routing | N22,29 |
| Streamside recreation | 20 | Damage to stream channels, banks and riparian zones | Channel stability, Habitat diversity | Degraded channel structure & complexity Degraded riparian area & LWD recruitment | N13 |
| | 21 | Disturbance of spawning fish and redds | Harassment | NONE | N13 |
| "Ecological Legacy" | 22 | Slow recolonization of reopened habitats by small populations | | NONE | BW7 |

**Table 3.6: Upper Yakima population area threats and limiting factors**

| ***Upper Yakima Threats and Limiting Factors*** | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Regulation of stream flow for irrigation storage and flood control | 1 | High June-August flow below reservoirs | Flow | Altered hydrology | U3 |
| | 2 | Unstable and/or low Winter-Spring flows below diversions | Flow | Altered hydrology | U21 |
| Withdrawal of stream flow for irrigation and hydropower | 3 | Inadequate migration flow below diversions | Flow | Altered hydrology | U2 |
| | 4 | Loss of habitat quantity and diversity below diversions | Flow | Altered hydrology | U4 |
| | 5 | Increased summer water temperature below diversions | Temperature | Degraded water quality | U4,5,BW5 |
| Conveyance of irrigation deliveries and | 6 | High summer flow in delivery reaches | Flow | Altered hydrology | U3,11 |

| *Upper Yakima Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| return flow in streams | 7 | High temperature, sediment and other pollutants in summer flow | Temperature, Sediment load, Chemicals | Degraded water quality<br>Altered sediment routing | U19 |
| Water storage and diversion structures | 8 | Migration blockages at storage dams | Obstructions | Impaired fish passage | U8 |
| | 9 | Upstream migration blockages or delays at diversions | Obstructions | Impaired fish passage | U1,5,6,7,9 |
| Floodplain constriction and development | 10 | High water temperature, low flow in summer due to floodplain storage loss | Temperature, Flow | Altered hydrology<br>Degraded water quality | U12,14,15 |
| | 11 | Degraded riparian vegetation needed for shade, bank stability and food | Habitat diversity | Degraded riparian area & LWD recruitment | U15 |

| *Upper Yakima Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| | 12 | Reduced availability of woody debris in the channel and floodplain | Key habitat quantity | Degraded riparian area & LWD recruitment | U13,14 |
| | 13 | Simplified, degraded, and/or unstable stream channels | Channel stability, Key habitat quantity | Degraded channel structure & complexity | U11,12,13, 14,15 |
| | 14 | Reduced quantity and/or quality of side channel habitat | Habitat diversity, Key habitat quantity | Degraded floodplain connectivity & function | U12,13,15 |
| | 15 | Impassable and/or unstable stream crossings | Obstructions, Channel stability | Impaired fish passage<br>Degraded channel structure & complexity | |

| *Upper Yakima Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Watershed Development | 16 | Changes in timing and amount of stream flows due to altered upland runoff patterns (locally variable effects due to impervious areas, irrigation return flows etc.) | Flow, Temperature | Altered hydrology<br>Degraded water quality | U15,16,17<br>BW10 |
| | 17 | Stormwater runoff and associated water quality degradation | Sediment load, Chemicals | Degraded water quality<br>Altered sediment routing | U16,17,19,BW10 |
| Management of Gravel Pits | 18 | Increased habitat for predatory and exotic fish | Predation, Competition (with other species) | Predation/Competition/Disease | BW10 |
| | 19 | River capture creating channel instability and raising water temperature | Channel stability, Temperature | Degraded channel structure & complexity<br>Degraded water quality | U13,<br>BW10 |

| *Upper Yakima Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Forest harvest practices, road construction and fire suppression | 20 | Impassable and/or unstable stream crossings | Obstructions, Channel stability | Impaired fish passage<br>Degraded channel structure & complexity | U10 |
| | 21 | Loss of riparian, floodplain and wetland function due to tree harvest and road building | Habitat diversity, Flow | Degraded riparian area & LWD recruitment<br>Degraded floodplain connectivity & function | U13,18<br>BW10 |
| | 22 | Acceleration and degradation of runoff (sediment, high summer temperature) by road and skid trail drainage | Sediment load, Temperature | Altered hydrology<br>Degraded water quality | U18, BW10 |
| | 23 | Loss of forest cover needed to moderate snowmelt | Flow, Temperature | Altered hydrology<br>Degraded water quality | U18, BW10,13 |

| *Upper Yakima Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| Livestock grazing | 24 | Damage to stream channels, banks and riparian zones | Channel stability, Habitat diversity | Degraded channel structure & complexity<br>Degraded riparian area & LWD recruitment | U14 |
| | 25 | Sedimentation of streams | Sediment load<br>Temperature | Altered sediment routing<br>Degraded channel structure & complexity | |
| | 26 | High water temperature, low flow in summer due to wet meadow storage loss | Temperature, Flow | Altered hydrology<br>Degraded water quality | U20 |
| | 27 | Stock water diversions during low stream flow periods | Flow, Temperature | Altered hydrology<br>Degraded water quality | |
| Streamside Recreation | 28 | Damage to stream channels, banks and riparian zones | Channel stability, Habitat diversity | Degraded channel structure & complexity<br>Degraded riparian area & LWD recruitment | |
| | 29 | Disturbance of spawning fish and redds | Harassment | NONE | |

| *Upper Yakima Threats and Limiting Factors* | | | | | |
|---|---|---|---|---|---|
| **Threat** | **#** | **Limiting Factor** | **Level 3 EDT Survival Factors** | **NOAA Limiting Factors** | **Actions** |
| | 30 | Blockage of fish migration | Obstructions | Impaired fish passage | |
| "Ecological Legacy" | 31 | Slow recolonization of reopened habitats by small populations | NONE | NONE | BW7 |

### 3.2.3 Relationships of Threats to Limiting Factors

The relationship between threats and limiting factors can be complex, with a single threat affecting many limiting factors, and a single limiting factor being a function of many interacting threats. Sections 3.5.1 to 3.5.6 describe the interaction of threats and limiting factors that affect the basin as a whole, the shared migration corridor of the lower mainstem and the four population areas. Section 3.6 gives a brief overview of threats and limiting factors acting on Yakima Basin steelhead during their time outside of the Yakima Basin.

## 3.3 In-Basin Threats and Limiting Factors

The following sections describe the threats and limiting factors that occur throughout the basin, in the Lower Yakima River, and in the four population areas—Satus Creek, Toppenish Creek, Naches River and Upper Yakima.

### 3.3.1 Basinwide Threats and Limiting Factors

See Table 3.1. for a compilation of basinwide threats and limiting factors, which are also linked to the recovery actions described in Chapter 5, Recovery Actions.

**Basinwide Effects of Changed Flow Regimes**

In the Yakima Basin, water is an essential resource. Since the 1850s, extensive water supply systems have been developed to store and deliver water to irrigated agriculture and, to a lesser degree, to industrial, domestic, and hydropower users. This has made the Yakima Basin one of the most productive agricultural regions in the United States and the world. The federal government authorized the Yakima Irrigation Project in 1905. This brought a number of private irrigation projects under the jurisdiction of the BOR and resulted in construction of five storage reservoirs that enabled expansion of irrigated acreage to 464,000 acres in six divisions. Lands irrigated under the Project extend from Cle Elum to the Tri-Cities. There are six major diversion dams (Easton, Roza, Tieton, Wapato, Sunnyside, and Prosser), 420 miles of canals, 1,697 miles of laterals, 30 pumping plants, and 144 miles of drains. Generators served by Roza and Chandler canals produce hydroelectric power ((BOR 2002), and a generator was installed at Tieton Dam in 2006. The Wapato Irrigation Project diverts its water from the river just below Union Gap to serve 136,000 acres of irrigated lands on the Yakama Reservation. Water delivery and storage systems in the basin range from these larger systems to small ditches on tributaries owned and managed by one or two private landowners. Many tributaries have been converted into irrigation distribution systems, such as the Wilson/Naneum Creek system in the Kittitas Valley, or drainage systems such as lower Toppenish Creek and Marion Drain.

These diverse systems are an essential part of the basin's economy, past, and present. They have also had significant impacts on fish populations in the basin. Managing water supply and delivery systems in a manner that meets economic needs while minimizing negative impacts on fish populations is one of the principal challenges faced in recovering steelhead populations. There have been many efforts to lessen the impact of this infrastructure on fish—improved screening, improvements in water use efficiency, reconstruction for improved or restored passage—but the infrastructure itself has remained in place and expanded over time. Additional changes in the configuration of infrastructure—the function and location of storage dams, delivery and return points for irrigation water conveyance, delivery, and routing of water—are required to address the impacts of the altered flow regimes (see Chapter 5).

Adequate flows are necessary for migrating adult steelhead to pass upstream to spawning areas, provide rearing habitat, and facilitate smolt emigration to marine environments. Flows also affect other habitat parameters like temperature, riparian vegetation, and food supply. In an unregulated condition, the flows in the Yakima Basin would be dominated by snowmelt-driven discharge peaks in May or June that then decline to ground-water driven base flows in August and September. Late autumn rainfall and minor snowmelt would augment summer base flow, with Chinook winds causing occasional winter high water events. Steelhead are adapted to these natural seasonal flow patterns, which maintained a variety of habitats and facilitated migratory behavior.

Management of water storage and delivery systems in the Yakima Basin has significantly altered this flow pattern. Now winter and spring runoff from the upper Yakima, Kachess, Cle Elum, Tieton and Bumping rivers is captured in storage reservoirs and is utilized to meet summer irrigation needs in accordance with yearly entitlements. These operations result in streamflows across the basin that are often out of phase with the life-history requirements of native salmonids (Fast et al. 1991; Stanford et al. 2002) and riparian species such as cottonwoods (Jamieson and Braatne 2001). The most significant changes in flow regimes are the creation of: 1) unnaturally low flows, 2) unnaturally high flows, 3) rapidly changing flow levels, 4) return flows, and 5) altered sediment and wood transport. Issues associated with each of these are described below. The most significant area in which a largely natural flow regime has been maintained is the Naches River above its confluence with the Tieton.

### Reduced Flows

Low flows arise under two basic situations. From April through October, irrigation diversions and other water withdrawals reduce streamflows in tributaries throughout the basin (examples include Manastash, Ahtanum, and Cowiche creeks and the Teanaway River), in the lower mainstem Naches, and in the mainstem Yakima below Sunnyside Dam.[28] These low flows and associated increased temperatures limit the availability of summer and early fall rearing habitat in affected tributary and lower mainstem reaches and create passage barriers for migrating and rearing steelhead. As discussed in section 2.5.1.1, the timing of the start of upstream migration into the Yakima River by adult steelhead is driven by flow and temperature conditions. Decreased flows and increased temperatures generally prevent adults from entering the Yakima River prior to September. Since fish are holding in either the Columbia or Yakima rivers from mid-

---

[28] Winter diversions for power generation and, in some tributaries, for stock water, can also decrease stream flows. These instances are addressed in the area-specific discussions.

summer until spawning begins in late winter, the effect that this delay in in-migration has on survival and reproductive success is unknown.

Low flows also occur in the Tieton River below Tieton dam and the Upper Yakima and Cle Elum rivers when releases from Cle Elum, Kachess, and Keechelus dams are minimized to store water for irrigation. The effects of these low winter and spring flows on rearing juveniles are not well understood. Lowered flows also occur in the bypass reaches associated with the Roza and Chandler Hydro power plants.

These low flows and associated increases in water temperature are hypothesized to increase travel times for migrating smolts, expose smolts to increased predation rates, and reduce the extent and variety of off-channel habitat available for use during the out-migration period. In many years, these low flows truncate the out-migration window for smolts migrating downstream and may alter the emigration cues that trigger smolts to emigrate towards the ocean. It is also likely that reduced streamflow and longer travel time in the lower Yakima River decrease survival of kelts during their downstream migration. The need for a better understanding of the relationship between flows, temperature and other habitat conditions and survival of outmigrating smolts is highlighted in Chapter 7.

Overall, decreased flows and associated temperature regimes have a selective effect on Yakima Basin steelhead for both in-migration (delaying entry to the system) and out-migration (truncating the smolt run and kelt out-migration in late spring). EDT model results based on spawn timing and flow in the tributaries show that these effects probably are most severe on the Naches and Upper Yakima populations. The potential for viable steelhead life histories that included both short- and long-term juvenile rearing in mainstem habitats has been reduced by the loss of summer rearing habitat extent (low flow) and suitability (temperature) in the lower Naches River and the Yakima River below Sunnyside diversion dams.

**Increased Flows**

The mainstem Yakima, Cle Elum, Tieton, and lower Naches rivers are all used to deliver water stored in large headwater reservoirs to downstream users. This results in unseasonably high flows (Bumping Reservoir has a much more limited effect on the Bumping and Naches rivers due to its small size). Flows are increased further due to the "flip-flop" flow management strategy, which was established in 1981 in response to a suit brought against BOR by the Yakama Nation in order to protect spring Chinook redds in the Upper Yakima and Cle Elum rivers. Flip-flop consists of delivering water primarily via the Upper Yakima in the spring and summer while conserving water in Rimrock reservoir for use in August through October, when flows in the Upper Yakima are dropped to the levels that will be sustained through the winter in order to protect redds.

Water deliveries in general and flip-flop operations in particular result in high summer flow through the Cle Elum/Yakima arm until September when the water supply is switched to the Rimrock and Bumping reservoirs in the Tieton/Naches arm, which then experiences high flow until the irrigation season ends in October. While flip-flop has helped to protect upper Yakima spring Chinook, associated high flows have significantly impacted steelhead habitat. The most drastic impacts are in the Tieton River, where the unnaturally high and sustained flows in late summer and fall are posited to have greatly reduced available habitat for rearing steelhead, both through the immediate influence of high velocities and the reduction in mid-to small sized sediment and woody debris (currently Oak Creek, a small tributary with unregulated flows, is the only part of the Tieton River watershed consistently used by spawning steelhead).

Fry emergence in the Upper Yakima occurs from mid-June through the end of July, when natural flows would begin to drop. The sustained high flows associated with irrigation water deliveries are hypothesized to reduce growth and potentially survival. Pearsons et al. (1993) studied at *O. mykiss* in regulated reaches of the Yakima Basin and hypothesized that such flow fluctuations during the month following swim-up were responsible for the scarcity of young-of-the-year observed during subsequent snorkeling and electro-fishing surveys in areas with highest redd densities. They also found that *O. mykiss* in the Yakima River grow slower than trout in other regional rivers, and attributed these slow growth rates to degraded growing conditions produced by reservoir releases throughout the summer rearing period. Flow manipulation may also affect steelhead through competition for food, which becomes scarcer under fluctuating or artificially high flows (James et al. 1999). The increases in summer flows and associated decreases in summer temperatures in the Upper Yakima are hypothesized to favor resident life histories in the mainstem, potentially reducing the number of anadromous smolts produced. Chapter 7 identifies better understanding the impacts of delivery flows and flip-flop on juvenile steelhead as a key knowledge gap.

In tributary settings, high flows associated with use for irrigation conveyance and operation spill from canals can have mixed effects on habitat conditions. This is primarily an issue in the lower reaches of tributaries to the Upper Yakima, which are used to convey irrigation delivery and return flows.

**Rapid Changes in Flow**

Flow oscillations during the irrigation season may also reduce habitat quality for juvenile steelhead. While a seasonal range of flows is vital, stable base flows support high salmonid growth rates during periods of high ecosystem production from late spring through early fall (Poff and Ward 1989; Stanford et al. 1996). Rapid reductions in flow associated with flip-flop operations in the Upper Yakima and Naches and the initiation of storage control below Parker can reduce macroinvertebrate populations that serve as food source (Arango 2001), and limit growth of riparian vegetation, especially cottonwood seedlings. Power plant operation and screen maintenance activities in the Chandler and Roza canals can also combine to produce large flow fluctuations in the Yakima River when the canals are dropped for maintenance and rewatered to generate power.

**Return Flows**

Return flows associated with irrigation use can increase stream temperatures and transport sediment and associated contaminants into natural waterways. Return flows can also create false attraction when water diverted upstream is released well downstream and attracts returning adults that gravitate towards the characteristics of the upper basin water source. Note that subsurface return flows can also reduce water temperatures and provide habitat benefits. Specific return flow issues are addressed in subsequent sections.

### Affects of Altered Flows on Sediment and Wood Transport

River systems naturally transport large amounts of sediment downstream. The continuous removal and deposition of sediment plays a key role in the formation of complex floodplains and associated fish habitat. These changes also affect fish through the availability of appropriately sized spawning gravels and the productivity of macro-invertebrate populations and other prey species. Both instream structures and changed flow regimes associated with water delivery and use can change sediment transport.

Large dams may prevent movement of sediment, resulting in reduced availability of sediment downstream. Smaller diversion dams and other instream structures can dramatically change sediment dynamics in upstream and downstream reaches. Changes in flow regimes change the ability of stream systems to transport and deposit sediments. Reaches regularly exposed to artificially high flows may show scouring, loss of spawning gravels, channel simplification, and loss of habitat diversity; inversely, areas with reduced flows may show increased deposition of fine sediments.

Dams, diversions, other structures, and changes in flow regimes can also significantly change the distribution of large woody debris in a river system by blocking its downstream movement in some areas and by washing it out of other areas. Woody debris has also frequently been removed as part of system operations and maintenance.

### Flow-induced Changes in Vegetation

Altered flow regimes in most mainstem reaches are incompatible with the flow characteristics required for black cottonwood to successfully regenerate from seed (Jamieson and Braatne 2001). Cottonwood is dependent on a gradual reduction in the spring snowmelt runoff and on exposed sediments on gravel bars for seed establishment. Too rapid a drop in spring flows exceeds new seedlings' root growth ability, resulting in loss of root contact with the local water table and seedling death. Constant of increasing streamflow from spring into summer (as occurs in the Upper Yakima) limits the exposure of suitable substrates. High streamflow during the fall months (as occurs in the Tieton and lower Naches rivers) scours and "drowns" newly established seedlings. The effects are most notable in the Naches and Wapato reaches, where the number of exposed gravel bars and the channel width/depth ratio has increased over time. In the Upper Yakima, higher flows allow replacement of cottonwood stands by other shrub and grass dominated riparian vegetation (typically dominated by Russian olive, Pacific willow, reed canary grass, or European silver willow). It is currently unknown how the loss of cottonwood recruitment will affect steelhead. Cottonwood is a keystone species to interior Columbia riparian zones. Loss of this species will affect shade, large wood input, temperature, width/depth ratios, availability of riparian prey items for salmonids, and other ecosystem scale effects. Natural high spring flows may also play a role in limiting the extent of aquatic vegetation in the lower mainstem Yakima River.

### Unscreened Diversions

Diversion structures and other water delivery infrastructure and practices (such as running irrigation ditches across natural streams) can also funnel fish into water delivery systems that are not managed as fish habitat. This can result in significant mortality when fish enter pumped systems or are stranded in irrigation ditches. It may also cause delay and injury for fish that are able to return to natural stream systems. Screening of diversions has been a priority in the Yakima Basin since the 1920s, when some of the first self-cleaning fish screen designs were developed in the basin. Many diversions, especially larger ones, have had effective fish screens installed, but there are also still many unscreened diversions in the basin.

### Floodplain Development

The floodplain reaches of the Naches and Yakima rivers once consisted of complex networks of braided channels covered by dense riparian forests. In many areas, river channels have been leveed, armored, realigned, and shortened, severely diminishing natural river-floodplain interactions. Floodplains have always been favored sites for agricultural fields, industrial areas, residential and commercial structures, railways and roads, and extensive systems of dikes and drains have been built to protect these areas. Overall, floodplain development has resulted in profound alterations in fish habitat in the Yakima Basin, including:

- Reduced connectivity between streams and adjacent riparian areas, floodplains, and uplands
- Elevated fine sediment yields and water temperatures
- Reduced large woody debris to trap sediment, stabilize banks and form pools
- Reduced vegetative canopy to minimize solar heating of streams and provide bank stability and food
- Modified streams channels with reducing rearing habitat and increasing water temperature fluctuations
- Altered peak flow volume and timing, leading to channel changes and potentially altering fish migration behavior
- Altered floodplain function, water tables, and base flows
- Reduced flows in summer due to floodplain storage loss

For more general background on the impacts of floodplain development, see Henjum et al. (1994), McIntosh et al. (1994), Rhodes et al. (1994), Wissmar et al. (1994), National Research Council (1996), Spence et al. (1996), and Lee et al. (Lee et al. 1997). The best references on floodplain conditions on the Yakima are Snyder and Stanford (2001), Sanford et al. (2002), and Eitemiller et al. (2002).

**Gravel Mines**

Floodplain gravel mining has had significant impacts on floodplains throughout the basin, including along I-90 in Kittitas County, near the cities of Yakima and Selah and in the Wapato reach downstream. Dikes associated with gravel mines constrict the floodplain, and when they burst, gravel pits can cause avulsion of the river channel and act as sediment sinks that increase stream power and erosion downstream. Ponds in abandoned gravel pits can warm adjacent river temperatures and act as reservoirs for bass, catfish and other potential introduced species that prey on and/or compete with steelhead. Management of past, current and future gravel pit operations should strive to minimize these impacts (Yakima River Floodplain Mining Impact Study Team 2004).

**Upland Watershed Development**

While the effect of floodplain development on fish habitat is generally far more dramatic, upland development for commercial, residential, and agricultural use can also impact steelhead habitat. Increases in impervious area associated with buildings and pavement, reductions in vegetative cover, and the presence of roads, drainage ditches and storm water systems all facilitate rapid drainage of surface water, increasing streamflows and sediment inputs immediately after precipitation events, and reducing groundwater recharge and associated base flows in streams. Both overland flows and contamination of groundwater can result in transport of pollutants from upland areas to stream systems. Development pressure in the Yakima Basin is focused in the Naches and Upper Yakima population areas, in the greater Yakima area and in the corridor from Easton to Ellensburg.

**Population Growth and Associated Development**

While many of the impacts to fish habitat addressed in this plan are a function of past land use patterns, it must also address future development impacts. Human population growth in the Yakima Basin will continue, both from relatively high birth rates in the valley, and immigration into the valley. A review of the Comprehensive Plan Land Use maps of communities within the basin clearly indicate that whether urban or rural, the bulk of land use and development for future population growth will occur along the Yakima River main-stem and major tributary corridors where there is water, an existing core of rail and road transportation infrastructure, major concentrations of urban services, and high value shoreline property. Additionally, large numbers of eastern Washington residents recreate along the basin waterways. Population growth may increase camping, hiking, fishing, and off-road-vehicle activities, especially on the publicly owned lands of the upper watersheds. Numerous programs within local government, land use planning, and development regulations are designed to manage the impacts of population growth; applying these in a balanced manner that protects steelhead habitat while supporting economic growth and private property rights will require a strong commitment from local governments, landowners and the public at large.

**Increased Forest Disease, Pests, and Landscape-scale Fire**

The health and stability of many forest stands in the basin are declining, especially in the managed forests at lower and middle elevations on the Yakama Reservation, on state and private lands, and on USFS lands in the Naches, Swauk, Teanaway, and Cle Elum drainages. A legacy of fire suppression has increased the density of less fire- and pest-resistant tree species, and consequently catastrophic fire or pest outbreaks are increasingly likely to occur. While periodic, low-level disturbance contributes to overall forest health, landscape-scale fires would likely result in increased peak flows, lower summer flows, and increased sediment delivery for several decades, increasing the risk of extinction for steelhead. The relationship between wildland fire to aquatic ecosystems is reviewed by Dunham et al. (2003) and Riemann et al. (2003) Current low funding levels for efforts to improve forest health suggest that the risk may continue to increase.

### Forestry Practices

Habitat conditions in the forested areas of the basin are generally better than in lowlands, but past forest harvest practices, road construction and maintenance, and fire suppression have all had impacts of steelhead habitat. These activities can lead to road encroachment on streams and floodplains, riparian damage, impassable and/or unstable stream crossings, acceleration of runoff, increased landslides and sediment loading, elevated water temperatures, and increased streamflows or flood frequency due to loss of forest cover, especially on south facing watersheds. Numerous programs are underway to improve habitat conditions on federal, state, and private lands, but it will take several decades for the full benefits of these actions to accrue.

The Forest Service manages habitat for listed fish species on federal forestlands through several programs, including the Northwest Forest Plan and PACFISH/INFISH[29] Biological Opinions. The State of Washington's Forest Practice Rules address forest habitat conditions and functions needed for listed fish on non-federal lands, but there is some uncertainty as to the long-term adequacy of these rules to address all major ecological processes that maintain properly functioning habitat for all life stages of listed fish species. These efforts to regulate forestry activity will need to be reviewed to ensure that they adequately protect listed species and their habitats.

Managing the existing networks of forest roads so as to minimize watershed impacts will continue to be a priority. Timber companies are disposing of large blocks of private forestland in the Yakima Basin. Efforts to work with landowners to maintain economically viable working forests that also sustain steelhead habitat will be an important part of larger efforts to reduce fragmentation of the landscape.

### Climate Change

The regional climate in the Northwest may be changing in response to global atmospheric changes. Scientists predict reduced winter snow pack, increased winter rainfall and increased summer drought. These changes affect fish populations when changes in precipitation and snow pack patterns directly affect streamflows and when higher

---

[29] PACFISH is the Interim Strategy for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, and Portions of California. INFISH is the Interim Strategy for Managing Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana, and Portions of Nevada.

summer temperatures result in more evapotranspiration and increased water temperatures. Actions in this plan, including maintenance of habitats in high elevation areas, restoration of hydrology and passage, and improvement of riparian zones may reduce the effects of global warming. Climate change may also make colder habitats that are currently unsuitable for steelhead more suitable. The potential impacts of global climate change are recognized at national and international levels. The risks of global climate change are potentially great for Yakima Basin stocks because of the sensitivity of salmon stocks to climate-related shifts in the position of the sub-arctic boundary, the strength of the California Current, the intensity of coastal upwelling, and the frequency and intensity of El Nino events (Yakima Subbasin Fish and Wildlife Planning Board 2005). These changes could have significant effects on the success of recovery actions and the status of listed fish populations in the Yakima Basin (Climate Impacts Group 2009; Mastin 2008). Understanding and responding to changes in climate will be an important part of long-term recovery actions.

**In-basin Harvest**

Impacts of current fisheries in the basin are of two sorts: 1) incidental take during legal fisheries, and 2) illegal take and harassment. Both occur, but neither is considered a primary limiting factor for steelhead at this time. Past recreational steelhead fisheries had significant impacts on the run, with harvest levels ranging from 14% to 68% of the run between 1983 and 1988 (Yakima Subbasin Fish and Wildlife Planning Board 2005, p. 2-193). The harvest rate dropped in the late 80s and early 1990s, and the Yakima River and its tributaries were closed to steelhead fishing in 1994.

Current legal fisheries in the basin are highly regulated to reduce negative impacts on steelhead. Selective gear rules (no bait, single barbless hooks) for trout fishing are in effect in other tributaries known to support bull trout and steelhead spawning and rearing (e.g., Yakima River upstream of Roza Dam, Taneum, Swauk, Teanaway, Naches, Little Naches, Bumping, Rattlesnake, and American rivers). In some areas, including the Yakima River upstream of Roza Dam, the lower Cle Elum River, part of the Naches River and Rattlesnake Creek, trout fishing is limited to catch and release only. In remaining areas there are low catch limits for trout (generally two trout, minimum length 8 or 12 inches). Areas near the mouths of Toppenish and Satus creeks are closed for coho and fall Chinook during fall salmon fisheries to protect pre-spawning steelhead that hold in these areas during upstream migration. These regulations are designed to protect adult and juvenile steelhead and bull trout populations, while allowing economically important recreational fisheries for resident trout.

Despite these regulations, both incidental take and illegal harvest of steelhead occur. Angler interviews conducted by WDFW in the lower Yakima River during sport fisheries indicate that steelhead are incidentally hooked and released during Chinook and coho fisheries. Interviews suggest that there were between 13 and 146 steelhead caught and released each year during legal salmon seasons. Based on a 5% hooking mortality rate, this activity would kill up to seven steelhead in a given year. Both incidental take and poaching of steelhead during the winter fishery for whitefish pose a risk to steelhead adults holding prior to spawning. Starting in 2008, the winter whitefish fishery below

Granger was closed to protect holding steelhead, which are known to concentrate near the mouth of Satus Creek.

**Loss of Nutrients from Anadromous Species**

At the watershed scale, the loss of major contributors to the basin nutrient base, such as coho, sockeye, summer Chinook and components of the remaining steelhead and spring and fall Chinook populations, negatively affects the productivity of the ecosystem as a whole. Martin et al. (1994) suggested that low biomass in the Upper Yakima River may be related to low dissolved solids as expressed in conductivity measurements, but the correlation is not strong when certain other rivers are considered. Specific nutrients may correlate better with productivity, and salmon carcasses have been found in a number of studies to be a major source of these nutrients. Lowered ecosystem productivity has selective effects on steelhead life history (by reducing the tributary food base and selecting for shorter tributary residence), further reducing the potential for longer-term juvenile rearing within the basin. The lack of understanding about the actual effects of reduced nutrient transport by anadromous fish is a key knowledge gap identified in Chapter 7.

**Reduction in Beaver Activity**

In the Yakima Basin, the abundance and distribution of American Beaver (*Castor canadensis*) have been greatly reduced. Beaver have a tremendous influence on salmonid habitat quantity and quality. Loss of beaver dams has reduced the number of pools and straightened, widened, and incised channels. Streams have become disconnected from their floodplains and LWD supplies to streams have been diminished. The loss of beaver activity also alters sediment routing, stream temperature and hydrograph, and riparian zone composition and productivity. The loss of the ecological functions that beavers provide directly diminishes salmon productivity (Lichatowich 1999). These effects occur in both the upper watershed and in side channels along downstream river reaches.

**Increased Predation**

Fish, mammals, and birds are the primary natural predators of steelhead in the Yakima Basin. Although the behavior of steelhead precludes any single predator from focusing exclusively on steelhead, predation by certain species can be seasonally and locally significant. Recent changes in predator and prey populations along with major changes in habitat conditions have reshaped the role of predation (Li et al. 1987). Better understanding predation dynamics is identified as a knowledge gap in Chapter 7.

Non-native salmonids with the potential to prey on steelhead include hatchery-strains of rainbow, brook trout, and brown trout, all of which are found in upper parts of the Basin.[30] In the lower mainstem Yakima, introduced bass and catfish prey on steelhead, although the smolt out-migration occurs during periods that are cooler than optimal for

---

[30] WDFW ended stocking of brook trout and brown trout in the Yakima Basin in 2006 and now only stocks rainbow trout in lakes.

bass and catfish, and multiple years of bass diet data from the lower Yakima showed that bass generally do not prey on yearling-sized salmonids (Fritts 2004; Fritts 2006).

Changes in ecological dynamics caused by habitat changes have also increased predation by native species. Northern pikeminnow (a native fish whose abundance has increased due to more favorable habitat conditions under current river management) has the greatest potential to negatively affect the abundance of juvenile salmonids in the Yakima Basin. The pikeminnow is a large, opportunistic predator that readily adjusts feeding patterns to prey availability. Most adult salmonids within the Yakima Basin are opportunistic feeders and are therefore capable of preying on juvenile steelhead and bull trout. Native salmonids likely to have some effect on the survival of juvenile salmonids include adult bull trout, rainbow/steelhead trout, and cutthroat trout. Native species such as sculpins also prey on salmonid eggs and juveniles (Hunter 1959; Patten 1962; Patten 1971a; Patten 1971b).

Predation risk is also linked to water temperature. Studies have indicated predation rates increase at higher temperatures (Collis et al. 2000a; Gray and Rondorf 1986; NMFS 2000). Predation and high temperature may be acting synergistically to increase selection pressure on juvenile outmigration, although steelhead are considered less vulnerable than other salmonid species to piscine predators.

Avian predation on fish contributes to the loss of migrating juvenile salmonids in the Yakima River Basin. Fish-eating birds that occur in the Yakima Basin include great blue herons (*Ardea herodias*), gulls (*Larus spp*.), osprey (*Pandion haliaetu*s), common mergansers (*Mergus merganser*), American white pelicans (*Pelecanus erythrorhynchos*), double-crested cormorants (*Phalacrocorax spp*.), Caspian terns (*Sterna caspia*), belted kingfishers (*Ceryle alcyon*), black-crowned night herons (*Nycticorax nycticorax*), Forster’s terns (*Sterna forsteri*), hooded mergansers (*Lophodytes cucullatus*) and bald eagles (*Haliaeetus leucocephalus*) (Stephenson and Fast 2005). These birds have high metabolic rates and require large quantities of food relative to their body size.

Yakama Nation data (J. Siegel, personal communication, 2006) point to common mergansers as the primary avian fish predator in the Yakima River from Keechelus Dam downstream to Roza Dam, and white pelicans as the primary avian predator from Roza Dam to the Columbia River, with a significant gull population at Wanawish (Horn Rapids) Dam. These estimates are based primarily on census data multiplied by consumption rates from the literature and are not prey species-specific. However, *O. mykiss* is only a significant component of the fish biomass in the Yakima River upstream of Roza Dam (G. Temple,WDFW, communication 2006).

Mammals may be an important agent of mortality to steelhead in the Yakima Basin. Predators such as river otters (*Lutra canadensis*), raccoons (*Procyon lotor*), mink (*Mustela vison*), and black bears (*Ursus americanus*) are common. These animals, especially river otters, are capable of removing large numbers of salmon and trout (Dolloff 1993). Otter-killed adult steelhead are frequently found along Satus Creek during spawner surveys (B. Rogers, YN, communication 2006). Black bears generally scavenge spawned-out salmon.

**Increased Competition with Native Species**

Increased competition can occur not only between steelhead and introduced species that did not co-evolve, but also between steelhead and other native species. This happens when anthropomorphic induced habitat change alters competitive relationships. For example, Reeves et al. (1987) found that redside shiners dominated juvenile steelhead at warmer temperatures. Thus, where habitat changes result in increased water temperature, increased competition with shiners may affect steelhead.

Human-caused changes in the relative abundance of native species can also change competitive interactions. For example, although coho salmon were native to the basin, the species was extirpated by the early 1980s. Recent efforts to re-establish coho (Hubble et al. 2004) and the ongoing supplementation of Chinook populations in the Yakima Basin are providing an opportunity for research on possible human-induced changes in competitive interactions. As noted in Section 3.5.1.11, however, these reintroduced coho and supplemented Chinook may also have the beneficial effect of importing oceanic nutrients into the basin.

Recent analyses (Pearsons et al. 2004) of the potential effects of reintroduced species on steelhead and bull trout have found some depression of rainbow and steelhead mean size at age since coho reintroduction and spring Chinook supplementation began in the Yakima Basin. However, preliminary results of Yakima/Klickitat Fisheries Project (YKFP) research indicate that this trend was not related to supplementation activities. This YKFP research continues.

**Increased Disease**

A variety of bacterial, viral, fungal, and microparasitic pathogens can infect steelhead. Numerous diseases may result from pathogens that occur naturally in the wild or are transmitted to wild fish by infected hatchery fish. Infectious hematopoietic necrosis virus, bacterial kidney disease (BKD) (*Renibacterium salmoninarum*), coldwater disease (*Flavobacterium psychrophilum*), and columnaris (*F. columnare*) have all been identified in salmonids in the Yakima River (BPA Division of Fish and Wildlife 1990; Pearsons and Thomas 2003; Yakima Indian Nation et al. 1990). Beginning as early as mid-April in water-short years, water temperatures in the lower Yakima River are in the range favorable for the development and serious progression of infectious salmonid diseases (Fryer and Sanders 1981; Jobling 1981). Steelhead are more resistant to BKD than are other salmon species, although Foott (1992) found high incidence of BKD in wild steelhead populations in the Trinity River.

Sublethal chronic infections can impair the performance of steelhead in the wild, thereby contributing to mortality or reduced reproductive success. Fish weakened by disease are more sensitive to other environmental stresses and may become more vulnerable to predation (Hoffman and Bauer 1971) or less able to compete with other species. When Reeves et al. (1987) found that water temperature affected competitive interactions between redside shiners and steelhead, they determined that the outcomes of interactions were, in part, related to infection with *F. columnare*. In their study, most steelhead were infected at warmer temperatures, whereas shiners showed a higher incidence of infection at cooler temperatures.

### Increased Gaps Between Populations

Gaps between steelhead populations are assumed to have increased with the advent of irrigation, water storage, and floodplain development. Disproportionate decreases in abundance and productivity in lower tributaries of the Naches and Yakima rivers, (e.g., Cowiche Creek on the Naches; and Wenas and Umtanum creeks on the Yakima), along with increased mortality of the progeny of mainstem spawners due to flow manipulation and habitat damage, are believed to have widened the gaps between the Upper Yakima, Naches, and Satus steelhead populations. However, spawning in the Toppenish Creek watershed was probably limited to upper reaches throughout the Holocene epoch; also, spawning appears to be more prevalent today in the upper Yakima River mainstem than previously assumed (Karp et al. 2003; Karp et al. 2005). Whether successful spawning occurs in the Yakima below the Naches confluence is unknown and is identified as a knowledge gap in Chapter 7.

### Genetic Impacts of Past Hatchery Management

Introduction of hatchery-origin rainbow trout or non-local steelhead from mixed Columbia Basin or Skamania stocks subjected all steelhead populations to some degree of genetic risk. During the 20th century, steelhead from several sources were introduced into the Yakima Basin; the predominant one was the Skamania stock from the Washougal River. In the mid-1980s, the Yakama Nation and WDFW agreed to produce fish from wild Yakima broodstock. Between 1985 and 1989, the Yakama Nation trapped broodstock at Prosser Dam for spawning, egg incubation, and rearing at the WDFW Yakima hatchery, with assistance from the Northwest Steelheaders and Trout Unlimited. The co-managers agreed to discontinue wild broodstock collection after 1989 because of the low smolt-to-adult survival rate and the inability to select population-specific broodstock at Prosser Dam. From 1990 through 1992, a small number of adult Yakima Basin steelhead were trapped and their progeny reared by YKFP researchers to evaluate species interactions in the upper Yakima River. Hatchery-produced steelhead smolts were last released in the Yakima Basin in 1993 (Fast and Berg 2001). Although these practices no longer occur, interbreeding with hatchery fish may have reduced the genetic fitness of some steelhead populations.

Introductions of resident rainbow trout are believed to have contributed to the decline of the anadromous form of *O. mykiss* in the upper Yakima. Genetic introgression from non-indigenous hatchery trout populations into the rainbow trout population of the upper Yakima is believed to have occurred (Phelps et al. 2000). Because interbreeding of resident rainbow and steelhead has been observed in the field (Pearsons et al. 1998), this introgression likely has also occurred in what remains of the upper Yakima steelhead stock. There is less evidence of introgression into the Naches stock (Phelps et al. 2000). While planting of hatchery trout has ceased, the continued presence of non-native genes in the rainbow population presents genetic risks to steelhead.

### 3.3.2 Lower Mainstem Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the lower mainstem Yakima (from the mouth to the Naches confluence), see Table 3.2. These threats are discussed in more detail below.

**Altered Streamflows**

Low flows in much of the lower Yakima River combine with high air temperatures, degraded riparian vegetation, and reduced floodplain function to create extended river reaches with water temperatures that exceed the physiological tolerances of native salmonids. Native and non-native predatory fish tolerate these conditions well and may be more efficient predators under these conditions. Additionally, poor water quality conditions in the lower Yakima River can lead to increased mortality rates in steelhead and other native anadromous smolts from water-borne pathogens (BPA Division of Fish and Wildlife 1990; Pearsons and Thomas 2003). High water temperatures persist in the lower Yakima River throughout the irrigation season. Migrating adult steelhead must hold on the Columbia River near the mouth of the Yakima River until the river cools in late summer or fall.

Changes in flow and associated temperature regimes may have had a strong selection effect on all populations of steelhead during both upstream migration (delaying adult entry to the system) and the downstream migration (truncating the smolt run and kelt outmigration in late spring/early summer). Steelhead life histories that include both short- and long-term juvenile rearing in the lower mainstem are no longer viable due to high temperatures, reduced water quality, and the resulting loss of summer rearing habitats in the lower mainstem Yakima.

**Floodplain Alteration**

The lower mainstem Yakima River flows through extensive floodplains in the Union Gap and Wapato reaches. Highways, railroads, and dike systems have cut off significant portions of the floodplain, reducing floodplain function and the availability of side-channel habitat. Stanford et al. (2002) identified the Union Gap reach as having the greatest potential for floodplain restoration. The Bureau of Reclamation's YRBWEP program has acquired significant amounts of floodplain property and is working with the county, the city of Yakima, gravel mine operators, and others to significantly improve floodplain function in this reach. In lower reaches of the Yakima, residential development along the river and associated alterations to natural riparian vegetation are becoming increasingly common. Little attention has been given to the floodplain reaches in the Tri-Cities area near the mouth of the Yakima River.

**Creation of False Attraction Flows**

Hydropower wasteways, such as Roza Power Plant Wasteway, irrigation drains, and spillways, including Sulphur Creek Wasteway and Marion Drain, discharge flow that can entrain or confuse adult steelhead during the upstream migration period. This can result in stranding of fish in unsuitable habitat and/or delays in upstream migration.

## Reduced Water Quality

Degraded water quality (especially pH, dissolved oxygen [DO], and temperature conditions) significantly reduces habitat quality in the lower Yakima. Intensive agricultural production, including drainage improvements, and the use of fertilizers and pesticides have left a legacy of contamination (i.e., DDT and DDE in aquatic sediments and arsenic and lead in the soil profile), and residual concentrations of nutrients (i.e., phosphorus in lower river sediments), which may diminish only slowly over time.

Throughout the irrigation season, the lower Yakima River (downstream from Granger, RM 82) receives large volumes of irrigation return flows (Johnson et al. 1986; Rinella et al. 1999; Rinella et al. 1992). In 1997, the Roza Sunnyside Board of Joint Control initiated a water quality improvement program for drains and wasteways in the lower Yakima River, making significant strides at improving water quality in the lower river. In particular, fine sediment discharge has been reduced, although not eliminated.

The recent explosive growth of water star-grass in the lower Yakima River has led to concerns about its effect on water quality (especially dissolved oxygen), habitat, and migration conditions for salmonids. Growth of this native plant may have been augmented by advances in controlling suspended sediments, which increased light-penetration into the water column, and by long periods without bed-scouring high flows.

The Washington Department of Ecology (WDOE) has placed 72 watercourse segments throughout the Yakima Basin on the most recent 303(d) list (in 1998) of threatened and impaired water bodies (WDOE 1998). Primary impairments leading to these listings included increased temperatures, high agricultural pollutant concentrations (e.g., 4,4'-DDE, DDT, dieldrin, 4,4'-DDD, chlorpyrifos, endosulfan, and PCB), dissolved oxygen deficits, and a host of other water quality constituents (e.g., arsenic, mercury, silver, fecal coliform, pH, ammonia, chlorine, turbidity, and phosphorous) that are generally detrimental to fish health and persistence (Johnson et al. 1986; Morace et al. 1999; Rinella et al. 1999; Rinella et al. 1992). Current agricultural trends may result in reduced water use (e.g., conversion of large areas to wine grapes), but also increased nutrient loading and waste (e.g., from expansion of the dairy industry and other confined animal feeding operations). Recent dramatic improvements in water quality in the lower river have shown that concerted efforts by all parties can reduce agriculture’s impacts on water quality.

## Predation by Introduced Species

Non-native fish species can prey on juvenile salmonids. Smallmouth bass have the greatest potential to negatively affect the abundance of juvenile steelhead in the lower mainstem of the Yakima. They are large, opportunistic predators that readily adjust their feeding patterns to prey availability. Abundant channel catfish also have the potential to prey on juvenile salmonids. WDFW currently has no catch limits on bass in the Yakima River, although only bass less than 12" or greater than 17" may be retained, of which no more than one may be over 17". There are no catch limits for channel catfish. Smolt outmigration generally occurs in conditions that are cooler than optimal for bass, as noted under predation in Section 3.3.1, but some overlap occurs. Better estimating the impacts of predation by bass is identified as a research need in Chapter 7.

**Impaired Fish Passage**

Significant work has been done to ensure fish passage at major irrigation diversions in the mainstem Yakima River. However specific seasonal operations and flow conditions at some diversions with fish ladders can still hinder adult upstream migrations. There is also significant uncertainty over the impacts of diversion structures on the survival of downstream migrating smolts, with some structures known to cause physical injury and/or concentrate predation (e.g., Horn Rapids (Wanawish) Dam and the Chandler Canal screen entrance and bypass outfall).

## 3.3.3 Satus Population Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the Satus Creek Watershed, see Table 3.3. Loss of floodplain habitats, reduced riparian zone health caused by intrusive roads and poor grazing management practice, and increased peak flow and sediment loads from forestry activities, including an extensive network of forest roads, have all diminished habitat productivity in this system. The Yakama Nation has had an active watershed restoration program in this basin since the 1980s.

**Floodplain Alteration**

The lowest eight miles of Satus Creek (below Mule-Dry Creek) have been simplified and confined to increase agricultural acreage. Although excavation and filling essentially ceased in the late 1980s, impacts to channel morphology and function remain (Ringer and McCoy 1998). Farther upstream, State Route 97 crosses Satus Creek five times and confines it for several miles. Riparian roads parallel several tributaries, confining stream channels and acting as alternative drainage systems.

**Grazing Impacts**

Fencing, off-stream water development, and conservation leasing of key riparian parcels have largely addressed negative impacts from cattle grazing, but wild horses have a heavy impact on wide areas of the watershed. Tributary wet meadow systems have become incised through loss of stabilizing vegetation, woody debris, and reduced lower beaver activity.

**Forestry Impacts**

Increased peak flows and sediment loads from forestry activities and the associated network of forest roads negatively affect Satus Creek. Work is ongoing to address road-related issues in the watershed.

**Altered Streamflows**

Streamflow in Satus Creek is essentially unregulated. The four irrigation diversions present on Satus Creek in 1980 were all shut down by 1991 to protect instream flows. In dry summers, the creek can still dry up for several miles within the alluvial reach upstream of the Logy Creek confluence (mile 23.6). Past grazing practices and extensive flooding in the early 1970s and 1990s have degraded floodplain conditions; ongoing efforts to improve floodplain and upland function will be required to improve flow conditions.

**Impaired Passage**

The Wapato Irrigation Project's abandoned Satus diversion dam may act as a partial barrier to steelhead passage. A complete passage barrier exists where Highway 97 crosses Shinando Creek. Other barriers may exist on small tributaries in association with forest road networks.

**Reduced Water Quality**

Most of the Satus Creek watershed is undeveloped and is not exposed to agricultural, industrial, or domestic effluents, but because of degraded riparian habitats and low flows, maximum weekly average temperatures can exceed 26$^{o}$C in the Satus Creek reach between Logy Creek and Wilson Charley Creek (RM 39.3). Logy Creek may cool Satus Creek for a few miles downstream from their confluence. Water quality suffers (although water quantity increases) as Satus Creek flows through the Wapato Irrigation Project (WIP) in its lower eight miles. Improved management of return flows would increase conditions in the lower eight miles of Satus Creek. The relatively young and rapid steelhead outmigration from Satus Creek described in an earlier section appears to be a population response to harsh summer conditions.

### 3.3.4 Toppenish Population Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the Toppenish population area, see Table 3.4. Reduction in habitat productivity in this system is related to loss and alteration of floodplain habitats in lower Toppenish Creek, altered surface water/groundwater interactions in lower Toppenish Creek, altered flow characteristics on the alluvial fan of Toppenish Creek, reduction in flow and passage barriers in the Simcoe/Wahtum/Agency creek systems, and increased peak flow and sediment loads from forestry activities.

**Floodplain Alteration**

The Toppenish Creek channel historically assumed an anabranched appearance downstream of the Simcoe Creek confluence and flowed through an extensive network of wetlands for nearly 30 miles to the Yakima River. This system has been simplified to facilitate agriculture, grazing, and management of waterfowl habitat. Between RM 45 and the Simcoe Creek confluence (RM 32.7), diking, channel straightening, installation of drains, and low-capacity crossings have caused alternating deep incision and heavy deposition as the creek traverses its alluvial fan, reduced riparian vegetation, and compromised floodplain function.

Channel conditions upstream of the mouth of Toppenish Canyon are considered to be significantly better than in the downstream reaches. Riparian roads associated with timber harvest and the loss of beaver dams have straightened, widened, and incised the channel upstream of the mouth of Toppenish Canyon and degraded riparian conditions in the canyon portion of the watershed. Rapid deposition of gravel behind new channel grade controls just below the canyon indicates more rapid erosion upstream than managers had assumed.

**Altered Streamflows**

The Toppenish Lateral Canal (TLC) at RM 44.2 historically diverted all flow in the creek from mid-June to mid-October. Despite recent adherence to a 10-cfs minimum flow requirement below the TLC diversion, natural seepage of up to 18 cfs into the expansive Toppenish Creek/Mill Creek alluvial fan results in a dry reach by late summer for several miles downstream from the three-way diversion. Most of the seepage does not reappear downstream before WIP return flows enter Toppenish Creek. A portion of the loss appears to seep into Simcoe Creek, which wraps around the toe of the fan, although seepage from the creek and from the TLC cannot be easily distinguished at this location. Other possible sinks are Harrah and Marion drains and large irrigation wells in the underlying basalt, which may be in communication with the fan. Despite this loss, the perennial section of stream downstream from the dam provides summer habitat for approximately 2,000 juvenile steelhead.

Two irrigation diversions downstream from the TLC supply Unit 2 and the Satus area of the WIP, primarily using return flows routed into Toppenish Creek via Mud Lake and Marion drains. Marion Drain, which is much deeper than Toppenish Creek for much of its length, intercepts subsurface flows that once entered the creek from the north.

The North Fork of Simcoe Creek provides the majority of flow in the Simcoe Creek watershed. Four private diversions and a WIP diversion (Simcoe Feeder Canal) historically took most of the base flow of Simcoe Creek. Since 2002, the Yakama Nation has worked to maintain minimum instream flows below all five Simcoe Creek diversions.

**Reduced Water Quality**

High water temperatures in lower Toppenish, Simcoe, and Agency creeks have resulted from diversion of annual spring flooding, draining of wetlands, riparian degradation, and the large volume of warm water irrigation returns routed from WIP down Simcoe and Toppenish creeks. As in Satus Creek, stream temperatures increase with proximity to the mouth of Toppenish Creek, with the highest weekly average temperature among four stations in 2004 approaching 24 degrees Celsius at a point 10 miles above the mouth. Data from the summer of 2007 indicate some cooling below stream mile 10 that may be related to upwelling. Temperatures in Marion Drain are about 6°C cooler in the summer and 5°C warmer in the winter than temperatures in the mainstem. This thermal moderation is attributable to the large proportion of groundwater in the drain; before the drain was constructed much of this groundwater presumably flowed into nearby Toppenish Creek.

**Impaired Passage**

In February 2006, Yakama Nation personnel confirmed that a private road crossing of Toppenish Creek just upstream from the Simcoe Creek confluence was impeding adult steelhead passage at moderately high streamflows of several hundred cfs. This crossing has the potential to hinder passage into the entire Toppenish Creek spawning population.

Several other passage barriers and unscreened diversions exist in Simcoe Creek and other tributaries.

**Grazing Impacts**

Fencing, off-stream water development, and conservation leasing of key riparian parcels have largely addressed negative impacts from cattle grazing, but wild horses have a heavy impact on wide areas of the watershed. Tributary wet meadow systems have become incised through loss of stabilizing vegetation and woody debris and lower beaver population size and activity.

**Forestry Impacts**

Increased peak flows and sediment loads from forestry activities and the associated network of forest roads affect the Toppenish Creek system. Work is ongoing to address road related issues in the watershed.

## 3.3.5 Naches Population Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the Naches population area, see Table 3.5. These threats are discussed in more detail below:

**Floodplain Alteration**

Most of the braided, alluvial floodplain reaches in the Naches system have been altered by highways, gravel pits, levees, local roads, agriculture, irrigation diversions, and rural and urban development, with the most severe impacts on the lower Naches below the Tieton confluence. The diversity of channel types in the Naches River upstream from the Tieton River confluence (RM 17.5) has been greatly reduced. Basalt canyon walls, riprapped dikes, road embankments, and revetments confine the upper channel. Bedload movement is apparent in some of the more narrowly confined reaches of the upper Naches River, and right-bank revetments, which protect homes, have cut off historic side channels and spring brooks.

Downstream from the Tieton confluence, the Naches River floodplain widens, although a highway and other structures have isolated the river from part of the active floodplain. Floodplain activities and structures (e.g., highways, gravel pits, levees, local roads, agriculture, irrigation diversions, rural and urban development) have degraded, removed, or altered the functional condition of the river-floodplain ecosystem.

The lower Little Naches River and the lower Bumping River are confined by highways and associated levees, which constrict floodplains and cut off historic side channels and meanders.

**Channel Simplification**

As noted earlier, changed flow regimes in the Tieton River combine with its natural confinement to simplify its channel. Tieton Dam captures the river’s main source of gravel, and the remaining gravel supply is readily transported by high flow. Because of unsuitable conditions in the mainstem Tieton, Oak Creek is the only portion of the Tieton

River watershed currently occupied by steelhead. Sections of the Little Naches have also been simplified by a highway that runs alongside the river for much of its length.

**Impaired Passage**

Tieton Dam has inundated or blocked the most productive habitats in the Tieton River drainage, which comprises a fourth of the entire Naches watershed, and Bumping Dam blocks six miles of upstream habitat. Telemetry data and spawning ground surveys suggest that only a small number of adult steelhead now reach the base of these dams, probably because upstream migration coincides with reservoir filling and low river discharge, which is most pronounced in the Tieton River, Migration efforts are further compounded by poor passage at the Yakima-Tieton diversion dam (RM 14.2). Modifications to the fish passage facilities at the Yakima-Tieton Diversion Dam are scheduled for completion in 2008. Passage into Cowiche Creek was eliminated or greatly reduced through the $20^{th}$ century, but recent diversion improvements have reopened that watershed. Partial passage barriers have also been removed from the Ahtanum Creek watershed, and similar work is ongoing in Rattlesnake, Nile, and Wide Hollow creeks. Passage into other Naches tributaries is generally unimpaired.

**Grazing Impacts**

In the middle and upper portions of Cowiche Creek, Ahtanum Creek, and other mid-elevation tributaries, livestock have negatively impacted riparian zones by grazing and trampling streambanks. Cooperative projects with livestock managers have reduced grazing impacts in many of these areas. Extensive sheep grazing in the late 19th and early 20th centuries also significantly affected upland and riparian conditions throughout the Naches population area.

**Forestry Impacts**

Past forest practices and road networks have been affected Ahtanum and Cowiche creeks; ongoing efforts to manage and improve road systems will be needed. The upper watershed of the Little Naches River has been heavily logged. Spawning gravel is abundant in the Little Naches River and tributaries, although deposition of fine sediments increased after the initiation of large-scale clear-cutting. The lower 4.4 miles of the Little Naches River now afford the poorest spawning and rearing habitat in the drainage due sedimentation and confinement by roads and levees. Fine sediment in spawning substrates may be declining since an apparent peak in 1993 (Muir 2003).

**Streamside Recreation**

The upper Naches River watershed is a popular recreation area. Activities, which include recreational mining, establishment of dispersed camp sites, and off-road vehicle use, have had major impacts on various streams, streamside habitats and species, increased sedimentation, reduced riparian and floodplain function, and reduced abundance and spatial structure of listed species. Impacts have been greatest in the Little Naches and American River watersheds, but recent efforts by the USFS and others are significantly moderating these impacts.

### Altered Streamflows

Flow regimes in the Naches Basin and associated tributaries can be put into three groups: 1) the highly modified flows of the Tieton and Lower Naches rivers; 2) the relatively natural flow regimes of the Naches and its tributaries above the Tieton River and of tributaries above Rimrock and Clear lakes; and 3) the lower tributaries subject to irrigation withdrawals, such as Cowiche, Ahtanum, and Rattlesnake creeks.

The Tieton River has the most skewed hydrograph of all Naches River tributaries, varying from less than 100 cfs, while the Rimrock Lake reservoir is filled from late October through March to nearly 2,000 cfs when the reservoir supplies most of the Yakima Project's irrigation demand each September as part of flip-flop operations. These flow effects persist downstream, with Naches River discharge rapidly quadrupling in late summer as the Tieton Dam gates are opened. This rapid increase in flow in the Tieton and lower Naches during a time of year when natural flow fluctuations would be uncommon is likely to displace and even injure or kill early juvenile steelhead, which are not large enough to maintain position in high river flow. Although flip-flop flows in the lower Naches may open access to side- and off-channel areas that could be used by juvenile steelhead, the rapid increase and decrease in flow can cause dewatering and stranding. Monitoring is needed to understand what happens when these conditions occur. From October through early summer, the Naches, Tieton, and Bumping rivers are flowing below estimated unregulated stream flow levels, which also affect salmonid habitat values.

During the summer months, irrigation withdrawals reduce flows in the lower Naches River, decreasing the availability of rearing habitat. Recently, the BOR and WDOE acquired the Wapatox hydropower site and its water right. Flows that formerly were diverted for power generation at this site are now remaining in-stream in a critical low-flow reach of the Naches River. However, the Wapatox Canal also serves irrigators, and their requirement for conveyance water limits the quantity of water that can be placed instream.

In contrast to the Tieton and the lower Naches, the Naches River and its tributaries upstream from the Tieton River still exhibit a largely normative flow regime, regulated only by the relatively small Bumping Lake reservoir.

Cowiche, Ahtanum, lower Nile, and Rattlesnake creeks have numerous irrigation diversions, which significantly reduce summer and fall flows, and at times have dried up portions of the creek beds. In recent years, significant efforts have been made to secure instream flows in Cowiche and Ahtanum creeks. The small steelhead subpopulation in Ahtanum Creek was mostly ignored through a century of over-appropriation and dewatering of the lower reaches, but appears to be responding to recent efforts to maintain a summer flow of 10 cfs throughout the mainstem.

Rattlesnake Creek provides good to excellent habitats in its middle and upper reaches. In the lower reaches of Rattlesnake Creek, irrigation diversions, low flow associated with floodplain loss, and the accumulation of coarse sediments limit habitat availability and diversity.

**Impacts from Increased Development**

Rapid population growth and development is occurring in Yakima County (including the cities of Yakima, Union Gap, Selah, Moxee, and outlying rural areas). In the Ahtanum Creek watershed, along the Naches River above the Tieton, and parts of the Cowiche Creek watershed, residential or recreational home development is often located adjacent to streambanks. Near the cities of Yakima and Union Gap, agricultural lands, many with shallow groundwater, are being converted to residential, commercial, and industrial uses. Conversion of agricultural lands to other uses will be accompanied by fragmentation of ownerships and land uses, each with different management goals. The probability of conflict between new land owners/land uses and floodplain/stream channel functions (which sustain fish habitat and conveyance of water and sediment) is high.

### 3.3.6 Upper Yakima Population Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the Upper Yakima population area, see Table 3.6. These threats are discussed in more detail below:

**Floodplain Alteration**

The once extensive floodplains of the Upper Yakima in the Easton, Cle Elum, Ellensburg, and Selah reaches contained multiple channels and large areas of spawning and rearing habitat for steelhead. Roads, including I-90, railroads, and dikes associated with agriculture, development, and gravel mining have constricted these floodplains. Near Ellensburg significant efforts are being made to reopen access to side channel habitat that has been incorporated into irrigation systems.

**Impaired Passage**

Passage barriers have significantly reduced the habitat available to anadromous steelhead in the Upper Yakima population area. Cle Elum, Kachess, and Keechelus dams block all upstream movements and allow only limited downstream movements. Cle Elum Dam has inundated or blocked an important component of Yakima River tributary steelhead habitat, the BOR estimating that 29.4 miles of potentially useable anadromous habitat are located upstream of Lake Cle Elum ((BOR 2005).

A number of tributaries to the Upper Yakima River (e.g., Swauk, Wilson, Naneum, Big, Little, Taneum, Manastash, Tucker, Cooke, Caribou, Coleman, and Reecer creeks and the Teanaway River) are likely to have historically supported steelhead, but impassable dams, dry reaches below dams and unscreened and inadequately screened diversions have eliminated steelhead from many of these tributaries. Diversion structures at Tucker, Naneum, Manastash, Cooke, and Caribou creeks were built without passage facilities. In many cases (e.g., Manastash, Taneum and Naneum creeks), the forested watersheds above the agricultural zone support very good habitat. Low flows and unstable channel conditions, including the construction of recreational dams during the summer migration season, also inhibit movement of steelhead in the Teanaway River.

Roza Dam is a potential bottleneck for outmigrating smolts. When runoff is low, the design of the Roza spillway gates hinders downstream passage for fish that miss the bypass, as the only available passage is a narrow slot underneath the gates. Under these conditions, significant concentrations of smolts have been observed in the pool above the dam. Delays can result in immediate mortality, residualization, or delaying arrival in the lower Yakima River until periods when low flow, high temperature, and increased predator activity reduce survival.[31] BOR has recently been "tucking" a spillway gate at Roza Dam to allow surface spill when river flow permits and is evaluating options for modify the spillway gates so that surface spill can take place at lower river flow.

Historically Roza Dam was also a seasonal barrier to migrating adults moving upstream. Every year between 1939 and 1958 when winter power diversions were first begun, the Roza Dam forebay was kept at minimum elevation for significant periods between mid-October and mid-March. The fish ladder was operational only at full pool, while the spillway was and is impassable at all pool levels. Based on the University of Washington's DART database, between 1999 and 2009, 20% of the steelhead passing Roza was counted between November 1 and March 15. These data, collected since power diversions and associated winter ladder operations were initiated, suggest that a significant proportion of the steelhead bound for the Upper Yakima prior to 1958 may have been delayed or prevented from reaching their destination due to the seasonal ladder closures.

The original Roza Dam fish ladder only operated at full pool levels. A new ladder was installed at Roza Dam in 1989 that allows passage at minimum pool and full pool levels, but there is no passage at levels between these extremes, which occur while the pool, is being drained or filled (a period of days a few times a year). There is also the possibility of reduced passage at Easton Dam in dry years when BOR guidelines call for closing the dam's fish ladder in the spring to prevent spring Chinook from spawning in sections of the Upper Yakima that will not have sufficient winter flows to protect the redds. Closure of the Easton Dam fish ladder has not occurred since 1996.

Although major water diversions are screened, numerous unscreened diversions exist on tributaries. These are being addressed in conjunction with efforts to remove passage barriers and improve riparian conditions in the lower reaches of tributaries in the Ellensburg area.

**Altered Streamflows**

Unnaturally low flows in the Upper Yakima and Cle Elum rivers when reservoirs are being filled may inhibit steelhead migration and spawning. An emphasis on reservoir refill in water-short years may also result in low winter and spring streamflows that affect the extent and quality of juvenile rearing habitat. More data are needed on the impact of reservoir fill timing and associated low flows on adult and juvenile migrations and juvenile steelhead rearing environments.

[31] While empirical data on the constraints to juvenile passage at Roza are primarily available for hatchery Chinook smolts, the same conditions are expected to be encountered by outmigrating steelhead.

There are large releases of water into the Upper Yakima and Cle Elum rivers during the summer irrigation season. As discussed in Section 3.5.1.3, this may both reduce growth and survival of young-of-the-year steelhead and promote residency for older juveniles. Due to the flip-flop regimes, significant portions of streambed along the Upper Yakima and Cle Elum rivers are dewatered within a week in early September, with likely adverse effects on benthic macroinvertebrates and juvenile native and anadromous fish (Arango 2001; James et al. 1999; Pearsons et al. 1996). Pearsons et al. (1996) surveyed juvenile salmonid (including steelhead) use of side channel habitat in the Cle Elum and Upper Yakima rivers, and determined that 3 of the 21 monitored side channels and sloughs were totally dewatered and another was disconnected from the main channel after flip-flop. The authors concluded from this indirect evidence that nearly all juvenile salmonids they found in these side channels before flip-flop were likely killed because of rapid dewatering (83% flow reduction in two weeks). Monitoring is needed to understand what happens when these conditions occur.

Irrigation diversions have dewatered the lower reaches of many tributaries (e.g., Swauk, Teanaway, Taneum, Manastash and Big creeks), creating flow and temperature conditions that reduce juvenile rearing capacity. Efforts to secure instream flows in these reaches are ongoing. Other tributaries (e.g., the Reecer and Wilson creek systems) have flows that have been significantly increased in summer due to their use for irrigation water conveyance.

**Simplification of Natural Waterways Used for Conveyance**

In the Wilson/Naneum and Currier/Reecer creek systems in the Kittitas Valley, tributaries and side channels have been highly modified to facilitate use as part of irrigation distribution systems. This has resulted in simplification of channel structure due to ‘ditch’ cleaning, diking, and removal of vegetation. These areas are also typically subject to passage barriers by numerous diversions and to degraded water quality. Habitat that was once suitable for rearing and, in some cases, for spawning has often been rendered inaccessible and/or inhospitable. The Kittitas County Conservation District, Yakama Nation, Kittitas Conservation Trust, and others are working to open up many of these areas.

**Reduced Water Quality**

Although water quality in the Upper Yakima Basin is generally much better than in the lower basin, irrigation effluents and flow regulation have adversely affected some areas (Joy 2002; Joy and Patterson 1997). The Upper Yakima and Cle Elum rivers, as well as tributaries to the Yakima River in the Kittitas Valley (e.g., Cherry, Cooke, Wilson, Taneum, and Manastash creeks), are 303(d)-listed for numerous water quality problems.[32] Seasonal decreases in natural flow, along with added irrigation effluents expose regulated reaches to high late-summer ambient temperatures, suspended sediments, agricultural pollutants, and other adverse water quality constituents, including

---

[32] For more information on 303-d listings see the Department of Ecology’s State Water Quality Assessments at http://www.ecy.wa.gov/programs/wq/303d/index.html

fecal coliform bacteria, low dissolved oxygen, and elevated nutrients. These issues are most pronounced in the Wilson Creek system.

**Forestry Impacts**

Past forest practices and road networks have affected many parts of the Upper Yakima; ongoing efforts to manage and improve road systems will be needed. Because of its south-facing aspect and its steep, confined tributaries, the Teanaway watershed is especially prone to increases in peak flow resulting from changes in watershed condition associated with forest road networks and timber harvest activities. Recovery planners consider the Teanaway River to be the highest priority in the basin for identifying and reducing impacts from forest practices.

**Grazing Impacts**

Past and current grazing practices have negatively affected riparian conditions in many of the mid-elevation tributaries to the Upper Yakima River. Cooperative efforts to work with livestock managers to address remaining impacts are ongoing.

**Streamside Recreation**

The Upper Yakima Population Area contains a number of popular streamside recreation areas. Recreational mining, establishment of dispersed campsites, and off-road vehicle use have increased sedimentation and reduced riparian and floodplain function on various streams, streamside habitats, and species within the basin. These conditions have contributed to the reduced abundance and productivity of listed fish species.

**Impacts from Increased Development**

Kittitas County and cities within the county, such as Ellensburg, Cle Elum, Ronald, Roslyn, and others, are experiencing rapid population growth and associated development. In many areas, forest and agricultural lands are being converted to residential development. Development immediately adjacent to the mainstem river and to tributaries can result in reduction or elimination of riparian zones and increase flood hazard. Adjacent to the city of Ellensburg, agricultural lands (many with shallow groundwater) are being converted to residential, commercial, and industrial uses. Conversion of agricultural lands to other uses will be accompanied by fragmentation of ownership and land use. The probability of conflict between new land owners/land uses and floodplain/stream channel functions (which sustain fish habitat and conveyance of water and sediment) is high.

## 3.4 Out-of-Basin Threats and Limiting Factors

Conditions in the Columbia River, its estuary, and the Pacific Ocean significantly affect the productivity, abundance, and life history diversity of Yakima Basin steelhead. In its All-H analysis, NOAA Fisheries is estimating the survival rates for the Middle Columbia Steelhead DPS from the mainstem Columbia to the ocean and back. There are currently no estimates of the effect of out of basin factors on the other VSP metrics for Yakima steelhead populations. The BPA, the Corps of Engineers, the BOR, NOAA Fisheries, WDFW, Tribes, and others are implementing actions to improve survival of anadromous fish in the Columbia and the ocean. Current and proposed actions are being assessed as part of development of a new Biological Opinion for the Federal Columbia River Power System.

This plan focuses on conditions within the Yakima Basin, but understanding how in-basin actions interact with these out-of-basin factors is crucial to understanding the potential effectiveness of our in-basin actions. This requires monitoring out-of-basin survival rates for Yakima Basin steelhead populations (see Chapter 7).

While this plan does not address out-of-basin impacts on Middle Columbia River Steelhead in detail, a brief overview of significant issues is given below. Areas where impacts on Yakima Basin steelhead may be different from impacts on Middle Columbia River Steelhead as a whole are highlighted.

### 3.4.1 Out-of-Basin Effects on the Lower Yakima Basin

Conditions immediately beyond the mouth of the Yakima River influence conditions for steelhead in the lowest part of the Yakima River. The mainstem Columbia now provides excellent habitats for exotic species such as smallmouth bass and catfish, which migrate into the lower Yakima and may increase in-basin predation risk. The diverse habitat of the Yakima River delta, which once included an extensive forested riparian zone and numerous side channels, has been degraded and partially submerged by McNary Pool, an adjacent portion of the Columbia River upstream of McNary Dam. Changes to the Columbia River hydrograph may also affect the shared groundwater/surface water system of the Yakima River downstream of Wanawish Dam, where temperature extremes currently limit salmonid survival and diversity. These potential out-of-basin impacts on the Lower Yakima need to be studied to determine if they are negatively affecting listed species, and if so, how their effects can be reduced.

### 3.4.2 Columbia River Dams

Steelhead migrating to and from the Yakima Basin pass four Columbia River hydroelectric dams: Bonneville, The Dalles, John Day, and McNary. These dams are maintained for primarily hydroelectric production, navigation, and irrigation. They affect survival rates, migratory patterns, and timing of Yakima steelhead populations. Access and passage through these dams results in the direct mortality of both adults and juveniles at each dam. These dams have also significantly changed the nature of fish habitat in the Columbia above Bonneville Dam, replacing former rapids, pools, and riffles with wide, deep, slow-moving reservoir habitat. These impoundments affect the temperatures and travel times faced by migrating fish and result in increased exposure to predation. Extensive efforts are being made to improve the survival of anadromous fish through the Columbia River hydrosystem. The future of these actions is being negotiated as part of development of the revised Biological Opinion for the Federal Columbia River Power System.

### 3.4.3 Columbia River Estuary

The Columbia River estuary is a key habitat where juvenile and adult fish make the physiological transition from fresh to saltwater and vice versa. Pearcy et al. (1992) found that environmental conditions encountered by juveniles in the ocean, which includes the estuary and the river plume, are important predictors of the success of a brood year and the overall adult return rates.

The Columbia River estuary has been extensively modified. Estuary habitat has been lost due to dredging of a shipping lane, diking and the sedimentation and active filling of side channels (Weitkamp 1994). Dredge spoils have been used to create artificial islands in the estuary, which fish eating birds (e.g., Caspian terns, Double-crested Cormorants and gulls) use as nesting, resting, and foraging grounds. Upriver dams have created reservoirs that act as settling ponds, reducing the delivery of sediment and organic matter to the estuary (Sherwood et al. 1990). The cumulative effects of urbanization, industrialization, agricultural practices, and dams have degraded water quality in the estuary.

Prior to flow regulation, spring freshets created an immense freshwater plume at the mouth of the Columbia during the time that smolts were entering the ocean. Conditions within the plume may protect juvenile salmon making the transition to the ocean. The freshwater-saltwater margins of the plume provide key feeding areas. Reduction in the spring flows from the Columbia River has greatly reduced the size of the plume and its influence on nearshore marine conditions (Sherwood et al. 1990) and is believed to reduce survival conditions for emigrating juvenile salmonids (Pearcy 1992).

### 3.4.4 Ocean Conditions

Listed steelhead from the Yakima Basin spend a significant portion of their lives and accumulate most of their body mass in the marine environment. About half the mortality to salmonids occurs in the ocean (Bradford 1995). Conditions in the ocean affecting survival are subject to short-and long-term variation and are a source of significant variation in salmon returns to freshwater (Beamish and Bouillon 1993). Specific understanding of the marine ecosystem inhabited by Columbia Basin salmon and steelhead is limited. However, it is clear that short- and long-term cycles drive marine productivity and salmon survival. These cycles are the result of forces acting across the Pacific Ocean that affect currents, temperature, upwelling, and nutrients in coastal areas inhabited by Yakima Basin steelhead. Short- and long-term changes in marine productivity cascade through the food chain and affect salmonid abundance. Annual fluctuations in ocean survival make the potentially positive effects of freshwater restoration actions difficult to detect. At the same time, the negative effects of habitat degradation may be masked by improving marine conditions, leading to deeper reductions when the ocean subsequently shifts to a regime of poorer conditions (Lawson 1993).[33] The need to evaluate smolt-to-adult and adult-to-smolt ratios to separate out the influences of in- and out-of-basin conditions is highlighted in section 7.2.2. The effects of

---

[33] Much of the background information on lower river, estuary, and ocean effects is taken from the Snake River Salmon Recovery Plan (2005).

ocean conditions on Yakima Basin steelhead will be incorporated into NOAA Fisheries' all-H analysis for the Middle Columbia River Steelhead DPS as a whole. We are not aware of any aspects of ocean survival that are distinct for Yakima steelhead stocks when compared to Middle Columbia River Steelhead as a whole.

### 3.4.5 Out-of-Basin Harvest

Harvest in the Columbia River, estuary, and ocean fisheries has historically been a major limiting factor for anadromous fish in the Yakima Basin. Current commercial, recreational and subsistence fisheries are managed to minimize impacts on listed stocks, but some level of incidental mortality in mixed-stock fisheries is known to occur. Better estimating the impacts of fisheries in the Columbia will help us understand the degree to which harvest affects in-basin returns.

### 3.4.6 Predation

The altered environments of the mainstem Columbia and its estuary support a variety of both native and non-native predators. Changed river conditions have increased predation by native northern pikeminnow, while introduced species like walleye and bass also prey on migrating smolts. Avian predators such as Caspian terns, Double-crested Cormorants and gulls also have significant impacts (NMFS 2000). The creation of artificial islands in the Columbia River estuary from dredge spoils attracts opportunistic fish-eating birds, which feed on juvenile salmonids migrating from the Columbia River to marine habitats (Antolos et al. 2005). In the Columbia River estuary, avian predators are estimated to have consumed 18% (range, 11-30%) of smolts (all species) reaching the estuary in 1998 (Collis et al. 2000b). Relocation of nesting terns from Rice Island to East Sand Island has resulted in a reduction of the percentage composition of salmonids in their diet (Collis et al. 2002).

Yakima steelhead populations are exposed to out-of-basin avian predation that other Middle Columbia River Steelhead major population groups bypass because of the Yakima River's location. Bird populations on islands in the Columbia near the mouth of the Yakima are known to consume steelhead migrating out of the Yakima River. In 2005, an estimated 1% (22) of PIT tags from outmigrating Yakima River steelhead were subsequently recovered on the Crescent Island Caspian tern colony. In 2004, the figure was 2% (A. Evans, Real Time Research Inc., communication 2006). In 2005, only 0.1% (3 PIT tags) of PIT-tagged Yakima River steelhead were recovered on the Badger Island pelican colony (located just downstream from the mouth of the Yakima with >1057 adult birds present). PIT tag recoveries from the Foundation Island colony of double-crested cormorants, situated 8 km upstream of Crescent and Badger islands indicated an overall steelhead predation rate about 1/5 as great as for the tern colony, though this is changing as tern numbers drop and cormorant numbers increase (Collis and Roby 2006). These rates do not account for ingested PIT tags deposited off the colonies or for mortality of tagged fish (at least 50% for Yakima steelhead) between release sites and the Yakima River mouth.

Pinnipeds, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Steller's sea lions (*Eumetopia jubatus*) are the primary marine mammals preying on steelhead originating from the Yakima Basin (Spence et al. 1996). Pacific striped dolphin (*Lagenorhynchus obliquidens*) and killer whale (*Orcinus orca*) may also prey on adult steelhead. Seal and sea lion predation is primarily in saltwater and estuarine environments, although they are known to travel well into freshwater terrain in pursuit of migrating fish. While in recent years, significant numbers of sea lions have entered the Columbia River below Bonneville during the spring, they are not generally present during the July-August migration window for Yakima steelhead. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable. Although marine mammals and salmon coexisted long before man interfered ecologically, human alterations and management practices throughout the species' ranges have resulted in a reduction in salmon and steelhead abundance to the point that increased or targeted predation can have more significant effects on population viability.

### 3.4.7 Competition with Non-Native Species

A potentially important source of exploitative competition occurring outside the basin may be between the exotic American shad (*Alosa sapidissima*) and juvenile steelhead. Palmisano et al. (1993) concluded that increased numbers of shad likely compete with juvenile salmon and steelhead, resulting in reduced abundance and production of salmon and steelhead. It is also hypothesized that the large numbers of shad in the Columbia contribute to the growth of northern pikeminnow, smallmouth bass, and walleye, which are important predators of salmon and steelhead. Shad may be sustaining large populations of predators during periods when salmon and steelhead are not available to the predators, and, as a result, more and larger predators are present during periods when salmon and steelhead are moving through the Columbia River. Research is needed to assess the direct and indirect effects of American shad on the abundance and survival of Yakima Basin steelhead.

# 4 Recovery Goals and Criteria



Recovering listed species requires reducing or eliminating threats to the long-term persistence of populations, maintaining widely distributed populations across the diversity of habitats in their native ranges, and preserving genetic diversity and life-history characteristics. According to current guidance from NOAA Fisheries, demonstrating recovery of the Middle Columbia River Steelhead will require showing that populations, MPGs and the DPS, have met certain measurable and objective criteria based on the Viable Salmonid Populations (VSP) framework (ICTRT 2004) and the threats criteria identified in the listing.[34] This chapter presents measurable goals, objectives, and criteria based on the four VSP parameters of abundance, productivity, spatial structure, and diversity and then describes general strategies for achieving these criteria. Specific actions that implement the general strategies are described in Chapter 5.

## 4.1 Recovery Goals

The overall goal of this plan is to ensure long-term persistence of viable populations of naturally produced steelhead distributed across their native range in the Yakima Basin. A “viable” population is defined as an independent population that has negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe. This recovery plan is build around three separate but linked sets of thresholds for assessing progress towards recovery: a delisting threshold, a short-term recovery threshold, and a long-term recovery threshold.

### 4.1.1 Delisting Threshold

The delisting threshold is based on the recovery scenarios identified by the ICTRT (2007a; 2007b) with minor modifications based on discussions between local recovery planners and the ICTRT. When these criteria and similar criteria for other MPGs within the Middle Columbia DPS are met, a proposal to delist the DPS is considered appropriate by the ICTRT. According to the ICTRT (2007b, p. 8), an MPG meeting the following five criteria would be at low risk:

1) At least one-half of the populations historically within the MPG (with a minimum of two populations) should meet viability standards.

2) At least one population should be classified as “Highly Viable.”

3) Viable populations within an MPG should include some populations classified (based on historical intrinsic potential) as “Very Large,” “Large,” or “Intermediate,” generally reflecting the proportions historically present within the

[34] See the Federal Register, Volume 71, p. 834.

MPG. In particular, Very Large and Large populations should be at or above their composite historical fraction within each MPG.

4) All major life history strategies that were present historically within the MPG should be represented in populations meeting viability requirements.

5) Populations not meeting viability standards should meet or exceed the maintenance standard[35] with (a) sufficient productivity so the overall MPG productivity does not fall below replacement (i.e., these areas should not serve as significant population sinks) and (b) sufficient spatial structure and diversity demonstrated by achieving such maintenance standards.

Choices made by the Yakima Basin Fish & Wildlife Recovery Board in applying the ICTRT standards include presuming that 1) the Naches would achieve at least the Viable standard (meeting the ICTRT requirement for one of the large populations to be classed as Viable), 2) the Satus population is the most likely candidate for Highly Viable status, and that 3) the Toppenish and Upper Yakima populations would meet or exceed the maintenance standard for remaining populations. Other combinations that also meet ICTRT guidelines are possible, and if during implementation these seem more appropriate to pursue, the delisting strategy should be revised accordingly.

The Yakima Basin Fish & Wildlife Recovery Board also split the Satus Population into the Satus Creek and Mainstem blocks, as described in section 2.2. The Satus Creek block is attributed the number of spawners the ICTRT would have identified for a population based just on the habitat available in the Satus Creek watershed itself; planners believe that achieving “high viability” status for this block, using the criteria for a basic population, is likely. The “mainstem block” represents steelhead identified by the ICTRT as being potentially produced in the lower Yakima River portion of the Satus Population Area (from the Satus Creek confluence to the Columbia River). Given the uncertainties about both historic and future potential for significant amounts of spawning in this portion of the basin, the Board chose to treat that portion of the Satus population as a block of spawners that can be produced in the lower mainstem Yakima and its tributaries or in the portion of the mainstem Yakima upstream of Satus Creek and below the Naches River. If mainstem spawning in these reaches is not found to be viable, additional fish produced beyond the abundance thresholds in one or more of the other population areas can make up for the “mainstem block.”

[35] The ICTRT calls for a “maintained” population to have an abundance/productivity combination above the 25% extinction risk on their viability curves and a spatial structure/diversity risk rating as per Figure 4.1, with the qualification that the minimum abundance threshold for a basic population should be 250 spawners and the minimum for intermediate through very large populations should be at least 500 spawners (ICTRT 2007b, p. 79).

### 4.1.2 Short-term Recovery Threshold

The short-term recovery threshold calls for recovering all four steelhead populations in the Yakima Basin to the ICTRT's Viable status (a 5% or less risk of extinction over a 100 year period). This threshold differs from the delisting threshold in that all populations must exceed maintained status and be classified as viable, and no population is singled out for Highly Viable status. This threshold was the one originally developed by the Yakima Subbasin Planning Board prior to development of the final ICTRT recommendations. It was retained in order to emphasize the Yakima Basin Fish & Wildlife Recovery Board's commitment to achieving viability across all four populations in order to minimize long-term extinction risks. The Board recognizes the delisting threshold as an appropriate point at which to consider delisting, but holds that continuing on beyond delisting to achieve the short-term recovery goal is both important and feasible in the 15-30 years needed to implement actions from this plan and see a population-level response by steelhead.

### 4.1.3 Delisting & Short-term Recovery Threshold Differences

The matrix presented in Figure 4.1 helps clarify the difference between the delisting and short-term recovery thresholds. The figure is adapted from the ICTRT's stock status reports (ICTRT In press); a full description of the ICTRT approach to determining Viability can be found in ICTRT (2007b).

**Figure 4.1: VSP parameter risk ratings for Yakima steelhead populations**

| | | **Spatial Structure/Diversity Risk** | | | |
|---|---|---|---|---|---|
| | | **Very Low** | **Low** | **Moderate** | **High** |
| **Abundance/Productivity Risk** | **Very Low (<1%)** | **HV** | **HV** | **V** | M |
| | **Low (1-5%)** | **V** | **V** | **V** | M |
| | **Moderate (6-25%)** | M | M | M Toppenish Satus | |
| | **High (>25%)** | | | Naches | Upper Yakima |

**HV = Highly Viable; V = Viable; M = Maintained; Shaded cells do not meet viability criteria**

The short-term recovery threshold calls for moving all four of the Yakima Basin populations to a 5% viability level. Looking at the figure, this would require moving them from the lower right portion of the diagram to one of the boxes marked with a V in the second row. The ICTRT's viability criteria for the Yakima Basin Major Population Group (MPG) calls for two of the populations (including one of the large populations) to move to Viable status or better, with one of the Viable populations then moving on to Highly Viable status. The remaining two populations must reach or exceed Maintained status. The most likely scenario addressing these criteria was described in Section 4.1.1.

### 4.1.4 Long-term Recovery Threshold

Achieving the delisting and short-term recovery goals described above are only the first steps towards increasing the abundance and productivity of Yakima Basin steelhead populations to levels that allow for harvest for recreational, commercial, and ceremonial purposes in keeping with the Vision 2020 statement in Section 1.2. The specific long-term recovery targets identified in this plan are far from definitive determinations of what may be possible. They do serve to remind us that while the short-term goals of recovering steelhead to the point that they no longer require the protective measures of the Endangered Species Act is an immediate priority, the long-term recovery vision of the Yakima Basin Fish & Wildlife Recovery Board will require building on that initial success and continuing recovery efforts long after delisting is achieved. No time frame is set for achieving long-term recovery.

### 4.1.5 Relationship of Recovery Thresholds to NOAA Delisting Decisions

NOAA Fisheries' decision whether or not to delist Middle Columbia River Steelhead should be guided by the Board and ICTRT recovery thresholds, but is not required to be strictly determined by them. NOAA has the discretion to determine when it considers the MPG sufficiently recovered to be labeled as Viable. NOAA Fisheries also has the ability to proceed with delisting even if neither threshold is met, based on the determination that substantial progress towards recovery is being made. Because steelhead populations within the Yakima Basin make up only a portion of the total Middle Columbia River DPS, it is also possible that Yakima Basin steelhead meet their recovery criteria but are not delisted, based on concerns over the status of other steelhead MPGs in the DPS.

## 4.2 Recovery Objectives and Criteria

This section describes recovery objectives and criteria developed in accordance with NOAA Fisheries guidance (NMFS 2004) and the ICTRT Yakima Stock Status Assessments described in Chapter 2 (ICTRT In press). The purpose of these objectives and criteria is to provide concrete measures of progress towards meeting the recovery goals. These objectives and criteria are based on quantitative and qualitative measurements of abundance, productivity, and spatial structure/diversity on a population basis. Criteria for the delisting and short-term recovery thresholds are drawn directly from the ICTRT's Stock Status Assessments, with the delisting threshold based on the most likely application of the maintenance standard to one large population (Upper

Yakima) and one other population (Toppenish), and the short-term recovery threshold based on achieving Viability for each of the four populations. Productivity and diversity criteria for the long-term recovery threshold are the same as for the short-term threshold. Long-term recovery threshold abundance and spatial structure criteria are based on restoring full access to historically accessible stream reaches throughout the basin that that can be restored consistent with the Board's commitment to sustaining local customs and economies.

### 4.2.1 Abundance

The abundance objective is to maintain the number of steelhead within each population in the Yakima Basin at levels consistent with viability. The abundance criteria call for maintaining the 10-year geometric mean for spawner abundance at levels equal to or exceeding the values given in Table 4.1.

**Table 4.1: Minimum abundance criteria for recovery thresholds**

| Population | Delisting Threshold | Short-Term Recovery | Long-term Recovery |
|---|---|---|---|
| **Satus:**<br>Satus Watershed<br>Mainstem Block[36] | <br>500<br>500 | <br>500<br>500 | 2,000 |
| **Toppenish** | 250 | 500 | 1,500 |
| **Naches** | 1,500 | 1,500 | 5,400 |
| **Upper Yakima** | 500 | 1,500 | 7,700 |
| **Total for MPG** | 3,250 | 4,500 | 16,600 |

The long-term recovery targets presented here were calculated by averaging and rounding the results of the 2005 subbasin planning EDT restoration threshold for steelhead and an extrapolation to spawner abundance from the ICTRT total weighted and temperature limited habitat area for the Yakima Basin (discussed in Sections 2.3 and 2.4.1) times an average of 10 spawners per 10,000 $m^2$ of high-quality habitat (a rate currently seen in good habitat in the Yakima Basin) as shown in Table 4.2.

[36] As noted in Section 4.1.1, the "mainstem block" represents spawners attributed to the Satus population by the ICTRT that local recovery planners call for producing either in the portion of the mainstem Yakima below the Naches River, or if mainstem spawning in these reaches is not found to be viable, as additional fish produced beyond the abundance thresholds in any of the population areas.

**Table 4.2: Sources for long-term recovery abundance targets**

| Population | EDT Restoration Scenario | ICTRT Expansion | Average of EDT & ICTRT |
|---|---|---|---|
| **Satus** | 2,733 | 1,280 | 2,007 |
| **Toppenish** | 1,784 | 1,171 | 1,478 |
| **Naches** | 4,911 | 5,849 | 5,380 |
| **Upper Yakima** | 6,533 | 8,795 | 7,664 |
| ***Total*** | ***15,961*** | ***17,095*** | ***16,528*** |

Note that these numbers do not take into account interactions with resident rainbow

Although the total abundance target for the long-term recovery threshold is approximately an order of magnitude greater than recent 10-year average abundance, it is still only one third of the estimated historic abundance levels discussed in Section 2.4.1. Both methods assume that the anadromous form of *O. mykiss* dominates the entire Upper Yakima population area. Reviewing this assumption is identified as a key research need in Chapter 7. These long-term abundance targets should not be interpreted as definitive goals. They are meant to encourage discussion and ongoing research about the potential size of fully recovered steelhead populations in the Yakima Basin.

### 4.2.2 Productivity

The productivity goal is to increase the number of reproductive offspring per spawner within each population to levels that, together with increased abundance, result in low risk of extinction. All thresholds call for the Yakima major population group to maintain a long-term average spawner:spawner ratio greater than or equal to 1.0, indicating stable or increasing long-term population size. Productivity criteria are based on intrinsic productivities calculated using the ICTRT's methods[37] in order to assess the ability of populations to rebound when reduced to below average abundances. Criteria for minimum 10-yr geometric means for intrinsic productivity at the size threshold for each population and threshold are indicated in Table 4.3. Criteria are based on the ICTRT Viability Curves (ICTRT 2007b).

[37] See explanation of ICTRT intrinsic productivity calculations in Section 2.4.2.3.

**Table 4.3: Spawners and spawner:spawner ratio**

| Population | Delisting Threshold | Short-Term Recovery | Long-term Recovery |
|---|---|---|---|
| **Satus:**<br>Satus Watershed<br>Mainstem Block | <br>2.00 (High Viable)<br>1.56 (Viable) | <br>1.56 (Viable)<br>1.56 (Viable) | <br>1.2<br>1.2 |
| **Toppenish** | 1.20 (Maintained +) | 1.56 (Viable) | 1.2 |
| **Naches** | 1.26 (Viable) | 1.26 (Viable) | 1.2 |
| **Upper Yakima** | 1.20 (Maintained +) | 1.26 (Viable) | 1.2 |

### 4.2.3 Spatial Structure

The spatial structure goal is to restore the distribution of steelhead across a broad range of habitats in historically occupied areas in order to maintain resilience and life history diversity. Distribution of steelhead spawning across the ICTRT designated spawning areas for each population is used to assess spatial distribution. Distribution is assessed based on the ICTRT's definition of occupancy:

> Occupied areas are those in which two or more redds from natural origin spawners have been observed in all years of the most recent brood cycle (i.e., the most recent generation) and have been observed for at least half of the most recent three brood cycles (approximately 15 years for steelhead and Chinook). A Minor Spawning Area (MiSA) is regarded as occupied when it has two or more redds present over the previously defined time periods. A MSA is regarded as occupied when it has two or more redds within BOTH the upper and lower half of the weighted spawning area within that MSA over the previously defined time periods. (ICTRT 2007b, p. 50).

**Satus Population**

Naturally produced steelhead should occupy both major spawning areas in the Satus watershed (Satus and Dry Creek MSAs) and the Mule-Dry minor spawning areas. Consistent spawning must occur in both major spawning areas.

**Toppenish Population**

Naturally produced steelhead spawning should occupy both of the major spawning areas in the Toppenish watershed (upper Toppenish and Simcoe MSAs). Consistent spawning must occur in both major spawning areas.

**Naches Population**

Naturally produced steelhead should occupy at least seven of the eight major spawning areas for the delisting and short-term recovery thresholds. For the long-term recovery threshold all eight will be occupied. Consistent spawning must occur within the Naches mainstem and Ahtanum, and Rattlesnake creeks to maintain distribution across habitat types and life histories.

**Upper Yakima Population**

Naturally produced steelhead should occupy at least 10 of the 14 major spawning areas for the delisting and short-term recovery thresholds. For the long-term recovery threshold 12 of 14 MSAs should be occupied. Spawning should consistently occur within at least the Yakima mainstem; Umtanum, Swauk, Manastash, and Taneum creeks; and the Teanaway River (West and North Teanaway MSAa and Lower Teanaway minor spawning area). While this threshold does not specifically require passage at Cle Elum, Kachess, and/or Keechelus dams, it recognizes that providing passage can play an important role in meeting these criteria. Table 4.4 summarizes the options for meeting the spatial structure criteria in the Upper Yakima.

**Table 4.4: Possible combinations of spawning areas for the Upper Yakima**

| Required MSAs | Plus at least three of these: | Recovery not required |
|---|---|---|
| Umtanum<br>Swauk<br>North Teanaway<br>West Teanaway<br>Taneum<br>Manastash<br>Upper Mainstem | Cle Elum<br>Naneum<br>Reecer MSA<br>Caribou MSA<br>Middle Mainstem | Wenas<br>Roza/Burbank |

### 4.2.4 Diversity

The diversity goal for all thresholds is to maintain and enhance both phenotypic (morphology, behavior, and life-history traits) and genotypic diversity while limiting introgression of non-local genes. This will be accomplished by continuing to carefully manage and/or minimize factors that alter the distribution of traits such as timing of spawning and upstream and downstream migrations, age structure, size, fecundity, morphology, behavior, and genetic characteristics.

Population-specific criteria based on measurable traits, including body length, run timing, age structure, sex ratio, and genetic composition have not been developed at this time. As noted in Chapter 2, data is available on these traits for the MPG as a whole, but only the Upper Yakima population can be characterized in any detail at this time (based on samples at Roza Dam). Developing methods to identify fish by population at Prosser Dam fish ladders will play an important role in developing the information base needed to develop population specific diversity criteria. Additional information on the research needed to develop detailed population-specific diversity criteria is given in Chapter 7. The hatchery stray rate into the basin should be maintained at less than 5% of the total spawner abundance in the MPG (based on Prosser counts). Monitoring of genetic composition to detect the presence of non-indigenous genetic markers should be established.

## 4.3 Recovery Strategies

This section describes the geographic priorities and action strategies that will need to be applied to successfully meet the recovery goals, objectives, and thresholds described above. It provides an overview and framework for the more detailed discussion of specific recovery actions in Chapter 5. The action strategies were chosen to serve as a linkage between the specific action descriptions in this plan and the more general summary in the draft NOAA Fisheries recovery plan for the Middle Columbia River Steelhead DPS. These strategies are specific to the Yakima Basin; additional strategies to address factors affecting Yakima steelhead in the Columbia River and the ocean will be addressed in the NOAA Middle Columbia River Steelhead Recovery Plan.

Recovery strategies for the Yakima Basin are:

### 4.3.1 Habitat Strategies

1) Protect existing functional habitats
2) Restore unimpeded upstream and downstream fish passage (includes screening diversions)
3) Restore floodplain connectivity and function
4) Restore channel structure and complexity
5) Restore riparian condition and future LWD recruitment
6) Improve flow conditions
7) Improve water quality
8) Improve upland watershed conditions
9) Enhance upstream nutrient supplies

### 4.3.2 Predation Strategies

1) Reconfigure infrastructure to reduce predation
2) Evaluate and modify predator management options

### 4.3.3 Harvest Strategies

1) Maintain in-basin fishing regulations that protect steelhead, including regulations of other fisheries aimed at eliminating by-catch of steelhead and reducing negative impacts of introduced species

### 4.3.4 Hatchery Strategies

1) Use small-scale supplementation to accelerate recovery
2) Promote repeat spawning of kelts

All of the actions in Chapter 5 are classified according to the action strategies they implement and the limiting factors they address.

### 4.3.5 Recovery Strategies Outside of the Yakima Basin

Recovery actions in the mainstem Columbia, estuary, and ocean are identified and implemented through a complex framework of federal and state programs and policies over which Yakima Basin stakeholders have little control. The choice of which out-of-basin recovery actions to implement and the rate that they are completed will significantly affect the survival of Yakima steelhead during their upstream, downstream, and oceanic migrations. This plan focuses on recovery strategies within the Yakima Basin, but assumes that significant improvements will also be made out-side of the basin. Out-of-basin strategies and actions are to be addressed in detail as part of NOAA's Middle Columbia Steelhead Recovery Plan.

### 4.3.6 Recovery Strategies Affecting All Yakima Populations

All four Yakima populations will benefit significantly from efforts to improve conditions for upstream adult and downstream smolt migrations in the mainstem Yakima River. This will require:

1) Altering irrigation delivery and storage operations in the Yakima Basin to improve flows and temperatures in migration periods (Habitat Strategy 6) and utilize managed high flows to maintain floodplain habitat

2) Improving channel and floodplain conditions and reducing predation through the shared migratory reach (Habitat Strategies 3, 4 & 5 and Predation Strategy 1)

All four Yakima populations also benefit from the kelt-reconditioning program (Hatchery Strategy 2), protective fisheries regulations (Harvest Strategy 1), and ongoing efforts to protect existing functional habitat (Habitat Strategy 1). The Upper Yakima and Naches populations would also benefit from the conservation-oriented supplementation programs under consideration (Hatchery Strategy 1).

### 4.3.7 Role of Areas Above Storage Dams in Steelhead Recovery

When the five major Yakima Basin storage dams were constructed early in the 20th century, steelhead access to streams above the dams was blocked. The BOR has assessed the amount of anadromous fish habitat potentially available if passage facilities are built as 13.8 miles above Keechelus Dam, 2.4 miles above Kachess Dam, 29.4 miles above Cle Elum Dam, 6.0 miles above Bumping Lake Dam, and 36.8 miles above Tieton Dam ((BOR 2005). There is some uncertainty over the degree of productivity and past use of these areas by steelhead (Yakima Subbasin Fish and Wildlife Planning Board 2005, p. 2-335), but this may be offset by the prospect that these colder waters could become more important refugia for steelhead if climate change leads to decrease flows and increased water temperatures at lower elevations. Even limited use of these areas would increase the viability of the populations through improvements in spatial structure and life history diversity. If Chinook, sockeye, or coho also recolonize these habitats, the resulting marine-derived nutrients would benefit steelhead.

The costs of providing passage at the storage dams are substantial when compared solely to their potential benefit to steelhead. It is the contention of the Yakima Basin Fish & Wildlife Recovery Board that 1) recovery of steelhead to levels of viability sufficient to warrant delisting under the ESA may be feasible without restoration of access to habitat above the storage dams, but that 2) access at some or all of the storage dams would greatly facilitate the process of steelhead recovery. Accordingly, our recovery criteria for steelhead do not require establishment of spawning populations above the passage dams, but do recognize that passage at the storage dams can help in reaching steelhead recovery goals. Fish passage at some or all of the storage dams is a key component for both bull trout recovery and re-establishment of sockeye salmon in the Yakima Basin, and offers significant benefits to non-listed Chinook and coho. When the benefits for all salmonid species are considered, passage at the storage dams becomes a much higher priority than it would be for steelhead on their own. Construction of Lake Cle Elum and Bumping Lake passage facilities are identified as specific actions in Chapter 5. Passage at all five storage dams should continue to be assessed based on the full range of benefits it would provide.

### 4.3.8 Toppenish Population Recovery Strategies

**Geographic Focus**

Recovery efforts should focus equally on both MSAs and their shared migration corridor. No specific actions are identified for the Mill Creek minor spawning area, but it should benefit from the general watershed-wide and lower Toppenish Creek actions.

**Key Strategies**

Achieving recovery goals for the Toppenish Population will require:

1) Continuing efforts to protect existing functional habitat (Habitat Strategy 1)
2) Significant efforts to improve passage, flows, and riparian conditions in Toppenish Creek and its tributaries (Habitat Strategies 2, 5, 6, 7 & 8)
3) Restoration of floodplain function in lower Toppenish Creek (Habitat Strategies 3 & 4)
4) Improving migration conditions in the mainstem Yakima River as detailed in Section 4.3.6

### 4.3.9 Satus Population Recovery Strategies

**Geographic Focus**

Within the Satus Creek watershed itself, recovery efforts should focus equally on both MSAs and their shared migration corridor. No specific actions are identified for the Mule-Dry minor spawning area, but it should benefit from the general watershed-wide and lower Satus Creek actions. Within the mainstem Yakima portion of the ICTRT Satus Population Area, recovery efforts should focus on improving habitat and survival for upstream and downstream migration by all populations. Specific efforts to restore spawning aggregations in the lower mainstem and its tributaries should only occur if there is evidence that successful life history strategies based in the lower river and its tributaries currently exist or can be re-established.

Recovery actions in tributary drainages to the lower Yakima River are not identified in this plan. Portions of Snipes, Spring, and Corral creeks and Amon Wasteway[38] may have potential to produce steelhead (Romey and Cramer 2001), and some level of use by salmon and *O. mykiss* is known to occur (Monk 2001). These waterways were identified as parts of minor spawning areas in the ICTRT intrinsic potential analysis. However, as discussed in Chapter 2, flows in these waterways are dominated by return flows from irrigation systems. Evidence that they would not have sustained significant year-round flows prior to the establishment of irrigation is presented by Smith et al. (2006). The Kennewick Irrigation District provided the Yakima Basin Fish & Wildlife Recovery Board with aerial photographs of Amon Wasteway from 1948 and 1955 that show a dry channel prior to irrigation development in the surrounding area (letter sent 12/26/07). This plan does not require these areas to be managed for steelhead in order to meet recovery objectives; and local recovery planners have indicated to the ICTRT that these areas should not be included as part of modeled historic habitat (See Appendix A).

Management of these waterways for fish habitat values has been limited. The irrigation districts manage these waterways as part of their drainage infrastructure and are concerned about potential regulatory burdens. WDFW notes that maintenance of the drainage networks need not prevent the protection and management of these waterways as fish-bearing waters. If these interests can be reconciled in a mutually acceptable manner, maintaining and enhancing fish habitat in the lower ends of these waterways should be encouraged as part of improving migratory habitat in the lower river.

Amon Wasteway is currently the focus of significant conservation efforts by the Tapteal Greenway Association. If habitat conditions that sustain steelhead production can be maintained and mutually acceptable agreements regarding future management reached by the Kennewick Irrigation District, WDFW, and other key stakeholders, management of this area as steelhead spawning habitat may be possible. However maintenance of steelhead spawning in this area is not a prerequisite for recovery and delisting of Yakima Basin steelhead.

**Key Strategies**

Achieving recovery goals for the Satus Population will require:

---

[38] Spring, Corral, and Snipes creeks and Amon Wasteway are referred to by the names used on the USGS 7.5 minute topographic maps. The first three are referred to as drainageways by local irrigation districts, while Amon Wasteway is often referred to as Amon Creek. The use of these names in this document is in no way meant to indicate any conclusions regarding ongoing disputes about the legal status of these waterways.

1) Continuing efforts to protect existing functional habitat (Habitat Strategy 1)

2) Continuing ongoing efforts by the Yakama Nation to improve watershed and riparian conditions within the Satus drainage ((Habitat Strategies 5, 7 & 8)

3) Restoring floodplain function and channel complexity in lower Satus Creek (Habitat Strategies 3 & 4)

4) Improving migration conditions in the mainstem Yakima River as detailed Section 4.3.6

### 4.3.10 Naches Population Recovery Strategies

**Geographic Focus**

The recovery threshold presented in this plan requires steelhead occupancy in seven of the eight major spawning areas. Currently there is at least some level of use in all eight MSAs, though steelhead spawning in the Tieton MSA is only confirmed from Oak Creek and the portion of the mainstem Naches associated with this MSA. Re-establishment of steelhead spawning in the Tieton River would make a valuable contribution to long-term recovery, but is not required by the de-listing threshold described in this plan. Efforts to increase steelhead use of the lower Tieton will only become feasible if fall high flows associated with flip-flop can be addressed; restoring use of the Tieton and its tributaries above Tieton Dam would require providing both upstream and downstream fish passage at the dam (see discussion of storage dams in Section 4.3.1).

The location of the Ahtanum and Cowiche MSAs between the Satus and Toppenish populations and the remainder of the Naches population make them important components of the spatial diversity of the population and the Yakima MPG as a whole.

The ICTRT has identified two minor spawning areas, Wide Hollow and Moxie, in the Naches population area. The Wide Hollow spawning area may have the ability to support limited steelhead spawning, but irrigation conveyance, return flows, and surrounding urban development hinder spawning activity. Establishment of steelhead in Wide Hollow is not a required part of recovery thresholds presented in this plan. The Moxee spawning area identified by the ICTRT is not considered to have had sufficient flows to support steelhead spawning, as noted in Section 2.3.3. The recovery thresholds presented in this plan do not require the establishment of steelhead in the Moxie area. Managing the lower reaches of Wide Hollow Creek and Moxee Drain to provide rearing habitat for fish moving to and from the mainstem Yakima, however, would be beneficial to Naches steelhead recovery.

The Naches River upstream from the Tieton confluence is the only mainstem reach in the basin with flows that are currently in a nearly normative state. Increasing the availability and quality of habitat in this portion of the basin will help offset the loss or alteration of mainstem habitats in other portions of the basin.

EDT model results indicate that conditions in the Naches River for the 17.5 miles below the Tieton confluence have a steelhead mortality rate—compared to the predevelopment estimate—of more than five times that for the 27.1 miles of the Naches upstream from the confluence. Most of the modeled impact is due to daily maximum river temperatures during the summer period before the flow spike associated with flip-flop. According to BOR flow data for water years 1995-1999, average regulated flow in the lower Naches was significantly lower than modeled average unregulated flow in July and the first half of August. Improving conditions in this reach will benefit all upstream MSAs. The purchase of the Wapatox water right by BOR (Sec. 3.3.5.7) is a significant step towards improving flows in this reach.

The 47-mile section of the mainstem Yakima included by the ICTRT in the Naches Population is a critical part of migratory and rearing habitat for both Naches and Upper Yakima steelhead. The degree to which it currently supports spawning that results in successful production of smolts is unknown. If successful life histories based on spawning in this area exist or can be established, the reach will be a candidate for meeting the "mainstem spawner" abundance objective identified in Section 4.1.1. The extent and viability of spawning in this mainstem reach is identified as a key knowledge gap.

**Key Strategies**

Achieving recovery goals for the Naches Population will require:

1) Continuing efforts to protect existing functional habitat (Habitat Strategy 1)
2) Making significant efforts to protect and improve passage, flows, and instream and riparian conditions in tributaries (Ahtanum, Bumping, Cowiche, Rattlesnake, Nile and Little Naches watersheds) (Habitat Strategies 2, 5, 6, 7 & 8)
3) Addressing the effects on steelhead of reservoir operations and irrigation withdrawals that create winter/spring/early summer low flows and late summer/fall high flows in the Tieton, lower Bumping and lower Naches River (Habitat Strategy 6)
4) Improve floodplain function and habitat conditions in the mainstem Naches River
5) Improving migration conditions in the mainstem Yakima River as detailed in Section 4.3.6

### 4.3.11 Upper Yakima Population Recovery Strategies

Recovery planners recognize that the Upper Yakima River steelhead population has the highest risk of extinction of the four populations in the MPG and will likely require more time and effort to recover than the Satus, Toppenish, and Naches populations. Just achieving "maintained" status in accordance with ICTRT maintenance guidelines will require a significant commitment to recovery actions in the Upper Yakima.

**Geographic Focus**

The Upper Yakima has the largest, most complex and diverse spatial structure of the four population areas, with 14 major and 2 minor spawning areas spread across a wide range of ecological settings. It is also the population with the most limited current distribution relative to the estimated historic distribution.

### *Lower Upper Yakima Tributaries*

The ICTRT's Wenas Creek MSA is not required in the recovery thresholds identified in this plan. If passage and appropriate migratory conditions in lower Wenas Creek could be assured, the upper watershed could potentially support a significant amount of steelhead spawning. The significant challenges associated with restoring passage and migratory conditions mean that it is not considered a short-term priority in this plan. If conditions change such that restoring Wenas Creek becomes feasible (e.g., major changes to irrigation systems and Wenas Dam), or if it is clear that production from the higher priority areas identified in this plan will not be sufficient to meet recovery objectives, restoration of steelhead spawning in Wenas Creek should be given higher priority. Efforts to maintain the lowest reaches of Wenas Creek as off-channel habitat for fish in the mainstem Yakima should be continued. The Selah Creek portion of the ICTRT's Wenas Creek MSA is not considered by local recovery planners to have ever maintained the streamflow needed to support steelhead and is not considered a recovery priority.

The Umtanum Creek portion of the Umtanum MSA is a mandatory element of the recovery threshold. Umtanum Creek itself is the only tributary with near-natural flow and habitat conditions that supports steelhead in the lower portion of the Upper Yakima population (it is managed as part of WDFW's LT Murray Wildlife Area). Potential contributions of Umtanum Creek to overall abundance and productivity of the Upper Yakima population as a whole are minor, but its role in improving gene flow between steelhead populations and as an island of relatively intact habitat in the Upper Yakima make it an important component of the spatial structure and diversity of the Upper Yakima population. While no specific actions are proposed for Umtanum Creek (the last significant passage barrier was removed in 2005-6), maintaining current management and protections is a high priority. While Lmuma Creek (also included in the ICTRT's Umtanum MSA) has the potential to support limited steelhead spawning, priority should be on restoring conditions in the lower end for use as an off-channel refuge by steelhead in the mainstem Yakima. Roza and Burbank creeks were also identified as potential habitat by the ICTRT, but have intermittent flows and limited access because of alluvial fans at their mouths. Neither is required as part of this recovery threshold. Work by the Department of Defense and other landowners aimed at improving watershed conditions in these areas should continue based on the benefits to downstream areas.

### *Ellensburg Area Tributaries*

The Reecer and Caribou MSAs both contain complex networks of small creeks, including Dry, Reecer, and Currier (Reecer MSA) and Cherry, Cooke, Coleman, Park, and others (Caribou MSA). These creeks have been managed for a century as part of a complex network of irrigation ditches and drains. The lower ends of these tributaries have high value as off-channel rearing habitat for the adjoining reach of the mainstem Yakima and are being restored to serve as such through YTHAP restoration efforts. These creeks have only limited spawning potential due to their low gradients and highly altered hydrographs.

The Naneum MSA includes the Naneum and Wilson creek systems. The upper Naneum Creek watershed includes significant amounts of potential habitat and is thought to have sustained steelhead spawning prior to development of the irrigation infrastructure that now blocks passage into the upper watershed. Several possible routes exist for opening up passage through the interconnected network of streams and irrigation ditches east of Ellensburg. Identifying the most effective route and prioritizing barrier removal and habitat actions through this route is a significant but feasible challenge. Ongoing efforts to restore passage in Wilson Creek upstream to the city of Ellensburg are opening access to valuable rearing habitat; however, the high cost and logistical challenges of opening Wilson Creek through the city make working further up on Wilson Creek a low priority.

#### *Other Upper Yakima Area Tributaries*

The Swauk Creek, North Teanaway and West Teanaway MSAs and the Lower Teanaway minor spawning area are the current tributary strongholds for steelhead production in the Upper Yakima (the Middle Fork Teanaway is a portion of the West Teanaway MSA). Maintaining these spawning areas is required to meet the Upper Yakima recovery threshold. Taneum Creek has high quality habitat that is currently partially accessible. Projects to assure unimpeded fish passage are underway. Manastash Creek is currently inaccessible to steelhead due to passage barriers at irrigation dams; cooperative efforts to remove these barriers and improve instream flows are underway. Both of these MSAs are anticipated to be consistent producers of the anadromous form of *O. mykiss* and are required components of this recovery scenario.

#### *Mainstem Spawning Areas*

The Middle Mainstem MSA between the Teanaway and Cle Elum rivers is currently accessible. The Upper Mainstem MSA includes the accessible reaches of the mainstem Yakima River upstream from the Cle Elum River, tributaries such as Big Creek, and up to 15 miles of currently blocked habitat above Kachess and Keechelus dams. The Cle Elum MSA is split into the accessible section below Cle Elum Dam and up to 30 miles of blocked habitat above the dam. All are candidates for recovery.

### Key Strategies

The complex interactions between habitat conditions and anadromous and resident life histories of *O. mykiss* in the Upper Yakima will require ongoing monitoring and research aimed at understanding what conditions promote anadromy, and specifically, whether residency is more a reflection of favorable local habitat or unfavorable migration conditions. Research outcomes will guide restoration in addition to the obvious needs for improved passage. For example, if flow manipulation has a disproportionate effect on early juveniles, moderating its effects may shift the current balance toward anadromy.

Actions that are expected to benefit the Upper Yakima steelhead population include:

1) Continuing efforts to protect existing functional habitat (Habitat Strategy 1)

2) Providing unimpeded passage for steelhead in key tributaries (Manastash, Taneum and if feasible, Naneum and Cle Elum) (Habitat Strategy 2)

3) Improving outmigration conditions at Roza Dam (Habitat Strategies 2 & 6)
4) Addressing the effects of reservoir and irrigation system operations that create winter/spring/fall low flows and summer high flows in the lower Cle Elum and mainstem Yakima rivers (Habitat Strategy 6)
5) Protecting and enhancing floodplain conditions along the mainstem Yakima (Habitat Strategy 3)
6) Improving flows and instream and riparian conditions in tributaries and side channels (Habitat Strategy 4, 5, 6 & 9)
7) Improving migration conditions in the lower mainstem Yakima River as detailed in Section 4.3.6

# 5 Recovery Actions



## 5.1 Identifying and Describing Recovery Actions

This chapter of the recovery plan recommends specific recovery actions that will contribute directly to restoring steelhead in the Yakima Basin to viable levels. Research and monitoring actions are described in Chapter 7, and outreach and education actions are described in Chapter 8. Both of these sets of actions do not directly alleviate threats to steelhead viability, but are essential to improving our ability to design and implement actions that do. Implementation of the recovery actions identified in this chapter should restore steelhead populations to viable levels. These actions will also benefit other fish species and some wildlife and lessen the chance for additional listings in the Yakima Basin.

Some of the actions identified in this plan were developed in other forums or processes (e.g., the Yakima Subbasin Plan and the HB 2514 Watershed Planning process) and are incorporated with little or no modification. Specific restoration actions that have been completed and are not ongoing in nature are not listed here; an inventory of past restoration actions was included in the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005); and the Yakima Basin Fish & Wildlife Recovery Board anticipates maintaining a continually updated database of completed recovery actions. Intensive fish restoration work has occurred in the Yakima Basin for over three decades and continuing, refining, and expanding these existing efforts will be a key component of steelhead recovery in the Yakima Basin. Recovery will also require a significant commitment to new actions. Both new and ongoing actions are detailed in this plan. The following NOAA Fisheries recovery planning guidelines were applied when selecting and describing recovery actions (NMFS 2004):

- Recovery actions should be discrete and action-oriented.
- Whenever possible, recovery actions should be site-specific, as per ESA Section 4(f)(1)(B)(i).
- Recovery actions should be feasible and fundable.
- The plan should include both near-term (completed in less than 15 years) and long-term (taking longer than 15 years) actions.
- Recovery actions should be described with sensitivity and discretion.

Actions identified in this plan are classified into six groups, Basinwide, Lower Mainstem, Naches, Status, Toppenish, and Upper Yakima. Basinwide actions are those that can be applied throughout the basin. Most are programmatic in nature, though a few key basinwide actions involve specific proposals for river and hatchery operations. Lower Mainstem actions are site-specific actions in the shared migratory corridor from the mouth of the Yakima upstream to the confluence of the Naches. Actions below the Toppenish Creek confluence are noted as benefiting all population areas, while those above are noted as benefiting the Naches and Upper Yakima populations.

All other actions are population-specific; where actions occur in and/or specifically benefit individual Major Spawning Areas (MSAs), these areas are indicated in the action description. Note that while MSAs are often named after a single creek, they typically include a complex of nearby creeks. For example, the Caribou Creek MSA also includes Coleman, Parke, Cooke, Cherry, and other creeks (see figure 2.5 for clarification).

As noted in Chapter 4, for local planning purposes we have broken the ICTRT's Satus population area into two components. The Satus Creek actions listed here are specific to the Satus Creek Watershed, while actions in the lower mainstem Yakima (technically part of the ICTRT's Satus population) are listed separately due to their broad benefits to all populations. Similarly, while the ICTRT Naches population area includes the Yakima mainstem from the mouth of Toppenish Creek upstream to the Naches confluence, we have included actions in this area under the mainstem actions category.

Additional information provided for each recovery action includes:

- Key partners
- Focal area
- Strategies implemented by the action
- Likelihood of implementation
- Time to implement
- Time to realize benefits
- Cost estimates

Key partners are entities likely to play a significant role in implementing the action.

Focal area is the location of the action itself.

For strategies implemented by the action, see Chapter 4.

Likelihood of implementation was scored in one of three categories. Only actions in the first two categories were retained:

- High (action is technically feasible, support is likely and there is little or no opposition)
- Moderate (action is technically feasible, there is some support, and opposition could likely be resolved)
- Low (action involves substantial technical issues and/or has little apparent or likely support or would likely encounter opposition)

Time to implement indicates the time required to implement the action on the ground. Categories were:

- Ongoing (action is in place and needs to be continued at roughly current levels)
- Expand ongoing effort (action is in place but needs to be expanded)
- 0-3 years required to implement
- 4-6 years
- 6-10 years
- Greater than 10 years

Time to realize benefits indicates the time needed following implementation for benefits of the action to be fully realized. This time ranges from instantaneous (e.g., improved passage is available the day after a dam is removed) to decades long (e.g., for plantings to generate new woody debris).

Cost estimates given in this plan are preliminary estimates based on the best information on hand. The accuracy of estimates varies greatly from action to action, and the estimates should not be taken as definitive. Each estimate represents the total cost of implementing the action, but does not include either the value of resulting benefits or opportunity costs incurred as a result of the action. The cost proportions indicate the percentage of the project costs attributed to benefiting fish in general and steelhead in particular. These are general estimates meant to indicate if a project would be done specifically to benefit steelhead (e.g., 100% fish, 100% steelhead), benefit steelhead and other fish species (e.g., 100% fish, 50% steelhead), or benefit fish indirectly (e.g., water conservation efforts that directly benefit irrigators in addition to their fish benefits).

Each action description is meant to give an overview of the proposed action and its key components. As part of the development of a recovery implementation schedule, action descriptions will be refined and expanded, and more detailed descriptions of specific components of the actions will be developed. This implementation schedule will be maintained in a tiered structure, with general strategies identified in this plan at Tier I (e.g., “Restore unimpeded fish passage”) and the actions described in this plan at Tier II (e.g., “Restore passage in lower Taneum Creek”). Tier III will include detailed descriptions of specific projects that implement the Tier II actions (e.g., “Install rock-weir fishway at the Bruton Diversion”). All of the actions described in this plan have been compiled into a simple database that will be regularly updated in response. See Chapter 6 for more information about how this will be integrated into the recovery implementation process.

## 5.2 Timeframe for Implementing of Actions

Actions in this recovery plan are intended to be implemented in the next 15 years. Recovery of the species themselves may take considerably longer (up to several decades) because of delayed environmental response (e.g., the time required for a planted riparian zone to reach maturity and full function) and subsequent population response (e.g., the time required for a population to incorporate restored portions of its range into its life history). Actions are assigned to one of three time frames:

1) Actions classified as Ongoing are generally currently being undertaken by existing entities that have a history successfully implementing similar actions. In most cases ongoing actions will need to be continuously implemented in the future.

2) Short-term Actions are one-time or unique actions that can be implemented within the next six years.

3) Long-term Actions generally require additional technical study, policy review, and public comment prior to implementation. Implementation of these actions should begin within the 15-year time frame and continue thereafter. This requires that studies, policy review, and public involvement begin early in the implementation process. Specific timeframes for implementation of these long-term actions will be developed during the implementation scheduling process described in Chapter 6.

## 5.3 Necessity and Sufficiency of Proposed Actions

Given 1) natural variability in climate and ocean conditions, 2) uncertainty about the implementation and survival benefits of recovery actions in the ocean, estuary and mainstem Columbia, and 3) uncertainties about the rates and types of biological responses to within-basin recovery actions described in this plan, it is impossible to predict exactly which subset of the recovery actions described in the plan will be required to meet each of the separate goals of delisting, short-term, and long-term recovery. Implementing some or all of the actions presented here should significantly improve the abundance, productivity, spatial structure, and diversity of steelhead in the Yakima Basin. Recovery planners anticipate that the full suite of actions presented here, if combined with expected improvements outside of the Yakima Basin, will be more than sufficient to meet de-listing and short term recovery goals, but that additional actions may need to reach long-term broad sense recovery goals.

The Yakima Basin Fish & Wildlife Recovery Board is working with recovery stakeholders to refine the actions presented in this plan and developing a detailed Implementation Schedule that will be regularly updated to indicate the status of actions and identify priorities for future action based on their biological benefit and socio-economic feasibility. More detail on this process is given in Chapter 6.

Chapter 7 describes the monitoring and research efforts needed to track progress towards recovery goals and help us understand which recovery actions will be required to meet those goals. Evaluating the effectiveness of implemented recovery actions will require a rigorous and quantitative approach to adaptive management as priority actions are being implemented. Actual implementation efforts will have to be adjusted over time based on monitoring results. Detailed recommendations on implementing a strong adaptive management process will be included in the Research, Monitoring and Evaluation (RME) supplement to the Yakima Steelhead Recovery Plan that is currently being developed by the Yakima Basin Fish & Wildlife Recovery Board. Local recovery planners encourage interested parties to participate in the development of the RME supplement and the ongoing adaptive management and implementation scheduling process.

This plan does not include a quantitative effort to analyze the sufficiency of the recovery actions recommended in this plan. At this time we do not have the level of detailed information needed to make quantitative predictions about the benefits of specific actions and the exact suite of actions that will be required to meet recovery goals. The Yakima Basin Fish & Wildlife Recovery Board and its partners will develop some of this detail as part of a regularly updated implementation schedule that identifies and prioritizes specific steps needed to implement the recovery actions in the Yakima Steelhead Recovery Plan. This process will focus on identifying specific habitat goals and tracking progress towards meeting them.

As part of development of NOAA Fisheries' Middle Columbia DPS Recovery Plan, the broad recovery scenario developed using the EDT model as part of the 2005 Yakima Subbasin Plan is being integrated into an all-H model that predicts steelhead response to recovery actions across the basin, the Columbia River, and the ocean. This EDT recovery scenario is described in Appendix B. More information about the integrated modeling effort will be available in the NOAA Fisheries' Mid-Columbia Steelhead Recovery Plan.

## 5.4 Overall Cost of Recovery

The cost identified for each action in this plan is a preliminary estimate of the cost of implementing the actions and was developed in accordance with NOAA Fisheries' guidelines for recovery plans. Costs are all in current dollars; they have not been adjusted for inflation or discounted to account for opportunity costs. Because these costs are preliminary and the specific set of actions that will be required to meet de-listing goals is not yet known, the sum of the costs presented here should not be presumed to be the cost of achieving de-listing. No attempt has been made to quantify either opportunity costs or economic benefits associated with proposed actions. While some actions described here will be implemented specifically to benefit steelhead and will be paid for by funds devoted to that purpose, many others will be implemented to achieve a wide range of benefits and will be paid for using an accordingly wide range of funding sources (e.g., floodplain enhancement projects that will improve habitat but also reduce infrastructure maintenance costs, improve flood protection for developable lands, and meet open space and recreation needs). Other actions (e.g., improving on-farm irrigation efficiency) will only occur when justified by direct benefits to the implementer, with benefits to fish as an incidental benefit. Section 5.1 described our attempt to address this complexity by assigning cost proportions, but to truly understand the economic impacts of specific actions requires a level of cost-benefit analysis not included in this plan.

## 5.5 Recovery Action Descriptions

This section provides detail on the 94 separate actions identified in this planning process. The action descriptions are given in a standardized format generated by the actions database maintained by the Yakima Basin Fish & Wildlife Recovery Board. This database will continue to be developed and will be linked with the implementation schedules that will guide on-the-ground implementation and prioritization of recovery actions. Actions are presented in six groups: 1) Basinwide actions (16 total), which apply equally to all population areas, 2) Lower Mainstem Actions (9 total), which occur in the mainstem Yakima in areas shared by multiple populations (from the Columbia River to Roza Dam), and then 3) Naches (31 total), Satus (8 total), Toppenish (10 total) and Upper Yakima population area-specific actions (21 total), in that order. The sequence of actions does not indicate any priority; prioritization of actions will be specified in the implementation schedules under development. The references listed under limiting factors are the numbers of the related limiting factors in Tables 3.1 through 3.6.

| | |
|---|---|
| **Basinwide Action #1** | **Modify reservoir operations to improve out-migration flows** |

**Key Partners:** Bureau of Reclamation

**Affected MSAs:** All Spawning Areas

**Focal Area:** Mainstem Yakima and Naches Rivers **Implementation Likelihood:** Moderate

**Time to Implement:** 0-3 years

**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions
Improve flow conditions
Improve flow conditions

**Limiting Factors:** BW1,2,3

**Cost Derivation:** Operational change; no specific cost identified.

**Total Cost:** **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:**

Sufficient spring outmigration flows are essential for steelhead survival. Low spring flows increase smolt travel times and exposure to high temperatures and predators in the mainstem Yakima. In spring, BOR reservoir operations balance the need to refill storage with flood control. Flood control rule curves call for maintaining reservoirs at less than full levels in the early spring to provide capacity capture rapid runoff that would otherwise cause flooding. Later in spring, outflows are minimized to ensure refilling of reservoirs. This reduction in flows typically coincides with the smolt out-migration period. BOR has committed to studying alteration of rule curves themselves and is already altering operations to fill reservoirs sooner and spill in spring; other options include making releases during the outmigration period based on runoff predicitions, rather than spilling after reservoirs fill, and managing pulse flows. Evaluating the effects of changes in reservoir operations on water supply, flood hazard, and ecological functions should be facilitated by the work underway through the Storage Study. The potential of these changes to return the river to a more normative hydrograph without significantly impacting water supplies should be evaluated. Changes in spring/early summer reservoir operations may increase frequency of short-term overbank flooding, but would decrease the extent of long duration high water events, decreasing flood hazard, and increasing channel stability. Increased cottonwood regeneration and reductions in aquatic plant densities in the lower river are other potential benefits.

| **Basinwide Action #2** | **Adequately screen all water diversions** |
|---|---|

**Key Partners:**
- Yakima Tributary Access and Habitat Program
- Yakama Reservation Watersheds Project
- Irrigation Districts
- Individual irrigators
- Conservation Districts
- Bureau of Reclamation
- Washington Department of Fish & Wildlife
- Bonneville Power Administration

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Basinwide

**Implementation Likelihood:** High

**Time to Implement:** Expand ongoing

**Time to Benefit:** 0-3 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**
BW3

**Cost Derivation:** $300,000/year for 15 years based on current efforts.

**Total Cost:** $4,500,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $2,250,000

In the 1980s and 1990s, WDFW and the BOR updated fish screens on the larger diversions in the basin. These screens need ongoing maintenance and upgrading. Smaller diversions are being screened via the WDFW screen shop and the YTAHP program. Many smaller surface water and pump diversions need screening throughout the basin. Programs for these actions are in place, but limited by funding. Existing screens need to be operated and updated in a manner that ensures that they meet current criteria. Where fish are present in canals, fish salvage operations should continue. Entrainment in unscreened diversions is an issue for kelts as well as juveniles.

**Basinwide Action #3** **Increase on-farm irrigation efficiency**

**Key Partners:**
- Irrigation Districts
- Department of Ecology
- Bureau of Reclamation
- Individual irrigators
- USDA Natural Resource Conservation Service
- Conservation Districts

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Irrigated lands throughout the basin **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 0-3 years

**Strategies:**
Improve flow conditions
Improve water quality

**Limiting Factors:**
BW1,2

**Cost Derivation:** Work on 30% of 474,000 irrigated acres at a cost of $3,500/acre.

**Total Cost:** $497,700,000 **Fisheries:** 25% **Steelhead:** 50% **Steelhead Cost:** $62,212,500

Increases in on-farm irrigation efficiency can reduce the amount of water diverted from the river and reduce return flows and associated water quality issues. Benefits often also include increased agricultural productivity and reduced labor needs. Significant improvements have been made in recent decades by individual irrigators and NRCS, conservation districts, WSU extension and other programs. These efforts should be continued and expanded. Programs should ensure that reductions in on-farm water use can be tracked and utilized in a manner that directly contributes to instream flows at key locations and times (see actions that identify priority areas for flow improvement).

**Basinwide Action #4** **Increase irrigation water delivery efficiency**

**Key Partners:**
- Bureau of Reclamation
- Irrigation Districts
- Department of Ecology
- Bureau of Reclamation
- Washington Department of Agriculture

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Irrigation systems throughout the basin **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 0-3 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
BW1,2

**Cost Derivation:** Specific costs for high priority systems listed under specific actions.

**Total Cost:** **Fisheries:** 30% **Steelhead:** 50% **Steelhead Cost:**

Many of the irrigation systems in the basin could be upgraded. Where older systems have been converted to pressurized systems (e.g. the Yakima-Tieton) water consumption has been reduced, crop production has become more efficient, and susceptibility to drought has decreased. Even with increased irrigation assessments to maintain new systems, total cost of irrigation water has been reduced via reduced power demand and on-farm pumping. Delivery efficiency should be broadly promoted throughout the basin to reduce overall water demand and increase flexibility in reservoir operations. Power conservation programs, such as BPA's, should be used to support system improvements. Fisheries benefits are greatest where low flows are limiting during irrigation season; specific actions that address these areas are listed separately.

**Basinwide Action #5** **Utilize Trust Water Rights Program to improve instream flows**

**Key Partners:**
- Department of Ecology Water Trust Program
- Washington Department of Fish & Wildlife
- Bureau of Reclamation
- Water Trust & Conservancies

**Affected MSAs:** All Spawning Areas

**Focal Area:** Basinwide as opportunities arise **Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing
**Time to Benefit:** 0-3 years
**Strategies:** Improve flow conditions
**Limiting Factors:** BW1,2

**Cost Derivation:** $200,000/year plus 1 FTE & expenses at $75,000/year for 15 years.

**Total Cost:** $4,125,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $1,546,875

The Department of Ecology, BOR, Washington Water Trust, Washington Rivers Conservancy, Columbia Basin Water Transactions Program, and others have developed programs to lease and purchase water rights for instream use. Use of these programs could be significantly enhanced through education and outreach. This action is associated with the need for better water rights enforcement to ensure that once water is put into trust, it remains in-stream and is not diverted by down stream users. Benefits will be greatest in specific tributary locations; these are identified as separate actions in this plan.

**Basinwide Action #6** **Continue kelt reconditioning**

**Key Partners:**
- Columbia River Inter-Tribal Fisheries Commission
- Yakima Klickitat Fisheries Project

**Affected MSAs:** All Spawning Areas

**Focal Area:** Prosser Hatchery Facility **Implementation Likelihood:** High

**Time to Implement:** Ongoing
**Time to Benefit:** 0-3 years
**Strategies:** Promote repeat spawning of kelts
**Limiting Factors:** BW3,8

**Cost Derivation:** Existing program cost of $446,000/year (1/3 of BPA# 200306200 & 2/3 of BPA #200001700 as Yakima basin portion plus $50,000/yr YKFP contributions) for 15 years.

**Total Cost:** $6,690,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $6,690,000

The Yakima kelt reconditioning program directly increases the abundance of spawning adult steelhead with a relatively low risk of altering population characteristics. The kelt reconditioning program could play a role in reintroduction of populations to newly re-opened suitable habitats and in directed efforts to increase the numbers of spawning adults in specific steelhead populations in the subbasin. Monitoring of kelt reproductive success and genetic impacts should be expanded to ensure the kelt program is successful contributing to meeting recovery goals.

**Basinwide Action #7** **Use artificial production techniques to restore steelhead to underutilized habitats**

**Key Partners:**
National Marine Fisheries Service
Yakama Nation
Washington Department of Fish & Wildlife
Yakima Klickitat Fisheries Project

**Affected MSAs:**
All Naches
All Upper Yakima

**Focal Area:** Targeted spawning areas in Naches and Upper Yakima Populations

**Implementation Likelihood:** Moderate

**Time to Implement:** 6-10 years
**Time to Benefit:** 6-10 years

**Strategies:**
Use small-scale supplementation

**Limiting Factors:**
BW8

**Cost Derivation:** $500,000 startup costs plus $200,000/year for 15 years based on use/expansion of existing facilities.

**Total Cost:** $3,500,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $3,500,000

Small-scale targeted supplementation that is designed to enhance steelhead VSP parameters may play an important role in accelerating recovery of the Upper Yakima and Naches populations. Focal areas would be watersheds with good habitat conditions where steelhead are not present or severely reduced due to historic passage barriers that have been or are being removed. Leading candidates include Cowiche, Manashtash, and Taneum watersheds. If passage into Naneum Creek and above Cle Elum and/or Bumping Dam is secured, these areas would also be strong candidates. Metrics should be developed to evaluate desired recolonization rates and population characteristics and the range of cultural actions that would be appropriate if these rates or populations characteristics are not met. The rate of colonization, productivity, life-history form (anadromous versus resident), and genetic structure of new populations should be closely monitored. The Yakima-Klickitat Fisheries Program is currently developing a Master Plan that will assess supplementation options.

**Basinwide Action #8** **Continue coho, sockeye and summer Chinook reintroduction efforts**

**Key Partners:**
Yakima Klickitat Fisheries Project

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Basinwide

**Implementation Likelihood:** High

**Time to Implement:** Ongoing
**Time to Benefit:** 6-10 years

**Strategies:**
Enhance upstream nutrient supplies

**Limiting Factors:**
BW9

**Cost Derivation:** Costs not directly attributable to steelhead recovery.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

The Yakima/Klickitat Fisheries Project is currently working to reintroduce coho to the subbasin and is evaluating the possibility of reintroducing sockeye and summer Chinook. These efforts have the potential to benefit steelhead by increasing the flow of ocean-derived nutrients into rearing areas in the Yakima Basin. Possibilities for competetive interactions also exist and should continue to be monitored by YKFP.

**Basinwide Action #9** **Maintain a local policy and informational entity for steelhead recovery**

**Key Partners:**
Yakima Basin Fish & Wildlife Recovery Board

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Basinwide

**Implementation Likelihood:** High

**Time to Implement:** Ongoing

**Time to Benefit:** 0-3 years

**Strategies:**

**Limiting Factors:**

**Cost Derivation:** $200,000/year over 15 years for steelhead portion.

**Total Cost:** $3,000,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $3,000,000

The Yakima Basin Fish & Widllife Recovery Board was established in 2006 to act as the regional recovery organization for the Yakima Basin under the State of Washington's salmon recovery framework. The Board plays an important role in 1) updating the local and federal steelhead recovery plans, 2) coordinating recovery actions both in the basin and with other recovery entities in the Mid-Columbia steelhead DPS, 3) tracking and reporting on the status of recovery efforts, and 4) building local and regional support for recovery efforts.

**Basinwide Action #10** **Promote land and resource use decisions that protect and enhance fisheries resource values**

**Key Partners:**
Natural Resource Management Agencies
Local governments

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Basinwide

**Implementation Likelihood:** Moderate

**Time to Implement:** Ongoing

**Time to Benefit:** 0-3 years

**Strategies:**
Protect existing functional habitat

**Limiting Factors:**
All

**Cost Derivation:** Costs not directly attributable to steelhead recovery.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

Existing regulations and management programs that govern natural resource use need to be implemented in a manner that protects steelhead habitat and the upland and watershed functions that sustain it. These actions need to be coordinated with efforts to protect open space, wildlife habitat, and working landscapes; reduce flood damage; and support development that enhances the quality of life of local communities and meets the needs of private landowners. This plan identifies a number of specific non-regulatory protection actions that should be coordinated with ongoing work to build an effective and balanced system of land use management and zoning.

**Basinwide Action #11** **Restore beaver populations**

**Key Partners:**
- Yakama Reservation Watersheds Project
- Local governments
- Washington Department of Fish & Wildlife

**Affected MSAs:** All Spawning Areas

**Focal Area:** Basinwide

**Implementation Likelihood:** Moderate

**Time to Implement:** Ongoing

**Time to Benefit:** 3-10 years

**Strategies:**
- Restore floodplain connectivity/function
- Restore channel structure/complexity

**Limiting Factors:** BW10

**Cost Derivation:** Policy aspect not costed; Relocation & habitat management priced at $150,000/year for 15 years.

**Total Cost:** $2,250,000 **Fisheries:** 50% **Steelhead:** 75% **Steelhead Cost:** $843,750

Beaver played an important role in the pre-European hydrology of the Yakima Basin. Beaver dams and associated meadows can provide complex habitat and increase floodplain storage and the volume and quality of stream baseflows. Where beaver presence is compatible with land uses, it should be encouraged, via reductions in trapping and development of food sources (e.g. riparian plantings). Beaver dams that are potential nusiances can be managed to reduce flood risks or beavers can be relocated to more appropriate locations.

**Basinwide Action #12** **Improve recruitment of cottonwoods**

**Key Partners:**
- Bureau of Reclamation
- USDA Natural Resource Conservation Service
- Private landowners and lessees
- Regional Fisheries Enhancement Group or other volunteer groups
- Conservation Districts
- Local governments
- Washington Department of Fish & Wildlife

**Affected MSAs:** All Spawning Areas

**Focal Area:** Floodplain reaches of the mainstem Yakima and Naches Rivers

**Implementation Likelihood:** Moderate

**Time to Implement:** Ongoing

**Time to Benefit:** 6-10 years

**Strategies:**
- Restore riparian condition/future LWD

**Limiting Factors:** BW2

**Cost Derivation:** Undetermined.

**Total Cost:** **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:**

Natural black cottonwood germination generally requires overbank flow in late spring when seeds are dispersing and then a gradual reduction in flows as seedlings establish. This requirement is often at odds with current river operations. The regulated hydrograph could be altered in some years to increase the cottonwood regeneration rate in some reaches; identifying how to do so will require additional analysis. Many floodplain reaches have been heavily grazed and cottonwood regeneration has occurred in places where grazing pressure is relaxed, even under current flow regimes. This highlights the value of ongoing efforts to improve grazing management in riparian areas and floodplains. In the short term, planting programs for cottonwood, especially in the Wapato Reach, would benefit salmonids and the ecosystem as a whole.

**Basinwide Action #13** **Address forest health issues**

**Key Partners:**
- US Forest Service
- Washington Department of Natural Resources
- Private landowners
- Bureau of Indian Affairs, Yakama Agency

**Affected MSAs:** All Spawning Areas

**Focal Area:** Forested areas throughout Yakima Basin

**Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing

**Time to Benefit:** 6-10 years

**Strategies:**
- Restore riparian condition/future LWD
- Improve upland watershed conditions

**Limiting Factors:** BW4

**Cost Derivation:** Costs not directly attributable to steelhead recovery.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

The condition of forest stands directly affects watershed processes, and current increases in disease, pest and fire damage all threaten steelhead habitat. The U.S. Forest Service, the Bureau of Indian Affairs (which manages forests on the Yakama Reservation) and the Washington Department of Natural Resources all have programs to address forest health issues, but the need for treatment greatly exceeds the resources available to perform these tasks. Local interests such as the Yakima Basin Fish & Widllife Recovery Board, the Joint Board of Irrigators, Chambers of Commerce, the Farm Bureau, and federal agencies such as NOAA Fisheries, the BOR and BPA should make federal, state and local decision makers aware of the central role that healthy forests play in fish and wildlife conservation, cultural and recreational activities, management of the public and private water supplies and the health of the entire subbasin economy.

**Basinwide Action #14** **Maintain and enforce in-basin fisheries regulations that protect steelhead**

**Key Partners:**
- Washington Department of Fish & Wildlife
- Yakama Nation

**Affected MSAs:** All Spawning Areas

**Focal Area:** Basinwide

**Implementation Likelihood:** High

**Time to Implement:** Ongoing

**Time to Benefit:** 0-3 years

**Strategies:**
- Maintain protective fishing regulations

**Limiting Factors:** BW6,7

**Cost Derivation:** Policy action & use of existing enforcement capacity; no new cost charged to recovery.

**Total Cost:** **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:**

There is no directed recreational steelhead fishing allowed in the basin, and other fisheries are regulated to minimize impacts on steelhead. WDFW and the Yakama Nation should maintain protective regulations and ensure that they are adequately enforced.

**Basinwide Action #15** **Evaluate and implement nutrient enhancement in steelhead streams**

**Key Partners:**
Yakima Klickitat Fisheries Project

**Affected MSAs:**
All Naches
All Upper Yakima

**Focal Area:** Selected tributary subwatersheds **Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Enhance upstream nutrient supplies

**Limiting Factors:**
BW9

**Cost Derivation:** $0.50 (0.35/ft plus 0.15/ft program overhead based on NOAA fisheries estimates) per foot per year for 5 five mile reaches for 15 years.

**Total Cost:** $198,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $148,500

Historically, higher salmon runs transported significantly more oceanic-derived nutrients to Yakima Basin headwaters. There is interest in launching pilot nutrient enhancement projects in selected tributaries using salmon carcasses and/or carcass analogues. Potential sites include Taneum Creek and the Little Naches River, where carcass placement would occur following large woody debris enhancement (to facilitate retention of carcasses in headwaters). Nutrient enhancement should be coordinated with monitoring of steelhead response.

**Basinwide Action #16** **Explore fisheries management options that reduce predation**

**Key Partners:**
Washington Department of Fish & Wildlife

**Affected MSAs:**
All Spawning Areas

**Focal Area:** mainstem Yakima River **Implementation Likelihood:** Moderate

**Time to Implement:** 0-3 years
**Time to Benefit:** 3-10 years

**Strategies:**
Maintain protective fishing regulations

**Limiting Factors:**
LM9

**Cost Derivation:** Policy decisions without specific cost to implement.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

Management of existing recreational fisheries for species that prey on steelhead could be implemented in a manner that reduces predation on steelhead, particularly during the outmigration of smolts. Changing recreational fishing rules for bass and catfish in the lower river to reduce number and/or change age structures so as to reduce predation on salmonids and establishing a pikeminnow bounty program have been identified as possible actions. Any efforts to adjust fisheries to reduce predation should be coordinated with ongoing monitoring designed to evaluate the impacts of these adjustments.

**Lower Mainstem Action #1** **Increase flows in Chandler bypass reach to improve juvenile out-migration conditions**

**Key Partners:**
Bureau of Reclamation

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Yakima mainstem below Prosser Dam **Implementation Likelihood:** Moderate

**Time to Implement:** 0-3 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
LM1

**Cost Derivation:** No cost to implement, but lost revenue due to reduced power sales (amount not specified at this time).

**Total Cost:** **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:**

Flows diverted to run the Chandler power plant reduce flows in the Yakima River from Prosser Dam to the powerplant return 12 miles downstream. During the spring, BOR currently reduces generation at the Chandler plant whenever flows would otherwise drop below the 1000 cfs subordination target during the spring. Increasing this minimum flow level when steelhead smolts are moving through the lower Yakima would improve passage conditions for smolts at Chandler Dam and in the bypass reach downstream. It would also reduce the proportion of juvenile entrainment in the Chandler powerhouse diversion and thereby reduce mortality rates in the Chandler canal and at the Chandler outfall. BOR has not committed to this action at this time; implementation would be facilitated by proposed changes to the KID irrigation system.

**Lower Mainstem Action #2** **Improve flows below Parker through irrigation system improvements**

**Key Partners:**
Bureau of Reclamation
Roza-Sunnyside Board of Joint Control
Irrigation Districts
Bureau of Reclamation
BIA/Wapato Irrigation Project

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Irrigation Districts in lower Yakima Valley **Implementation Likelihood:** Moderate

**Time to Implement:** > 10 years
**Time to Benefit:** 10-25 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
LM2,4,5

**Cost Derivation:** Roza ID, $40 million; Benton ID, $16 million; SVID, $50 million; KID, $35 million; WIP, $150 million; all very preliminary figures.

**Total Cost:** $291,000,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $72,750,000

The Sunnyside Irrigation District is nearing completion of a canal improvement project that will result in the dedication of about 20,000 acre/ft of water to instream use. The Wapato Irrigation Project is working with YRBWEP to move diversions for the Satus diversion from Wapato Dam to a new pump station near Granger, which would leave the water to be diverted instream for an additional 25 miles. The Kennewick Irrigation District is working with YRBWEP on several proposals to move some or all of their diversions downstream, potentially as far as the Columbia mainstem, and the Benton Irrigation District has also proposed moving diversions downstream. These proposal (and similar future proposals) would result in significant improvements in mainstem flows during the irrigation season while also resulting in improved water delivery for irrigators.

**Lower Mainstem Action #3 Reconfigure infrastructure to improve smolt survival rates**

**Key Partners:**
Bureau of Reclamation
Irrigation Districts

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Chandler outfall, Wanawish/Horn Rapids Dam, WIP and SVID bypasses

**Implementation Likelihood:** High

**Time to Implement:** 0-3 years

**Time to Benefit:** 3-10 years

**Strategies:** Change structures to reduce predation

**Limiting Factors:** LM6,14,15,16

**Cost Derivation:** BOR cost estimate for outfall structure & a grade control in the river below the Chandler outfall.

**Total Cost:** $500,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $250,000

The current configuration of the Chandler juvenile bypass outfall and the condition of fish as they exit the bypass result in high concentrations of avian and aquatic predators and high predation rates at that site. Migrating smolts may also be subject to physiological stress and mortality in the bypass system. A more diffuse outfall, improved instream passage routes, bird deterrents and/or provision of additional cover or safe recovery areas for juveniles that transit the bypass would improve survival. Other potential bypass reaches and predation hotspots that should be assessed include Wanawish (Horn Rapids) Dam and the WIP and SVID screen bypass outfalls.

**Lower Mainstem Action #5 Improve hydrograph through artificial storage and/or Columbia River water transfer**

**Key Partners:**
Bureau of Reclamation
Department of Ecology

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Lower basin (Parker and below)

**Implementation Likelihood:** Moderate

**Time to Implement:** > 10 years

**Time to Benefit:** 10-25 years

**Strategies:** Improve flow conditions

**Limiting Factors:** LM1,2

**Cost Derivation:** Cost as proposed is up to $6.5 billion; cost not attributed to steelhead recovery at this time.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

The Yakima Basin Storage Study is assessing proposals to increase water storage capacity through construction of the Black Rock and/or Wymer reservoirs and the possible transfer of water from the Columbia Basin to Yakima Basin irrigation use. As proposed, Black Rock Reservoir would eliminate the most severe effects of the flip-flop flow regime, improve flow and temperature in the Wapato reach, and potentially further delay the onset of lethal temperature regimes. There is still considerable uncertainty about the technical and economic feasibility of the Black Rock project; these questions should be resolved in the EIS to be released by the BOR in 2008. Any efforts to use water from outside the basin will need to ensure that imported water does not negatively affect homing of salmon and steelhead.

**Lower Mainstem Action #6** **Restore mainstem and side channel habitats in the Union Gap reach**

**Key Partners:**
- US Army Corps of Engineers
- Yakima County
- Bureau of Reclamation
- Yakima Basin Side Channels Project

**Affected MSAs:**
- All Naches
- All Upper Yakima

**Focal Area:** Mainstem near City of Yakima **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 3-10 years

**Strategies:**
- Restore floodplain connectivity/function
- Restore channel structure/complexity

**Limiting Factors:** LM8,9,10,11

**Cost Derivation:** Based on preliminary estimate by Yakima County.

**Total Cost:** $13,500,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $3,375,000

The Union Gap reach of the Yakima River between Naches River and Wapato Dam is considered to have very high restoration potential. It is one of the only mainstem reaches that is not currently limited by severely altered flow and temperature regimes. YRBWEP has purchased large areas of floodplain habitat to the east of the river. The majority of this area is currently isolated by levees and passage barriers. Yakima County Flood Control Zone District is proposing to set back the levees in this reach to significantly increase the size of the active floodplain, including on the YRBWEP properties. WSDOT has constructed a new bridge at SR 24 which is much longer than the old bridge to allow the levee setback to proceed. Floodplain restoration work is being coordinated with Central Pre-mix's gravel mining operation.

**Lower Mainstem Action #7** **Protect and restore mainstem and floodplain habitats below Sunnyside Dam**

**Key Partners:**

US Army Corps of Engineers
Yakima County
Bureau of Reclamation
Yakima Basin Side Channels Project
Land Conservancies
Yakama Nation Riparian/Wetlands Restoration Project

**Affected MSAs:**

All Spawning Areas

**Focal Area:** Floodplain reaches below Parker **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing

**Time to Benefit:** 0-3 years

**Strategies:**

Protect existing functional habitat
Restore floodplain connectivity/function
Restore channel structure/complexity
Restore riparian condition/future LWD

**Limiting Factors:**

LM1,3,7,8,9,11 ,14,15,16

**Cost Derivation:** 500 acres floodplain restoration (dike setback/reveg) at $10,000/acre, CREP/easement costs for 636 acres (5% of 1000' x 105 miles) at $3000/ac.

**Total Cost:** $6,908,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $2,590,500

Lower river conditions play a major role in migration timing for adults and survival of out-migrating smolts. Protecting and restorating mainstem and off-channel habitats (especially those that provide thermal refugia) is critical for these life stages. The best opportunities for restoration lie in the Wapato Reach (especially between the Toppenish/Satus confluences);additional opportunities exist in the very lower river at the Barker Ranch and adjacent to the City of West Richland. Work may include protecting habitat through acquisition, easements or cooperative agreements (including the CREP program), and activities like riparian plantings, reactivation of side channels, and winter irrigation to saturate floodplains. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

**Lower Mainstem Action #8 Reduce adult attraction to Sulphur Creek & Roza Wasteways**

**Key Partners:**
Roza-Sunnyside Board of Joint Control
Irrigation Districts

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Sulfur Drain (by Sunnyside) **Implementation Likelihood:** High

**Time to Implement:** 0-3 years
**Time to Benefit:** 0-3 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**

**Cost Derivation:** $400,000 cost for barrier estimated by SVID; reducing flows costed in other actions. No cost available for Roza action.

**Total Cost:** $400,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $200,000

Sulphur Creek Wasteway (RM 61.0) receives return flows from the Roza and Sunnyside irrigation districts, and has attracted steelhead and salmon that can be stranded in the drain system when irrigation delivery ceases. To avoid this, fish are trapped and removed from the drain each fall. Even if stranding does not occur, passage delays associated with false attraction expose fish to predators and harassment by humans, and exposure to warm water can lessen their reproductive success. Measures to prevent or minimize such attraction are likely to increase steelhead spawning success. The Roza-Sunnyside Joint Board of Control is currently pursuing installation of a fish barrier in Sulfur Creek Wasteway 3/4 of a mile above the Yakima River [note: the fish barrier was completed in 2008 whiloe this plan was under review]. Reducing or eliminating return flows through the drain through improved irrigation system management is also a key part of long-term resolution of this issue (see Basinwide Action #3 and Lower Mainstem Action #2). Roza Wasteway near the City of Yakima is also known to have attract adult salmonids; Reclamation is currently looking at methods to improve the effectiveness of the barrier at the mouth of the wasteway.

**Lower Mainstem Action #9 Improve quality of irrigation return flows**

**Key Partners:**
BIA/Wapato Irrigation Project
Roza-Sunnyside Board of Joint Control
Department of Ecology
Irrigation Districts
Individual irrigators
USDA Natural Resource Conservation Service

**Affected MSAs:**
All Spawning Areas

**Focal Area:** Irrigation drains entering the lower Yakima River **Implementation Likelihood:** Moderate

**Time to Implement:** Ongoing
**Time to Benefit:** 0-3 years

**Strategies:**
Improve water quality

**Limiting Factors:**
LM4,5

**Cost Derivation:** Costs of Clean Water Act programs not attributed to specifically to steelhead recovery.

**Total Cost:** **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:**

In the last decade, the quality of return flows in the lower Yakima River has improved dramatically, with an ~90% decrease in turbidity due to improved irrigation management and implemention of the sediment TMDL for the lower Yakima River. The improved water quality is believed to be contributing to the rapid expansion of water star grass in the lower river. Work to continue water quality improvements should continue and should be accompanied by ongoing research to understand and respond to the ecological changes it is causing.

| Naches Action #1 | Improve Wapatox Canal conveyance efficiency |
|---|---|

**Key Partners:**
- Irrigation Districts
- Bureau of Reclamation

**Affected MSAs:**
- American
- Bumping
- Middle Naches
- Rattlesnake
- Tieton
- Upper Naches

**Focal Area:** Wapatox by-pass reach of the lower Naches

**Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years

**Time to Benefit:** 3-10 years

**Strategies:** Improve flow conditions

**Limiting Factors:** N3,4

**Cost Derivation:** Based on preliminary discussions with BOR.

**Total Cost:** $3,000,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $1,500,000

BOR acquired the Wapatox power plant and diversion in 2002 in order to use the associated 300-450 cfs water right to augment instream flows in 7.4 miles of the lower Naches River. The Wapatox diversion also supplies 50 cfs of water to irrigators so the diversion remains active. The conveyance system was designed for 400 cfs and needs a minimum of approximately 130 cfs to provide sufficient head to run the system. This has reduced the amount of water BOR has been able to put to instream use. Improving the efficiency of the conveyance system would allow irrigators access to their full water rights while allowing all of the BOR's water right to be left instream. Consolidating the Wapatox and Naches-Selah diversions has been proposed, which would address this issue, increase instream flows between the Naches-Selah and Wapatox diversions, and reduce constraints on Bumping Reservoir operations.

| Naches Action #2 | Improve water use efficiency and habitat in South Naches Irrigation District |
|---|---|

**Key Partners:**
- Irrigation Districts
- Bureau of Reclamation

**Affected MSAs:**
- American
- Bumping
- Middle Naches
- Rattlesnake
- Tieton
- Upper Naches

**Focal Area:** Lower mainstem Naches

**Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years

**Time to Benefit:** 3-10 years

**Strategies:** Improve flow conditions

**Limiting Factors:** N3,4

**Cost Derivation:** $1,000,000 estimate in Daily Journal of Commerce article (www.djc.com/news/en/11170266.html).

**Total Cost:** $1,000,000 **Fisheries:** 33% **Steelhead:** 50% **Steelhead Cost:** $165,000

The South Naches Irrigation District is currently examining means of improving efficiency of the irrigation system and habitat quality in the South Naches Channel. The South Naches Channel is composed of a mixture of natural and artificial channels that parallels the lower Naches for four miles and is used to conveys irrigation water. If appropriate habitat conditions and screening can be assured, the channel can provide increased steelhead rearing habitat. Water savings from efficiency improvements could be allocated to improve instream flows in the South Naches Channel and/or mainstem Naches.

| **Naches Action #3** | **Improve water use efficiency in lower Naches irrrigation districts** |
|---|---|

**Key Partners:**
- Irrigation Districts
- Bureau of Reclamation

**Affected MSAs:**
- American
- Bumping
- Cowiche
- Middle Naches
- Rattlesnake
- Tieton
- Upper Naches

**Focal Area:** Lower mainstem Naches River **Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
N3,4

**Cost Derivation:** $13 million City of Yakima system improvements; $5 million to move Fruitvale diversion to Nelson Dam;$5 million for other Districts.

**Total Cost:** $23,000,000 **Fisheries:** 33% **Steelhead:** 50% **Steelhead Cost:** $3,795,000

Irrigation system improvements that would increase instream flows have been proposed for the Naches-Selah Irrigation District, Naches Cowiche Canal Company, City of Yakima General Irrigation District (Nelson Dam), Fruitvale (City of Yakima), New Schanno Company, Fruitvale Schanno Company, Yakima Valley Canal Company (Congden Ditch), and Old Union Irrigation Company. These diversions reduce summer flows in steelhead rearing habitat between the diversion points and return flow locations. Increasing conveyance and on-farm efficiencies in these systems and using a portion of the water savings to increase instream flows will improve conditions for the Naches steelhead populations.

**Naches Action #4** **Modify flip-flop flow regime**

**Key Partners:**
Bureau of Reclamation

**Affected MSAs:**
American
Bumping
Cowiche
Middle Naches
Rattlesnake
Tieton
Upper Naches

**Focal Area:** Tieton and Lower Naches Rivers **Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
N2,3,4

**Cost Derivation:** Not estimated at this time; reservoir operation alternatives would have no direct cost, while major structural improvements would have high costs.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

The majority of the streams within the Naches watershed have a relatively unregulated flow regime that is nearer to natural conditions than the rest of the basin. However, flows in the Tieton and the Naches below the confluence with the Tieton are driven by Rimrock Reservoir operations. The flip-flop regime results in low flows in the Tieton through most of the irrigation season and then high (essentially bankfull) flows in the fall. Modifications to the flip-flop flow regime that improve habitat, flow, and temperature conditions for steelhead and other salmonid species in the Tieton and Lower Naches subbasin would have broad benefits for the Naches steelhead population. The negative effects of flip-flop could be addressed through alteration of reservoir operations, conservation, additional storage, or a combination of these and other measures. The Bureau of Reclamation, in collaboration with other subbasin resource managers and stakeholders, should determine if and how flip-flop can be modified to achieve these goals, make the necessary changes, and monitor habitat and fish population response.

**Naches Action #5** **Restore lower Naches River floodplain**

**Key Partners:**
- Lower Naches River Partnership Group
- Yakima County
- Regional Fisheries Enhancement Group or other volunteer groups

**Affected MSAs:**
- American
- Bumping
- Cowiche
- Middle Naches
- Rattlesnake
- Tieton
- Upper Naches

**Focal Area:** Lower Naches from Powerhouse Bridge area to confluence

**Implementation Likelihood:** High

**Time to Implement:** 6-10 years

**Time to Benefit:** 10-25 years

**Strategies:** Restore floodplain connectivity/function

**Limiting Factors:** N9,11

**Cost Derivation:** 1.2 mile dike removed & reconfigured at $5,000,000/mile.

**Total Cost:** $6,000,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $1,500,000

A cooperative project between the City of Yakima, Yakima County and WSDOT is seeking to restore floodplain functions in conjunction with planned capital projects for water conservation, elimination of irrigation diversions, reconstruction of Power House Road, and actions to protect US 12 from erosion. Wetland habitats with relatively cool water sources are found at several places along the river: across from Naches Wonderland, within and downstream of Eschbach Park, and the Buckskin Slough in the lower Naches. All of these areas could support increased rearing for salmonids and should be the focus of restoration activities. Proposals are described in the Upper Yakima Comprehensive Flood Management Plan.

**Naches Action #6** **Improve sediment transport in lower Naches River**

**Key Partners:**
- Irrigation Districts
- Bureau of Reclamation
- Yakima County
- US Army Corps of Engineers

**Affected MSAs:**
- American
- Bumping
- Cowiche
- Middle Naches
- Rattlesnake
- Tieton
- Upper Naches

**Focal Area:** Lower mainstem Naches

**Implementation Likelihood:** Moderate

**Time to Implement:** > 10 years

**Time to Benefit:** 10-25 years

**Strategies:** Restore channel structure/complexity

**Limiting Factors:** N12

**Cost Derivation:** Diversion at Gleed (Naches Union) at $300,000, Naches-Cowiche diversion at $5,000,000, City of Yakima diversion at $100,00

**Total Cost:** $5,400,000 **Fisheries:** 33% **Steelhead:** 50% **Steelhead Cost:** $891,000

Confinement of the lower Naches has reduced sediment transport efficiency, causing aggradation upstream and channel incision or avulsion downstream. Where these facilities are located in the lower end of the alluvial valleys, such as near Eschbach Park/Yakima Water Treatment Plant, and at Rambler's Park/Cowiche (Nelson) Dam, their effects further reduce the amount of rearing habitat (i.e., side channels fed by groundwater return), which should be available in these locations. Improving sediment transport by modification of dam structure and levee reconfiguration will improve habitat availability over the long term. The Upper Yakima Comprehensive Flood Hazard Management Plan contains more detail regarding proposed reworking of Naches-Cowiche, Yakima Water Treatment Plant and Gleed (Naches Union) diversion dams to facilitate sediment movement (efforts will also benefit fish passage at the Naches-Cowiche diversion).

| Naches Action #7 | Protect habitats in Naches River mainstem above Tieton confluence |
|---|---|

**Key Partners:**
- Private landowners
- Land Conservancies
- Washington Department of Fish & Wildlife
- Yakima County

**Affected MSAs:**
- American
- Bumping
- Middle Naches
- Rattlesnake
- Upper Naches

**Focal Area:** Nile and Oak Flats areas

**Implementation Likelihood:** Moderate

**Time to Implement:** > 10 years

**Time to Benefit:** 10-25 years

**Strategies:**
Protect existing functional habitat

**Limiting Factors:**
N10,14

**Cost Derivation:** Nile area side channels (60 acres @ $3,500/ac) & Oak Flats in progress ($600,000).

**Total Cost:** $816,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $204,000

Above the confluence with the Tieton, the Naches River is the least regulated of all Yakima Basin large rivers. Protecting functional habitat in the mainstem Naches and its floodplain above the Tieton confluence should be a priority and may involve a combination of acquisitions, conservation easements, and cooperative agreements. Priority areas include Oak Flats and the Nile area. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

| Naches Action #8 | Maintain, upgrade or abandon forest roads |
|---|---|

**Key Partners:**
- Private landowners
- Washington Department of Natural Resources
- US Forest Service
- Washington Department of Fish & Wildlife

**Affected MSAs:**
- All Naches
- Cowiche
- Upper Naches

**Focal Area:** Forested areas throughout population area

**Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing

**Time to Benefit:** 3-10 years

**Strategies:**
Improve water quality
Improve upland watershed conditions

**Limiting Factors:**
N14,15

**Cost Derivation:** 25 miles /year at $10,000/mile for fifteen years.

**Total Cost:** $3,750,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $937,500

Programs to address watershed impacts of forest roads exist for US Forest Service and WDNR lands, but are currently limited by funding/staffing and need to be expanded. The Forests and Fish Law applies on private lands. The Cowiche Creek and Little Naches watersheds should be a priority for development and implementation of Road Maintenance and Abandonment Plans under the Forests and Fish agreement. On Forest Service lands, a public scoping process, analysis, and a NEPA decision must be completed before a road can removed from the system.

**Naches Action #9** **Provide passage at Bumping Lake Dam**

**Key Partners:**
Bureau of Reclamation

**Affected MSAs:**
Bumping

**Focal Area:** Upper Bumping River watershed **Implementation Likelihood:** Moderate

**Time to Implement:** 6-10 years
**Time to Benefit:** 10-25 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**
N6

**Cost Derivation:** BOR has estimated costs of between $8.7 & $31 million; cost given here is for new spillway & fish ladder options.

**Total Cost:** $15,600,000 **Fisheries:** 100% **Steelhead:** 25% **Steelhead Cost:** $3,900,000

Bumping Lake is a natural glacial lake that supported a run of sockeye salmon. When a dam was constructed to raise the lake to store irrigation water, fish passage was not provided. Providing upstream and downstream fish passage at Bumping Lake would open up 6.6 miles of high quality habitat for steelhead. The BOR Fish Passage Study gives a detailed description (BOR 2005).

**Naches Action #10** **Improve habitat in Lower Bumping**

**Key Partners:**
US Forest Service
Washington State Department of Transportation
Yakima County

**Affected MSAs:**
Bumping

**Focal Area:** Lower Bumping River **Implementation Likelihood:** High

**Time to Implement:** 0-3 years
**Time to Benefit:** 3-10 years

**Strategies:**
Restore floodplain connectivity/function
Restore channel structure/complexity

**Limiting Factors:**
N9,10,11

**Cost Derivation:** Based on USFS Naches Ranger District estimates.

**Total Cost:** $370,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $185,000

Redesign of the Bumping Road by the Federal Highways Administration is currently under way. The current design calls for road relocation and expansion to improve safety and reduce travel time. Habitat improvement work has been proposed as part of this road project, and would include: 1) strategically placing about 350 LWD pieces as engineered log jams and small clumps into wood deficient stream reaches (1, 3-4, 6) and along rip rap locations; and 2) Improving riparian conditions and streambank stability at 20-30 dispersed and developed camping areas (about 30 acres) in the Bumping River drainage through motor vehicle barriers, soil decompaction, road obliteration, campsite closures, replanting native vegetation, interpretive signing, and public education.

**Naches Action #11** **Restore side channels and floodplain of Little Naches River**

**Key Partners:**
US Forest Service
Kittitas County
Yakama Nation

**Affected MSAs:**
Upper Naches

**Focal Area:** Little Naches mainstem **Implementation Likelihood:** Moderate

**Time to Implement:** 6-10 years
**Time to Benefit:** 3-10 years

**Strategies:** Restore floodplain connectivity/function **Limiting Factors:** N9,10,11

**Cost Derivation:** Preliminary costs estimates by USFS & YN staff.

**Total Cost:** $950,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $356,250

After floods in the 1970s and 1980s, the main road accessing the Little Naches drainage was reconstructed as a levee and and over 6,000 tons of large wood debris were removed from the channel. Over time, this has led to aggradation and degredation of the main channel and isolation of the main channel from side channel and wetland habitats. Restoration of the Little Naches floodplain and reconfiguration of the road/levee system is a major undertaking and will require significant funding and technical support from the US Forest Service and/or the Federal Highway Administration via Kittitas County road department.

**Naches Action #12** **Place large woody debris in Little Naches**

**Key Partners:**
US Forest Service
Yakama Nation
Regional Fisheries Enhancement Group or other volunteer groups

**Affected MSAs:**
Upper Naches

**Focal Area:** Lower mainstem Little Naches **Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing
**Time to Benefit:** 0-3 years

**Strategies:** Restore channel structure/complexity **Limiting Factors:** N9,10,11

**Cost Derivation:** 10 engineered log jams at $25,000 each.

**Total Cost:** $250,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $125,000

Lower reaches of the Little Naches lack large woody debris (LWD), in part due to large-scale wood removal efforts following flooding in the 1970s. This has contributed to downcutting of the stream channel, isolation or dewatering of off-channel habitats, channel instability and habitat simplification. LWD installation projects have been implemented in this watershed with the intent of improving fish habitat and reducing threats to developed campgrounds. Additional projects should be focus on improving fish habitat.

**Naches Action #13** **Reduce dispersed recreation impacts in key tributaries**

**Key Partners:**
- Private landowners
- Regional Fisheries Enhancement Group or other volunteer groups
- US Forest Service
- Washington Department of Fish & Wildlife

**Affected MSAs:**
- Upper Naches
- Rattlesnake
- Middle Naches

**Focal Area:** Little Naches, American & Bumping rivers; Oak Creek

**Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing

**Time to Benefit:** 3-10 years

**Strategies:**
- Restore riparian condition/future LWD
- Improve water quality
- Improve upland watershed conditions

**Limiting Factors:** N20,21

**Cost Derivation:** $80,000/year for 4 months of 5 person crew & $50,000/year for equipment & supplies for 15 years.

**Total Cost:** $1,950,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $731,250

Impacts of recreational activities including dispersed camping and off-road vehicle (ORV) use can be significant in sensitive riparian areas. Over the last five years, the US Forest Service and partners have implemented successful programs to reduce these impacts. Coordinated education, enforcement, and on-the-ground restoration and protection efforts should be maintained and/or expanded in areas with high recreational use. The Little Naches will continue to be a focal area due to the high use by ORVs and the expected growth of this activity. These tasks will require additional funding for the US Forest Service and private forest landowners. ORV groups and the US Forest Service have developed a good working relationship, and the opportunity to partner with these organizations is high.

**Naches Action #14** **Protect habitats in Little Naches River**

**Key Partners:**
- Private landowners
- Forest managers and partners
- Land Conservancies
- US Forest Service

**Affected MSAs:**
- Upper Naches

**Focal Area:** Private timberland in Little Naches drainage

**Implementation Likelihood:** Moderate

**Time to Implement:** > 10 years

**Time to Benefit:** 10-25 years

**Strategies:**
- Protect existing functional habitat

**Limiting Factors:** N10,14

**Cost Derivation:** 960 acres at $2,000/acre.

**Total Cost:** $1,920,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $1,080,000

The upper Little Naches passes through a checkerboard of US Forest Service and private timber company land. Ensuring long term protection of the fisheries habitat on private lands can be done through purchases, easements and cooperative agreements; acquisition of the 960 areas along the Little Naches could be integrated into significantly larger landscape-scale protection efforts in the Little Naches watershed. Land is currently protected through the Plum Creek Habitat Conservation Plan. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

**Naches Action #15** **Improve Nile Creek flows through improved irrigation management**

**Key Partners:**
Yakima County
Yakima Tributary Access and Habitat Program
North Yakima Conservation District

**Affected MSAs:**
Middle Naches

**Focal Area:** Lower Nile Creek

**Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
N3,4

**Cost Derivation:** $500/acre water conservation costs x 160 acres plus $120,000 infrastructure costs.

**Total Cost:** $200,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $50,000

Flows in lower Nile Creek are currently limited by irrigation water withdrawals. Improvements to irrigation infrastructure and potential transfer, lease or acquisition of water rights would increase summer and fall stream flows. Cost estimates for water conservation are generic estimates based on possible amounts; any actual amounts will be based on voluntary agreements negotiated with landowners.

**Naches Action #16** **Improve channel conditions at the mouth of Nile Creek**

**Key Partners:**
Yakima County
Yakima Tributary Access and Habitat Program

**Affected MSAs:**
Middle Naches

**Focal Area:** Lower 1/4 mile of Nile Creek

**Implementation Likelihood:** High

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**
N7

**Cost Derivation:** Based on existing designs.

**Total Cost:** $400,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $200,000

The box culvert across Nile Creek 1/4 mile above the Naches constricts the channel, resulting in sediment deposition and subsurface flows. The installation of a new bridge and channel reconstruction work would dramatically improve passage at this partial barrier. The current culvert is scheduled to be replaced in 2008; the new bridge will have a larger span that allows for improved sediment transport.

**Naches Action #17** **Increase instream flows in lower Rattlesnake Creek**

**Key Partners:**
Department of Ecology
North Yakima Conservation District
Individual irrigators
Washington Department of Fish & Wildlife

**Affected MSAs:**
Rattlesnake

**Focal Area:** Lower Rattlesnake Creek **Implementation Likelihood:** Moderate

**Time to Implement:** Ongoing
**Time to Benefit:** 0-3 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
N3,4

**Cost Derivation:** Based on cost of $500/acre foot conservation or acquisition for 500 acre feet total.

**Total Cost:** $250,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $125,000

Irrigation diversions from Rattlesnake Creek can dewater the lower creek, where steelhead spawning has been documented. Improving irrigation and conveyance efficiencies, switching water users to shallow groundwater wells, leasing water rights and ensuring diversions are limited to legal rights can all be used to reduce diversions. Cost estimates for water conservation are generic estimates based on possible amounts; any actual amounts will be based on voluntary agreements negotiated with landowners.

**Naches Action #18** **Improve sediment transport at Rattlesnake Creek/Naches confluence**

**Key Partners:**
Washington State Department of Transportation
Yakima County

**Affected MSAs:**
Rattlesnake

**Focal Area:** Confluence of Rattlesnake Creek and Naches River **Implementation Likelihood:** Moderate

**Time to Implement:** > 10 years
**Time to Benefit:** 10-25 years

**Strategies:**
Restore floodplain connectivity/function

**Limiting Factors:**
N12

**Cost Derivation:** Excavation of 2,500 yds @ $10/yd; non-fish proportion is flood control.

**Total Cost:** $25,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $6,250

The unstable alluvial fan at the mouth of Rattlesnake Creek creates a pasage barrier in low-flow years. The configuration of the irrigation diversion, the Nile Road bridge, and levees on Rattlesnake Creek and the Naches River combine to reduce sediment transport. Improvement or reduction in the impact of the diversion upstream of the bridge and improvements to floodplain connectivity would improve sediment transport out of the Rattlesnake, improving habitat quality in both systems.

**Naches Action #19** **Restore lower Cowiche Creek floodplain**

**Key Partners:**

Lower Naches River Partnership Group
Yakima County
Washington State Department of Transportation
Irrigation Districts
Regional Fisheries Enhancement Group or other volunteer groups

**Affected MSAs:**

Cowiche

**Focal Area:** Lower Cowiche Creek and confluence with Naches River

**Implementation Likelihood:** High

**Time to Implement:** Ongoing

**Time to Benefit:** 10-25 years

**Strategies:**

Restore unimpeded fish passage
Restore floodplain connectivity/function

**Limiting Factors:**

N9,11

**Cost Derivation:** Acquisition of 32 acres of floodplain (350 ft x 3/4 mile) at $7,000/acre & movement of 30,000 cubic yard of dike materials at $10/yard.

**Total Cost:** $524,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $294,750

The lower end of Cowiche Creek has been confined by dikes and has been checked up in order to convey Naches River irrigation water (a potential source of false attraction). This action involves seperating delivery of Naches River water from Cowiche Creek, removing the check-structure and associated high-maintenance fish ladder, pulling back and/or removing the levees and improving riparian habitats. Associated infrastructure changes for the City of Yakima (Fruitvale) irrigation diversion are included under Naches Action #3. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

| **Naches Action #20** | **Protect Cowiche Creek watershed from increasing development pressure** |
|---|---|

**Key Partners:**

Washington Department of Fish & Wildlife
Yakima (City) Habitat Improvement Project
Yakima County
North Yakima Conservation District
Private landowners
Land Conservancies

**Affected MSAs:**

Cowiche

**Focal Area:** Cowiche Creek watershed **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 3-10 years

**Strategies:**

Protect existing functional habitat
Improve upland watershed conditions

**Limiting Factors:**

N9,10,11

**Cost Derivation:** Purchase of 360 acres of riparian corridor easement at $600/acre & 6 sections (3840 acres) at $800/ac (mix of easement & acquisition).

**Total Cost:** $3,288,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $1,644,000

Large parcels of private timber and rangelands in the upper Cowiche Creek watershed and smaller parcels lower in the watershed are all subject to increased development pressure. A mix of conservation easements, land purchases and cooperative agreements should be pursued to ensure that fish habitat and associated uplands are not negatively impacted. The area should be maintained in very low density zoning and regulation of road standards and wildland/urban interface standards for fire protection. This action overlaps with ongoing open space/wildlife habitat protection efforts. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

| **Naches Action #21** | **Reduce irrigation diversions from Cowiche Creek** |
|---|---|

**Key Partners:**

Individual irrigators
North Yakima Conservation District
Washington Department of Fish & Wildlife
Irrigation Districts
Water Trust & Conservancies
Bureau of Reclamation

**Affected MSAs:**

Cowiche

**Focal Area:** South Fork and Mainstem Cowiche Creek

**Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing

**Time to Benefit:** 3-10 years

**Strategies:**

Improve flow conditions

**Limiting Factors:**

N3,4

**Cost Derivation:** Phase I currently being proposed by the Cowiche Water Users Association (7 cfs for $350,000). Phase II still to be defined.

**Total Cost:** $350,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $350,000

Irrigation diversions significantly reduce summer and falls flows in the lower 12 miles of the Cowiche Creek system. Irrigation system improvements that increase water use efficiencies, cooperative agreements with irrigators, and leases and purchase of water rights can all be used to reduce diversions. Much of the land irrigated from Cowiche Creek could potentially be served by the Yakima Tieton Irrigation District, and the possibility for agreements that provide irrigators with Yakima-Tieton water in exchange for leaving surface flows in Cowiche Creek should continue to be pursued.

| **Naches Action #22** | **Improve riparian, floodplain, and temperature conditions in Cowiche Creek** |
|---|---|

**Key Partners:**
- Washington Department of Fish & Wildlife
- Yakima Tributary Access and Habitat Program
- North Yakima Conservation District
- Private landowners and lessees
- Regional Fisheries Enhancement Group or other volunteer groups

**Affected MSAs:** Cowiche

**Focal Area:** Mainstem and South Fork of Cowiche Creek; possibly Reynolds Creek

**Implementation Likelihood:** High

**Time to Implement:** > 10 years

**Time to Benefit:** 10-25 years

**Strategies:**
- Restore floodplain connectivity/function
- Restore channel structure/complexity
- Restore riparian condition/future LWD

**Limiting Factors:** N14,18,19

**Cost Derivation:** Riparian plantings along 10 miles at $15,000/mile, 3 miles of channel/floodplain restoration at $200,000/mile, instream LWD at $500 per installed piece at 50/mile for 5 miles & 6 miles fence at $10,000/mile.

**Total Cost:** $935,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $935,000

This action involves riparian planting, livestock fencing, grazing system improvements, channel/floodplain reconstruction, and large woody debris placement along numerous sites along Cowiche Creek. The middle reach will involve working with a number of smaller landowners, while the upper and canyon reaches are a mix of WDFW, Cowiche Canyon Conservancy, and large private lands that are suitable for large-scale restoration projects. Implementation of these actions should improve natural floodplain function, reduce flooding, and increase base flows, and water quality. The North Fork Cowiche historically comprised only a small proportion of the available habitat in the watershed and is not proposed for full restoration due to limited opportunities and high costs.

| **Naches Action #23** | **Restore Oak Creek habitat** |
|---|---|

**Key Partners:**
- US Forest Service
- Washington Department of Fish & Wildlife
- Yakima Tributary Access and Habitat Program

**Affected MSAs:** Tieton

**Focal Area:** Lower Oak Creek

**Implementation Likelihood:** High

**Time to Implement:** > 10 years

**Time to Benefit:** 10-25 years

**Strategies:**
- Restore channel structure/complexity
- Restore riparian condition/future LWD

**Limiting Factors:** N14,17

**Cost Derivation:** Revegetate 100 ft buffer each side of the creek for 3.5 miles for $30,000 & weed control of 3.5 miles for $2,500/mile for 3 years.

**Total Cost:** $56,250 **Fisheries:** 75% **Steelhead:** 100% **Steelhead Cost:** $42,188

Oak Creek is the only portion of the Tieton system that has been confirmed as supporting steelhead spawning. The entire watershed is owned by WDFW, US Forest Service and The Nature Conservancy. Much of the lower watershed (especially the riparian zone) has burned in recent wildfires and would benefit from replanting and weed control. Possibilities to improve instream and floodplain habitat and address road impacts should also be evaluated.

**Naches Action #24** **Protect instream flow improvements in Ahtanum Creek**

**Key Partners:**
Ahtanum Irrigation District
BIA/Wapato Irrigation Project
Yakama Reservation Watersheds Project

**Affected MSAs:**
Ahtanum

**Focal Area:** Mainstem Ahtanum Creek **Implementation Likelihood:** High

**Time to Implement:** Ongoing
**Time to Benefit:** 0-3 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
N3,4

**Cost Derivation:** 1 FTE & expenses at $75,000/year.

**Total Cost:** $1,125,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $843,750

Recent improvements in both summer and winter instream flows in Ahtanum Creek are due to agreements between the Yakama Nation, the Wapato Irrigation Project and Ahtanum Irrigation District. A network of wading discharge measurement transects and gauging stations are key to maintaining these agreements. Both the agreements and the supporting monitoring efforts should be continued.

**Naches Action #25** **Develop off-channel storage in Ahtanum Creek**

**Key Partners:**
Ahtanum Irrigation District
BIA/Wapato Irrigation Project
Department of Ecology

**Affected MSAs:**
Ahtanum

**Focal Area:** Ahtanum, Bachelor and Hatton Creeks **Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
N3,4

**Cost Derivation:** Cost as identified in preliminary feasibility study.

**Total Cost:** $45,000,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $11,250,000

The proposed Pine Hollow Reservoir would increasing the amount of water avaialble to meet and increase instream flows and meet irrigators' water needs. Associated irrigation system and habitat improvements would further increase benefits to steelhead by allowing full access to Bachelor and possibly Hatton Creeks. Implementation of the Pine Hollow project would require significant restructuring of complex water rights, including cooperation with the Yakama Nation, BIA/WIP, the Ahtanum Irrigation District, and private diverters. Funding for the project is not yet secured and environmental analyses have not been completed.

**Naches Action #26** **Minimize irrigation conveyance loss in Ahtanum Creek**

**Key Partners:**
BIA/Wapato Irrigation Project

**Affected MSAs:**
Ahtanum

**Focal Area:** WIP Ahtanum Main Canal **Implementation Likelihood:** High

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
N3,4

**Cost Derivation:** 2005 engineer's estimate was $116,305/mile for 5 miles. Multiplied by 1.2 for cost inflation since 2005.

**Total Cost:** $697,830 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $392,529

Areas of high seepage loss from the Wapato Irrigation Project's Ahtanum Main Canal have been identified and substantially increase the amount of water that has to be diverted to supply users near the end of the canal. Lining these sections of the canal would help in limiting diversions and increase instream flow.

**Naches Action #27** **Ahtanum Creek floodplain and side channel restoration**

**Key Partners:**
Washington Department of Fish & Wildlife
Yakama Reservation Watersheds Project
Yakima County
North Yakima Conservation District

**Affected MSAs:**
Ahtanum

**Focal Area:** Ahtanum Creek and side channels **Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing
**Time to Benefit:** 3-10 years

**Strategies:**
Restore floodplain connectivity/function

**Limiting Factors:**
N10,11

**Cost Derivation:** Based on $90,000 cost of completed Herke side channel x 150% cost adjustment for 5 projects.

**Total Cost:** $675,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $379,688

There are several opportunities to reconnect side channels and enhance floodplain function in the Ahtanum Creek system, including the 7-mile spring creek through the airport, smaller channels upstream of major diversions, and, if agreements with irrigators can be developed (see Action #22), the Bachelor/Hatton system. Where there are opportunities to reconnect side channels, especially upstream from major diversions, both fish habitat and flood conveyance can be improved. Habitat restoration in lower Ahtanum will also benefit steelhead from other MSAs by providing rearing habitat adjacent to the Yakima River.

**Naches Action #28** **Protect Ahtanum Creek riparian areas to lessen development impacts**

**Key Partners:**
Washington Department of Fish & Wildlife
Yakima County
Yakama Nation
Yakima (City) Habitat Improvement Project
Land Conservancies

**Affected MSAs:**
Ahtanum

**Focal Area:** Lower Ahtanum Creek **Implementation Likelihood:** Moderate

**Time to Implement:** 0-3 years
**Time to Benefit:** 3-10 years

**Strategies:**
Protect existing functional habitat

**Limiting Factors:**
N9,10,11

**Cost Derivation:** 450 deeded riparian acres on south side at $8,000/acre; easements on 300 ft buffer for 50% of 10 miles (~180 acres) on northside at $8,000/acre.

**Total Cost:** $5,040,000 **Fisheries:** 50% **Steelhead:** 75% **Steelhead Cost:** $1,890,000

The lower part of Ahtanum Creek is affected by urbanization in Union Gap, Yakima, and nearby unincorporated areas, while the middle section is experiencing increased residential development. Residential/retirement/recreational development is also increasing in the upper watershed. Current opportunities to protect riparian areas and key floodplain parcels in lower Ahtanum Creek will disappear over time. Tools include land purchases and leases, conservation agreements, and cooperative agreements with landowners (e.g., incorporating protections into development plans). Development within Urban Growth Areas should be carefully planned to protect floodplains, riparian and instream resources, and private properties in this especially flood-prone watershed. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

**Naches Action #29** **Reduce livestock impacts on Ahtanum Creek riparian areas**

**Key Partners:**
Washington Department of Fish & Wildlife
Yakama Reservation Watersheds Project
North Yakima Conservation District

**Affected MSAs:**
Ahtanum

**Focal Area:** Ahtanum Creek and tributaries **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 3-10 years

**Strategies:**
Restore riparian condition/future LWD
Improve upland watershed conditions

**Limiting Factors:**
N18,19

**Cost Derivation:** Based on 20% of $250,000/year cost of Yakama Nation restoration crew; $20,000/year in riparian fencing materials; 5 stock water wells at $60,000 each; annual lease on 640 acres on reservation at $85/acre/yr for 15 years; 7 miles fencing at $10,000/mile; & 2 miles of riparian plantings at $15,000/mile on Northside.

**Total Cost:** $2,216,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $1,246,500

Improving the condition of Ahtanum Creek's riparian areas will help realize the maximum benefit from instream flow improvements. The Yakama Reservation Watersheds Program has been active on the south side of the creek, while the North Yakima Conservation District has worked extensively with landowners on the North side in its successful efforts to address screening and passage barriers. The Ahtanum Watershed Restoration EIS includes several specific actions.

**Naches Action #30** **Improve winter flows below storage dams**

**Key Partners:**
Bureau of Reclamation

**Affected MSAs:**
Tieton
Bumping

**Focal Area:** Tieton, Bumping and Naches rivers below Rimrock and Bumping Lakes

**Implementation Likelihood:** Moderate

**Time to Implement:** 0-3 years
**Time to Benefit:** 0-3 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
N1

**Cost Derivation:** Operational change; no specific cost identified.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

Late fall/winter flows below Rimrock and Bumping reservoirs are maintained at low levels relative to the unregulated hydrograph, with occassional large releases made for flood control purposes. Effects on the Bumping River are minimal in most years, but the Tieton is significantly affected. Adjusting reservoir operations to increase winter base flows will improve overwintering habitat. The Bureau increased winter flow in the Tieton in 2008 (to a base of ~100-125 cfs vs earlier targets as low as 30cfs); this commitment should be continued.

---

**Naches Action #31** **Restore side channels and floodplain of Upper Naches River**

**Key Partners:**
US Forest Service
Washington Department of Fish & Wildlife
Private landowners
Regional Fisheries Enhancement Group or other volunteer groups

**Affected MSAs:**

**Focal Area:** Naches River between Tieton confluence and Little Naches

**Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Restore floodplain connectivity/function
Restore channel structure/complexity

**Limiting Factors:**
N9,10,11

**Cost Derivation:** Preliminary cost estimates by US Forest Service staff.

**Total Cost:** $200,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $100,000

Several historic off channel habitats could be enhanced by increasing water flow into them for longer seasonal periods of the year. These off channel habitats are important rearing and refuge areas for juvenile salmonids. Engineered log jams or other instream hydrologic structures could regulate flows into these low gradient side channels.

| **Satus Action #1** | **Reconnect Satus Creek floodplain** |
|---|---|

**Key Partners:**
- Yakama Nation Riparian/Wetlands Restoration Project
- Washington State Department of Transportation
- Yakama Reservation Watersheds Project

**Affected MSAs:**
- Dry
- Satus

**Focal Area:** Mainstem of Satus Creek (lower 8 miles and along Highway 97)

**Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing

**Time to Benefit:** 3-10 years

**Strategies:** Restore floodplain connectivity/function

**Limiting Factors:** S3,4,5

**Cost Derivation:** Construction of 50 check structure at $20,000 per structure; purchase of 320 acres floodplain at $4000/acre & $215/yr restoration/maintenance cost; & lease of 5000 acres (Satus Wildlife Area, Mule-Dry Confluence, Hwy 97 corridor) at $50/ac/yr lease plus $30/yr maintenance for 15 yrs. Estimate does not include WSDOT cost such as bridge replacement.

**Total Cost:** $9,312,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $5,238,000

Lower Satus Creek is entrenched and partly confined by dikes. It may not be possible to elevate the creek to the its original floodplain in this reach, but allowing it to meander at its present level, and introducing appropriate roughness features will restore some of the original channel complexity and floodplain functions. Impacts from US 97 farther uspstream are being addressed through a cooperative consultation process between the Yakama Nation and the WSDOT. Examples include the planned replacement of the US 97 crossing of Logy Creek near its confluence with Satus Creek (RM 23.7), which needs to include floodplain restoration at the previous crossing alignment as well as careful design of the replacement and reactivating the floodplain in the reach immediately downstream from the “High Bridge” (RM 32.4). US 97 also restricts the movement of bedload from tributary streams into Satus Creek at several crossings including Kusshi, Shinando, and a host of unnamed tributaries, contributing to incision of Satus Creek. There are also several large levees that could be removed to promote better stream/floodplain connectivity. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

**Satus Action #2** **Continue improving management of cattle and improve management of feral horses**

**Key Partners:**
Yakama Reservation Watersheds Project

**Affected MSAs:**
Dry
Satus

**Focal Area:** Entire Satus Creek Watershed **Implementation Likelihood:** Moderate

**Time to Implement:** Ongoing
**Time to Benefit:** 3-10 years

**Strategies:**
Restore riparian condition/future LWD
Improve upland watershed conditions

**Limiting Factors:** S9,10

**Cost Derivation:** 20% of restoration crew cost of $250,000/yr plus materials to build & repair range, riparian, & meadow fencing at $10,000/yr plus lease of critical grazing units at $25,000/yr; all for 15 years & 10 stock water well installations at $60,000 each.

**Total Cost:** $1,875,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $937,500

Recent and ongoing improvements in the management of cattle grazing have reduced grazing impacts in the Satus Creek watershed. Impacts from wild horses are ongoing, and the Yakama Nation is developing a wild horse management plan for the Satus and Toppenish Creek watersheds which will focus on limiting riparian zone damage.

**Satus Action #3** **Reroute North Drain to address return flow issues in lower Satus Creek**

**Key Partners:**
Bonneville Power Administration
Yakama Nation Riparian/Wetlands Restoration Project
US Fish & Wildlife Service
US Army Corps of Engineers
USDA
Yakama Reservation Watersheds Project

**Affected MSAs:**
Dry
Satus

**Focal Area:** Lower mainstem of Satus Creek **Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions
Improve water quality

**Limiting Factors:** S1

**Cost Derivation:** Cost of $3,000,000 based on estimates by US Army Corps of Engineers & Yakama Nation.

**Total Cost:** $3,000,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $1,125,000

Between 5 and 40 cfs of irrigation return flows from the Wapato Irrigation Project enter lower Satus Creek via the North Drain. Rerouting the North Drain into wetlands on the Satus Wildlife Area would reduce the quantity and increase the quality of return flows into Satus Creek. Initial plans have been developed in cooperation with the US Army Corps of Engineers.

**Satus Action #4** **Improve Satus East and West Laterals to address return flow issues**

**Key Partners:**
BIA/Wapato Irrigation Project
Yakama Reservation Watersheds Project
Bureau of Reclamation

**Affected MSAs:**
Dry
Satus

**Focal Area:** Lower mainstem of Satus Creek **Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions
Improve water quality

**Limiting Factors:**
S1

**Cost Derivation:** $3,380,000 based on 2001 conservation plan (1998 costs).

**Total Cost:** $3,380,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $845,000

The Satus East and West Laterals empty into Satus Creek. Piping the Satus Area of the Wapato Irrigation Project will allow for better management of return flows to Satus Creek. This is one component of the Yakima River Basin Water Enhancement Program's conservation plan for the Wapato Irrigation District. The Secretary of Interior has approved the infrastructure portion of the WIP Priority Water Conservation Measures Plan and a 1990 authorization of $18 million is allocated to the project, but may need to be supplemented. Implementing the Conservation Measures Plan will also improve instream flow and water quality in the Yakima River (see Lower Mainstem Action #10).

**Satus Action #5** **Remove BIA Satus Diversion Dam**

**Key Partners:**
Yakama Reservation Watersheds Project

**Affected MSAs:**
Dry
Satus

**Focal Area:** Lower mainstem of Satus Creek **Implementation Likelihood:** High

**Time to Implement:** 0-3 years
**Time to Benefit:** 0-3 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**
S2

**Cost Derivation:** Preliminary engineering estimated at $90,000 & construction at $250,000.

**Total Cost:** $340,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $340,000

The Satus Diversion Dam is no longer in use. Its rudimetary fish ladder is prone to tampering by recreationists. Removing the existing concrete diversion dam and diversion canal headworks would improve stream channel habitat, eliminate a partial steelhead passage barrier and restore this reach of the creek to a more natural and productive condition.

**Satus Action #6** **Restore passage in Shinando Creek at Highway 97 crossing**

**Key Partners:**
Washington State Department of Transportation
Yakama Reservation Watersheds Project

**Affected MSAs:**
Satus

**Focal Area:** Shinando Creek

**Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years

**Time to Benefit:** 3-10 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**
S6

**Cost Derivation:** The project presents challenges (hence the high cost estimate) but pipe boring techniques are improving, which may decrease cost below estimate.

**Total Cost:** $1,500,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $1,500,000

Fish access to the Shinando drainage is blocked by an impassable structure under Highway 97 that is under deep fill. Preliminary engineering indicates that it may be feasible to restore passage without removal of the fill.

**Satus Action #7** **Improve, relocate, or close forest roads**

**Key Partners:**
Bureau of Indian Affairs, Yakama Agency
Yakama Reservation Watersheds Project

**Affected MSAs:**
Dry
Satus

**Focal Area:** Entire Satus Creek Watershed

**Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years

**Time to Benefit:** 3-10 years

**Strategies:**
Improve upland watershed conditions

**Limiting Factors:**
S7,8

**Cost Derivation:** 5 miles/yr of road reconstruction, upgrade, or abandonment at $10,000/mi x 15 yrs.

**Total Cost:** $750,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $375,000

Overall, forest roads have been built and maintained to a lower standard on the Yakama Reservation than on, for example, US Forest Service land. There is a need to continue and expand road closures, relocations and drainage improvements to reduce sediment and peak flows deliveries to creeks. The Yakama Reservation Watersheds Project and other tribal programs have assessed these needs and will coordinate a road improvement program with BIA, which manages reservation forestlands.

| Satus Action #8 | Restore headwater meadows | |
|---|---|---|
| **Key Partners:** Bureau of Indian Affairs, Yakama Agency; Yakama Reservation Watersheds Project | | **Affected MSAs:** Dry; Satus |
| **Focal Area:** Entire Satus Creek Watershed | | **Implementation Likelihood:** High |
| **Time to Implement:** Expand ongoing<br>**Time to Benefit:** 3-10 years | **Strategies:**<br>Improve flow conditions<br>Improve water quality | **Limiting Factors:**<br>S11 |
| **Cost Derivation:** 10% of $250,000/yr cost for restoration crew plus $15,000/yr construction costs (most work will be hand work, but several locations will require machinery). Fencing is covered under Action #12. $200,000 is included for possible land purchases. | | |
| **Total Cost:** $800,000 | **Fisheries:** 75% **Steelhead:** 100% | **Steelhead Cost:** $600,000 |

Steelhead productivity in the Satus Creek watershed is hampered by rapid runoff and minimal summer streamflow. Some of this problem can be traced to headwater meadows that are dissected by gullies and no longer store runoff efficiently. The Yakama Reservation Watersheds Project has been refining headwater meadow restoration techniques and will coordinate further restoration efforts.

| **Toppenish Action #1** | **Rehabilitate alluvial fan and downstream floodplain of Toppenish Creek** |
|---|---|

**Key Partners:**
BIA/Wapato Irrigation Project
Yakama Nation Riparian/Wetlands Restoration Project
Yakama Reservation Watersheds Project
Bureau of Reclamation

**Affected MSAs:**
Simcoe
Toppenish

**Focal Area:** Lower mainstem of Toppenish Creek **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 3-10 years

**Strategies:** Restore floodplain connectivity/function
**Limiting Factors:** T5,7,9,10,11

**Cost Derivation:** On the alluvial fan, open 14 swale crossings at $150,000 each & breach/remove 0.5 miles of dike at 60,000 yards/mi & $10/yd. For the downstream floodplain, 10 miles of side channel reconnection & grade control at $150,000/mi, 20 miles of revegetation at $15,000/mi across 2 channels. Seepage study based on 0.5 FTE x $75,000 x 2 yr & $50,000 materials. Maintain 2,000 acreat $35/ac/yr for 15 years.

**Total Cost:** $5,675,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $2,837,500

The Yakama Nation plans to restore floodplain functions on the Toppenish Creek alluvial fan and along lower Toppenish Creek. This action builds on 1) BIA-funded rehabilitation of the lower canyon/upper fan reach of Toppenish Creek, 2) the acquisition and rehabilitation of riparian lands on lower Toppenish Creek funded by BPA and other entities, and 3) instream flow improvements mandated by the Yakama Nation below a BIA diversion. Funding for the Toppenish Creek Corridor Enhancement Plan is being pursued via YRBWEP and the continuation of existing funded restoration programs. This action should include studies of seepage loss in the alluvial fan reach of the creek to determine if agricultural drains or deep well pumping are contributing to the loss of instream flows and, if so, identify possible mitigation efforts.

| **Toppenish Action #2** | **Elevate Marion Drain to restore Toppenish Creek flows and water quality** |
|---|---|

**Key Partners:**
BIA/Wapato Irrigation Project
Yakama Reservation Watersheds Project
Bureau of Reclamation

**Affected MSAs:**
Simcoe
Toppenish

**Focal Area:** Lower mainstem of Toppenish Creek **Implementation Likelihood:** Moderate

**Time to Implement:** 0-3 years
**Time to Benefit:** 3-10 years

**Strategies:** Restore floodplain connectivity/function; Improve flow conditions
**Limiting Factors:** T3,7

**Cost Derivation:** Yakama Nation Engineering preliminary estimate.

**Total Cost:** $2,000,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $1,125,000

Marion Drain runs parallel to Toppenish Creek for 18 miles, and is deeper than Toppenish Creek for most of its length. It intercepts groundwater that would otherwise reach Toppenish Creek. The drain is deeper than needed for agricultural drainage. Constructing grade controls to raise the water surface in the drain could improve water quantity and quality throughout a 25-mile reach of Toppenish Creek without reducing the drain's ability to meet agricultural needs.

**Toppenish Action #3** **Replace undersized crossing culvert in Toppenish Creek**

**Key Partners:**
Yakama Reservation Watersheds Project
Private landowners

**Affected MSAs:**
Toppenish

**Focal Area:** Mainstem of Toppenish Creek above Simcoe Creek

**Implementation Likelihood:** High

**Time to Implement:** 0-3 years

**Time to Benefit:** 0-3 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**
T12

**Cost Derivation:** Engineering for $40,000. Project construction estimates begin at $150,000 & could be significantly higher.

**Total Cost:** $230,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $230,000

In February 2006, Yakama Nation personnel found a farm crossing of Toppenish Creek just upstream from the Simcoe Creek confluence that appears to impede adult steelhead passage at moderately high streamflow of several hundred cfs. This structure should be removed or replaced to provide unimpeded fish passage; purchasing 139 acres (appraised at $660k) would make the crossing unnecessary and protect nearly a mile of Toppenish and Simcoe creeks.

**Toppenish Action #4** **Complete passage and screening projects in Simcoe Creek**

**Key Partners:**
Yakama Reservation Watersheds Project
Individual irrigators

**Affected MSAs:**
Simcoe

**Focal Area:** Lower Simcoe Creek

**Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing

**Time to Benefit:** 0-3 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**
T6,12

**Cost Derivation:** Based on a cost of $20,000/cfs for previous screens in area.

**Total Cost:** $300,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $300,000

There are three remaining unscreened irrigation diversions on Simcoe Creek (South Fork, Hubbard and Smartlowit), with a total capacity of 15 cfs. Screening is complicated by the dynamic nature of the stream channel. A proposal to supply the Hubbard Diversion from the existing screened Hoptowit Diversion could not be implemented. Other options should be explored to lessen this cost.

| **Toppenish Action #5** | **Further reduce diversions by improved water management.** |
|---|---|

**Key Partners:**
Yakama Reservation Watersheds Project

**Affected MSAs:**
Simcoe
Toppenish

**Focal Area:** Lower Simcoe and Toppenish creeks **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
T12,18

**Cost Derivation:** Cost based on 1 FTE staff at 75,000/yr for 15 years & 10 stock water wells at $50,000 each.

**Total Cost:** $1,625,000 **Fisheries:** 75% **Steelhead:** 100% **Steelhead Cost:** $1,218,750

Efforts should be made to increase water use efficiencies, reducing diversions, and increasing instream flow. This could include additional wells to provide stock water during the low-flow period, replacing inefficient surface water delivery. A number of stock water wells are already in operation, which has allowed the Yakama Nation to limit diversions and increase instream flow. Cost includes staff time to monitor flow, calibrate gauges, work with irrigators to implement criteria, and improve water management for fisheries benefits.

| **Toppenish Action #6** | **Remove irrigation spills and returns from Toppenish and Simcoe creeks** |
|---|---|

**Key Partners:**
BIA/Wapato Irrigation Project
Yakama Reservation Watersheds Project
Bureau of Reclamation

**Affected MSAs:**
Toppenish
Simcoe

**Focal Area:** Lower Toppenish and Simcoe creeks **Implementation Likelihood:** Moderate

**Time to Implement:** 6-10 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions
Improve water quality

**Limiting Factors:**
N3,4,5

**Cost Derivation:** Yakama Nation Engineering preliminary estimate.

**Total Cost:** $3,750,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $2,109,375

The Wapato Irrigation Project (BIA) routes operational spills and sediment-laden return flows down Toppenish and Simcoe creeks to supply other areas of the project. Studies have been initiated by the Yakama Nation on the feasibility of separating these irrigation flows from the creek system. Elimination of return flow should be combined with efforts to restore groundwater seepage, currently intercepted by Marion Drain, back into Toppenish Creek (see Action #2).

**Toppenish Action #7** **Continue leases, purchase, and management of riparian areas**

**Key Partners:**
Yakama Nation Riparian/Wetlands Restoration Project
Yakama Reservation Watersheds Project
Bureau of Reclamation

**Affected MSAs:**
Toppenish
Simcoe

**Focal Area:** Lower Toppenish and Simcoe creeks **Implementation Likelihood:** High

**Time to Implement:** Ongoing
**Time to Benefit:** 3-10 years

**Strategies:**
Protect existing functional habitat
Restore riparian condition/future LWD

**Limiting Factors:** N8

**Cost Derivation:** Cost based on current program cost of $1,000,000/year for 15 years.

**Total Cost:** $15,000,000 **Fisheries:** 50% **Steelhead:** 75% **Steelhead Cost:** $5,625,000

Current efforts to protect riparian and floodplain lands via acquisition of land, easements, and Tribal trust leases need to continue in order to protect and restore lower Toppenish and Simcoe creek adult migration and holding areas and juvenile fall, winter, and spring rearing areas. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

**Toppenish Action #8** **Improve, relocate, or close forest roads**

**Key Partners:**
Bureau of Indian Affairs, Yakama Agency
Yakama Reservation Watersheds Project

**Affected MSAs:**
Simcoe
Toppenish

**Focal Area:** Entire Toppenish Creek Watershed **Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 3-10 years

**Strategies:**
Improve upland watershed conditions

**Limiting Factors:** N13,14

**Cost Derivation:** 5 miles/year of road reconstruction, upgrade, or abandonment at $10,000/mi for 15 yrs.

**Total Cost:** $750,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $375,000

Overall, forest roads have been built and maintained to a lower standard on the Yakama Reservation than on, for example, US Forest Service land. There is a need to continue and expand road closures, relocations, and drainage improvements to reduce sediment and peak flows deliveries to creeks. The Yakama Reservation Watersheds Project and other tribal programs have assessed these needs and will coordinate a road improvement program with BIA, which manages reservation forestlands.

| **Toppenish Action #9** | **Continue improving management of cattle and improve management of feral horses** |
|---|---|

**Key Partners:**
Yakama Reservation Watersheds Project

**Affected MSAs:**
Simcoe
Toppenish

**Focal Area:** Entire Toppenish Creek Watershed **Implementation Likelihood:** Moderate

**Time to Implement:** Ongoing
**Time to Benefit:** 3-10 years

**Strategies:**
Restore riparian condition/future LWD
Improve upland watershed conditions

**Limiting Factors:** N15,16

**Cost Derivation:** 20% of restoration crew cost of $250,000/yr plus materials to build & repair range, riparian, & meadow fencing at $10,000/year; all for 15 years & 5 stock water well installations at $60,000 each.

**Total Cost:** $1,200,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $600,000

Recent and ongoing improvements in the management of cattle grazing have reduced impacts in the Toppenish Creek watershed. Impacts from wild horses are ongoing and the Yakama Nation is developing a wild horse management plan for the Satus and Toppenish Creek watersheds, which will focus on limiting riparian zone damage.

| **Toppenish Action #10** | **Restore headwater meadows** |
|---|---|

**Key Partners:**
Bureau of Indian Affairs, Yakama Agency
Yakama Reservation Watersheds Project

**Affected MSAs:**
Satus
Toppenish

**Focal Area:** Entire Toppenish Creek Watershed **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 3-10 years

**Strategies:**
Improve flow conditions
Improve water quality

**Limiting Factors:** N17

**Cost Derivation:** 10% of $250,000/yr cost for restoration crew plus $15,000/yr construction costs (most work will be hand work, but several locations will require machinery). Fencing is covered under Action #9. $200,000 is included for possible land purchases.

**Total Cost:** $800,000 **Fisheries:** 75% **Steelhead:** 100% **Steelhead Cost:** $600,000

Steelhead productivity in the Toppenish Creek watershed is limited in large part by summer streamflow. Some of this problem can be traced to headwater meadows that are dissected by gullies and no longer store runoff efficiently. The Yakama Reservation Watersheds Project has been refining headwater meadow restoration techniques and will coordinate further restoration efforts.

| | | | |
|---|---|---|---|
| **Upper Yakima Action #1** | **Redesign Roza Dam facilities to improve downstream smolt passage** | | |
| **Key Partners:** Bureau of Reclamation | | | **Affected MSAs:** All Upper Yakima |
| **Focal Area:** Roza Dam | | **Implementation Likelihood:** High | |
| **Time to Implement:** 4-6 years<br>**Time to Benefit:** 3-10 years | **Strategies:**<br>Restore unimpeded fish passage | | **Limiting Factors:**<br>U9 |
| **Cost Derivation:** | Price noted at BOR presentation at Yakima Basin Science & Management Conference in 2006. | | |
| **Total Cost:** $4,500,000 | **Fisheries:** 100% | **Steelhead:** 50% | **Steelhead Cost:** $2,250,000 |

Roza Dam's spill gates currently hinder smolt outmigration unless "tucked" periodically to allow surface spill. When no surface spill occurs at Roza Dam, downstream migrating fish must either navigate through the fish screen bypass located in slackwater with poor attraction flows or sound deep to pass through a small slot near the bottom of the dam structure. The passage obstacle at Roza is thought to increase overall travel time for migrants, prolong exposure to predation in the dam pool, and physically harm passing fish. Proposed modifications would allow some surface spill to be maintained under all conditions. BOR has completed a preliminary design and is scheduled to begin construction in 2009. Gate modifications that allow for surface spill at lower flows should not be used to justify maintenance of insufficient instream flows below Roza (see Upper Yakima Action #2).

| | | | |
|---|---|---|---|
| **Upper Yakima Action #2** | **Improve instream flows below Roza Dam** | | |
| **Key Partners:** Bureau of Reclamation<br>Irrigation Districts | | | **Affected MSAs:** All Upper Yakima |
| **Focal Area:** Mainstem Yakima River from below Roza to Yakima | | **Implementation Likelihood:** Moderate | |
| **Time to Implement:** Ongoing<br>**Time to Benefit:** 0-3 years | **Strategies:**<br>Improve flow conditions | | **Limiting Factors:**<br>U3 |
| **Cost Derivation:** | Cost of lost power under different scenarios are currently being calculated by BPA. Initial estimates for cost of tucking gates whenever flows during the spring allow are ~$160,000/yr. | | |
| **Total Cost:** $2,400,000 | **Fisheries:** 100% | **Steelhead:** 50% | **Steelhead Cost:** $1,200,000 |

Water diversions used for power generation decrease flows in the Yakima River between Roza Dam and the powerplant outfall 15 miles downstream. Many fish biologists in the basin have recommended provisions of higher outmigration flows below Roza Dam to reduce downstream travel times and increase smolt survival. This requires developing biologically based instream flow targets for this reach for the smolt outmigration (April 1 to May 31st) and then reducing or eliminating power diversions at Roza when needed to meet recommended flows. The Bureau of Reclamation has not yet agreed to this action, and its implementation may have funding consequences for Reclamation and the Roza Irrigation District. The possibility of making up for this loss of revenue through a contract with BPA should be explored in conjunction with this action.

**Upper Yakima Action #3** **Modify flip-flop flow regime**

**Key Partners:** Bureau of Reclamation

**Affected MSAs:** All Upper Yakima

**Focal Area:**

**Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years

**Time to Benefit:** 3-10 years

**Strategies:** Improve flow conditions

**Limiting Factors:** U1,6

**Cost Derivation:** Not estimated at this time; reservoir operation alternatives would have no direct cost, while major structural improvements would have high costs.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

The flip-flop flow regime results in high flows in the mainstem Yakima throughout most of the summer as Lake Cle Elum serves as the primary source for lower valley irrigation, and then a significant reduction in flows in the fall as BOR shifts to Rimrock Reservoir. The flip-flop regime was devised in response to a court order to protect spring chinook redds in the upper Yakima and Cle Elum rivers, but it is hypothesized to be significantly reducing rearing capacity for juvenile salmonids. Modifications to the flip-flop flow regime that improve habitat, flow, and temperature conditions for steelhead and other salmonid species in the regulated reaches of the subbasin would have broad benefits. The negative effects of flip-flop could be addressed through alteration of reservoir operations, conservation, additional storage, or a combination of these, and other measures. The Bureau of Reclamation, in collaboration with other subbasin resource managers and stakeholders, should determine if and how flip-flop can be modified to achieve these goals, make the necessary changes, and monitor habitat and fish population response.

**Upper Yakima Action #4** **Improve instream flows in Swauk Creek and Teanaway watersheds**

**Key Partners:**

Bureau of Reclamation
Department of Ecology
Individual irrigators
Kittitas County Conservation District
Kittitas Conservation Trust
Water Trust & Conservancies
Bonneville Power Administration
Regional Fisheries Enhancement Group or other volunteer groups

**Affected MSAs:**

Swauk
North Teanaway
West Teanaway

**Focal Area:** Teanaway River, Swauk Creek and tributaries

**Implementation Likelihood:** Moderate

**Time to Implement:** Ongoing

**Time to Benefit:** 0-3 years

**Strategies:** Improve flow conditions

**Limiting Factors:** U4,5

**Cost Derivation:** Costs depend on options pursued & could be made part of development conditions; projected cost based on acquisition of 1000 acre feet of water at $500/af.

**Total Cost:** $500,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $500,000

The Teanaway River and its forks and Swauk Creek and its tributaries have summer/fall stream flows that are significantly reduced by irrigations withdrawals. Improving instream flows through improved water management, off-stream storage, and water acquisitions and transfers will improve rearing habitats. The Teanaway has been the focus of water conservation projects by YRBWEP, Ecology, and Kittitas County Conservation District; WDFW, the Yakama Nation, and the Kittitas Conservation Trust have been active in Swauk Creek.

**Upper Yakima Action #5** **Provide passage and instream flows in lower Manastash Creek**

**Key Partners:**
- Kittitas County Conservation District
- Individual irrigators
- Yakima Tributary Access and Habitat Program
- Yakama Nation
- Water Trust & Conservancies

**Affected MSAs:** Manastash

**Focal Area:** Lower 3 miles of Manastash Creek **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 3-10 years

**Strategies:**
- Restore unimpeded fish passage
- Improve flow conditions

**Limiting Factors:** U4,5

**Cost Derivation:** $5,000,000 estimate by Kiititas County Conserrvation District.

**Total Cost:** $5,000,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $2,812,500

Manastash Creek has numerous small water diversions across the large alluvial fan in the lower reaches which block fish passage and can dewater the creek. Resolution of flow and passage issues in this watershed is high priority for the basin as a whole due to the quantity of suitable but unoccupied habitat in Manastash Creek and its location in the lower portion of the Upper Yakima. Work is currently underway by a local working group led by the Kittitas County Conservation District with support from the Department of Ecology and BPA.

**Upper Yakima Action #6** **Provide unimpeded fish passage in Taneum Creek**

**Key Partners:**
- Kittitas Conservation Trust
- Yakima Tributary Access and Habitat Program
- Individual irrigators

**Affected MSAs:** Taneum

**Focal Area:** Lower 3 miles of Taneum Creek **Implementation Likelihood:** High

**Time to Implement:** > 10 years
**Time to Benefit:** 0-3 years

**Strategies:**
- Restore unimpeded fish passage

**Limiting Factors:** U9

**Cost Derivation:** Preliminary design estimates.

**Total Cost:** $600,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $450,000

Taneum Creek has several medium-sized diversions in the lower portions of the creek that partially block fish passage. Concrete fishways were installed in the 1980s but rarely provide full adult passage and do not allow juvenile passage. Above those diversions, flows and habitat conditions are good to excellent. Recent improved flow conditions in Taneum Creek have resulted in steelhead use of the most accessible portions of the creek. The Kittitas Conservation Trust is taking the lead on efforts to install low-maintenance fish passage structures.

**Upper Yakima Action #7** **Provide fish passage into Upper Naneum Creek**

**Key Partners:**
- City governments
- Individual irrigators
- Kittitas County Conservation District
- Kittitas County
- Yakima Tributary Access and Habitat Program
- Irrigation Districts
- Bureau of Reclamation

**Affected MSAs:** Naneum

**Focal Area:** Lower and middle reaches of Naneum Creek **Implementation Likelihood:** Moderate

**Time to Implement:** > 10 years
**Time to Benefit:** 10-25 years

**Strategies:** Restore unimpeded fish passage

**Limiting Factors:** U9

**Cost Derivation:** 25 structures at $200,000 each.

**Total Cost:** $5,000,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $3,750,000

The upper portions of Naneum Creek are presumed to have been historic spawning and rearing habitat for steelhead. There are multiple stream courses that connect the middle reaches of Naneum to the Yakima River, and coordinated planning will be required to identify the most effective route to restore. This will require the involvement of YTAHPs, the Kittitas County Conservation District, Kittitas County, the City of Ellensburg, Cascade Canal Company, Kittitas Reclamation District, Ellensburg Water Company, and private irrigators. Work will involve removing passage barriers, screening diversions, and improving instream flows.

**Upper Yakima Action #8** **Provide passage at Cle Elum Dam**

**Key Partners:**
- Bureau of Reclamation

**Affected MSAs:** Cle Elum

**Focal Area:** Cle Elum Dam **Implementation Likelihood:** Moderate

**Time to Implement:** 6-10 years
**Time to Benefit:** 10-25 years

**Strategies:** Restore unimpeded fish passage

**Limiting Factors:** U8

**Cost Derivation:** 2008 cost estimate of $96,000,000 by Bureau of Reclamation.

**Total Cost:** $96,000,000 **Fisheries:** 100% **Steelhead:** 20% **Steelhead Cost:** $19,200,000

Lake Cle Elum is a natural glacial lake that supported a run of sockeye salmon. When a dam was constructed to raise the lake to store irrigation water, fish passage was not provided. Providing upstream and downstream fish passage at Cle Elum Dam would open up 30 miles of high quality habitat for steelhead. The BOR Fish Passage Study gives a detailed description (BOR 2005). Actions and evaluation at Cle Elum Dam should precede actions at Keechelus and Kachess dams.

**Upper Yakima Action #9** **Continue providing access to the Yakima River above Easton Dam in all years**

**Key Partners:**
Bureau of Reclamation

**Affected MSAs:**
Upper Yakima

**Focal Area:** Easton Dam

**Implementation Likelihood:** Moderate

**Time to Implement:** 0-3 years

**Time to Benefit:** 3-10 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**
U9

**Cost Derivation:** Operational action without a specific cost.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

In projected low-flow years, BOR operating plans allow for closing the Easton fish ladder in the spring to block chinook from spawning in areas that may be subsequently dewatered. This would also block steelhead from the upper 12 miles of the Yakima River and its tributaries during spawning season. Closure of the Easton ladder has not occurred since 1996 due to the successful use of the "little flip-flop" flow regime and improvements to the Kachess outlet works, and closure of the ladder is not anticipated in the future (prior to 1996, closures occurred during the latter part of expected steelhead spawning time windows). Continuing to provide year-round access to and adequate flows in the Yakima River above Easton Dam will enable steelhead to successfully spawn and rear in this highly complex and productive reach of the Yakima River.

**Upper Yakima Action #10** **Replace County Road culverts on Jack and Indian Creeks**

**Key Partners:**
Kittitas County Conservation District
Kittitas County
US Forest Service
Kittitas Conservation Trust

**Affected MSAs:**
North Teanaway

**Focal Area:** Lower sections of Jack and Indian Creeks

**Implementation Likelihood:** High

**Time to Implement:** 0-3 years

**Time to Benefit:** 3-10 years

**Strategies:**
Restore unimpeded fish passage

**Limiting Factors:**
U20

**Cost Derivation:** Based on preliminary project budgets.

**Total Cost:** $750,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $375,000

While the Teanaway system is generally accessible to steelhead, there are passage-limiting culverts where the North Fork Teanaway Road crosses Jack Creek and Indian Creek. These culverts block access to about 8.8 miles of upstream habitat. A project to replace them with fish-friendly structures is being developed by the Kittitas County Conservation District and partners.

**Upper Yakima Action #11** **Restore passage, separate irrigation conveyance, and screen diversions in Ellensburg-area tributaries**

**Key Partners:**

Kittitas County Conservation District
Yakima Tributary Access and Habitat Program
Yakama Nation
Irrigation Districts
Kittitas Conservation Trust
Water Trust & Conservancies

**Affected MSAs:**

Reecer
Naneum
Caribou

**Focal Area:** Dry, Reecer, and Wilson creeks and associated tributaries

**Implementation Likelihood:** High

**Time to Implement:** Ongoing

**Time to Benefit:** 0-3 years

**Strategies:** Restore unimpeded fish passage

**Limiting Factors:** U6,13

**Cost Derivation:** 30 structures at $200,000 each.

**Total Cost:** $6,000,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $2,250,000

The complicated network of tributaries in the Ellensburg area has been highly modified as part of the development of irrigation systems, roads, and other infrastructure. The Yakima Tributary Habitat and Access Program is removing passage barriers, screening irrigation diversions, and seperating irrigation water conveyence from natural streams. The lower reaches of these streams are expected to provide a dramatic increase in available rearing habitat in the Kittitas Valley that would offset the reduction in rearing habitat due to confinement of the mainstem. Monitoring should be conducted to confirm value of this habitat for rearing fish. Cost-effective implementation of this action will require careful analysis of options and prioritization of actions; current plans are to focus on resotration of selected creeks up to the Cascade Ditch crossings. Work should be coordinated with riparian restoration under Upper Yakima Action #15.

**Upper Yakima Action #12** **Reduce confinement of Upper Yakima River**

**Key Partners:**

US Army Corps of Engineers
Gravel mine operators
Kittitas County
Washington State Department of Transportation
Yakama Nation
Yakima County
Bureau of Reclamation
Bureau of Reclamation

**Affected MSAs:**

All Upper Yakima

**Focal Area:** Floodplain of the Yakima River

**Implementation Likelihood:** Moderate

**Time to Implement:** Ongoing

**Time to Benefit:** 10-25 years

**Strategies:**

Restore floodplain connectivity/function
Restore channel structure/complexity

**Limiting Factors:** U10,14,24

**Cost Derivation:** Estimated at 1,000 acres at $10,000/acre.

**Total Cost:** $10,000,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $3,750,000

Rearing habitat in the mainstem of the Upper Yakima River is limited by the combination of high flows and confined channels. Efforts to reduce confinement through levee setbacks and other infrastructure changes will both reduce the effect of the altered flow regime in the upper Yakima and increase effective habitat area. Proposed locations include the I-90 ponds at mile 101, the BOR's Schaake levee pullback near Ellensburg, the Selah-area (gravel pits and Taylor ditch) and sites associated the I-90 upgrades above Easton. There is the possibility of actions in other locations through setback of abandoned railroad levees and flood control levees on public lands.

**Upper Yakima Action #13** **Protect & restore floodplain, riparian and in-channel habitats in Upper Yakima, Kittitas and Easton/Cle Elum Reaches**

**Key Partners:**

Land Conservancies
Private landowners
Yakima Tributary Access and Habitat Program
Yakima Basin Side Channels Project

**Affected MSAs:**

Caribou
Cle Elum
Manastash
Middle Mainstem Yakima
Naneum
North Teanaway
Reecer
Swauk
Taneum
Upper Mainstem Yakima
Upper Yakima
West Teanaway

**Focal Area:** Upper Yakima River and tributaries **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 10-25 years

**Strategies:** Protect existing functional habitat

**Limiting Factors:** U12,13,14,19, 21

**Cost Derivation:** 2,000 acres at $8,000/acre.

**Total Cost:** $16,000,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $8,000,000

There are several ongoing efforts to protect fisheries habitat in key Upper Yakima reaches through acquisition of land and conservation easements. These include the Yakama Nation's side channels project, the Cascade Conservation Partnership and Mountain-to-Sound Greenway Programs, and YRBWEP's acquisition efforts. Habitat restoration should be integrated with these acquisition programs. Much of this work has been guided by the Reaches Study conducted by Stanford and Snyder, which identified key alluvial floodplain reaches. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

| **Upper Yakima Action #14** | **Restore instream and floodplain habitat complexity in Swauk and Taneum creeks and Teanaway and lower Cle Elum rivers** |
|---|---|

**Key Partners:**
- Kittitas Conservation Trust
- Cascade Land Conservancy
- Kittitas County
- Yakama Nation
- Washington Department of Fish & Wildlife
- Kittitas County Conservation District
- Bureau of Reclamation
- Washington State Department of Transportation
- Regional Fisheries Enhancement Group or other volunteer groups

**Affected MSAs:**
- Cle Elum
- Taneum
- West Teanaway
- North Teanaway
- Swauk

**Focal Area:** Key tributraies to the Upper Yakima **Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 10-25 years

**Strategies:**
- Restore floodplain connectivity/function
- Restore channel structure/complexity

**Limiting Factors:** U10,12,13,24

**Cost Derivation:** 5 miles on Swauk, 17 on Teanaway, 10 on Taneum, 8 on Cle Elum for 40 miles total; 50% treatment = 20 mi x $100,000/mile treatment co.st

**Total Cost:** $2,000,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $1,500,000

Efforts to improve channel/floodplain connectivity and riparian habitat will improve habitat conditions in key tributares in the Upper Yakima. Activities may include placing large woody debris and engineered log jams, bank reshaping, channel reconstruction, and other instream habitat work and addressing confinment created by road beds (including US 97 on Swauk Creek). Any passage barriers in these creeks and fish-bearing portions of tributaries to these creeks should also be addressed. Specific areas in Swauk Creek and its tributaries have been inventoried as being in need of restoration; work is currently underway on the lower Cle Elum and under development for Taneum Creek.

**Upper Yakima Action #15 Restore tributary riparian areas**

| **Key Partners:** | **Affected MSAs:** |
|---|---|
| Kittitas County Conservation District | Caribou |
| Kittitas Conservation Trust | Manastash |
| Yakama Nation | Middle Mainstem Yakima |
| Yakima Tributary Access and Habitat Program | Naneum |
| Regional Fisheries Enhancement Group or other volunteer groups | North Teanaway |
| | Reecer |
| | Swauk |
| | Taneum |
| | Upper Mainstem Yakima |
| | West Teanaway |

**Focal Area:** Tributary riparian areas **Implementation Likelihood:** High

**Time to Implement:** Ongoing
**Time to Benefit:** 3-10 years

**Strategies:** Restore riparian condition/future LWD
**Limiting Factors:** U13,14,19,21

**Cost Derivation:** 13 creeks at 3 miles/creek totals 39 miles; fencing & planting of 50% at $20,000/mile.

**Total Cost:** $390,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $195,000

Due to regulation and artificial confinement of the upper Yakima, the best available locations for rearing fish in normative flow and temperature conditions are in the lower ends of tributaries. Restoring riparian conditions will improve rearing conditions. Lower Reecer, Currier, Whiskey, Mercer, Wilson, Naneum, Coleman, Cherry, Manashtash, Taneum, Swauk, and Lmumma Creeks and the Teanaway River are all candidates; some work has been completed. This action should be integrated with the passage restoration efforts identified in other actions.

| | |
|---|---|
| **Upper Yakima Action #16** | **Build conservation easements and other habitat protections into development plans** |

**Key Partners:**
Cascade Land Conservancy
City governments
Kittitas Conservation Trust
Kittitas County

**Affected MSAs:**
All Upper Yakima

**Focal Area:** Floodplain and riparian areas throughout population area

**Implementation Likelihood:** Moderate

**Time to Implement:** 4-6 years
**Time to Benefit:** 10-25 years

**Strategies:**
Protect existing functional habitat

**Limiting Factors:**
U16,17

**Cost Derivation:** Cost for personnel to coordinate action at 2 FTE x $75,000/FTE/yr for 15 years; other costs subsumed into cost of new developments.

**Total Cost:** $2,250,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $562,500

Current and expected rapid population growth in Kittitas County has the potential to impact currently functioning habitat and reduce restoration options. Areas where development pressure and steelhead habitat overlap include the Teanaway River, Big and Swauk creek watersheds, the Ellensburg urban growth area and floodplain locations along the mainstem Yakima. Assuring that habitat values of riparian and floodplain habitat on private lands are protected and that development does not impair upland watershed processes are high priorities. This will require community-led efforts to 1) utilize the planning processes required by the Growth Management Act, 2) work with developers to promote incorporation of greenbelts and open space that protect fish habitat and reduce flood damages, and 3) develop innovative approaches that integrate habitat protections with ongoing efforts to protect open space, recreational values, livable communities, and working landscapes while protecting private property rights. The recent Suncadia development provides one example of extensive environmental mitigation being incorporated into a successful development proposal.

**Upper Yakima Action #17** **Protect Teanaway watershed from negative impacts of development**

**Key Partners:**
- Land Conservancies
- Washington Department of Fish & Wildlife
- Kittitas Conservation Trust
- US Forest Service
- Bureau of Reclamation

**Affected MSAs:**
- North Teanaway
- West Teanaway

**Focal Area:** Teanaway River watershed **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 10-25 years

**Strategies:** Protect existing functional habitat

**Limiting Factors:** U16,17

**Cost Derivation:** $1,004,740 currently allocated to KCT easement proposals; also easements on 365 acres (~600' over 50% of 10 miles at $10,000/acre).

**Total Cost:** $4,654,740 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $1,745,528

The Teanaway watershed is currently subject to intense recreational/residential/retirement development pressure as large forestland holdings are sold off. Assuring that habitat values of riparian and floodplain habitat on private lands are protected and that development does not impair upland watershed processes are high priorities; land acquisitions, conservation easements, and cooperative agreements with developers will be key tools in ensuring these protections. This action will need to be integrated with ongoing efforts to protect open space, recreational values, and working landscapes. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

**Upper Yakima Action #18** **Relocate forest roads and campsites and revegetate clearcuts in the Teanaway River watershed**

**Key Partners:**
- Washington Department of Natural Resources
- Private landowners
- US Forest Service
- Regional Fisheries Enhancement Group or other volunteer groups

**Affected MSAs:**
- North Teanaway
- West Teanaway

**Focal Area:** Forestlands in the Teanaway watershed **Implementation Likelihood:** High

**Time to Implement:** Expand ongoing
**Time to Benefit:** 3-10 years

**Strategies:** Improve upland watershed conditions

**Limiting Factors:** U21,22,23

**Cost Derivation:** 30 miles of road work at $5,000/mile; 500 acres of plantings at $300/acre.

**Total Cost:** $300,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $75,000

Because of its south-facing aspect and steep, confined nature of the tributaries, the Teanaway is especially prone to increases in peak flow resulting from changes in watershed condition. Actions that improve forest practices, such as addressing the impacts of roads located next to salmon-bearing streams and revegetating clear cuts south-facing slopes, will help protect and improve watershed function. Efforts to relocate and reduce soil compaction at dispersed campsites will also improve watershed function. Due to the critical nature of all salmonid populations that inhabit the Teanaway, this watershed has the highest priority for identifying and reducing impacts from forest practices in the subbasin.

**Upper Yakima Action #19** **Coordinate water quality improvements in Reecer, Wilson, Naneum, Cherry, Coleman, and Dry creeks**

**Key Partners:**
- Individual irrigators
- Kittitas County Conservation District
- USDA Natural Resource Conservation Service
- Department of Ecology
- City governments
- Irrigation Districts
- Washington Department of Natural Resources

**Affected MSAs:**
- Caribou
- Naneum
- Reecer

**Focal Area:** Ellensburg-area watersheds

**Implementation Likelihood:** Moderate

**Time to Implement:** Expand ongoing

**Time to Benefit:** 3-10 years

**Strategies:** Improve water quality

**Limiting Factors:** U17

**Cost Derivation:** Costs of Clean Water Act programs not attributed to steelhead recovery.

**Total Cost:** **Fisheries:** **Steelhead:** **Steelhead Cost:**

Water quality in Ellensburg-area tributaries is degraded by agricultural activities, urban stormwater, and forestry activities in the upper watersheds. Agricultural practices are improving, but more work is needed on stormwater and reduction of peak flows from forestry activities. A sediment TMDL is being developed for the Upper Yakima; implementation is currently limited by funding.

**Upper Yakima Action #20** **Restore tributary headwater meadows**

**Key Partners:**
- US Forest Service

**Affected MSAs:**

**Focal Area:** Headwaters of key Upper Yakima tributaries

**Implementation Likelihood:** High

**Time to Implement:** 4-6 years

**Time to Benefit:** 3-10 years

**Strategies:**
- Improve flow conditions
- Improve water quality

**Limiting Factors:** U26

**Cost Derivation:** Cost for restoration crew time & equiment at 30,000/yr for 15 yrs.

**Total Cost:** $450,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $253,125

Protecting and restoring the function of wet meadows in the upper watersheds of Swauk, Taneum, and Manashtash creeks and Cle Elum River and its tributaries (e.g. Thorp and French Cabin creeks) will help maintain and improve the quantity and quality of instream flows in downstream steelhead habitat. For the Cle Elum watershed, this only becomes relevant pending completion of Upper Yakima Action #8: Provide passage at Cle Elum Dam.

| | |
|---|---|
| **Upper Yakima Action #21** | **Provide adequate late fall/winter flows below storage dams** |

**Key Partners:**
Bureau of Reclamation

**Affected MSAs:**
Cle Elum
Upper Yakima

**Focal Area:** Upper Yakima and Cle Elum rivers **Implementation Likelihood:** Moderate

**Time to Implement:** 0-3 years
**Time to Benefit:** 0-3 years

**Strategies:**
Improve flow conditions

**Limiting Factors:**
U2

**Cost Derivation:** Operational change; no specific cost identified.

**Total Cost:** **Fisheries:** 100% **Steelhead:** 25% **Steelhead Cost:**

Late fall/winter flows below Kachees, Keechelus and Cle Elum reservoirs are maintained at relatively low levels by releases from the storage dams as natural reservoir inflows are used to refill storage capacity. Releases may also vary substantially based on flood control operations and efforts to assure adequate storage in dry years. The primary fisheries emphasis in this area is on maintaining appropriate spawning and incubation flows for spring Chinook. Consideration should also be given to ensuring productive spawning and rearing conditions for juvenile steelhead.

# 6 Plan Implementation



This plan is a beginning, not an end. It identifies proposed recovery actions, lays out a framework for assessing progress towards recovery goals, and identifies issues that will need to be assessed during recovery efforts. Implementing the plan and achieving recovery goals will require sustained long-term efforts by a wide range of stakeholders. Coordinating these efforts and ensuring that limited funding is used effectively will require ongoing collaboration within the basin and between in-basin stakeholders and state, tribal, and federal entities. This chapter gives an overview of what will be required to achieve this coordination.

## 6.1 Approach to Implementation

### 6.1.1 Voluntary and Non-Regulatory Nature of Plan

As noted in section 1.2.3, both the NOAA Fisheries' Recovery Plan for the Middle Columbia River Steelhead DPS and the Yakima Subbasin Salmon Recovery Plan are not regulatory documents. Both promote cooperative and voluntary approaches to undertaking recovery actions. For this voluntary approach to work, recovery plan implementation will need to be supported by broad outreach, targeted technical and logistic support to landowners and project proponents, and funding and incentive programs that support recovery actions.

This plan does not make specific recommendations to change existing regulatory programs, but does recognize that how regulatory programs are implemented will affect the progress of steelhead recovery. Elected officials, agency staff, stakeholder groups, and voters should consider the recovery needs of steelhead as these programs are established, revised, and implemented.

Effectively designed and well-implemented regulatory programs that strike an appropriate balance between habitat protection and other legitimate land use goals will be a critical component of salmon recovery. Specific regulatory programs that intersect with steelhead recovery include local land use management such as the Growth Management, Shorelines, and Critical Areas Ordinance programs of local governments; the establishment and enforcement of fisheries regulations by WDFW; the implementation of the ESA by NOAA Fisheries (including issuance of Section 7 Biological Opinions and Section 10 take permits); development and implementation of Total Maximum Daily Loads (TMDLs) in accordance with the Clean Water Act; and the issuance of instream work permits by WDFW, WDOE, the Yakama Nation and the U.S. Army Corps of Engineers. Our hope is that the information and proposed actions in this plan can inform ongoing public dialogues about implementation of these regulatory programs.

### 6.1.2 Coordination of Existing Recovery Programs

Salmon recovery is not a new pursuit in the Yakima Basin. Fish screening efforts began in the early 20th century, and intensive recovery efforts have been ongoing since the 1980s. The steelhead recovery actions proposed in this plan are a natural extension of this work and should build upon existing programs, relationships, and funding sources whenever possible. Developing collaborative partnerships among existing organizations should take precedence over the creation of new organizations and programs unless there is a clear need for a new structure.

The Yakama Nation and the WDFW have played a central role in salmon recovery work in the Yakima Basin. Much of the funding has come from the BPA with oversight from the Northwest Power and Conservation Council, which was established by the Northwest Power Act of 1980. BPA is currently working with basin stakeholders to target its funding in a manner that meets power planning act requirements and contributes to mitigating the impacts of the Federal Columbia River Power System on ESA-listed species. This is occurring as part of the negotiation of an ESA-mandated Biological Opinion for the Federal Columbia River Power System; a draft Biological Opinion was released in October 2007.

Another significant source of funding for recovery actions is the federal Pacific Coast Salmon Recovery Fund (PCSRF). Washington has used its allocation of PCSRF funding along with state funding to support salmon recovery efforts overseen by the Washington Salmon Recovery Funding Board (SRFB). To date, over $8.7 million has been committed to salmon recovery projects in the Yakima Basin via Salmon Recovery Funding Board (SRFB) programs; this funding has leveraged another $5.5 million in locally secured match from diverse sources.

The BOR has also been a key supporter of salmon recovery efforts in the Basin (see Section 6.1.4 for more detail). Federal, state, tribal, and private land managers have incorporated salmon recovery needs into their land management activities and plans (see Section 6.1.5). Local governments, irrigation districts, the South-Central Washington RC & D, and conservation districts have all become active proponents of salmon recovery projects and have built the organizational capacity needed to plan, fund, and implement these projects.

Most of the recovery actions outlined in this plan can be implemented through these programs. This will require ongoing efforts to coordinate diverse programs and identify joint priorities to ensure that recovery efforts build on existing capacities and are implemented efficiently.

### 6.1.3 Coordination with Bureau of Reclamation Yakima Project

For the last 20 years, BOR has been improving fish passage and installing protective facilities in the Yakima Basin. They maintain a project list and inventory of pending and proposed projects that conserve fish resources and are actively balancing fish requirements and water production needs in Yakima Project operations.

Congress established the Yakima River Basin Water Enhancement Project (YRBWEP) in 1994. YRBWEP has funded a wide range of salmon recovery actions, including major irrigation system improvements, purchase of water rights for transfer to instream flow, cooperative projects with smaller irrigators, and purchase and management of floodplain habitat in key river reaches. BOR also works closely with the System Operations Advisory Committee (SOAC), which consists of representatives of WDFW, the Yakama Nation, the USFWS, and the Yakima Basin Joint Board and was created by the Yakima Basin watermaster in 1981. SOAC provides recommendations to BOR on how fish needs are incorporated into Yakima Project operations.

BOR is working closely with WDFW and the Yakama Nation to assess the possibility of re-establishing fish passage at the five storage dams (see section 4.3.3) through the Storage Dam Passage Feasibility Study scheduled for completion in 2008. The Yakima Basin Storage Study is a major effort by BOR to identify and assess options for increasing water storage capacity in the Yakima Basin to better meet the long-term water supply needs of agriculture, municipal users, and anadromous fish. The draft EIS for the storage study is also due in 2008.[39] Models and other planning documents that BOR is developing as part of the storage study have great potential for informing broader discussions of recovery needs.

In a meeting on February 28, 2005 and in a subsequent letter, BOR staff identified existing projects that could contribute to a salmon recovery plan. As with all federal agencies interviewed, they identified limited budgets and resources as a concern in assisting with salmon recovery planning efforts.

BOR submitted extensive comments on the October 2005 version of the Yakima Subbasin Salmon Recovery Plan and drafts of this steelhead extract. The Yakima Basin Fish & Wildlife Recovery Board will work with BOR to continue these discussions. Several key actions identified in this plan involve BOR and will only move forward to the degree that BOR supports them. The Board hopes that this plan will be a useful document for BOR as it continues its efforts to protect and enhance Yakima Basin steelhead.

### 6.1.4 Coordination with Land Management Agencies

The USFS, the Bureau of Land Management, the USFWS, and the Washington Departments of Natural Resources and Fish and Wildlife all manage lands in the Yakima Basin. Their management activities are governed by a range of laws, plans, and agreements, including some that specifically address management needs of listed fish species (e.g., Biological Opinions, Habitat Conservation Plans, and the Forests and Fish Act). In addition to general land management decisions, these agencies have many opportunities to undertake specific recovery projects, but rates of implementation are constrained by staffing and budget limitations. These agencies will be key participants in

[39] The BOR's study is coupled with work by the Washington State Department of Ecology to assess non-storage options for improving basin water supplies.

ongoing efforts to prioritize, coordinate, fund, and implement recovery actions identified in this plan.

### 6.1.5 Coordination with Other Planning Efforts

Section 1.4.1 discussed the relationship between this plan and the Yakima Subbasin Plan and the Yakima Basin Watershed Plan. Other planning efforts that will inform and guide actions called for in this plan include:

- Flood Hazard Management Plans developed by local counties
- Statewide Steelhead Management Plan currently under development by the WDFW
- Steelhead Master Plan being developed by the Yakima/Klickitat Fisheries Project, Comprehensive Irrigation District Management Plans developed by local irrigation districts
- Land management plans developed by the USFS, the BLM, and the Washington Department of Natural Resources
- Capital facilities improvement plans developed by local, state, tribal, and federal governments to guide work on highway systems, water systems, and other critical infrastructure that influences steelhead habitat

It is our intent that this recovery plan and the ongoing collaborative network on which it is built can help make it easier for these diverse groups of planners to understand and incorporate steelhead recovery needs into these plans. The Yakima Basin Fish & Wildlife Recovery Board is committed to working with all of these partners.

### 6.1.6 Coordination with Local Land Use Planning

While this plan does not make any specific proposals regarding land use planning or associated regulations, local jurisdictions are encouraged to review local subdivision ordinances to see if they encourage creative approaches that balance habitat protection with site planning (possible examples include density bonuses, transfers of development rights, binding site plans, and tax incentives). Local jurisdictions are also encouraged to use the information in this recovery plan as they review their Critical Areas and Shorelines and Flood Hazard Management ordinances to see if they address habitat protection in a consistent and logical manner that avoids redundancy, uses the best available science, and works with adjacent jurisdictions to assure that ordinances do not conflict across the landscape. Cities and counties are also encouraged to seek funding to monitor adherence to development permit conditions and how effectively they met their intended goals.

### 6.1.7 Role of Yakima Basin Fish & Wildlife Recovery Board

Early in the recovery planning process, planners realized that existing structures, while adequate for supporting the initial development of subbasin and recovery plans (via the

Yakima Subbasin Fish & Wildlife Planning Board) and allocating SRFB funding through the Lead Entity structure (via the Yakima River Basin Salmon Recovery Board), were not capable of coordinating long-term recovery efforts. In response, the two organizations merged to form the Yakima Basin Fish & Wildlife Recovery Board (YBFWRB) in April of 2006. Since then, the YBFWRB has hired a director and staff, secured funding from WDFW and the SRFB, established offices, acted as the Lead Entity for SRFB programs in the Yakima Basin, and coordinated the recovery plan revision process and development of this steelhead extract. The YBFWRB anticipates a key role coordinating and supporting recovery actions and associated research, monitoring, and evaluation efforts (See Chapter 7). The YBFWRB is also planning a strong outreach program that builds community knowledge of and support for salmon recovery actions (See Chapter 8).

## 6.2 Funding

### 6.2.1 Total Time and Cost of Recovery

Initial cost estimates for implementing all of the actions identified in this plan over 15 years total $1,168.3 million, with $269.3 million of that cost attributed to steelhead recovery. The remaining portion of the total cost is attributed to other sources based on anticipated benefits to agricultural producers (e.g. irrigation system improvements), flood control, open space, other fish and wildlife species, etc, according to the percentages identified in the action descriptions. Funding steelhead recovery actions will require working with other interests and entities to ensure that full funding can be secured for actions whose benefits to society extend beyond steelhead recovery.

This is a simple and very preliminary estimate of actual implementation costs for actions. It is not a cost-benefit analysis of the proposed actions and does not include indirect costs such as opportunity and compliance costs associated with recovery efforts. It should not be taken as the total cost of recovery, as achieving delisting goals may require only implementing some of the actions included in this plan, while long-term recovery may require additional actions not included in the plan.

This estimate does not include specific costs for steelhead-related monitoring, which will be an essential component of recovery efforts. An initial placeholder of $300,000/yr for 15 years for steelhead-specific monitoring equals $4.5 million; cost estimates will be refined as a more detailed monitoring plan is developed (see discussion in Chapter 7).

### 6.2.2 Funding Sources

Significant funding is already available for salmon recovery in the Yakima Basin via the BPA Fish and Wildlife Program, SRFB programs, the Department of Ecology Columbia River Initiative, USDA programs like EQIP and CREP, and others. The Board will work with existing programs and partners to help ensure that funding is targeted to ensure real progress towards recovery. A broadly supported implementation schedule for recovery actions will be a key element in guiding how funding is applied (see Section 6.3).

Where existing funding sources are insufficient or cannot be applied to key recovery actions, the YBFWRB will work with partners to help secure new funding sources for recovery actions. Sources may include local, state, and federal appropriations, special improvement districts, grants from foundations, support from private businesses, and private donations. Many of the proposed actions have multiple benefits that extend far beyond salmon recovery. Funding for these may involve complex packages of funding from multiple sources, each of which focuses on specific sets of benefits, any one of which may or may not include salmon recovery.

Different funding sources have different goals, mandates, and application and contracting procedures. Increasing knowledge of different funding sources and their requirements, and streamlining application and contracting procedures would significantly reduce the transaction costs associated with recovery projects. The Board anticipates working with grantors and implementing organizations to increase efficiencies.

## 6.3 Implementation Scheduling

The YBFWRB has committed to maintaining an implementation schedule that identifies priority recovery actions and sets a schedule for implementing them. The Board will develop this schedule and update it at least annually in coordination with potential project sponsors, partners, and affected stakeholders. The implementation schedule does not create any formal obligations or commitments; it is will serve as a guide to recovery priorities and an informal record of commitments made in other forums.

The implementation schedule should serve as a menu from which project proponents can chose projects to implement. These choices should be guided by the following considerations:

- The degree to which projects address a priority limiting factor for steelhead
- The technical feasibility of implementing a project
- The level of certainty regarding project outcomes and the long-term response to them by steelhead populations
- The strength of the commitment of the parties involved in a project to implement and maintain it
- The cost-effectiveness of a proposed action
- The presence of a "champion" organization or individual with the interest and ability needed to develop and implement the action
- The presence or absence of general community support for a project
- The availability of funding that can be used for that specific project
- The presence of temporary windows of opportunity for completion of a project

Evaluating the effectiveness of implemented recovery actions and identifying future priorities will require a rigorous and quantitative approach to adaptive management as priority actions are being implemented. The implementation schedule will have to be adjusted over time based on monitoring results, as noted below under Adaptive Management in Section 6.4. Detailed recommendations on implementing a strong adaptive management process will be included in the RME supplement to the Yakima Steelhead Recovery Plan currently being developed by the YBFWRB. We encourage interested parties to participate in the development of the supplement and the ongoing maintenance of the implementation schedule.

The implementation schedule should become a widely used resource that informs project selection. In some contexts (e.g., SRFB project selection) it may become a driving force. However, given the diversity of project partners, funding sources, and the mandates and goals behind recovery actions, actions that are designated recovery priorities will continue to be funded by a wide range of programs that may be informed or guided by the implementation schedule, but are not specifically directed by it.

## 6.4 Adaptive Management

A key to effective implementation of this plan will be the use of a rigorous adaptive management framework that identifies and addresses key uncertainties through monitoring and research. This will include:

### 6.4.1 Tracking Implementation

The Board will work together with partners implementing recovery actions to track project completion, document their outcomes, and evaluate whether they are carried out as planned. Project summaries that describe what project sponsors accomplished, document project outcomes and lessons learned, and include maps and project photos will be assembled and maintained in a publicly accessible format. The YBFWRB will use this information to develop regular reports on the status of plan implementation.

### 6.4.2 Monitoring Habitat and Population Trends

To assess the effectiveness of recovery efforts and sustain the support of the public and key decision makers, we must be able to track progress towards recovery goals. This requires reliable empirical estimates of population status that can be compared to the recovery criteria identified in this plan. The Yakima Basin currently has an ability to monitor anadromous fish runs that has few equals in the region, thanks largely to the fish research infrastructure established by the Yakima/Klickitat Fisheries Project. However, effectively tracking the full range of VSP parameters (abundance, productivity, spatial structure, and diversity) for each individual population will mean adjusting and supplementing our monitoring programs. Chapter 7 describes current efforts to identify and implement the required steelhead population monitoring.

### 6.4.3 Designing Recovery Actions to Test Key Assumptions

Adaptive management is a powerful concept that is often misrepresented as simply regularly monitoring and reassessing progress. Effective adaptive management requires the application of the principles of experimental design to management actions so that they test basic hypotheses that improve our understanding of key uncertainties and help us better understand ecosystem responses to our actions. Chapter 7 describes the role of adaptive management in plan implementation and the key uncertainties identified during this planning process.

### 6.4.4 Revising the Recovery Plan

This plan should be a living document that is revised to reflect improved understanding of key uncertainties, account for progress towards recovery, and refine assessments of future recovery needs. Annual reports by the YBFWRB will describe progress in plan implementation. Plan revisions will be considered at least every five years in conjunction with the five-year status reviews to be conducted by NOAA Fisheries.

## 6.5 Removing Roadblocks to Implementation

Once actions have been identified and chosen as priorities, the actual work of implementation begins. This is often a complex process that consumes significant amounts of time and funding. Efforts that increase the efficiency of project implementation and remove known roadblocks will play an important role in speeding up the rate of recovery. Possible areas to focus are described below.

### 6.5.1 Permit Streamlining

It is ironic that those implementing fish habitat improvement projects often see state, federal, and local regulations as impediments, even though these regulations are designed to protect habitat and listed species. Streamlining permitting processes for recovery actions would greatly reduce the transaction costs associated with implementing recovery actions and increase the rate at which recovery actions are implemented. Recent efforts by the Governor's Salmon Recovery Office to work with NOAA Fisheries, the Corps of Engineers, and the USFWS to incorporate SRFB-approved actions identified in NOAA Fisheries-accepted recovery plans into programmatic permits are an excellent first step.

### 6.5.2 Providing ESA Assurances

In many cases, potentially valuable projects are not implemented out of participants' fears that they may create future liabilities under the ESA (e.g., refusing to improve fish passage on a creek based on fears that the presence of listed fish in previously blocked areas would create a new regulatory burden). This could be addressed through mechanisms and agreements that support good-faith recovery efforts based on the best scientific information available and limit or absolve any future liabilities that the projects might create. Legally binding mechanisms to discharge responsibility for impacts to steelhead populations based upon the performance of recovery actions could significantly increase voluntary participation in recovery planning. There are some existing programs to accomplish this under the ESA (Habitat Conservation Plans, Safe-harbor agreements, etc.), while other programs may need to be developed to meet specific needs.

### 6.5.3 Building Technical Capacity

Complex recovery actions require a range of expertise unavailable in local communities and small organizations. Resources can be shared to build the capacity to get these actions on the ground. Examples of new and existing technical capacity that could be shared among multiple recovery partners include engineering, geographic information systems, land transaction (especially regarding structuring, valuation, monitoring, and enforcement of conservation easements), and fund raising for large projects.

### 6.5.4 Supporting Network of Recovery Practitioners

Most groups implementing recovery actions are either small organizations or small units within large organizations with other areas of focus. Successful recovery actions will be built on effective communication between diverse groups and individuals. It will require networks that help people sustain a global understanding of recovery efforts while maintaining focus on their individual components. Networks of recovery practitioners and stakeholders (be they formal or informal) will be an important way of building capacity, sharing lessons, and sustaining mutual support and momentum.

## 6.6 Maintaining Links to Larger Recovery Efforts

While this plan focuses on steelhead recovery needs within the Yakima Basin, achieving steelhead recovery goals will also require coordination with actions taken outside of the basin. This will require recovery planners and other local stakeholders to engage in several state and regional processes, as discussed below:

### 6.6.1 Washington State Salmon Recovery Strategy

The State of Washington’s Governor’s Salmon Recovery Office (GSRO) recognizes the Yakima Basin Fish & Wildlife Recovery Board as one of six regional recovery organizations in the state. The Yakima Subbasin Salmon Recovery Plan that this extract is based on has been accepted as a regional salmon recovery plan in accordance with the Salmon Recovery Act (RCW 77-85). The GSRO and the SRFB are committed to using regional salmon recovery organizations as a key element in the statewide salmon recovery process, and the Yakima Basin Fish & Wildlife Recovery Board is committed to working with the state in this capacity. The Board is also under contract with WDFW to serve as the Lead Entity for the Yakima Basin. Based on these two commitments, the Board coordinates applications for SRFB funding of projects in the Yakima Basin and intensive local reviews of proposals to the SRFB. The Board is committed to making this plan an integral part of the Yakima Basin SRFB proposal review process. The Board will also work with GSRO on regional sections of the biennial State of the Salmon report produced by GSRO as required by state law. The legislature has designated regional recovery organizations as members of the Washington Forum on Monitoring Salmon Recovery and Watershed Health, which seeks to coordinate salmon recovery monitoring efforts throughout the state.

### 6.6.2 Middle Columbia DPS-wide Coordination

The Yakima Basin's steelhead make up only one of the four Major Population Groups that together comprise the Middle Columbia River Steelhead DPS. The geographic area of the Middle Columbia River Steelhead DPS encompasses a large part of north-central Oregon and south-central Washington. Under the ESA, delisting decisions are made at the level of the DPS as a whole. This means that steelhead in the Yakima Basin may meet recovery goals, but not be delisted due to conditions elsewhere in the DPS. Communities throughout the DPS must undertake targeted recovery actions to successfully meet recovery goals and delist the DPS. This process will be facilitated by ongoing communication and coordination among these communities. An initial step is being made as part of the development of the Mid-Columbia Steelhead Recovery Plan by NOAA Fisheries, in which local planning groups from Oregon and Washington are meeting regularly to discuss how plans developed for individual MPGs will be 'rolled up' into a DPS-wide plan to be issued by NOAA. The Yakima Basin Fish & Wildlife Recovery Board anticipates that the need to share information and resources and coordinate key recovery actions across the entire DPS will continue during recovery plan implementation. The Board is committed to continuing to engage in discussions at the DPS level.

### 6.6.3 Integration with Columbia River, Estuary and Ocean Recovery Efforts

Conditions and management actions in the Columbia River, its estuary, and the ocean inevitably affect the fate of steelhead in the Yakima Basin. The rate of progress towards recovery will be determined, in part, by decisions made in these areas. Although this plan focuses on actions within the Yakima Basin, it recognizes that in-basin stakeholders will also need to engage in decision making outside of the basin to ensure that in-basin actions are coordinated with out-of-basin actions. Some stakeholders in the Basin (e.g., WDFW, the Yakama Nation, and the BOR) are directly involved in key out-of-basin management decisions; others have the opportunity to participate via established public participation processes and associations with other decision makers. The Yakima Basin Fish & Wildlife Recovery Board anticipates participating in efforts to coordinate overall Middle Columbia River Steelhead DPS recovery efforts. The Board will also foster discussions about the best way for in-basin stakeholders to ensure that progress outside of the basin continues to complement the concerted efforts underway within the basin.

# 7 Research, Monitoring and Evaluation



Steelhead recovery occurs in a complex setting. There are numerous uncertainties about the status of steelhead populations, trends in habitat conditions, and the response of steelhead to recovery actions. Ongoing research, monitoring, and evaluation will be an essential element of recovery efforts. Research and monitoring must be targeted to address critical uncertainties, many of which were identified earlier in this plan and are described more fully in this chapter. The Yakima Basin Fish & Wildlife Recovery Board is tasked with developing a research, monitoring, and evaluation (RME) plan for steelhead recovery efforts. It will be working closely with in-basin partners, WDFW, the Yakama Nation, and NOAA Fisheries to identify key actions and coordinate their implementation. This chapter gives an overview of topics that will be addressed in more detail in the proposed RME plan.

Chapter 6 addressed monitoring of implementation of recovery actions. Monitoring long-term trends for the basin's four steelhead populations will be essential for assessing progress towards the recovery criteria identified in Chapter 4. Understanding long-term trends in habitat conditions and other factors affecting survival will allow objective assessments of progress towards addressing the threats criteria NOAA Fisheries is developing as part of the Middle Columbia River Steelhead Recovery Plan. Both types of information will be required to assess prospects for de-listing Middle Columbia River Steelhead DPS.

Monitoring and research also improve our understanding of how recovery actions affect steelhead populations. Evaluating how recovery actions affect habitat conditions and how steelhead respond to those changed conditions will guide the choice and design of subsequent recovery actions. Work focusing on the ecological and climatic dynamics of steelhead habitat—both in and outside of the Yakima Basin—will also be critical.

To implement this recovery plan, we will need an adaptive management framework that addresses the key uncertainties identified here through management experiments. This will require:

- Careful coordination between those implementing recovery actions on the ground and the research community
- Identification of key uncertainties and hypotheses about their links to steelhead recovery
- Development of system models that guide discussion about factors affecting steelhead recovery

- Incorporation of experimental design concepts into management actions

This adaptive management framework will be developed in more detail in the upcoming Research, Monitoring and Evaluation Plan.

## 7.1 Understanding Steelhead Population Trends

The ESA calls for status reviews for listed species every five years. Ongoing monitoring of steelhead populations will be required to allow objective comparisons between current status and trends of key VSP parameters and the recovery criteria identified in Chapter 4. This work should be closely coordinated among NOAA Fisheries, the Interior Columbia Technical Recovery Team, WDFW, the Yakama Nation, and the Yakima Basin Fish & Wildlife Recovery Board.

Research and monitoring efforts should also evaluate the appropriateness of the recovery criteria identified in Chapter 4 so that the criteria can be adjusted as needed. Two areas where research and monitoring efforts will directly inform the revision of recovery goals are:

- Evaluating the current and potential role of mainstem spawning in recovery scenarios and using that information to determine how to produce the “mainstem spawners” block identified under the Satus population in Chapter 4

- Understanding the dynamics underlying the balance between resident and anadromous life histories in the Upper Yakima and Naches populations to determine realistic long-term population goals for both steelhead and rainbow trout

This section gives a brief overview of current and proposed monitoring and research that focuses on understanding steelhead population VSP parameters.

### 7.1.1 Abundance and Productivity

The existing ability to track MPG-level abundance trends via ladder counts at Prosser is excellent and needs to be maintained. Our current ability to track abundance at the population level is variable, with the strongest estimates from Roza Dam counts for the Upper Yakima and the weakest from the Naches basin, which has no dam counts and redd counting conditions that make it difficult to estimate spawner abundance. Two proposals are currently being developed to allow improved tracking of abundance by population. The first relies on using genetic sampling of the adult and/or juvenile migrations at Prosser and using genetic signatures to attribute fish to specific population areas. Feasibility studies are currently under way by WDFW’s genetics lab in Olympia. The second calls for radio tracking to apportion steelhead passing Prosser to their eventual destination and would repeat and update the 15-year old study referenced in this plan (Hockersmith et al. 1995). The two efforts would be complementary since the radio tracking would help develop pre-spawning mortality rate estimates and help assess effectiveness of genetic population attribution. Both proposals will be developed in more detail in the upcoming RME plan.

### 7.1.2 Spatial Structure

**Existing Monitoring of Spatial Structure**

Our current knowledge of spatial structure is based on redd counts and radio-tracking data. The BPA-funded Yakama Nation Watersheds Project conducts extensive monitoring in the Satus, Toppenish, and Ahtanum creek watersheds. The redd surveys conducted by this program are the primary basis for understanding steelhead spatial structure in these watersheds and should be continued.

Redd surveys have been conducted in the Naches basin since 2004. The USFS Naches Ranger District and WDFW have led these efforts with support from other agencies. This has significantly expanded our knowledge of spawner distribution in the area, although high and turbid flows during the spawning season limit the utility of redd counts for estimating spawner abundance.

Our most current knowledge of spatial structure in the Upper Yakima population area comes from radio tracking conducted by BOR and YKFP in 2002 through 2005. This work provided a detailed picture of spawner distribution during this time period; it did not address the portion of the Upper Yakima population that spawns below Roza Dam. This work ended in 2005.

**Improve Tracking of Upper Yakima and Naches Distributions**

Effectively tracking long-term trends in spawner distributions in the Upper Yakima and Naches populations will require a combination of methods, including targeted redd counts in areas and years when conditions are favorable, periodic radio tracking from Prosser and/or Roza, and the use of new tagging and detection technologies—such as inserting PIT or acoustic tags in adults at Prosser and using detector arrays to track movements into tributaries, and using sonar-based detection systems, and installing automated counting facilities at key passage structures. Specific proposals and budgets will be developed as part of the RME plan.

**Role of Mainstem Spawning**

Our understanding of past, current, and potential future steelhead spawning in mainstem reaches is limited. The mainstem Yakima and Naches rivers and their complex of side-channels are generally presumed to have supported significant numbers of steelhead spawners prior to the population declines of the last 150 years. Changes in hydrology and significant reductions in the extent and function of floodplains are presumed to have significantly reduced the extent and success of mainstem spawning, especially downstream of Union Gap, but hard data are lacking. Redd surveys are generally not feasible in mainstem reaches because flows are often high during the spawning season. Two major radio-tracking efforts in the basin found relatively high rates of mainstem spawning (Hockersmith et al. 1995; Karp et al. 2003; Karp et al. 2005). Additional radio tracking is likely to be the most effective way to increase our understanding of the current extent of mainstem spawning and the microhabitats used by mainstem spawners. Further work is needed to determine the key factors that affect reproductive success of mainstem spawners. This will be a critical part of evaluating where mainstem spawning should be encouraged or discouraged in the course of recovery. As noted in Chapter 4, current uncertainties about the feasibility and success of mainstem spawning below Union Gap led recovery planners to identify a block of spawners from the Satus population that could either be produced from the mainstem Yakima or mitigated for by increased production elsewhere in the basin. Research that informs which of these alternatives to choose will help guide recovery efforts.

**Rates of Reestablishment of Steelhead in Previously Blocked Areas**

Significant efforts are being made to restore passage to parts of the basin that have been blocked by dams and other barriers. Passage barriers have been recently removed from Cowiche and Big creeks. Passage barrier removal is underway in Manastash and Taneum creeks and is proposed for Naneum Creek and the Cle Elum and Bumping rivers. Understanding the recolonization process is critical to 1) ensuring that significant investments in passage provide anticipated benefits, and 2) evaluating the possible need for short-term supplementation to re-establish populations in previously blocked areas.

### 7.1.3 Diversity

Currently, our understanding of the extent and role of phenotypic and genetic diversity in Yakima Basin steelhead populations is limited. Our understanding of population specific phenological and life history traits will be greatly improved by the anticipated ability to identify upstream migrants by population at Prosser.

**Phenotypic Diversity**

Fish measured at adult traps associated with fish ladders at Prosser and Roza dams are the best source of data on spawner lengths, weights, condition, and other phenotypic traits. Smolt lengths, weights, and condition can all be assessed at smolt traps (Prosser and Roza dams and tributary screw traps). Improving existing smolt and parr sampling and establishing new trapping locations should be considered. Data on phenological traits should be reviewed for correlation with run timing, genetic differences, and between and within population spatial distribution.

**Genetic Diversity**

The genetic sampling proposed to improve tracking abundance by population will also provide ample data for analyses of genetic diversity within and among the four populations. Radio-tracking data of genetically profiled individuals and/or spawning ground genetic samples can be used to assess inter-population stray rates and identify genotypic variations in habitat use.

**Hatchery Genetic Inputs**

Hatchery steelhead are not currently released in the Yakima Basin, and strays from others areas have comprised less than 5% of the total run on average, but the risk of long-term genetic impacts from interbreeding with hatchery stocks remains. We must continue current efforts to:

- Identify and track the hatchery component of steelhead runs, both at Prosser, and where possible, on the spawning grounds
- Assess genetic introgression from hatchery steelhead and rainbow trout in the Upper Yakima and Naches populations

**Understanding and Monitoring Life History Diversity**

As described in Chapter 2, our current understanding of steelhead life history diversity in the Yakima Basin is limited. Monitoring and research that improves our understanding of life history diversity within and among populations will allow recovery planners to build more explicit recovery criteria for the diversity component of the VSP framework.

Genetic sampling and PIT tagging can be used to build population specific estimates of run timing. Combining scale samples with this information can be used to determine age structures by population.

Understanding juvenile migration patterns between emergence and smoltification will be more challenging but essential. Key questions include:

- Comparing the frequency and relative survival benefits of different juvenile migration patterns (e.g., smoltification upstream vs. downstream movement of pre-smolts in late fall and winter)
- Distinguishing the role of mainstem and floodplain rearing habitat and the impacts on life history patterns from the loss of these rearing habitats in many parts of the basin (e.g., simplified channels throughout the basin, the Wapato Reach and, potentially, the floodplain reaches below Horn Rapids).

## 7.2 Understanding Key Factors Affecting Survival

In recent years our ability to track anadromous fish survival through multiple life-stages has improved dramatically. This makes it possible to determine the effects of specific habitat conditions on specific life stages. Currently PIT tags inserted at Yakama Nation smolt traps run in Satus, Toppenish, and Ahtanum creeks are the primary source of data on survival rates for smolt and adult life stages. Expanding the use and monitoring of PIT tags and other developing tagging technologies will help us make significant strides in understanding factors affecting survival rates and how those can be addressed via targeted recovery actions.

### 7.2.1 Role of Life-Cycle Models

Life-cycle models help us quantify how habitat conditions and other variables affect fish populations. Currently the most developed model in the Yakima Basin is the EDT model used in subbasin planning (See Appendix B). These models should be used to identify and evaluate working hypotheses about the effects of specific environmental conditions on survival and abundance of steelhead. Model results can then be used to help set restoration priorities and design management experiments that empirically test model assumptions.

### 7.2.2 Separating In and Out-of-Basin Survival Rates

To understand the interplay between in-basin and out-of-basin effects in determining the viability of Yakima steelhead populations requires tracking trends in out-of-basin survival rates. The smolt-to-adult return rate (SAR) reflects all agents of mortality affecting the life cycle of salmon and steelhead from migrating smolts through returning adults. There needs to be a way of counting smolts leaving the Yakima Basin each year and then the number of adults returning to the basin from that year's outmigration. The expanding network of PIT-tag detectors within and outside the Yakima Basin now enables us to count PIT-tagged outmigrants and returns. Currently we can estimate SARs for the Satus and Toppenish populations and the Ahtanum component of the Naches population. PIT tagging Upper Yakima and Naches steelhead would help us develop SARs more representative of the Yakima steelhead MPG.

### 7.2.3 Impacts of Mainstem Conditions on Smolt Survival

A key uncertainty that needs to be addressed is the relationship between flows, habitat conditions, and outmigration timing and survival. Steelhead data are limited, but work is being done based on more extensive PIT tag data and other monitoring of spring Chinook. Developing a more detailed understanding specific to steelhead will inform efforts to improve flow conditions during the spring outmigration and manage habitat in a manner that enhances outmigrant survival. This work should also focus on how refugia associated with in-stream diversity and side channel/floodplain habitats in the lower mainstem contribute to smolt survival. Survival rates through bypass systems associated with major irrigation diversions (Chandler, SVID, and WIP) should also be studied in order to identify if changes can be made to associated infrastructure that would improve passage conditions.

### 7.2.4 Impacts of High Delivery Flows on Juvenile Rearing

A key uncertainty identified in this plan is the effect on steelhead growth and survival of high summer delivery flows in general and the flip-flop flow regime in particular. Research and monitoring that improves our understanding of these impacts and tracks responses to any changes in delivery flow regimes implemented as part of recovery efforts will be critical. A review of past work on this topic and specific proposals for future research will be included in the RME plan under development.

### 7.2.5 Factors Affecting Upmigrating Adults

Factors that affect adult spawner survival and condition between passage at McNary and spawning are poorly understood. As detailed in Section 2.5.1.1, current flow and temperature conditions preclude migration into the basin from July until September. PIT tag detections and water temperature data suggest that steelhead hold in McNary pool. Understanding how this change in run-timing and holding habitat affects eventual survival and reproductive success will help guide recovery efforts. No actions recommended in this recovery plan are anticipated to significantly reduce average Columbia mainstem summer temperatures during that time period, although changes in flow regime may lengthen the period of cooler temperatures in the lower Yakima River. Additional research and monitoring would help determine if targeted efforts to improve specific habitats and create relatively small-scale temperature refugia would improve spawner survival and condition. In addition, as noted in Section 2.5.1, recent data indicates that a portion of steelhead returning to the Yakima continue significant distances up the Columbia before returning downstream and entering the Yakima. Additional monitoring and research is needed to understanding the rates, causes, and implications of these upstream movements.

### 7.2.6 Resident/Anadromous Interactions

Understanding the interplay between resident and anadromous life histories of *O. mykiss* in the Upper Yakima and Naches populations will help ensure that appropriate goals are set for these populations and that recovery actions are effectively targeted to increase the abundance of steelhead. Research on this topic is currently ongoing and has received new impetus as a result of the listing, formulation of this recovery plan, and work on the Steelhead Master Plan by YKFP. Elements that need additional study include the:

- Genetic differences (if any) between individuals that exhibit anadromy and those that exhibit residency, including examination of subpopulation structure and genetic diversity of the population as a whole
- Effects of habitat conditions and competitive interactions on growth and condition of juvenile *O. mykiss*, and the impact of those patterns on subsequent smoltification or maturation as resident fish
- Population response to newly re-opened habitat from the standpoint of genetic processes and life history diversity
- Role of resident *O. mykiss* in determining the viability of the anadromous form

## 7.3 Understanding Habitat Trends and Threats Criteria

To address the delisting criteria, NOAA Fisheries is developing—as part of the Middle Columbia Steelhead Recovery Plan—new and existing monitoring and research to assess regarding habitat status and trends, which will need to be integrated into individual recovery plans. An inventory of existing efforts and specific proposals designed to fill gaps will be incorporated into the RME plan under development by the Yakima Basin Fish & Wildlife Recovery Board.

## 7.4 Evaluating Recovery Action Effectiveness

Effectiveness monitoring is needed to understand the nature and rate of response of habitat conditions and steelhead populations to specific recovery actions. Effectiveness of recovery actions will be monitored using a variety of approaches, including the Before-After-Control-Impact (BACI) design with stratified random sampling described in the Comprehensive Statewide Monitoring Strategy (ISP 2000; Washington State Monitoring Oversight Committee 2002), the Intensively Monitored Watershed Program promoted by

NOAA Fisheries and the Washington Monitoring Forum, and the SRFB Statewide Effectiveness Monitoring Program developed by Tetra Tech Inc. Supplementation actions will continue to be monitored according to the Yakima/Klickitat Fisheries Project (YKFP). Not all recovery actions recommended in this plan need to be monitored for effectiveness, but a sufficient number of replicates of each type of action should be assessed. This work will need to engage ecologists, fish biologists, geologists, hydrologists, and other experts familiar with the region.

Even if all habitat actions could be implemented immediately, which they cannot, there will be delays in the response to actions. Populations will likely respond more quickly to some actions (e.g., diversion screens and barrier removals) than they will to others (e.g., riparian plantings). Targeted monitoring and research will help resolve remaining uncertainties about the effects of recovery strategies on population VSP parameters. This work should focus on the linkages between physical and biological processes so managers can predict changes in survival and productivity in response to selected recovery actions. It will need to address the interactions between multiple recovery actions and their broader ecological context. Work should integrate system models and their underlying hypotheses whenever possible.

Specific topics to be addressed include the:

- Impacts of large woody debris on steelhead rearing, spawning, and incubation conditions
- Long-term effectiveness of the kelt reconditioning program
- Response to reopening suitable habitat
- Response to improvements in channel, floodplain, and riparian conditions

## 7.5 Understanding Critical Ecological Dynamics

Steelhead exist within a complex ecological setting, and their fate is affected by competition with other species, predation, nutrient cycling, the presence of contaminants and vegetation dynamics. Understanding these diverse factors will improve recovery efforts.

### 7.5.1 In-Basin Predation

Predation is one of the main factors driving juvenile survival. Research and monitoring is needed to track trends in predator populations, understand their impacts on steelhead, and develop appropriate management techniques to reduce predation.

Predation by bass and pikeminnow on outmigrating smolts is a concern, although it is believed to have a smaller effect on steelhead than other species because most steelhead smolts have left the lower Yakima River before smallmouth bass and northern pikeminnow become active. Monitoring to develop better estimates of piscine predation in the lower river should continue.

Avian predation is known to be significant, with known concentrations of terns and gulls in the lower Yakima River, mergansers throughout the basin, and increasing numbers of white pelicans and cormorants visiting the basin. Research and monitoring that improves understanding of trends in species presence, their impacts on steelhead, and how these impacts can be managed are vital. This should include efforts to understand the interactions between habitat conditions and predation and the impacts of specific infrastructure (e.g., irrigation diversion dams) that may facilitate predation. Detection of excreted PIT tags at sites where predatory birds congregate has helped in estimating consumption of salmonids in the Yakima and Columbia rivers. The Yakima/Klickitat Fisheries Project is currently tracking avian predation (Siegel and Fast 2006); this work should be continued and expanded.

### 7.5.2 Interspecies Effects

The Yakima/Klickitat Fisheries Project Species Interaction Study is a long-standing effort to understand how fish culture activities (hatchery supplementation of Chinook and coho stocks) affect other species, including steelhead (McMichael et al. 1999; McMichael et al. 1997; Pearsons and Hopley 1999; Pearsons et al. 1996). This project has increased our understanding of the ecological dynamics that affect both resident and anadromous *O. mykiss* in the basin and should be continued and expanded.

Two other sets of questions about interspecies interactions with management implications are:

- How increased interspecific competition in juvenile rearing areas may affect the balance between anadromy and residency for *O. mykiss*
- How the presence of exotic species affects steelhead recovery efforts, and how those species with significant impacts can be eradicated or controlled

### 7.5.3 Changes in Nutrient Transport

Anadromous fish bring oceanic nutrients inland when they die and decompose in headwaters and transport nutrients accumulated in growing juveniles from the headwaters to the ocean. Pre-1850 returns of salmon and steelhead are estimated to have ranged from 10 to 100 times current runs. The reduction in anadromous fish runs caused significant changes in these nutrient cycles. Effectively managing steelhead requires understanding how these changes affect growth and survival under current conditions, and what can be done to address nutrient limitations (e.g., adding carcasses and analogs). Restoring side channels and natural obstructions, such as woody debris may help retain carcasses in headwaters.

### 7.5.4 Expansion of Aquatic Vegetation

The lower Yakima mainstem has seen a significant increase in the presence of aquatic vegetation in the last decade. The expansion of water star grass in the lower 100 miles of the river is the most dramatic example. Once a relatively rare native plant, the star grass has expanded to cover much of the riverbed with thick mats of vegetation. This is generally presumed to have been a response to the significant reduction in turbidity in the lower river over the last decade associated with improved quality of irrigation return flows. Effects on steelhead smolts and returning adults are unknown; the most likely impact is reduced habitat quality in the later part of the smolt outmigration and the early part of the adult immigration due the reduction in dissolved oxygen concentrations associated with star grass respiration. The South Yakima Conservation District's Eutrophication Study (Marie Zurowski, personal communication, 2007) has found that the relationship between vegetative growth and nutrient concentrations is complex. Understanding the factors that drive the spread of aquatic vegetation (increased light penetration and high nutrient concentrations) and those that limit it (scouring in flood events, high turbidity) will help managers respond. The Benton Conservation Districts conducting pilot work on control of water star grass.

### 7.5.5 Impacts of Pesticides and other Toxins

Agricultural lands in the Yakima Basin support a diversity of crops and more than 180 different pesticides are applied yearly in the basin (Rinella et al. 1999). Some widely used pesticide classes are known to interfere with the normal function of the nervous system in salmon and other fish, including the organophosphates (Beauvais et al. 2000; Brewer et al. 2001; Moore and Waring 2001; Morgan and Kiceniuk 1990; Scholz et al. 2000), the carbamates (Little et al. 1990; Waring and Moore 1997), the pyrethroids (Little et al. 1993; Moore and Waring 2001), and the triazines (Moore and Waring 1998; Saglio and Trijasse 1998). Many pesticides are known to interfere with the behavior or physiology of salmonids at concentrations well below lethal levels and within the range of exposure conditions that have been observed in the Yakima River and its tributaries (Cuffney et al. 1997; Ebbert and Embrey 2002; Joy and Patterson 1997; Morace et al. 1999; Rinella et al. 1999). Sublethal exposures to these chemicals may impair the neurochemistry, neurophysiology, or behavior of exposed salmonids. Recent research has also focused attention on the potential impacts of other contaminants on salmonids, including estrogens and other hormones. The effects of all of these contaminates on steelhead population VSP parameters in the Yakima Basin remain unknown, but the potential effects are significant and merit careful attention.

## 7.6 Understanding Impact of Long-Term Trends

Yakima Basin steelhead recovery will not happen under static conditions; rather their survival will occur within a dynamic human and climatic context. Understanding future trends in these areas is important.

### 7.6.1 Global Warming Impacts

There is broad consensus that worldwide climate is warming. Projections global warming impacts on the Pacific Northwest generally agree that there will be less snowpack accumulation and increased summer temperatures. Changes in precipitation are less certain with some models calling for increases and others for decreases. Research efforts are currently underway to understand how this will affect salmonid habitat in the Inland Columbia Basin (Beamish 1995; ISP 2002; 2002; 1989) and the Yakima Basin (Climate

Impacts Group 2009; Mastin 2008). Research will be vital to assuring that recovery efforts create real and sustained long-term improvement in habitat conditions.

### 7.6.2 Future Growth Impacts

In the last 150 years the landscapes and lifeways of the Yakima Basin have been transformed repeatedly, and such transformations will inevitably continue. Almost all projections for the Yakima Basin call for continued population growth. It is critical that proponents of steelhead recovery in the Yakima Basin anticipate how population growth and accompanying lifestyle decisions can be guided to protect fish habitats, local economies, and human quality of life.

## 7.7 Coordinating Research and Monitoring Efforts

The Yakima Basin is home to a wide range of long-term monitoring and research efforts, and the technical capacity within the basin and among out-of-basin partners actively engaged in the basin is impressive. Monitoring and research associated with steelhead recovery should be built upon these established resources. Extensive coordination will be required to ensure that existing resources are used effectively and that new resources are brought to bear in a targeted fashion that minimizes costs. The Yakima Basin Fish & Wildlife Recovery Board is currently working with partners in the basin to develop a working group focused on steelhead monitoring and research needs. Initial meetings have focused on understanding how data from current monitoring illuminates steelhead population trends and how gaps in current efforts can be filled to better track key VSP parameters. The hope is that this working group will coordinate and research and monitoring related to steelhead recovery plan efforts.

Currently, the YKFP is the dominant fish management monitoring and research organization for the Yakima Basin. The co-managers, Yakama Nation, and WDFW, develop monitoring and evaluation objectives and tasks through a joint process. The YKFP monitoring and evaluation program is organized into four categories: Natural Production, Harvest, Genetics, and Ecological Interactions. The co-managers' Science/Technical Advisory Committee employs the services of a work committee of scientists, the Monitoring Implementation Planning Team, to develop a Monitoring and Evaluation Plan (Fast and Sampson 2004). Although the YKFP's greatest monitoring emphasis has been on the targets of current YKFP supplementation efforts (spring Chinook, fall Chinook, and coho), the program also provides valuable information on steelhead. Steelhead out-migration is enumerated at Prosser Dam, steelhead have been a subject of YKFP species interactions studies, an EDT model has been developed for Yakima Basin steelhead, and a YKFP steelhead master plan is under development. YKFP also works with the Columbia River Inter-Tribal Fish Commission on the Yakima subbasin kelt reconditioning study and with the BOR on recent steelhead radio-tagging work in the upper Yakima River. Research and monitoring related to steelhead recovery should build upon the capacities of the YKFP program.

### 7.7.1 Integration with Regional Monitoring Programs

In the last five years, numerous regional monitoring initiatives have been developed, including the:

- Pacific Northwest Aquatic Monitoring Partnership
- Collaborative Systemwide Monitoring and Evaluation Project (CSMEP; administered by the Columbia Basin Fish & Wildlife Authority)
- Integrated Status and Effectiveness Monitoring Program (ISEMP) led by the NOAA Northwest Fisheries Science Center
- Washington Monitoring Forum (previously the Governor's Monitoring Forum)

Specific guidance documents that have been developed to guide monitoring related to recovery efforts include:

- Adaptive Management for Salmon Recovery: Decision Framework and Monitoring Guidance developed by the NOAA Northwest Fisheries Science Center (NMFS 2007)
- The Washington comprehensive monitoring strategy for watershed health and salmon recovery (ISP 2000; Washington State Monitoring Oversight Committee 2002)
- Governor's Forum On Monitoring, Recommendations to the Salmon Recovery Regions (GSRO and NMFS 2005)

Research and monitoring activities in the Yakima Basin will draw on the strategies, indicators, and protocols developed in these programs and documents in order to assure the use of valid sampling and statistical designs and consistent protocols and data management systems.

### 7.7.2 Out-of-Basin Research Needs

Long-term efforts to increase the survival of Yakima Basin steelhead will benefit from the broad range of monitoring and research already focused on the mainstem Columbia, its estuary, and the ocean. The efforts to better track out-of-basin survival for Yakima steelhead described in Section 7.1.4 will help connect the general work done out-of-basin with the specific impacts on Yakima Basin populations. Monitoring efforts in the basin should be coordinated with efforts outside of the basin; for example fish tagged in-basin can also provide valuable information on Columbia River and ocean survival. Specific research and monitoring efforts that will benefit Yakima Basin steelhead include those that focus on:

- Harvest rates of naturally produced steelhead and indirect mortalities associated with recreational and commercial fisheries in freshwater and ocean fisheries
- Fisheries management techniques that improve access to harvestable stocks while reducing undesirable direct and indirect impacts to naturally produced steelhead

- Interactions between hatchery and naturally produced steelhead in the mainstem Columbia and ocean, including possible density-dependent competition
- Hatchery programs' effects on the incidence of disease and predation on naturally produced fish
- Effects of upstream passage conditions in the Columbia River on the subsequent reproductive success of steelhead
- Factors that affect the survival rate of juvenile steelhead through the Columbia River dams
- Changes in predator prey relationships in the Columbia River, its estuary, and the ocean, and how they can be managed to increase survival rates for summer steelhead
- Factors that drive the variability in ocean conditions

# 8 Public Education and Outreach



## 8.1 Introduction

A key principle of the Yakima Basin Fish and Wildlife Recovery Board is that decisions regarding salmon recovery must occur within a transparent, inclusive, and collaborative process. This will require a strong public outreach program that informs and engages elected officials, federal, tribal, state, and local agencies, local interest groups, property owners, and the general public. Recovering steelhead in the Yakima Basin is by its very nature a long-term process that will require support and understanding from all of these parties. Without this support, recovery efforts will founder.

Every individual within the Yakima Basin directly or indirectly affects habitat functions essential to the survival of salmon on a daily basis. The most fundamental example of this is our daily consumption of water. Yet most of the public is not familiar with the complex and varied life cycle and habitat needs of salmonids or of the consequences to habitat functions and salmon populations of the choices we make in the daily pursuit of legitimate activities. Salmon recovery will require nurturing a broad understanding of these causes and effects.

Yakima Basin Environmental Education Project, WDFW, the Yakama Nation Fisheries and Wildlife, the USFS Respect the Rivers program, the Benton Conservation District Salmon in the Classroom program, and the Kittitas Environmental Education Network (KEEN) conduct salmon-recovery related outreach efforts in the basin. All of these efforts are to be lauded, but they will need to be supplemented with targeted outreach that focuses specifically on salmon recovery needs. The following factors will need to be addressed:

- Population growth in the Yakima Basin exceeded 25% in the previous decade and is projected to grow 45% more by 2020. Outreach to new residents to explain salmon recovery efforts will be an ongoing need.
- The information and education components of federal, state, and local programs have been drastically reduced over the past five years due to overall budget reductions. Rather than hiring full time personnel to develop and deliver public education, these functions are commonly added to existing staff's responsibilities.
- Agencies and personnel are largely "siloed," meaning there is very little knowledge, much less communication, about public education and outreach activities across agencies. The partnering that does occur is essentially dependent on a small cadre of highly energetic people who go above and beyond their required job responsibilities. The silo effect also occurs within large agencies. This is partly the result of information and education being dramatically reduced,

leaving staff to focus on public comment, and participation activities specific to regulatory requirements.

- Messaging tends to be narrow, focusing on the most critical issues facing an agency or group or meeting a specific regulatory requirement, e.g., a public comment period.
- Scant evidence is available to suggest that the public is aware of specific salmon recovery projects, what they are achieving, and how these projects fit into the big picture.
- Existing programs require local governments and state agencies to regulate land use on private and public property. Local experience shows that land use controls are not widely accepted unless there is broad public agreement with their intent, application, and result. Land use controls are only effective in their application if the property owners understand the purpose and support the limitations imposed on their range of land use activities. Outreach efforts can foster the dialogue and understanding required for existing programs to be implemented in an equitable and effective manner.

## 8.2 Education and Outreach Goals and Principles

Education and outreach efforts proposed in this plan should be characterized by:

- Close coordination with existing programs and entities, including the Yakima Basin Environmental Education Project (YBEEP) Conservation Districts, school districts, the USFS, local non-profit organizations, the WDFW, and the Washington State Department of Ecology
- Understanding that the future of the Yakima Basin be considered along with continued population and economic growth and that successful salmon recovery be a community-wide effort
- Recognition that salmon recovery efforts depend on voluntary efforts built on transparent processes and outreach to property owners and other stakeholders

## 8.3 Proposed Outreach Actions

The following list of proposed outreach actions will serve as a starting point for the Yakima Basin Fish & Wildlife Recovery Board's efforts to develop and coordinate a basinwide salmon recovery outreach strategy.

### 8.3.1 Short-Term Recovery Board Outreach Actions

Initial efforts by the Board will include:

- Summarizing existing education programs and materials in the basin
- Reformulating the education and public involvement committee developed during the Subbasin Planning Process in 2002-5

- Developing an education plan that targets specific audiences (school system, permit applicants, decision-makers, etc)
- Maintaining access to, and transparency of, all Board processes and programs, including regular meetings, special workshops or hearings and products developed by the Board
- Preparing and distributing newsletters and other regular updates on the Board's activities
- Developing a web page that provides the history of salmon recovery efforts in the basin, a calendar of board and committee meeting times, access to educational materials, access to planning and implementation documents, and access to current research
- Developing tools, such as display boards and PowerPoint presentations that staff can use at a variety of public gatherings, including county fairs or stakeholder group meetings, to explain activities and opportunities
- Working with county conservation districts, federal, tribal, and state resource agencies, water purveyors, school districts, and others to identify opportunities to leverage resources in a way that brings educational materials and learning opportunities directly to classrooms, landowners, recreationists, and other target audiences

### 8.3.2 Stakeholder Group Presentations

The subbasin planning board was very successful in scheduling and presenting information to stakeholder groups. In general, presentations were provided in PowerPoint format. By going directly to the meetings of stakeholders, two critical outcomes occurred. First, they reached a much broader audience; had a series of public meetings been held, perhaps a single representative of an organization would attend. At the organization's own meeting, many more individuals were reached directly. Second, going to "their turf" significantly changes the social dynamics. Individuals and groups believe they are being given greater respect, and they are more comfortable asking questions and sharing perspectives within their "natural setting." It is recommended that a round of stakeholder presentations be given each year. This can be done as part of a) releasing an annual report, b) soliciting review of or announcing the release of study or plan, or c) part of preparing and soliciting feedback on the annual work plan.

### 8.3.3 Newsletter/Annual Report

The Yakima Basin Fish & Wildlife Board should develop a newsletter/annual report, either on its own or in conjunction with other organizations. The newsletter should describe Board activities and give an overview of salmon recovery efforts throughout the basin. The newsletter should be sent to a broad-based mailing list, be posted online, and be available in hard copy at select public locations.

### 8.3.4 Project Tours

Even those who are actively engaged with salmon recovery issues often have only limited knowledge of on-the-ground projects. Project tours can help build this connection. A schedule of project tours should be developed and targeted at key audiences. Tours should provide both a general overview of recovery board efforts and project-specific information. “Virtual tours” based on photos taken in the field can be developed and made available on-line.

### 8.3.5 Posters and Handouts

Posters, brochures, and other handouts related to salmon recovery should be developed at made available in diverse public settings.

### 8.3.6 Workshops and Conferences

Workshops can cover a broad range of possible subject matter and can be developed to address the needs of specific groups. A conference held annually or every 18 months may also help link stakeholders, elected officials, and natural resource managers; possibilities for coordinating this with the annual Yakima Basin Science and Management conference should be investigated.

### 8.3.7 Mailing to Shoreline Landowners

One proposed outreach strategy is to send an *informational letter or brochure* to all shoreline property owners from each City Council or Board of County Commissioners. The letter or brochure would provide information on the biological, physical, and habitat values of the natural shoreline and the importance of those functions for water supply, water quality, shoreline stability, flood protection, and fish and wildlife habitat. The letter would inform owners that the natural condition of the shoreline is a State interest and the county/city have policy and codes required by the state legislature that regulate actions along the shoreline in order to protect those functions. It should include information on what property owners can do if they are losing shoreline to erosion and/or want to re-establish natural shoreline vegetation. It should note that the state and federal governments (including BPA) are spending millions of dollars per year in the Yakima Basin to recover a salmon fishery for the benefit of all basin interests and that this expenditure is wasted if actions by individual landowners result in the degradation of shorelines.

### 8.3.8 Create “Stream Stewards” Positions

This proposal calls for hiring a Stream Steward for each Watershed Resource Inventory Area (WRIA) or County within a basin that would be jointly funded by city, county, state and federal agencies. Possible roles of the steward would be to:

- Provide biological and technical assistance to local governments for projects, planning processes and reviews that involve shoreline habitat issues.

- Assist shoreline property owners interested in preserving natural habitat conditions or that have shoreline issues (erosion or bank protection).
- Act as a liaison between landowners, project proponents, and the local planning permitting/planning offices.
- Serve as a liaison between landowners and the Lead Entity application process for Salmon Recovery Funding Board funding.
- Be a resource for local non-profit organizations (e.g., greenways, land trusts).
- Be a classroom resource for elementary school teachers building shoreline/fish issues into curriculum.

# APPENDIX A: Local Review of ICTRT Habitat Model

## A.1 Overview of Review of ICTRT Intrinsic Potential Model

This appendix summarizes the results of local reviews of the Interior Columbia Technical Recovery Team (ICTRT)'s Intrinsic Potential Analysis for Middle Columbia River Steelhead in the Yakima Basin. The ICTRT developed a GIS-based model of habitat potential for steelhead that was used to estimate the historically available extent and quality of steelhead spawning and early rearing habitat. For more information on the development of the model and its use in ICTRT viability assessments for steelhead populations, see ICTRT (2007b), especially Appendix C.

As part of developing the Yakima Steelhead Recovery Plan, local biologists reviewed the areas identified as potential habitat by the ICTRT's GIS model. David Lind conducted the reviews for the Satus and Toppenish creek watersheds with the assistance of Tim Resseguie. Both are fish biologists with the Yakama Nation. Richard Visser (WDFW), David Lind (Yakama Nation), and Joel Freudenthal (Yakima County) conducted the Naches and Upper Yakima Area reviews. Alex Conley of the Yakima Basin Fish & Wildlife Recovery Board coordinated the review process. Extensive use was made of correspondence with other colleagues and existing documentation, including current fish distribution records and the Historic/Potential Steelhead Habitat analysis conducted as part of the Conservation Commission Limiting Factors Analysis for the Yakima Basin (Haring 2001).

The model results provided by the ICTRT in November of 2006 identified a number of areas as potential steelhead habitat that the local review team did not consider to be or have been potential steelhead habitat. Several reasons were noted:

1) In a number of cases, the model did not include the presence of known natural fish passage barriers. The local reviewers identified these and documentation was provided to the ICTRT; most have been incorporated into the most recent version of the ICTRT model. They are noted in the population-specific discussions below.

2) The model consistently assigned habitat potential to streams in arid portions of the basin that the review team identified as not generating enough flow to support even limited use by steelhead. Correcting this would require refining the model's approach to predicating flow in arid (under 16") rainfall regimes. Inclusion of streams with watersheds that do not have the precipitation and/or watershed area to generate any sustained base flows was primarily an issue in the Satus Creek watershed and the lowest elevations in the Upper Yakima and Naches Watersheds. In areas with over 16" annual precipitation, the model performed much better, and largely matched local surveys and expert opinion. The ICTRT is exploring using additional data sources and analyses to exclude streams with insufficient stream flow from the habitat model, but has not incorporated these into their model at the time of this writing. In the current drafts of the Yakima

MPG Stock Status reports the ICTRT does acknowledge this limitation to their model, and notes the areas excluded in the local review.

3) In a few instances, drainages that would not have generated enough flow to support even limited use by steelhead prior to European settlement currently convey return flow from irrigation systems. Some of these areas may have potential to produce steelhead (Romey and Cramer 2001), and some level of use by salmon and *O. mykiss* is known to occur (Monk 2001) even though they would not have served as habitat prior to irrigation development. These areas should not be included in assessments of historic habitat, and were identified as “sustained by return flows” by local reviewers. In the current drafts of the Yakima MPG Stock Status reports the ICTRT does acknowledge this limitation to their model, and note the areas excluded in the local review.

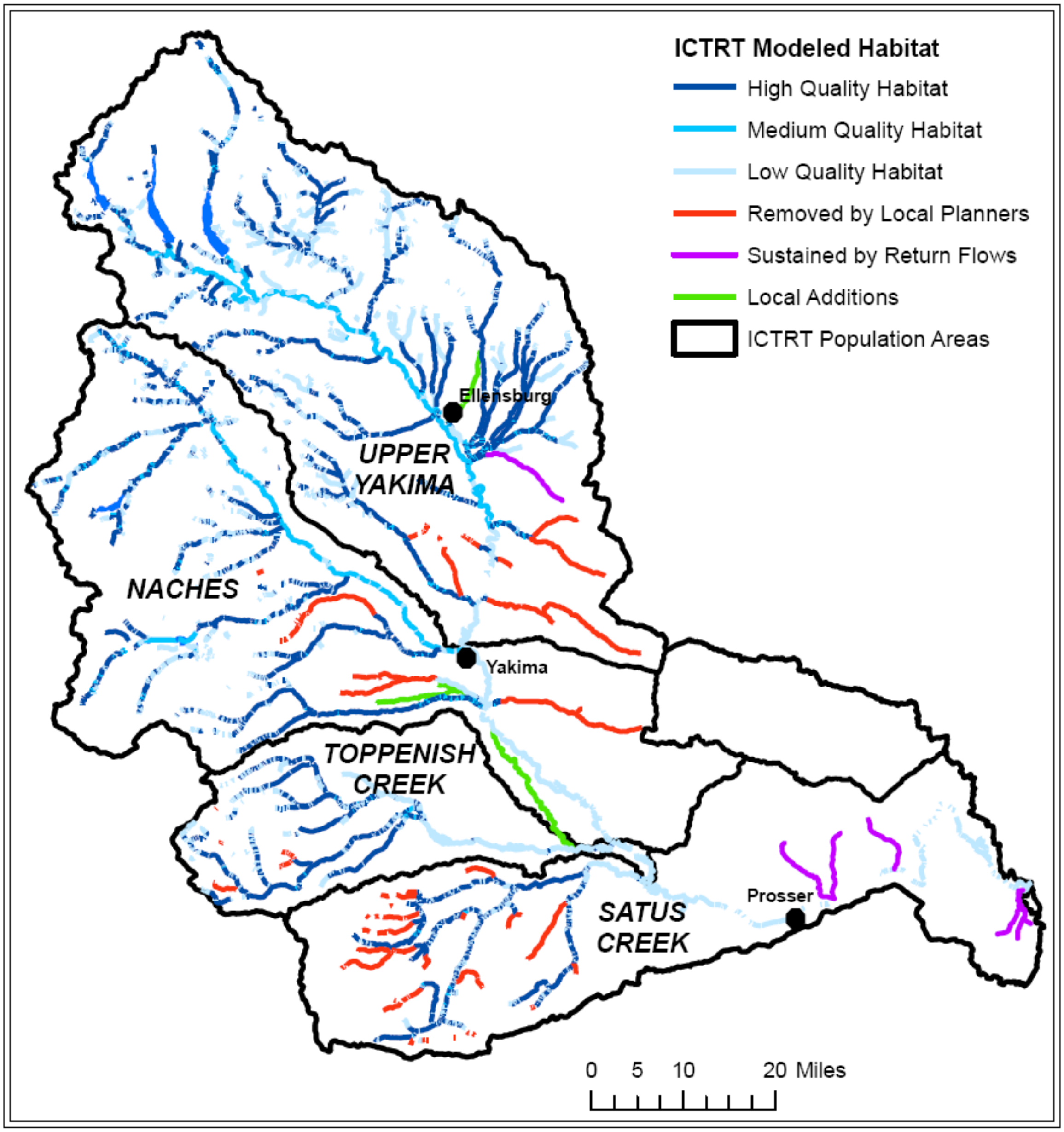
4) Local reviewers expressed concern that the identification of all of the lower Yakima mainstem as potential spawning and early rearing habitat risked biasing the estimate of available habitat. In response to these concerns and similar ones raised in other areas, the ICTRT developed an analysis based on channel morphology that specifically identifies mainstem areas with spawning potential. This analysis is based on analysis of the location of documented spawning in the Okanogan and Wenatchee rivers. The most recent versions of the ICTRT model incorporate this analysis; the areas it identifies as having spawning potential correspond better with local assessments.

The model consistently extended small extents of lower quality habitat higher up small tributaries and into headwater reaches than locally derived maps of current distributions, but these differences do not make significant differences in overall population-level weighted habitat area, and were considered as feasibly within historic potential by local reviewers.

The model also failed to include a few streams considered by the review team to be potential/historic habitat. In all of these cases the streams were either part of split channels connected to other streams at both upstream and downstream ends, or small spring fed creeks in floodplains. The ICTRT model routed flows down a single channel where channels diverged or did not recognize the streams as having sufficient watershed area to generate flow. The ICTRT has recognized these limitations to their model, but has not added these areas. These areas are limited in extent and are not identified as key areas for restoration, and their exclusion does not have any significant effects on the results of the ICTRT viability analysis.

Overall, the current revised version of the ICTRT Intrinsic Potential Analysis’ identification of potential steelhead habitat is a credible broad-brush estimation of the historic and potential habitat accessible to steelhead in the Yakima Basin. The ICTRT analysis or the locally revised analysis should not be used to classify specific areas and their current habitat values and/or potential at a reach or project level.

**Figure A.1: July 2007 ICTRT Intrinsic Potential model with local adjustments**




## A.2 Satus Population Area

Based on our initial review, the ICTRT model significantly overestimated potential steelhead habitat in the Satus Creek watershed. There were two main reasons: 1) several natural fish passage barriers not included in the model, and 2) the inclusion of numerous streams with no sustained base flows, only limited runoff in wet periods, and steep canyons with very little to no developed floodplain. There is also one reach that local biologists believe is of significantly higher quality than indicated by the model.

1) Area above Satus Falls inaccessible per David Lind, Yakama Nation Fisheries staff, 1/28/07) *Incorporated into 7/07 ICTRT model as Barrier*

2) Area above Logy Creek Falls inaccessible per David Lind, Yakama Nation Fisheries staff, 1/28/07). *Incorporated into 7/07 ICTRT model as Barrier*

3) Area of Dry Creek inaccessible due to Gradient Barriers in both forks above confluence; also lack of baseflow flow above canyons (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Incorporated into 7/07 ICTRT model as Barrier*

4) Several steep canyons without any sustained base flows, limited runoff even in wet periods, and little to no floodplain. In the few areas where floodplains exist in lower ends, ICTRT ratings were left intact to reflect possible historic potential, but are not deemed areas with any current potential (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Noted in updated text of ICTRT Satus Stock Status Report but not incorporated into GIS model; identified in red on* Figure A.1.

5) Smaller areas without any sustained base flows and limited runoff even in wet periods (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Noted in updated text of ICTRT Satus Stock Status Report but not incorporated into GIS model; identified in red on* Figure A.1.

6) Reach of mainstem Satus Creek considered high quality habitat for rearing (higher than adjoining areas given a higher rating) per David Lind, Yakama Nation Fisheries staff, 1/28/07. *Not incorporated into ICTRT products at this time.*

7) Adjustments to the designations of the mainstem Yakima based on the ICTRT analysis discussed in A.1, # 4 above. *Revised analysis of lower mainstem incorporated into 7/07 ICTRT model*

This local adjustments described here significantly reduce the amount of habitat available in the Satus Creek Population Area (see Table 2.2) but do not change the ICTRT-designated size class for the population.

## A.3 Toppenish Creek Steelhead Population

Generally, the model performed much better in Toppenish Creek, which has a less dendritic drainage structure and more precipitation than the Satus population area. There was some overestimation of habitat due to 1) inclusion of a few smaller tributaries local biologists did not identify as potential steelhead habitat due to flow limitations and 2) extension of habitat beyond known barriers. These were addressed as follows:

1) White Deer Creek has habitat that supports resident rainbow trout, but the steep canyon reach near the mouth precludes use by steelhead (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Incorporated into 7/07 ICTRT model as Barrier.*

2) Area inaccessible due to Agency Creek Falls (ID#4 in YN Barriers Shapefile) per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Incorporated into 7/07 ICTRT model as Barrier.*

3) Area of steep canyons without any sustained base flows, limited runoff even in wet periods, and little to no floodplain (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on* Figure A.1.

4) Tributary to South Fork of Toppenish Creek is inaccessible due to Gradient Barrier (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on* Figure A.1.

5) Miscellaneous isolated habitat patches in areas not considered potential habitat (per David Lind, Yakama Nation Fisheries staff, 1/28/07). *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on* Figure A.1.

6) There is also one habitat addition proposed here; the tail end of Wanity Slough enters into lower Toppenish Creek, and any fish using the slough are likely to be of Toppenish origin, even as geographically the Slough is mainly in the Naches population area. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in green on* Figure A.1.

The adjustments made by local reviewers have very little affect on the total area and spatial distribution of the Toppenish population, and have no effect on the ICTRT viability analysis results.

## A.4 Naches Population Area

Generally, the model performed quite well in the Naches Population Area. Local reviewers identified 1) barriers that were added to the model, 2) three areas that the local review team as having insufficient flows to be identified as habitat, and 3) five areas where the local review team felt that habitat with potential for steelhead had not been included in the model.

Local reviewers identified a number of natural barriers that had not been originally identified by the ICTRT. These were compiled from 1) WDFW's natural barriers coverage (from Brian McTeague), 2) consultations with Jim Cummins, Eric Anderson (fish biologists with WDFW in Yakima), and Yuki Reiss (fish biologist for the Naches Ranger District of the Wenatchee National Forest). These are:

1) Union Creek Falls (total passage barrier, on map). Incorporated by ICTRT; Fall # 470 in ICTRT yrbbarr shapefile.

2) Steep Canyon/gradient barrier on Kettle Creek per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 469 in ICTRT yrbbarr shapefile.

3) 50' falls on Deep Creek per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 468 in ICTRT yrbbarr shapefile.
4) Falls/gradient barrier on Copper Creek per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 466 in ICTRT yrbbarr shapefile.
5) Falls on NF Rattlesnake Ck per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 467 in ICTRT yrbbarr shapefile.
6) Impassable falls in Hindoo Creek per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 465 in ICTRT yrbbarr shapefile.
7) Falls on Oak Ck mapped by WDFW; confirmed by Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 237 in ICTRT yrbbarr shapefile.
8) S. Fork Tieton Falls (50') per Jim Cummins & Eric Anderson & USFS staff. Partially incorporated by ICTRT; Fall # 462 in ICTRT yrbbarr shapefile.
9) Bear Ck Falls (40') per Jim Cummins & Eric Anderson & USFS staff. Incorporated by ICTRT; Fall # 261 in ICTRT yrbbarr shapefile.
10) SF Cowiche Ck barrier falls per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 463 in ICTRT yrbbarr shapefile.
11) Reynolds Creek barrier falls per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 464 in ICTRT yrbbarr shapefile.
12) Crow Creek barrier falls per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 471 in ICTRT yrbbarr shapefile.
13) An isolated fragment in an Oak Creek Tributary was considered to be inaccessible to steelhead due to gradient and flow limitations in the canyon downstream. Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on Figure A.1.

The following areas were identified as having insufficient historic flows to be classified as steelhead habitat:

1) The upper portion of the North Fork of Cowiche Creek is an arid watershed with only limited intermittent flow. At the townsite of Cowiche there are several large springs, and the local review team concurred with the TRT designation from that point downstream. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on Figure A.1.*
2) The upper portion of the Wide Hollow Creek is an arid watershed with only limited intermittent flow. At 46$^{th}$ Street there are several large springs, and the local review team concurred with the TRT designation from that point downstream. There may be some increased potential above historic between this point and 96$^{th}$ St due to increased flows from irrigation return flows, but this does not apply above the forks. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on Figure A.1.*

3) Moxee Creek is an arid watershed with only limited intermittent flow (see discussion of arid creeks in the Upper Yakima section below); lower portions currently carry irrigation return flows. *Acknowledged in ICTRT Upper Yakima Stock Status Assessment but not incorporated into GIS model; identified in red on Figure A.1*.

There are five additions to the ICTRT-identified historic habitat that were identified by local reviewers:

1) Wanity Slough, which is the most prominent of the relic side channels of the Yakima River in the Wapato area. It is currently managed as an irrigation drain, but likely once served as steelhead habitat, and while a currently low priority for restoration, still has some potential. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in green on Figure A.1*.

2) Bachelor and Spring creeks in the Ahtanum Floodplain. These are historic side channels and/or spring fed creeks that were not identified as habitat by the model, but which would have historic/potential habitat value. Bachelor Creek is now managed as part of an irrigation delivery system and restoring flows to the Ahtanum Creek mainstem has been given much higher priority than work within Bachelor Creek. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in green on Figure A.1*.

3) Initial ICTRT model ended at a partial barrier on Crow Creek; the actual upper extent of fish access is further upstream. *Incorporated by ICTRT in the 7/07 model version.*

4) Initial ICTRT model ended at a partial barrier on the North Fork of Rattlesnake Creek; the actual upper extent of fish access is further upstream. *Incorporated by ICTRT in the 7/07 model version*.

5) Quality habitat extends ~1.5 miles upstream of the upper end of modeled habitat in Upper Rattlesnake Creek. *Not incorporated into ICTRT products at this time*.

The adjustments made by local reviewers have little affect on the total area and spatial distribution of the Naches population, and have no effect on the ICTRT viability analysis results.

## A.5 Upper Yakima Population Area

In most of the Upper Yakima Population Area, model results were consistent with review team expectations, except where unidentified passage barriers exist. However in the lower elevations, the model consistently identified low rainfall areas that do not support sufficient flow as steelhead habitat. There is also one proposed addition to the model.

The three barriers were incorporated into the model based on local review:

1) Thorp Creek has a gradient barrier in lower end of creek as identified by BOR's Yakima Storage Reservoir Fish Passage Study. *Incorporated by ICTRT; Fall # 453 in ICTRT yrbbarr shapefile.*

2) The Cooper River has an impassable fall at RM 0.6 (identified by BOR's Yakima Storage Reservoir Fish Passage Study and Jeff Thomas, USFWS). *Incorporated by ICTRT; Fall # 452 in ICTRT yrbbarr shapefile.*

3) Coleman Creek Falls (identified by Kittitas County Conservation District Stream Assessment data & photo). *Incorporated by ICTRT; Fall # 472 in ICTRT yrbbarr shapefile.*

The arid areas identified as not having sufficient flows to support steelhead fall into two classes:

1) Selah, Lmuma, and Whipple Wasteway/Badger creeks all drain larger watersheds at low elevations on the east side of the Yakima Basin. Maps from the Eastern Washington Stormwater Manual[40] show these streams within a climatic region where there are only about two and a half months of the year where precipitation exceeds potential evapotranspiration, and where in most years the excess is fully absorbed by the soils. The local review team was willing to consider the lower end of Lmuma Creek as having some habitat potential, as it is the wettest of these creeks, with a small portion of its watershed extending into a 16" precipitation zone that is expected to produce some runoff in a typical year. *Noted in updated text of ICTRT Upper Yakima Stock Status Report but not incorporated into GIS model; identified in red on Figure A.1*.

2) Roza and two Lower Wenas Tributaries drain small arid watershed, do not have hydric soils or groundwater inputs and are often elevated on fans at their lower ends. The local review team felt these did not have the flow regime needed to support steelhead. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on Figure A.1*.

Areas identified as historic/potential steelhead habitat by local reviewers, but not included in the ICTRT model include Wilson Creek splits off from Naneum Creek and was likely historic habitat, though extensive passage barriers in and below Ellensburg preclude current use by steelhead. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in green on* Figure A.1.

***Comment Regarding the Caribou, Reecer and Naneum MSAs.*** Numerous streams drain the hills around Ellensburg, with some arising in the arid foothills, and others extending higher into the forested zone. While the review team and the model both identified these as potential habitat, the relative productivity of streams in this area will be highly variable, with some reaches providing high quality habitat and others being marginal at best. Many of these streams are interconnected and have been incorporated into the irrigations systems. Efforts to restore fish passage and habitat in these areas are currently underway, and are being guided by prioritization efforts that carefully consider the historic potential of each waterway, current conditions and trade-offs associated with the interconnectedness of the stream system.

---

[40] http://watershedpledge.org/biblio/0410076maps.html

The adjustments made by local reviewers have very little affect on the total area and overall spatial distribution of the Upper Yakima population. They do significantly reduce the habitat area in a few MSAs and MiSAs, but have no effect on the overall ICTRT viability analysis results.

# APPENDIX B: EDT Model Results for Yakima Steelhead

## B.1 Overview of EDT Estimates of Population Performance

The Ecosystem Diagnosis and Treatment (EDT) was developed by Mobrand Biometrics (now part of Jones & Stokes) to help managers estimate the responses of anadromous fish populations to changes in habitat conditions (Lestelle et al. 1996; Lichatowich et al. 1995; Mobrand Biometrics 1999; Mobrand et al. 1997). The EDT model has been used in the Yakima Basin since the mid-1990s and was a key element in the 2002-2004 Subbasin Planning Process. This section gives an overview of the most recent EDT results for the four Yakima Basin steelhead populations. More detail on the EDT model is available at the Mobrand website (http://www.mobrand.com/MBI/library.html).

The EDT model quantifies the biological response to environmental conditions by estimating several components of population performance, including equilibrium abundance, productivity and life history diversity. It should be noted that these numbers reflect the average performance of a population over duration of years and are not specific to a single year or generation. Though numbers produced by the model reflect "average conditions", the model does take environmental variability into consideration through space and time.

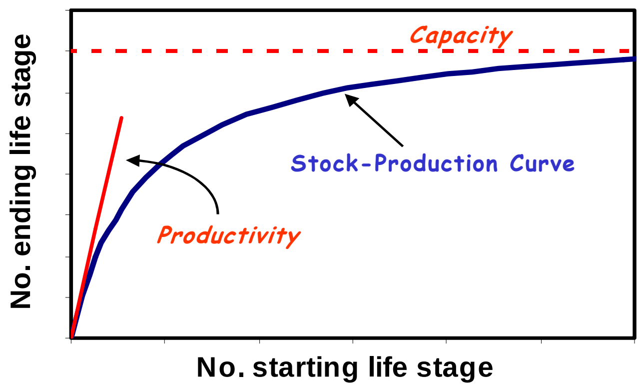
The Beverton-Holt stock recruitment function is foundational to the EDT model. The EDT model generates a unique stock recruitment function for each life stage by stream reach, which are all integrated to calculate population abundance and productivity (Figure B.1). The point where the stock recruitment curve intersects the replacement line defines the population equilibrium abundance. Productivity represents the density independent growth rate of a population and is expressed as the number of recruits per spawner. Productivity also represents the resiliency of a population or ability to endure catastrophic events while sustaining viable numbers. Life history diversity represents the proportion of successful life history pathways offered to a population through space and time. The diversity index indicates the variety of life history pathways offered to a population and is a buffering mechanism against catastrophic events that might occur at a somewhat localized scale and affect a proportion of a population. These population performance parameters indicate the long-term viability and sustenance of the targeted population.

To understand the kinds of information utilized and how it is applied, it is important to understand what the analysis aims to produce. Information is translated through the procedure to address two aspects of fish population performance: productivity and capacity. These two parameters define a theoretical stock-production (S-P) relationship, illustrated using a Beverton-Holt production function in Figure B.1. The S-P curve displayed here is an example of what a relationship might look like between the number of fish at the beginning of a life stage and those surviving to the end of the stage.

Productivity is equivalent to the concept of intrinsic productivity discussed in McElhany et al. (2000) to describe viable salmon populations with respect to the Endangered Species Act. It is survival without density dependence effects, i.e., the approximate rate that would occur when competition for resources among the population is minimal. In

Figure B.1, it is the slope of the S-P curve at its origin. Productivity is a function of the quality of the environment.[41] In contrast, environmental capacity limits how large a population can grow given finite space and food resources. Capacity is represented by the asymptote in Figure B.1 and controls the extent that density dependence is operative at different population levels. Capacity is a function of the quantity of key habitats and food resources available. Sets of rules are used by the EDT method to derive productivity, key habitat, and food parameter values from environmental information—these serve as inputs into the EDT model.[42]

**Figure B.1: Example stock-production relationship**




The EDT model predicts that the abundance of steelhead in the Yakima Basin declined by 83% to 95% due to the change from historic to current environmental conditions (Table B.1). According to the model, the Naches, Toppenish, and Upper Yakima populations exhibit reductions in life history diversity from 89% to 93% since pre settlement era. A common theme in the reduction in the diversity index centers around major blockages to fish passage in and out of headwater tributaries associated with dam construction. In conjunction with this, major tributaries that historically supported healthy steelhead populations were subject to significant surface water withdrawals and associated dewatered reaches, unscreened diversions and impassable obstructions. These overwhelming burdens not only reduced life history diversity, but also substantially reduced habitat capacity (Table B.1).

To some degree, the productivity values are indicative of the quality of available habitat offered to a population. Riparian corridors and flow regimes have remained relatively intact in the upper portions of Satus and Toppenish systems compared to the Naches and Upper Yakima portions of the basin. As a result, productivity values for Satus and Toppenish Creek steelhead are modestly higher than those of the Naches and Upper Yakima (Table B.1).

---

[41] Productivity measured across a full life cycle also incorporates sex ratio, fecundity, and fitness.

[42] In EDT, food is both a component of environmental quality (thereby affecting productivity) and quantity (since food is assumed to affect both density-independent and –dependent mortality.) Regarding its role in affecting density-dependent mortality, the food parameter is used in conjunction with the key habitat parameter in estimating capacity.

**Table B.1 Current and historic performance generated by EDT**

| Population | Scenario | Diversity index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| Naches Steelhead | Current without harvest | 10% | 1.6 | 2,287 | 849 |
| | Current with harvest | 10% | 1.6 | 2,287 | 849 |
| | Historic potential | 91% | 10.4 | 16,092 | 14,542 |
| Satus Steelhead | Current without harvest | 38% | 2.5 | 1,552 | 926 |
| | Current with harvest | 38% | 2.5 | 1,552 | 926 |
| | Historic potential | 92% | 10.3 | 6,382 | 5,761 |
| Toppenish Steelhead | Current without harvest | 13% | 2.3 | 876 | 497 |
| | Current with harvest | 13% | 2.3 | 876 | 497 |
| | Historic potential | 94% | 8.8 | 5,234 | 4,639 |
| Upper Yakima Steelhead | Current without harvest | 6% | 1.7 | 2,453 | 1,047 |
| | Current with harvest | 6% | 1.7 | 2,453 | 1,047 |
| | Historic potential | 91% | 10.6 | 23,355 | 21,152 |

Ladder diagrams produced by the model evaluate the degree to which restoration[43] and preservation of specific geographic areas will benefit a population. Geographic areas can be defined at a variety of scales from individual stream reaches up to an entire watershed, etc. For our purposes, geographic areas for streams other than the Yakima were primarily defined at the watershed and tributary scale depending on the size of the population. Upper and lower bounds of the Yakima mainstem geographic area were defined by a major tributaries or channel spanning structures such as diversion dams. Restoration and protection potential are generated for each geographic area and represent the potential increase or decrease in the population performance parameters.

## B.2 Restoration Potential and Limiting Factors by Populations

Table B.2, Table B.3, Table B.4, and Table B.5 present the geographic areas where restoration actions would make the greatest contribution to increasing abundance, productivity and capacity. The tables include areas that together comprise 75% of the total restoration potential with respect to abundance. The numbers reflect the potential increases in each performance parameter and are expressed as potential gains relevant to the current performance of the population generated by the model. The combined ranking shows the significance of a specific geographic area for a population that is pertinent to restoring all three components of population performance.

The strategic summary diagrams (Figure B.2, Figure B.3, Figure B.4, and Figure B.5) summarize the major physical and biological components limiting production of the target population within each specified geographic area. These limiting factors are known as the level 3 survival factors and are generated from a suite of level 2 attributes. Level 2 attributes are defined by data inputs that characterize the physical and biological environment. A single level 2 attribute acts as the primary component upon the Level 3

[43] Restoration Potential as referenced in EDT ladder diagrams is a comparison of Historical condition minus Current condition. In many instances it is not feasible to realize the full restoration potential.

Survival Factor. All other related level 2 attributes act as modifiers upon the level 3, which ultimately defines productivity, abundance and diversity index (Lestelle et al. 2004). In a nutshell, the level 3 correlates represent the biological response to the fluctuating environmental conditions through space and time. Negative impacts on survival are integrated across all life stages for each level 3 correlate. In a qualitative sense, the strategic summaries illustrate the severity of a level 3 attribute upon productivity. The large, medium and small dots in the diagram correspond to the three ranges of severity.

### B.2.1 Naches River Steelhead

Table B.2 indicates the geographic areas with the greatest restoration potential for the Naches steelhead population. The table also shows the hypothesized potential gains in the performance parameters expressed as percentages increase with respect to current performance if one was to restore the geographic area back to pre settlement era conditions. Figure B.2 qualitatively illustrates the major level 3 correlates compounded across all life stages impacting survival in the specified geographic area.

The Cowiche to Tieton reach is the geographic area that would increase the Naches steelhead population performance the most (+112.1% for abundance) if fully restored to historic conditions. Historically this was the largest floodplain in the Naches arm of the basin. Both currently and historically this geographic area is important for steelhead spawning and, summer and winter rearing. Due to the location of this geographic area in the basin, Naches steelhead spend one or more of their life stages within, stressing the importance of this geographic area. Unfortunately, because of extensive build out and placement of Highway 12 within this floodplain there is limited opportunity to fully realize its historic potential.

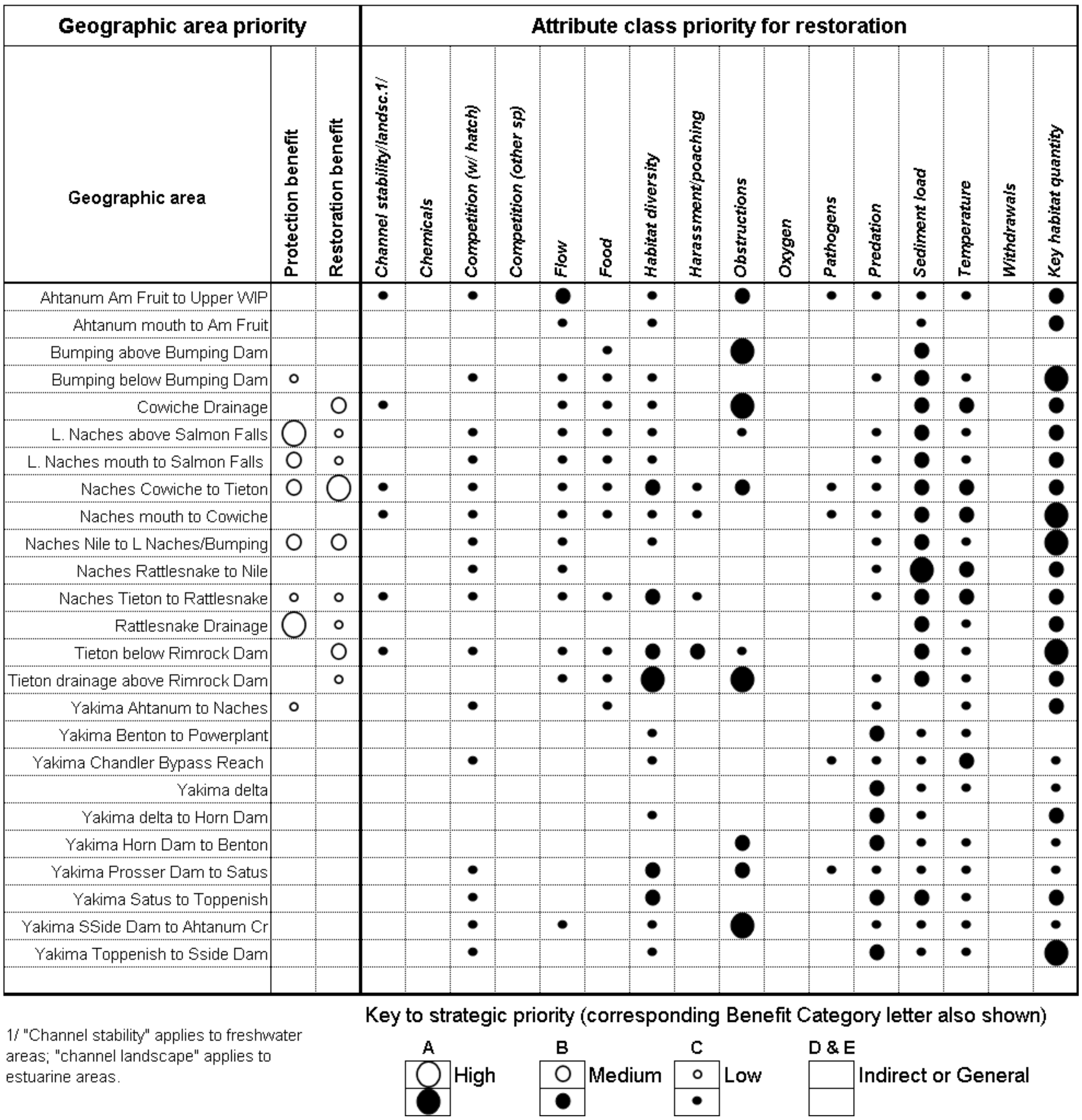
The model indicates the diversity index could be twice that of current life history pathways if the Cowiche drainage was fully restored). There have been major passage issues near the mouth of Cowiche that have severely reduced the life history pathways, productivity and abundance of the Naches steelhead population. Other degradations have occurred in the Cowiche geographic area in the form of increased temperatures, flow, sediment loads and habitat simplification.

**Table B.2 Restoration geographic areas for the Naches steelhead population**

| Naches Steelhead | Combined Rank | Diversity Index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| **Geographic Area** | | | | | |
| Naches Cowiche to Tieton | 1 | 124.5% | 72.9% | 23.7% | 112.1% |
| Cowiche Drainage | 2 | 100.0% | 37.1% | 8.2% | 57.8% |
| Tieton below Tieton Dam | 3 | 75.3% | 35.0% | 11.8% | 61.0% |
| Naches Nile to L Naches/Bumping | 4 | 63.7% | 36.4% | 4.8% | 52.2% |
| Naches Tieton to Rattlesnake | 5 | 73.1% | 28.7% | 5.5% | 45.3% |
| L. Naches above Salmon Falls | 6 | 54.9% | 28.8% | 4.1% | 43.5% |
| Tieton drainage above Tieton Dam | 7 | 41.2% | 24.4% | 24.5% | 65.9% |
| L. Naches mouth to Salmon Falls | 8 | 65.1% | 21.8% | 6.3% | 38.5% |
| Rattlesnake Drainage | 9 | 47.6% | 28.4% | 3.7% | 42.6% |
| Yakima Prosser Dam to Satus | 10 | 55.3% | 7.0% | 17.3% | 30.3% |
| Naches mouth to Cowiche | 12 | 13.7% | 17.7% | 4.1% | 30.7% |

Sorted by the combined rank; geographic areas shown below represent 75% of the restoration potential with respect to abundance.

**Figure B.2: Major reach-level limiting factors for the Naches population**




## B.2.2 Satus Creek Steelhead

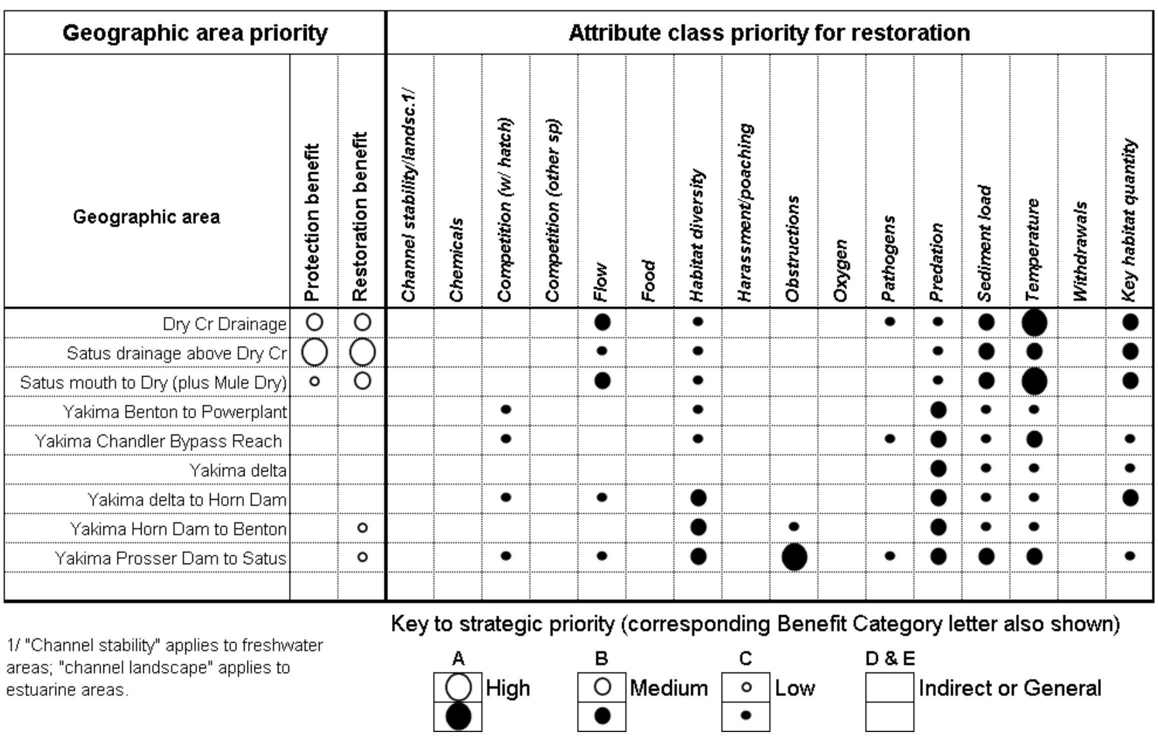
Table B.3 indicates the geographic areas with the greatest restoration potential for the Satus steelhead population. The table also shows the hypothesized potential gains in the performance parameters expressed as percentages increase with respect to current performance if one was to restore the geographic area back to pre settlement era conditions. Figure B.3 qualitatively illustrates the major level 3 correlates compounded across all life stages impacting survival in the specified geographic area.

**Table B.3: Restoration geographic areas for the Satus steelhead population**

| Satus Steelhead | Combined Rank | Diversity Index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| **Geographic Area** | | | | | |
| Satus drainage above Dry Cr | 1 | 30.6% | 59.3% | 30.2% | 63.0% |
| Dry Cr Drainage | 2 | 44.8% | 21.7% | 8.2% | 21.2% |
| Satus mouth to Dry (and Mule Dry) | 3 | 39.1% | 14.8% | 23.7% | 34.4% |
| Yakima Prosser Dam to Satus | 4 | 5.1% | 11.5% | 13.2% | 21.1% |

Sorted by the combined rank; geographic areas shown below represent 75% of the restoration potential with respect to abundance.

**Figure B.3: Major reach-level limiting factors for the Satus Creek population**




## B.2.3 Toppenish Creek Steelhead

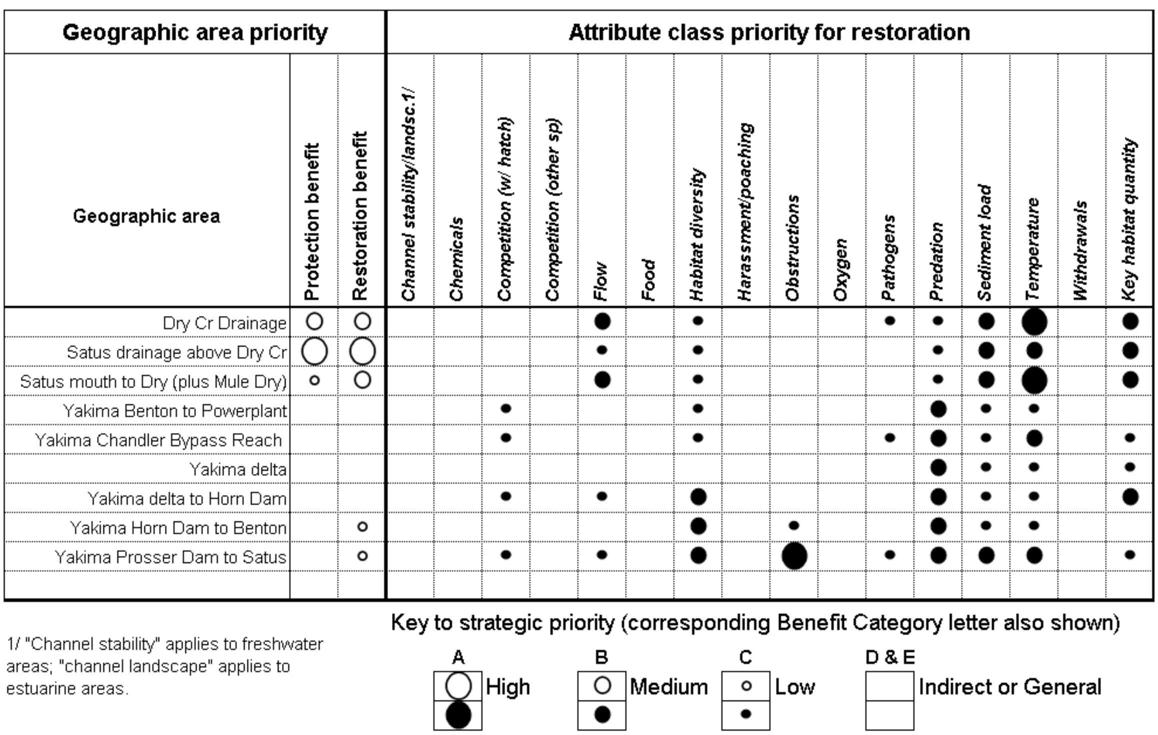
Table B.4 indicates the geographic areas with the greatest restoration potential for the Toppenish steelhead population. The table also shows the hypothesized potential gains in the performance parameters expressed as percentages increase with respect to current performance if one was to restore the geographic area back to pre settlement era conditions. Figure B.4 qualitatively illustrates the major level 3 correlates compounded across all life stages impacting survival in the specified geographic area.

**Table B.4: Restoration geographic areas for the Toppenish steelhead population**

| Toppenish Steelhead | Combined Rank | Diversity Index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| **Geographic Area:** | | | | | |
| Toppenish Unit II to Lateral Canal | 1 | 147.1% | 12.3% | 34.6% | 45.8% |
| Toppenish above Lateral Canal | 2 | 29.5% | 14.0% | 21.1% | 32.5% |
| Yakima Prosser Dam to Satus | 3 | 14.6% | 14.1% | 17.9% | 29.1% |
| Simcoe drainage above Agency | 3 | 97.1% | 11.0% | 16.8% | 25.6% |
| Topp. mouth to Unit II Diversion | 4 | 96.1% | 2.3% | 21.5% | 23.5% |

Sorted by the combined rank; geographic areas shown below represent 75% of the restoration potential with respect to abundance.

**Figure B.4: Major reach-level limiting factors for the Toppenish Creek population**



### B.2.4 Upper Yakima River Steelhead

Table B.5 indicates the geographic areas with the greatest restoration potential for the Upper Yakima steelhead population. The table also shows the hypothesized potential gains in the performance parameters expressed as percentages increase with respect to current performance if one was to restore the geographic area back to pre settlement era conditions. Figure B.5 qualitatively illustrates the major level 3 correlates compounded across all life stages impacting survival in the specified geographic area. Before discussing the results it should be stated that there is disparity between the EDT predicted steelhead equilibrium abundance for the upper Yakima population and what has been observed for the past 10 years based on Roza Dam fish counts. The EDT model does not currently have the capability to segregate population performance parameters between the resident and anadromous life history forms of *Oncorhynchus mykiss*; and the upper Yakima population is largely comprised of resident rainbow trout. Revision of the model to address this issue is currently under discussion.

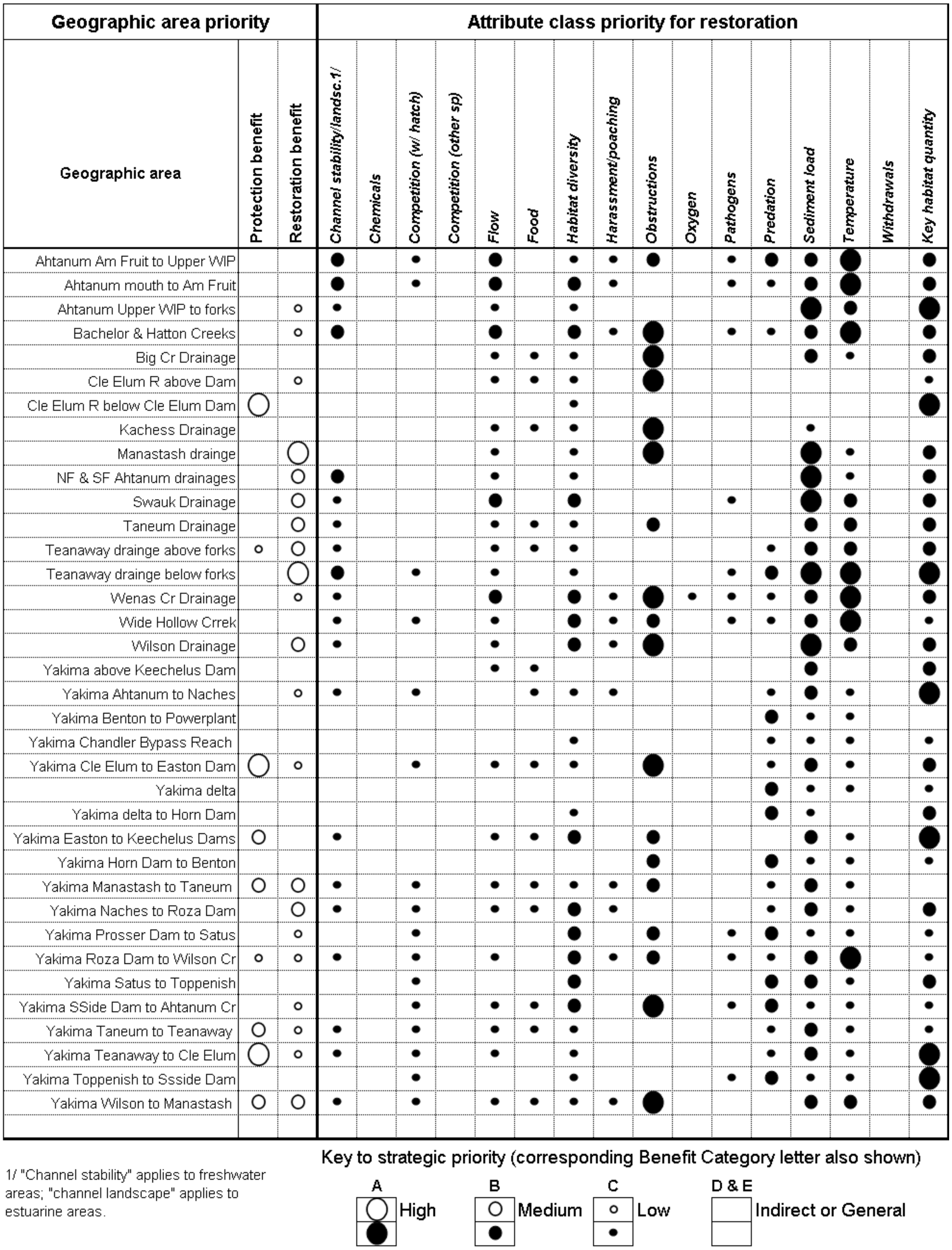
The upper Yakima steelhead population incorporates the largest geographic area of any of the basin steelhead populations. Not surprisingly 10 of the 15 geographic areas define tributary type watersheds suggesting the historical importance of tributary contribution to the upper Yakima population. This is illustrated by the fact that top three geographic areas were all major tributaries–Manastash, Teanaway (below the forks) and the Wilson drainage (which comprises many small tributaries).

Table B.5: Restoration geographic areas for the Upper Yakima steelhead population

| Upper Yakima Steelhead | Combined Rank | Diversity Index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| **Geographic Area:** | | | | | |
| Manastash drainage | 1 | 72.1% | 68.1% | 20.6% | 86.2% |
| Teanaway drainage below forks | 2 | 47.7% | 57.6% | 17.5% | 75.2% |
| Wilson Drainage | 3 | 188.3% | 26.4% | 19.8% | 53.4% |
| Yakima Manastash to Taneum | 4 | 41.4% | 34.8% | 4.4% | 40.7% |
| Teanaway drainage above forks | 5 | 113.8% | 24.1% | 8.8% | 37.2% |
| NF & SF Ahtanum drainages | 5 | 69.4% | 28.8% | 2.9% | 33.7% |
| Taneum Drainage | 6 | 38.7% | 35.1% | 3.8% | 40.0% |
| Yakima Wilson to Manastash | 7 | 40.5% | 31.6% | 4.1% | 37.6% |
| Yakima Naches to Roza Dam | 8 | 27.3% | 30.5% | 4.6% | 37.5% |
| Swauk Drainage | 8 | 43.5% | 24.4% | 3.3% | 30.5% |
| Wenas Cr Drainage | 9 | 54.7% | 19.0% | 7.0% | 29.9% |
| Cle Elum R above Dam | 10 | 36.9% | 14.1% | 23.4% | 43.8% |
| Yakima Prosser Dam to Satus | 12 | 47.1% | 7.7% | 17.6% | 28.9% |
| Yakima Ahtanum to Naches | 13 | 16.2% | 22.8% | 5.6% | 31.9% |
| Ahtanum Upper WIP to forks | 15 | 6.0% | 25.6% | 1.9% | 29.7% |

Sorted by the combined rank; geographic areas shown below represent 75% of the restoration potential with respect to abundance.

## Figure B.5: Major reach-level limiting factors for the Upper Yakima population




1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

## B.2.5 Integration of Restoration Priorities Across Populations

Table B.2, Table B.3, Table B.4, and Table B.5 have presented the geographic areas with the greatest potential for restoring the components of performance for the defined populations. The geographic areas listed for each population also represent 75% of the restoration potential in terms of restoring the population's abundance to near historic levels. When viewing these Geographic areas by population with the strategic summaries (Figure B.2, Figure B.3, Figure B.4, and Figure B.5), together they illustrate the "where" and "what" components of restoration specific to individual populations. However, if we want to take a coarsened scale view of the overall benefits for multiple species in terms of restoration, we must integrate overlapping geographic areas across species and populations. This allows identifying the geographic areas that provide the "biggest bang for your buck." Geographic areas totaling 75% of the abundance restoration potential were considered priority areas for each population and were counted across populations of modeled species where overlap occurred. Results from this exercise are presented in. The model indicates restoration actions in the top 13 geographic areas would benefit nearly all anadromous species currently modeled in the basin. Further more, restoration actions within the top six geographic areas listed would improve performance of multiple populations and species. A word of caution, geographic areas in the table below represent areas of significance for a population that also overlap across multiple species and populations, there are other geographic areas not included in Table B.6 with significant restoration potential for individual species or populations.

**Table B.6: Summation of individual geographic areas across steelhead populations**

Numbers under the species indicate the number of populations benefiting from restoration actions in the listed geographic area. Where only one steelhead population is shown as benefiting, geographic areas are ranked in descending order according to the additional number of populations of other species shown as benefiting in Appendix M of the Yakima Subbasin Plan.

| No. | Geographic Area | Steelhead |
|---|---|---|
| 1 | Yakima Prosser Dam to Satus Cr | 4 |
| 2 | Naches Cowiche Cr to Tieton R | 1 |
| 3 | Naches Tieton R to Rattlesnake Cr | 1 |
| 4 | Yakima Ahtanum Cr to Naches R | 1 |
| 5 | Naches Nile Cr to Little Naches/Bumping Confl. | 1 |
| 6 | Teanaway R below forks | 1 |
| 7 | Yakima Naches R to Roza Dam | 1 |
| 8 | Yakima Manastash Cr to Taneum Cr | 1 |
| 9 | Yakima Wilson Cr to Manastash Cr | 1 |
| 10 | Tieton drainage above Tieton Dam | 1 |
| 11 | Tieton R below Tieton Dam | 1 |
| 12 | Naches mouth to Cowiche Cr | 1 |
| 13 | Cle Elum drainage above Cle Elum Dam | 1 |
| 14 | Teanaway drainage above forks | 1 |
| 15 | Little Naches R mouth to Salmon Falls | 1 |
| 16 | Wilson Drainage | 1 |
| 17 | Cowiche Drainage | 1 |
| 18 | Rattlesnake Drainage | 1 |

## B.3 Preservation Potential for Individual Populations

Table B.7, Table B.8, Table B.9, and Table B.10 present the geographical areas where degradation of current habitat conditions of individual populations would have the most negative affects on modeled population characteristics. These areas should be priorities areas for efforts to protect existing habitat conditions. Geographic areas listed comprise 75% of the preservation potential with respect to abundance. The percentages should be interpreted as potential decreases in current performance of the designated population if the physical and biological environment was severely degraded. Thus, areas with high percentages should be considered priority areas for preservation. Also, the combined rank next to a geographic area considers losses endured by all performance parameters and is computed by the sum of individual ranks for each parameter.

### B.3.1 Naches Steelhead

Table B.7 summarizes the high priority geographic areas for preservation potential as it applies to the Naches steelhead population. The table also shows the hypothesized potential losses in the performance parameters expressed as percentages decrease in the current performance of the population. Due to the quality of spawning/rearing habitat in the Little Naches above Salmon Falls and the Rattlesnake drainage, the model indicates these as the primary Geographic areas for preservation.

**Table B.7: Geographic preservation priorities for the Naches population**

Geographic areas are sorted by the combined preservation rank of performance parameters.

| Naches Steelhead | Combined Rank | Diversity Index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| **Geographic Area:** | | | | | |
| L. Naches above Salmon Falls | 1 | -36.7% | -29.9% | -9.1% | -74.8% |
| Rattlesnake Drainage | 1 | -28.8% | -33.0% | -9.4% | -85.2% |
| Naches Nile to L Naches/Bumping | 2 | -30.0% | -20.5% | -8.5% | -48.6% |
| Naches Cowiche to Tieton | 3 | -25.1% | -13.0% | -14.0% | -35.8% |
| L. Naches mouth to Salmon Falls | 4 | -17.8% | -14.0% | -6.7% | -32.5% |

### B.3.2 Satus Steelhead

Table B.8 summarizes the high priority geographic areas for preservation potential as it applies to the Satus Creek steelhead population. Table B.8 also shows the hypothesized potential losses in the performance parameters expressed as percentages decrease in the current performance of the population. The model indicates degradation within the physical and biological environment of the Satus Drainage above Dry Creek would result in the loss of 80% life history pathways and 100% abundance. This is a rather large geographic area with a high proportion of Satus Creek steelhead spawning within, explaining the consequences of degradation of this reach.

**Table B.8: Geographic preservation priorities for the Satus Creek population**

Geographic areas are sorted by the combined preservation rank of performance parameters.

| Satus Steelhead | Combined Rank | Diversity Index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| **Geographic Area:** | | | | | |
| Satus drainage above Dry Cr | 1 | -80.0% | -77.2% | -45.5% | -100.0% |
| Dry Cr Drainage | 2 | -14.7% | -20.4% | -17.2% | -31.5% |
| Satus mouth to Dry (plus Mule-Dry) | 3 | -29.0% | -14.7% | -18.8% | -28.3% |

## B.3.3 Toppenish Steelhead

Table B.9 summarizes the high priority geographic areas for preservation potential as it applies to the Toppenish steelhead population. The table also shows the hypothesized potential losses in the performance parameters expressed as percentages decrease in the current performance of the population. The model indicates degradation within the physical and biological environment of Toppenish Creek above Lateral Canal would result in the loss of 88.6% life history pathways and 100% abundance. This is a rather large geographic area with a high proportion of Toppenish Creek steelhead spawning within, explaining the consequences of degradation of this reach.

**Table B.9: Geographic preservation priorities for the Toppenish population**

Geographic areas are sorted by the combined preservation rank of performance parameters.

| Toppenish Steelhead | Combined Rank | Diversity Index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| **Geographic Area:** | | | | | |
| Toppenish above Lateral Canal | 1 | -88.6% | -96.2% | -47.9% | -100.0% |
| Simcoe drainage above Agency | 2 | -5.8% | -0.7% | -10.2% | -10.7% |

## B.3.4 Upper Yakima Steelhead

Table B.10 summarizes the high priority geographic areas for preservation potential as it applies to the Upper Yakima steelhead population. The table also shows the hypothesized potential losses in the performance parameters expressed as percentages decrease in the current performance of the population. The top three preservation geographic areas incorporate the Yakima mainstem upstream of the Teanaway River to Easton Dam and the Cle Elum River downstream of the dam to the confluence to the Yakima River. These three geographic areas rank high because of their vast size, the quality of habitat relative to other geographic areas and the extended period time steelhead reside in these three geographic areas (i.e., spawning through smoltification).

**Table B.10: Geographic preservation priorities for the Upper Yakima population**

Geographic areas are sorted by the combined preservation rank of performance parameters.

| Upper Yakima Steelhead | **Combined Rank** | **Diversity Index** | **Productivity** | **Capacity** | **Abundance** |
|---|---|---|---|---|---|
| Geographic Area: | | | | | |
| Cle Elum R below Cle Elum Dam | 1 | -18.6% | -27.5% | -0.2% | -51.0% |
| Yakima Teanaway to Cle Elum | 1 | -32.1% | -23.5% | -2.6% | -42.9% |
| Yakima Cle Elum to Easton Dam | 2 | -35.1% | -22.9% | -3.5% | -42.0% |
| Yakima Taneum to Teanaway | 3 | -27.0% | -15.4% | -2.0% | -25.9% |
| Yakima Easton to Keechelus dams | 4 | -15.0% | -12.8% | -1.5% | -21.0% |
| Yakima Manastash to Taneum | 5 | -12.9% | -9.8% | -8.3% | -21.8% |
| Yakima Wilson to Manastash | 6 | -11.1% | -11.0% | -4.1% | -20.1% |
| Yakima Roza Dam to Wilson Cr | 7 | -5.4% | -5.0% | -5.6% | -12.2% |
| Teanaway drainage above forks | 8 | -3.0% | -4.5% | -9.1% | -14.8% |

## B.4 Use of EDT to Model Restoration Scenarios

Currently the best data available for making a quantitative assessment of the response of Yakima Basin steelhead populations to restoration activities comes from two restoration scenarios developed using the EDT model. The first was developed for the Yakima Subbasin Plan in 2004-5. The second is a more intensive restoration scenario developed by modeling restoring habitat to a level that provides 50% of Proper Functioning Condition in the EDT model.[44] The Yakima Basin Fish & Wildlife Recovery Board is working with NOAA Fisheries to integrate the results of these restoration scenario into an All-H Analyzer model that assess population responses to recovery actions in the mainstem Columbia, its estuary, and the Pacific Ocean. This work is detailed in Chapter 8 of the Middle Columbia River Steelhead Recovery Plan currently being developed by

[44] The 50% of PFC model for steelhead has been developed by the Columbia Basin Fish & Wildlife Authority and will be published as part of their 2008 proposals for amendments to the NPCC Fish and Wildlife Program.

NOAA Fisheries. The Board is also investigating the possibility of conducting additional analysis using update EDT data and more detailed modeling of specific recovery actions.

For the restoration scenario developed for the Yakima Subbasin Plan, the Aquatic Technical Committee developed a restoration scenario that characterized how habitat variables would respond to fish habitat restoration efforts, and then used the EDT model to estimate how anadromous fish populations would respond. For those attributes that could be characterized in the EDT model, and were considered major limiting factors to productivity, the technical committee estimated how much they thought a given attribute could be improved over the next 30 years (roughly the time for riparian vegetation to mature if planted) given the current conditions in the subbasin, and an unlimited budget, and using existing protection or restoration techniques such as riparian zone planting, purchase of water rights, levee relocation, etc. For example, in the Upper Yakima it was not thought likely that a massive relocation of Interstate 90 was going to occur, so confinement (a major limiting factor in the upper Yakima) was rated to remain nearly the same, while in the Union Gap reach, it could conceivably improve by over 40% without relocating the freeway or the Cities of Yakima or Union Gap. In a few cases, such as reaches located in Urban Growth Areas or other rapidly developing areas with still good habitat, some slight decreases in habitat quality were also entered into the model. Specific assumptions made in developing the restoration scenario include:

1) Anadromous fish passage is made available at Bumping and Cle Elum dams, but not Tieton, Keechelus or Kachess dams;

2) Full passage is restored at all other existing passage barriers;

3) Based on the Aquatic Technical Committee’s assessment of what was likely to be feasible, the model run reflects only a 10 to 15% improvement in flow conditions in the lower Naches (i.e., below the confluence with the Tieton) and lower Yakima (below Wapato Dam), which would still leave them at only an estimated 20 to 30% of unregulated averages.

4) Improvements did not cascade. In the real world, improvements in one attribute could be expected to have secondary effects on other attributes, or “cascade” through the ecosystem. Within the model, changes were made to the selected attributes only, and other attributes were held constant for the model run. This means that the Restoration reference condition is very conservative in regards to estimated productivity, abundance and diversity.

5) The model was based on existing defined populations; new spawning reaches in newly opened habitat, or entirely new populations were not defined for the restoration scenario.

The process of developing the restoration scenario and the specific adjustments to habitat parameters are described in detail in Appendix O of the Yakima Subbasin Plan (2005). In early 2008, the Subbasin plan scenario was adjusted to ensure that baseline and restored out of basin conditions were constant (this required lowering the ocean survival rates in the restoration scenario so that they matched those in the baseline scenario). Anticipated improvements in Columbia River habitat, hatchery and harvest conditions and variability in ocean conditions will be captured in the AHA modeling process currently being conducted by NOAA Fisheries. A second adjustment was made to redraw population area boundaries to match those used in this plan; this primarily affected the Naches population, which incorporates tributary and mainstem areas that were modeled separately in 2005. The 2005 EDT-based estimates of resulting population parameters are shown in Table B.11; Table B.12 shows the 2008 adjusted version. Compared to other modeled salmon species, steelhead respond well to restoration. All existing populations are modeled to improve substantially, and population levels are well above minimum thresholds for viability. The current abundance estimates in Table B.11 differs slightly from the current levels in Table B.1 due to the use of slightly different population delineations; both tables will be updated based on a new model run based on the ICTRT population delineations that is under development. The updated model run results will be incorporated into this document once available, but significant change in the modeled response of steelhead populations to the restoration scenario is not expected.

**Table B.11: EDT Subbasin restoration summary as developed in 2005**

| Population | Scenario | Diversity index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| Satus Steelhead | Current without harvest | 37% | 2.4 | 1,516 | 894 |
| | Current with harvest | 37% | 2.4 | 1,516 | 894 |
| | Restored Conditions | 49% | 5.2 | 3,379 | 2,733 |
| Toppenish Steelhead | Current without harvest | 13% | 2.5 | 866 | 513 |
| | Current with harvest | 13% | 2.5 | 866 | 513 |
| | Restored Conditions | 37% | 4.9 | 2,238 | 1,784 |
| Naches Steelhead | Current without harvest | 11% | 1.6 | 2,348 | 920 |
| | Current with harvest | 11% | 1.6 | 2,348 | 920 |
| | Reference Conditions | 60% | 2.9 | 7,563 | 4,911 |
| Upper Yakima Steelhead | Current without harvest | 6% | 1.9 | 3,177 | 1,479 |
| | Current with harvest | 6% | 1.9 | 3,177 | 1,479 |
| | Restored Conditions | 33% | 2.9 | 9,931 | 6,553 |

**Table B.12: EDT 2005 Subbasin restoration summary as adjusted in 2008**

| Population | Scenario | Diversity index | Productivity | Capacity | Abundance |
|---|---|---|---|---|---|
| Satus Steelhead | Current without harvest | 37% | 2.4 | 1,472 | 861 |
| | Current with harvest | 37% | 2.4 | 1,472 | 861 |
| | Restored Conditions | 44% | 2.6 | 1,551 | 961 |
| Toppenish Steelhead | Current without harvest | 12% | 2.4 | 860 | 505 |
| | Current with harvest | 12% | 2.4 | 860 | 505 |
| | Restored Conditions | 20% | 2.6 | 978 | 609 |
| Naches Steelhead | Current without harvest | 27% | 2.6 | 3,192 | 1,977 |
| | Current with harvest | 27% | 2.6 | 3,192 | 1,977 |
| | Reference Conditions | 33% | 3.0 | 3,710 | 2,472 |
| Upper Yakima Steelhead | Current without harvest | 15% | 2.6 | 1,809 | 1,114 |
| | Current with harvest | 15% | 2.6 | 1,809 | 1,114 |
| | Restored Conditions | 27% | 2.6 | 3,131 | 1,947 |

# APPENDIX C: RECOVERY PROGRAMS OVERVIEW

## C.1 Introduction

Fisheries restoration efforts in the Yakima Basin have a long history. Numerous federal, state and local programs have been established over the last 25 years. As noted in Chapter 6, this plan emphasizes implementing recovery actions through established programs and partnerships wherever possible. This appendix gives a brief overview of some of the most relevant programs. For more information, see the Yakima Subbasin Plan.

## C.2 NPCC/BPA Programs

The federal Northwest Power Act of 1982 created the Northwest Power and Conservation Council and tasked it with overseeing a fish and wildlife program that is funded by BPA and mitigates for the effects of the Federal Columbia River Power System. The Council/BPA program has been the primary source of funding for fish restoration efforts in the Yakima Basin over the last 25 years, and is likely to continue to be so into the future. Table C.1 lists projects in the Yakima Basin that are currently funded by BPA.

**Table C.1: BPA-funded programs in the Yakima Basin**

| Project # | Project Title | Sponsor | Current FY07 to 09 |
|---|---|---|---|
| 198812025 | YKFP Management, Data, Habitat | Yakama Nation | $454,000* |
| 199200900 | Yakima Phase II/Huntsville Screen Operation & Maintenance | WDFW | $484,500 |
| 199206200 | Yakama Nation - Riparian/Wetlands Restoration | Yakama Nation | $2,275,000 |
| 199405900 | Yakima Basin Environmental Education Program | Eco-Northwest | $100,000* |
| 199503300 | O&M Yakima Basin Fish Screens | BOR | $273,600 |
| 199506325 | Yakima Klickitat Fisheries Project - Monitoring And Evaluation | Yakama Nation & WDFW | $12,300,753 |
| 199506425 | YKFP Policy/Plan/Technical | WDFW | $540,000 |
| 199603501 | Yakama Reservation Watersheds Project | Yakama Nation | $1,016,457* |
| 199701325 | Yakima/Klickitat Fisheries Project Operations and Maintenance | Yakama Nation | $7,999,998 |
| 199705100 | Yakima Basin Side Channels | Yakama Nation | $1,500,000 |
| 200201400 | Sunnyside Wildlife Mitigation | WDFW | $634,255 |
| 200202501 | Yakima Tributary Access & Habitat Program | South Central Washington RC&D | $365,178 |
| *Capital* | *Yakima Tributary Access & Habitat Program* | South Central Washington RC&D | *$2165178* |
| *Capital* | *Manastash Creek Passage & Screening* | *Kittitas County Conservation District* | *$2327432* |
| 200600400 | Wenas Wildlife Area O&M | WDFW | $868,720 |
| 200702000 | Manastash Instream Flow Enhancement | Kittitas County Conservation | $892,998 |
| 200711200 | Teanaway Watershed Protection & Enhancement | Kittitas Conservation Trust | $1,020,000 |
| 200711300 | Cowiche Restoration and Protection Project | WDFW | $300,000 |
| 200719400 | Oak Flats Acquisition and Habitat Enhancement | WDFW | $550,000 |
| | | ***Totals*** | ***36,068,069*** |

***FY 2007 funding commitment only**

BPA is currently making commitments to additional funding for tributary habitat improvements as part of negotiating an ESA Biological Opinion for the Columbia River Power system, and it is likely that at least some of this funding will be used in the Yakima Basin to improve steelhead habitat.

Selected BPA-funded projects with strong ties to steelhead recovery are described below.

### C.2.1 The Yakima/Klickitat Fisheries Project

The Yakima Klickitat Fisheries Project (YKFP) is a joint project of the Yakama Nation Fisheries Program and WDFW that is funded via four separate contracts with BPA. It is the largest fish management program in the basin. Its goals are to:

- Enhance existing stocks of anadromous fish in the Yakima and Klickitat river basins while maintaining genetic resources and minimizing negative ecological interactions with wild populations.
- Reintroduce stocks formerly present in the basins.
- Apply knowledge gained about hatchery supplementation throughout the Columbia River Basin.

The YKFP program runs supplementation hatchery programs for spring and fall Chinook and coho salmon. Opportunities to reintroduce extirpated summer Chinook and sockeye runs are being evaluated. The YKFP program also undertakes extensive research and monitoring to understand factors affecting target populations, and to evaluate the effects of supplementation activities on other components of the ecosystem. The program maintains 15 different fish production and research facilities in the basin and employees approximately eighty people, including managers, scientists, technicians, fish culturists, laborers and office support personnel. It also supports efforts to improve, restore, and protect fish habitat in the basin, and to influence policies related to fish management in the Yakima Basin. The YKFP program is the primary source and steward of fish related data in the basin, and maintains the EDT model used to evaluate the historic, current and potential future conditions of fish habitat within the Yakima Subbasin.

YKFP activities focused on steelhead include the kelt reconditioning program at the Prosser hatchery, research into the genetics of Yakima Basin steelhead, and monitoring of steelhead adults, juveniles and smolts. The fish counting facilities at Roza and Prosser dams are operated by YKFP. The YKFP program is currently developing a steelhead master plan; this process will be coordinated with ongoing recovery planning and implementation, and will identify possible supplementation actions.

### C.2.2 Yakima Tributary Access and Habitat Program

The listing of Middle Columbia River Steelhead focused the attention of both landowners and regulatory agencies on the numerous unscreened irrigation diversions and passage barriers in Yakima and Kittitas counties. In response, local organizations, including the South Central RC & D, the Kittitas County and North Yakima Conservation Districts, WDFW, the Yakima Nation and others, partnered to apply for BPA funding for the Yakima Tributary Access & Habitat Program (YTAHP). This program has funded assessments of tributary passage, screening and habitat conditions, and subsequent on-the-ground projects to screen irrigation diversions, remove fish passage barriers and improve riparian habitat conditions. From 2002 to 2008, YTAHP and its partners screened 87 cfs of irrigation water, removed 21 passage barriers to access over 45 miles of habitat, trusted 4.5 cfs of water to instream use, planted 4.95 miles of stream bank, and used YTHAP funded staff and resources to leverage over $7.6 million in total project funding.

### C.2.3 Yakima Side Channels Program

This project has funded acquisition and restoration of side channel and floodplain habitats in alluvial reaches of the Yakima and Naches rivers.

### C.2.4 Yakama Reservation Watersheds Project

This project focuses on restoration of anadromous fish bearing streams on the Yakima Reservation. It has funded habitat protection and enhancement in Satus Creek, flow improvements, obstruction removal, and screening in Toppenish Creek, and flow restoration and riparian/floodplain protection on Ahtanum Creek. Redd surveys, smolt trapping and other monitoring are conducted in all three areas. This project has been the main source of funding for restoration actions for the Satus and Toppenish steelhead populations.

### C.2.5 Manastash Creek Passage/Screening/Flow Projects

These two projects focus on removing passage barriers and improving instream flows in the lower section of Manastash Creek, which has been inaccessible to steelhead for more than a century. Restoring access to Manastash Creek is a high priority action for the Upper Yakima steelhead population.

### C.2.6 Teanaway Watershed Protection and Enhancement

This project focuses on protecting and restoring the floodplains and riparian areas of the Teanaway River, which is one of the main areas currently used by steelhead in the Upper Yakima population area.

## C.3 U.S. Bureau of Reclamation Programs

### C.3.1 System Operations

The Yakima Field Office (YFO) Manager, in consultation with numerous entities, determines how the BOR's Yakima Project storage reservoirs and diversions are operated. In 1980, the Quackenbush decision required Reclamation to incorporate fish concerns into its management of the Yakima Project. The System Operations Advisory Committee (SOAC) was formed by the Yakima Field Office Manager in response to the supplemental instructions entitled 'Supplementary Instructions to the Water Master' November 28, 1980, in the case of Kittitas Reclamation District, et al. vs. the Sunnyside Valley Irrigation District, et al. SOAC is comprised of fish biologists representing the USFWS, the Yakama Nation, WDFW, and water users represented by the Yakima Basin Joint Board. SOAC and others provide input to the YFO Manager on operations of the Yakima Project for fish and wildlife purposes. The group worked with Reclamation to develop the flip-flop concept. Phase 2 of the Yakima enhancement legislation (see below) in 1994 directed SOAC to develop a report on biologically based flow needs for fish in the basin. The completed report lists recommendations for studies, models, etc. that may in turn result in biological flow recommendations.

## C.3.2 Yakima River Basin Water Enhancement Project

Public Law 103-434, Title XII, Yakima River Basin Water Enhancement Project (YRBWEP) was authorized by Congress in 1994. It is a multi-faceted program intended to promote water conservation, improve the reliability of the water supply for irrigation and protect, mitigate and enhance the fish and wildlife resources of the Yakima River Basin. The legislation authorizes Reclamation to work with partners to plan and implement water conservation measures throughout the Yakima River Basin, and to acquire land and water from willing sellers or lessors to improve instream flow conditions. For conservation projects, two-thirds of the conserved water is dedicated to improving instream flows. Key partners include the WDOE, the Yakama Nation, BPA, Natural Resources Conservation Service and irrigation districts. The Conservation Advisory Group (CAG) provides recommendations to the YFO Manager regarding the structure and implementation of the Basin Conservation Program. Funding for YRBWEP is dependant on Congressional appropriations. Examples of projects completed via YRBWEP include:

1) Purchase of the Wapatox Power Plant, which allows 260,000 acre-feet of water previous diverted out of the lower Naches River for power production to be left instream in an 8-mile long stretch of critical habitat
2) Work with irrigators, BPA and the Yakama Nation to increase instream flows in the Teanaway River by designing and installing two pumping plants and pipelines that increase irrigation efficiencies and divert water three miles below the original diversions
3) Sunnyside Valley Irrigation District’s construction of three reregulation reservoirs and numerous check structures. Close to 100 cfs of conserved water will be used to enhance instream flows in the Wapato reach, the most severely dewatered mainstem reach in the subbasin
4) Purchase of floodplain habitat on Taneum Creek and the Yakima River near Ellensburg
5) Purchase of lands in the Gap-to-Gap reach in the Yakima area. Approximately 600 acres of land purchased are now in various stages of being converted from agricultural or grazing lands to native grass stands

Current YRBWEP priorities include:

1) Continued cooperative work with numerous entities to set back levees and restore natural floodplain habitat and function in the Gap to Gap reach and other key sites

2) Efforts with the Yakama Nation and the Bureau of Indian Affairs to improve the efficiency of the Wapato Irrigation Project and restore the Toppenish Creek floodplain
3) Proposal to move the point of diversion for the Benton Irrigation District downstream. This would result in an additional 58 cfs remaining in the river for a 72 mile reach
4) Proposal to add a diversion at Kiona for the Kennewick Irrigation District. This would reduce the amount of water diverted at Chandler and leave additional water in the reach from Chandler to Kiona
5) Phase II irrigation efficiency improvements by the Sunnyside Irrigation District, such as piping laterals
6) Future conservation projects with other irrigation districts such as Naches-Selah and Roza, and others

### C.3.3 Yakima River Basin Water Storage Options Feasibility Study

The BOR and the state Department of Ecology are conducting a joint study of the feasibility of augmenting water supplies in the Yakima River Basin through construction of additional storage reservoirs, including the possibility of using of Columbia River water in the Yakima Basin. The goals of the proposals reviewed in the study are to: 1) improve flow conditions for anadromous fish, 2) provide a more reliable water supply for existing irrigators, and 3) provide additional water supply for future municipal demands. The study will be completed in 2008, and will detail the feasibility and costs and benefits of the:

1) Black Rock Reservoir proposal, which involves pumping water from the Columbia River into the proposed Black Rock Reservoir for subsequent use on the Roza and Sunnyside Irrigation Districts
2) Wymer Reservoir proposal, which involves a smaller reservoir which would be filled by pumping from the Yakima River during higher flow periods and by the winter release of Cle Elum Reservoir irrigation water.
3) Wymer proposal, as above, plus a pipeline that would pump water from the Columbia River to the Roza and Sunnyside Irrigation Districts.

Models and analyses developed as part of the storage study will increase our understanding of the relationship between flows, habitat characteristics such as sediment transport, water temperature and floodplain complexity, and fish production. These products will inform several key recovery actions identified in this plan.

The WDOE is conducting a parallel study of non-storage alternatives for increasing water availability, including: 1) enhanced water conservation, 2) market-based reallocation of water resources, and 3) groundwater storage.

### C.3.4 Storage Dam Fish Passage Feasibility Study

The BOR is working with the Yakama Nation, WDFW, USFWS, NOAA Fisheries and others to determine the feasibility of providing fish passage at the five Yakima Project storage dams (Tieton, Bumping, Kachess, Keechelus, and Cle Elum dams). Four of the five reservoirs were originally natural lakes and historically supported sockeye salmon and other anadromous and resident fish. When the dams were built to enlarge (or in the case of Tieton Dam, create) the lakes in the early 20$^{th}$ century, no fish passage facilities were provided. Providing fish passage at these dams has the potential to increase the distribution and abundance of steelhead, coho salmon, and Chinook salmon, allow for reintroduce of sockeye salmon to the basin, and reconnect isolated populations of bull trout. Reclamation began detailed studies to evaluate the feasibility of providing passage at the dams in 2004. Current feasibility-grade investigations are focusing on the engineering, operational, and biological parameters needed to provide fish passage at Cle Elum and Bumping Lake dams. Evaluation of passage opportunities at the other three dams will follow. The feasibility report on Cle Elum and Bumping Lake dams is scheduled for completion in 2008.

## C.4 US Forest Service Restoration Programs

The Cle Elum and Naches Ranger Districts of the Wenatchee National Forest encompass significant portions of the Upper Yakima and Naches population areas. Since 2002, both Districts have implemented the Respect the River education and restoration program, with each District expending at least $10-50,000 per year on education and on-the-ground restoration of recreation-impacted stream reaches. Cost-share partners in these projects include RCO, USFWS, Plum Creek, RIDGE, Mid-Columbia Fisheries Enhancement Group, Conservation Northwest, and the Forest Service’s Challenge Cost Share Program and Rural Development Act Title II funds. The USFS has also been actively removing known fish-passage barriers, improving riparian grazing management on Forest Service allotments, and reducing risk of landscape-scale fire.

## C.5 Washington State Fish Recovery Programs

### C.5.1 Regional Fisheries Enhancement Groups

Mid-Columbia Fisheries Enhancement Group is one of 14 Regional Fisheries Enhancement Groups (RFEGs) in Washington State. The RFEG program was created by the state legislature in 1990 to involve local communities, citizen volunteers, and landowners in the salmon enhancement. Since that time, the groups have become important partners in the state's salmon recovery efforts. The groups receive base funding from a surcharge on sport and commercial fishing license fees, through an account administered by the Washington Department of Fish & Wildlife.

The Mid-Columbia Fisheries Enhancement Group’s region covers south central Washington and includes all of the Yakima Basin. MCFEG is a non-profit organization dedicated restoring self-sustaining salmonid populations through habitat preservation, restoration and education projects, which assist landowners and promote community partnerships. A volunteer board of directors runs the group. Mid-Columbia Fisheries Enhancement Group supplements their base funding with grants, volunteer efforts, and community donations to promote, support, and sponsor fish habitat restoration and enhancement projects and watershed education programs.

### C.5.2 Salmon Recovery Funding Board Programs

After the listing of Columbia River and Puget Sound stocks under the Endangered Species Act, the governor and legislature of Washington State passed the Salmon Recovery Act of 1998. This created the statewide Salmon Recovery Funding Board (SRFB) and tasked it with funding habitat improvement projects with state appropriations and Washington's portion of the federal Pacific Coastal Salmon Recovery Fund administered by NOAA Fisheries. Washington's Recreation and Conservation Office administers the SRFB and its funding programs. The Salmon Recovery Act also called for creation of Lead Entities, which are local organizations that work at a watershed scale to prioritize and propose projects for SRFB funding. Lead Entities operate with technical and financial support from WDFW. The Yakima Basin Fish & Wildlife Recovery Board is under contract with WDFW to act as the Lead Entity for the Yakima Basin. From 1999 to 2006, the Yakima River Basin Salmon Recovery Board, which was administered by the city of Selah, served as the Lead Entity.

Each year, the Lead Entity solicits SRFB proposals from potential project sponsors in the basin, convenes technical and citizen's committees to review and prioritize the proposals, and submits a list of recommended projects to the SRFB. Priorities are guided by the Yakima Watershed Salmon Recovery Strategy, and, since 2006, the Yakima Subbasin Salmon Recovery Plan. Between 1999 and 2007, the SRFB has provided a total of $8.5 million for 44 fish habitat projects in the Yakima Basin. These include acquisitions of key fish habitat, projects to improve fish passage at road crossings and irrigation diversions, and projects that improve riparian and floodplain function. More information is available on the Board's webpage.

### C.5.3 Regional Salmon Recovery Organizations

As part of Washington's Strategy for Salmon Recovery, the State has encouraged the formation of local boards that are recognized by the state as "regional salmon recovery organizations." The state has contracted with these boards to develop regional salmon recovery plans that form the basin for federal Endangered Species Act recovery plans for salmonids in Washington. The state has provided technical and logistical support via the Governor's Salmon Recovery Office. The Yakima Subbasin Fish and Wildlife Planning Board (YSPB) was created in 2002, in response to requests from the Northwest Power and Conservation Council and the Washington Governor's Salmon Recovery Office. It drafted the Yakima Subbasin Plan under contract with BPA, and developed the initial 2005 draft of this plan with funding from the State of Washington, as described in Chapter 1. In April 2006, this Board and the Yakima Lead Entity were merged to form the Yakima Basin Fish & Wildlife Recovery Board, which was recognized as the regional salmon recovery organization for the Yakima Basin and took on responsibility for completion of the Yakima Subbasin Salmon Recovery Plan. It is under contract with the state to complete the plan and coordinate its implementation in the Yakima Basin, as described in Chapter 6.

### C.5.4 Ahtanum Creek Watershed Restoration Program

The Washington State Department of Ecology is facilitating development of a watershed restoration program for the Ahtanum Creek watershed. The objectives of the program are to:

- Develop water management strategies to improve water availability for agricultural and other out-of-stream uses in the Ahtanum Creek Watershed and provide a net benefit to the watershed aquatic ecosystem (such as fish, wildlife, plants, and habitat).
- Develop land use protection and restoration strategies to preserve and enhance Ahtanum Creek floodplain and habitat value, as well as the stability and longevity of the agricultural land uses and economy within the Ahtanum Creek Watershed.

A major action that is being considered in the Restoration Program is the Pine Hollow Reservoir, which would improve both irrigation water supplies and instream flows. The program is also developing a comprehensive list of fish habitat enhancement activities for the watershed. The program is described in detail in it Environmental Impact Statement (EIS).

## C.6 Washington Department of Ecology Water Quality Programs

In accordance with Section 303(d) of the Clean Water Act, every two years the state must identify its polluted water bodies and the type of pollution contaminating them and submit this list to EPA. In 2000, the state listed over 50 sections of streams and rivers in the Yakima Subbasin as impaired. The WDOE has initiated or completed Total Maximum Daily Load (TMDL) plans for the Granger Drain (sediment), the Teanaway River (temperature), the Lower Yakima River (sediment), the Upper Yakima River (sediment), Wilson Creek (sediment), and Naches (temperature). With cooperation from irrigation districts, agricultural organizations, other state and federal agencies and local governments, implementation of these TMDL plans has resulted in dramatic decreases in pollutant loading in both the upper and lower Yakima River. WDOE also funds water quality projects through its 319 and Centennial Water Quality grants program.

## C.8 Yakima Basin Joint Board

The Yakima Basin Joint Board of Control is a group of irrigation districts that works together to address common technical, legal, and policy issues. They are represented on SOAC by a fish biologist. The majority of projects the Joint Board funds are research or monitoring oriented. Past work includes assessments of fish use and habitat conditions within irrigation-district managed facilities, development of a water temperature model for the lower Yakima, and analysis of the population status of species that may be affected by management actions. Most major projects that improve water quality and irrigation efficiencies are undertaken by each individual irrigation entity, groups of irrigators, or through YRBWEP. The Roza-Sunnyside Board of Joint Control is a separate organization that administers the water quality program in the lower valley in association with South Yakima Conservation District; the Kittitas County Water Purveyors coordinates water quality and irrigation system improvements in the Upper Yakima.

## C.9 Local Government Land Use Regulations

### C.9.1 Growth Management Act

The Growth Management Act (GMA) (RCW 36.70A) was passed in 1990. Several of its provisions pertain to fish habitat:

- A Comprehensive Plan is the official land use policy for a local government
- Regulatory ordinances to implement the plan are required, and must and be consistent with the plan policy
- For public health and safety, the protection of ground and surface waters from pollution is require.
- Local governments must first identify (i.e., map) and then protect with regulations “natural resource lands” (agricultural and mineral resources lands), and “Critical Resources Areas,” of which there are five (frequently flooded areas, geologically hazardous areas, wetlands, critical aquifer recharge areas, and fish and wildlife habitat conservation areas)
- Regulations protecting Critical Resources must be based upon “best available science”

Not all counties and cities within the state are required to prepare and implement comprehensive plans under GMA. But all counties and cities, whether planning under GMA or not, are required to identify Critical Resource Areas and protect them by regulation. Critical Resource Area Ordinances are applied only through a development review process initiated by a submitted application to undertake a regulated action, or through an enforcement/compliance action related to a project action that has not been reviewed and authorized (permitted) by the local jurisdiction.

### C.9.2 Shoreline Management Act

The state Shoreline Management Act (SMA) requires cities and counties with lands on “state waters” to adopt a Shorelines Management Plan and implementing regulations. Typical plans prepared prior to the most recent edition of the State Shorelines Guidelines included three or four general land use designations (e.g., Rural, Urban, Industrial), and an implementing ordinance intended to regulate development consistent with the protection of shoreline resources and public access to the shoreline. Local SMA permit actions can be appealed to the State Shorelines Board, which can deny or modify a local permit action. Under the state rules, certain categories of development are exempt from shorelines review. The boundary of SMA jurisdiction is generally extends 200’ upland of the ordinary high water line but can extend further upland to include the 100 year floodplain and riverine wetlands. Public notice for shoreline actions is required.

# APPENDIX D: Stakeholder and Public Meetings

During the initial development of this plan, and extensive series of meeting was held to gather public input (see Section 1.3.2 and D.1 below). The October 2005 draft of the Yakima Subbasin Salmon Recovery Plan was made available via the Yakima Basin Fish & Wildlife Recovery Board's website and was put out for formal public review by NOAA Fisheries in the spring 2006 (See Section 1.1.3). Formal comments were received from American Rivers, the Yakima Basin Joint Board of Control, and the BOR. Meetings held following the Board's assumption of responsibility for the plan are listed in Section D.2. This final review draft will be made available via the Board's website and at public locations throughout the Basin. Additional meetings held after release of this review draft will be listed in section D.3 in the final version of this plan.

## D.1 Stakeholder Meetings Held in 2005

The Yakima Subbasin Fish & Wildlife Planning Board and partners met with the following organizations during development of the initial draft of the Yakima Subbasin Salmon Recovery Plan in 2005:

| | |
|---|---|
| Naches Ranger District, Wenatchee National Forest, USFS | *February 23, 2005* |
| Bureau of Reclamation, Yakima | *February 28, 2005* |
| Cle-Elum Ranger District, Wenatchee National Forest, USFS | *March 8, 2005* |
| North Yakima Conservation District | *March 9, 2005* |
| Washington State Department of Fish and Wildlife | *March 16, 2005* |
| Kittitas County Conservation District | *March 18, 2005* |
| Kittitas County Water Purveyors | *March 18, 2005* |
| City of Yakima Water Systems | *March 23, 2005* |
| City of Yakima Maintenance | *March 23, 2005* |
| City of Yakima Planning | *March 23, 2005* |
| Washington Department of Ecology | *March 25, 2005* |
| Yakima Basin Joint Board Of Control | *March 25, 2005* |
| Kittitas Irrigation District ` | *March 25, 2005* |
| Roza Irrigation District | *March 25, 2005* |
| Sunnyside Irrigation District | *March 25, 2005* |
| Richland Irrigation District | *March 25, 2005* |
| Cascade Irrigation District | *March 25, 2005* |
| Benton County Conservation District | *March 28, 2005* |

| | |
|---|---|
| South Yakima Conservation District | *March 28, 2005* |
| Barker Ranch | *March 28, 2005* |
| Yakima County Public Works Maintenance | *March 31, 2005* |
| City of Richland | *April 4, 2005* |
| Ahtanum Irrigation District | *April 4, 2005* |
| Washington Department Of Transportation | *April 4, 2005* |
| Yakima County Planning | *April 6, 2005* |
| South Central Washington Resource Conservation & Development | *April 6, 2005* |
| Yakima Tributary Access and Habitat Project | *April 6, 2005* |
| Yakima Audubon | *April 12, 2005* |
| Washington State Cattlemen's Association | *April 18, 2005* |
| City of Ellensburg Public Works Department | *April 19, 2005* |
| Washington Department of Natural Resources | *April 22, 2005* |
| Washington Farm Bureau | *April 25, 2005* |

## D.2 Stakeholder Meetings Held April 2006 to January 2008

Responsibility for completion of this plan transferred to the Yakima Basin Fish & Wildlife Recovery Board in April 2006. Regular updates on the planning process were held at the regular public meetings of the Yakima Basin Fish & Wildlife Recovery Board's Board of Directors. Additional stakeholder meeting that were held to update interested parties on the planning process following this transfer include:

| | |
|---|---|
| Selah Kiwanis | *November 28, 2006* |
| Mid-Columbia Regional Fisheries Enhancement Group | *January 18, 2007* |
| Yakima Aquatic Science & Management Conference | *June 14, 2007* |
| South Central WA Resource, Conservation & Development | *September 6, 2007* |
| Yakima/Klickitat Fisheries Project Policy Group | *September 19, 2007* |
| Benton County Conservation District | *October 10, 2007* |
| Yakima Basin Joint Board of Control | *Nov. 14 & 30, 2007* |
| Bureau of Reclamation, Yakima | *May 22, 2008* |
| Washington Department of Fish & Wildlife | *May 23, 2008* |

In April though June of 2008, the Board received informal comments on the March 24, 2008 review draft. A summary of comments and responses is available on the Board's website (www.ybfwrb.org); changes made to the plan in response to these comments are included in this draft.

## D.3 Plan Outreach During 2008 NOAA Comment Period

During the September 23rd to December 23rd formal comment period on the NOAA Middle Columbia Steelhead Recovery Plan, the Yakima Basin Fish & Wildlife Recovery Board conducted the following outreach activities:

**General Outreach:**

Press release to local papers on release day (resulted in Yakima Herald Article)

Information on plan and comment period posted on Board website

Federal Register notice on Sept. 24th by NOAA

Email about comment period to Board email contacts (last week of Sept & mid-Nov)

**Presentations:**

Yakima Basin Joint Board (major irrigators)

Yakima Audubon

Yakima Flyfishing Club

Cowiche Canyon Conservancy

Federal Caucus (federal agencies involved in Columbia salmon issues)

Federal legislative staffers (via NOAA conference call)

Yakima Basin Water Resources Agency Board

NOAA Public meeting Nov 19th

Yakima Basin Water Resources Agency Water Resource Advisory Board (Dec 1st)

South Yakima Conservation District

Kittitas Cattle Growers

**Informational materials and offer to present if requested provided to:**

Conservation Districts (North Yakima, Kittitas, South Yakima & Benton)

Kittitas Field & Stream Club

Mid-Columbia Regional Fisheries Enhancement Group

State legislators (via email on release date of NOAA plan)

Tapteal Greenway Association

Benton Conservation District

**Phone Discussions**

Bureau of Reclamation staff

US Forest Service staff

Native Fish Society

American Rivers

# REFERENCES

Antolos, M., and coauthors. 2005. Caspian tern predation on juvenile salmonids in the Mid-Columbia River. Transactions of the American Fisheries Society 134:466-480.

Arango, C. 2001. The effect of a sudden flow reduction on aquatic insects of the upper Yakima River Washington, USA. Masters thesis. Central Washington University, Ellensburg, WA.

Beamish, R. J. 1995. Climate change and northern fish populations. Canadian Special Publication of Fisheries and Aquatic Sciences 121:739.

Beamish, R. J., and D. R. Bouillon. 1993. Pacific salmon production trends in relation to climate. Canadian Journal of Fisheries and Aquatic Sciences 50:1002-1016.

Beauvais, S. L., S. B. Jones, S. K. Brewer, and E. E. Little. 2000. Physiological measures of neurotoxicity of diazinon and malathion to larval rainbow trout (*Oncorhynchus mykiss*) and their correlation with behavioral measures. Environmental Toxicology and Chemistry 19:1875-1880.

Bjornn, T. C., and D. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 *in* W. R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication, no. 19, Bethesda, MA.

BOR (U.S. Bureau of Reclamation). 2002. Interim comprehensive basin operating plan for the Yakima Project, Washington. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, ID.

BOR (U.S. Bureau of Reclamation). 2005. Reclamation--managing water in the West: Storage dam fish passage study, Yakima Project, Washington, Phase I Assessment Report. Pacific Northwest Region, Technical Series No. PN-YDFP-001, Boise, ID.

BPA (Bonneville Power Administration) Division of Fish and Wildlife. 1990. Preliminary design report for the Yakima/ Klickitat production project, March 1990, DOE/BP-00245, Portland, OR.

Bradford, M. J. 1995. Comparative analysis of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52:1327-1338.

Branstetter, R., and coauthors. 2005. Kelt reconditioning: A research project to enhance iteroparity in Columbia Basin steelhead (*Oncorhynchus mykiss*), Annual Report to Bonneville Power Administration, Project 200001700, DOE/BP-00020183-1, Portland, OR.

Bretz, J. H. 1969. The Lake Missoula floods and the channeled scabland. Journal of Geology 77:505-543.

Brewer, S. K., and coauthors. 2001. Behavioral dysfunctions correlate to altered physiology in rainbow trout (*Oncorhynchus mykiss*) exposed to cholinesterase-inhibiting chemicals. Archives of Environmental Contamination and Toxicology 40(1):70-76.

Busby, P. J., and coauthors. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon and California. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA, and National Marine Fisheries Service Southwest Region Protected Species Management Division, Long Beach, CA, U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-27.

Climate Impacts Group. 2009. The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate. University of Washington, Seattle, Washington.

Collis, K., S. Adamany, D. D. Roby, D. P. Craig, and D. E. Lyons. 2000a. Avian predation on juvenile salmonids in the Lower Columbia River, 1998 Annual Report to the Bonneville Power Administration and U.S. Army Corps of Engineers, Portland, OR.

Collis, K., D. Roby, D. P. Craig, B. A. Ryan, and R. D. Ledgerwood. 2000b. Colonial waterbird predation on juvenile salmonids tagged with passive integrated transponders in the Columbia River Estuary: Vulnerability of different of species, stocks, and rearing types. Transactions of the American Fisheries Society 131(3):537-550.

Collis, K., and D. D. Roby. 2006. Research, monitoring, and evaluation of avian predation on salmonid smolts in the Lower and Mid-Columbia River: Draft 2005 season summary. Bonneville Power Administration and the U.S. Army Corps of Engineers, Portland, OR.

Collis, K., and coauthors. 2002. Colony size and diet composition of piscivorous waterbirds on the Lower Columbia River: Implications for losses of juvenile salmonids to avian predation. Transactions of the American Fisheries Society 131(3):537-550.

Cooney, T., and D. Holzer. 2006. Appendix C: Interior Columbia Basin stream type Chinook salmon and steelhead populations: Habitat intrinsic potential analysis. Pages C1-21 *in* ICTRT (Interior Columbia Technical Recovery Team), editor. Viability criteria for application to Interior Columbia Basin salmonid ESUs (Technical review draft 2007). US Department of Commerce, NOAA Northwest Fisheries Science Center, Seattle, WA.

Craig, J., and R. Hacker. 1940. The history and development of the fisheries of the Columbia River. Bulletin of the U.S. Bureau of Fisheries 49:129-216.

Cramer, S. P., D. B. Lister, P. A. Monk, B. J. Pype, and K. L. Witty. 2003. A review of abundance trends, hatchery and wild fish interactions, and habitat features for the Middle Columbia Steelhead ESU. Prepared for Mid Columbia Stakeholders, S.P. Cramer & Associates, Sandy, OR.

Cramer, S. P., D. B. Lister, P. A. Monk, and K. L. Witty. 2004. Viability of the Middle Columbia Steelhead ESU. Prepared for Yakima Basin Joint Board, S.P. Cramer & Associates, Sandy, OR.

Cuffney, T. F., M. R. Meador, S. D. Porter, and M. E. Gurtz. 1997. Distribution of fish, benthic invertebrate, and algal communities in relation to physical and chemical conditions, Yakima River Basin. U.S. Department of the Interior, Geological Survey, Water Investigations Report 96-4280, Raleigh, NC.

Davidson, F. A. 1953. Historical notes on development of Yakima River Basin. Yakama Indian Nation, Mimeo report, Toppenish, WA.

Dolloff, C. A. 1993. Predation by river otters (*Lutra Canadensis*) on juvenile coho salmon (*Oncorhynchus kisutch*) and Dolly Varden (*Salvelinus malma*) in southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences 50:312-315.

Dunham, J. B., M. K. Young, R. E. Gresswell, and B. E. Rieman. 2003. Effects of fire on fish populations: landscape perspectives on persistence of native fishes and nonnative fish invasions. Forest Ecology and Management 178:183-196.

Ebbert, J. C., and S. S. Embrey. 2002. Pesticides in surface water of the Yakima River Basin, Washington, 1999–2000: Their occurrence and an assessment of factors affecting concentrations and loads. U.S. Department of the Interior, Geological Survey, Water Resources Investigations Report 01–4211.

Eitemiller, D. J., C. P. Arango, K.L. Clark, and M. L. Uebelacker. 2002. The effects of anthropogenic alterations to lateral connectivity on seven select alluvial floodplans within the Yakima River Basin, Washington. Department of Geography and Land Studies, Central Washington University, Ellensburg, WA.

Fast, D. E., and L. Berg. 2001. Yakima subbasin summary. Northwest Power Planning Council, Portland, OR.

Fast, D. E., J. D. Hubble, M. S. Kohn, and D. B. Watson. 1991. Yakima River spring Chinook enhancement study. Bonneville Power Administration, Final Report: Project No. 82-16, DOE/BP-39461-9, Portland, OR.

Foott, S. J. 1992. Disease survey of the Trinity River salmonid smolt populations, 1991 Report. U.S. Fish and Wildlife Service, California-Nevada Fish Health Center, Anderson, CA.

FPC (Fish Passage Center) and Comparative Survival Study Oversight Committee. 2006. Comparative survival study of PIT-tagged spring/summer Chinook and summer steelhead, 2006 Annual Report, Portland, OR.

Fritts, A. T. N. P. 2004. Smallmouth bass predation on hatchery and wild salmonids in the Yakima River, Washington. Transactions of the American Fisheries Society (133):880-895.

Fritts, A. T. N. P. 2006. Effects of predation by nonnative smallmouth bass on native salmonid prey: The role of predator and prey size. Transactions of the American Fisheries Society (135):853-860.

Fryer, J. L., and J. E. Sanders. 1981. Bacterial kidney disease of salmonid fish. Annual Review of Microbiology 35:273-298.

Gray, G., and D. Rondorf. 1986. Predation on juvenile salmonids in Columbia Basin reservoirs. Pages 178-185 *in* G. Hall, and M. V. D. Avyle, editors. Reservoir fisheries management strategies for the 80's. Southern Division American Fisheries Society, Bethesda, MD.

GSRO (Governor's Salmon Recovery Office) and NMFS (National Marine Fisheries Service). 2005. Recommendations to the Salmon Recovery Regions. Washington Recreation and Conservation Office, Olympia.

Haring, D. 2001. Habitat limiting factors, Yakima River watershed WRIAs 37-39, Final Report. Washington State Conservation Commission, Olympia.

Henjum, M. G., and coauthors. 1994. Interim protection for late-successional forests, fisheries, and watersheds: National forests east of the Cascades crest, Oregon and Washington. The Wildlife Technical Review 94(2).

Hockersmith, E., J. Vella, L. Stuehrenberg, R. N. Iwamoto, and G. Swan. 1995. Yakima River radio-telemetry study: Steelhead, 1989-93, U. S. Department of Energy, Bonneville Power Administration, Project Number 89-089, Contract Number DE-AI79439BP00276. Supercedes report DE95014444; PBD: 1 Jan 1995.

Hoffman, G. L., and O. N. Bauer. 1971. Fish parasitology in water reservoirs: A review. Pages 495-511 *in* G. E. Hall, editor. Reservoir fisheries and limnology. American Fisheries Society, Washington, D.C.

Howell, P. K., and coauthors. 1985. Stock assessment of Columbia River anadromous salmonids, volume II: Steelhead stock summaries stock transfer guidelines; information needs, Final Report to Bonneville Power Administration, Contract DE-AI79-84BP12737, Project 83-335, Portland, OR.

Hubble, J., T. Newsome, and J. Woodward. 2004. Yakima coho master plan, Yakima/Klickitat Fisheries Project. Yakama Indian Nation, in cooperation with Washington Department of Fish and Wildlife, Toppenish, WA.

Hunter, J. 1959. Survival and production of pink and chum salmon in a coastal stream. Journal of the Fisheries Research Board of Canada 16:835-886.

ICTRT (Interior Columbia Technical Recovery Team). 2003. Independent populations of Chinook, steelhead, and sockeye for listed Evolutionarily Significant Units within the Interior Columbia River Domain. U.S. Department of Commence, NOAA Fisheries Science Center, Seattle, WA.

ICTRT (Interior Columbia Technical Recovery Team). 2004a. Delisting criteria summary of approach and preliminary results. U.S. Department of Commence, NOAA Fisheries, Portland, OR.

ICTRT (Interior Columbia Technical Recovery Team). 2004b. Preliminary guidelines for population-level abundance, productivity, spatial structure, and diversity supporting viable salmonid populations: An update. U.S. Department of Commence, NOAA Fisheries Northwest Science Center, Portland, OR.

ICTRT (Interior Columbia Technical Recovery Team). 2005a. Interior Columbia Basin TRT: Viability criteria for application to Interior Columbia Basin salmonid ESUs. U.S. Department of Commence, NOAA Fisheries Northwest Science Center, Portland, OR.

ICTRT (Interior Columbia Technical Recovery Team). 2005b. Interior Columbia Basin TRT: Viability criteria for application to Interior Columbia Basin salmonid ESUs, update. U.S. Department of Commence, NOAA Fisheries Northwest Science Center, Portland, OR.

ICTRT (Interior Columbia Technical Recovery Team). 2005c. Updated population delineation in the interior Columbia Basin. U.S. Department of Commence, NOAA Fisheries Science Center, Seattle, WA.

ICTRT (Interior Columbia Technical Recovery Team). 2007a. Scenarios for MPG and ESU viability consistent with TRT viability criteria. U.S. Department of Commence, NOAA Northwest Fisheries Science Center, Seattle, WA.

ICTRT (Interior Columbia Technical Recovery Team). 2007b. Viability criteria for application to Interior Columbia Basin salmonid ESUs. Technical review draft. U.S. Department of Commence, NOAA Fisheries, Portland, OR.

ICTRT (Interior Columbia Technical Recovery Team). In press. Yakima Basin stock status assessments. U.S. Department of Commerce, NOAA Fisheries Northwest Science Center, Portland, OR.

ISAB (Independent Scientific Group). 1996. Return to the river: Restoration of salmonid fishes in the Columbia River ecosystem--development of an alternative conceptual foundation and review and synthesis of science underlying the Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council, Portland, OR.

ISAB (Independent Scientific Group). 2000. Return to the river 2000: Restoration of salmonid fishes in the Columbia River ecosystem. Northwest Power Planning Council, NPPC 2000-12, Portland, OR.

ISP (Independent Science Panel). 2000. Recommendations for monitoring salmon recovery in Washington State. Governor’s Salmon Recovery Office, ISP Report 2000-2, Olympia, WA.

ISP (Independent Science Panel). 2002. Responses of salmon and trout to habitat changes. Governor’s Salmon Recovery Office, ISP Technical Memorandum 2002-2, Olympia, WA.

James, B. B., T. N. Pearsons, and G. A. McMichael. 1999. Spring Chinook salmon interactions indices and residual/precocial monitoring in the upper Yakima Basin, 1998 Annual Report, U. S. Department of Energy, Bonneville Power Administration, DOE/BP-64878-4, Portland, OR.

Jamieson, B., and J. H. Braatne. 2001. Riparian Cottonwood Ecosystems and Regulated Flows in Kootenai and Yakima Subbasins: Impacts of Flow Regulation on Riparian Cottonwood Forests of the Yakima River. 2000-2001 Technical Report, Project No. 200006800. BPA Report DOE/BP-00000005-3.

Jobling, M. 1981. Temperature tolerance and the final preferendum- rapid methods for the assessment of optimum growth temperatures. Journal of Fish Biology 19(4):439-455.

Johnson, A., D. Norton, and W. Yake. 1986. Occurrence and significance of DDT compounds and other contaminants in fish, water, and sediment from the Yakima River Basin. Washington Department of Ecology, Publication No. 86-5, Olympia.

Joy, J. 2002. Suspended sediment and organochlorine pesticide total maximum daily load evaluation. Environmental Assessment Program, Washington Department of Ecology, Publication No. 02-30-012, Olympia.

Joy, J., and B. Patterson. 1997. A suspended sediment and DDT Total Maximum Daily Load evaluation report for the Yakima River. Washington State Department of Ecology Environmental Assessment Program, Publication #97-321, Olympia.

Karp, C., W. Larrick, M. Johnston, and T. Dick. 2003. Summary of upper Yakima River steelhead movement, winter 2002/2003. U. S. Department of Interior, Bureau of Reclamation.

Karp, C., W. Larrick, M. Johnston, and T. Dick. 2005. Steelhead movements in the upper Yakima Basin, winter 2003/2004. U. S. Department of Interior, Bureau of Reclamation Technical Service Center, Technical Memorandum 8290-05-01, Denver, CO.

Karp, C., W. Larrick, M. Johnston, and T. Dick. 2009. Steelhead Movements in the Upper Yakima River Basin, Fall 2002 – Spring 2006. U.S. Department of the Interior, Bureau of Reclamation Technical Service Center, Technical Memorandum No. 3290-07-05, Denver, Colorado.

Kinnison, H. B., and J. E. Sceva. 1963. Effects of hydraulic and geologic factors on streamflow of the Yakima River Basin, Washington. U.S. Government Printing Office, U.S. Geological Survey Water Supply Series, Washington, D.C.

Kreeger, K. E., and W. J. McNeil. 1993. Summary and estimation of the historic run-sizes of anadromous salmonids in the Columbia and Yakima rivers. Yakima River Basin Coalition, Yakima, WA.

Lawson, P. W. 1993. Cycles in ocean productivity, trends in habitat quality, and the restoration of salmon runs in Oregon. Fisheries 18(8):6-10.

Lee, D. C., J. R. Sedell, B. E. Rieman, R. F. Thurow, and J. E. Williams. 1997. Broadscale assessment of aquatic species and habitats. Pages 1,057-496 *in* T. M. Quigley, and S. Arbelbide, editors. An assessment of ecosystem components in the Interior Columbia Basin, volume III. General Technical Report PNW-GTR-405. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Lestelle, L. C., L. E. Mobrand, J. A. Lichatowich, and T. S.Vogel. 1996. Ecosystem Diagnosis and Treatment (EDT): Applied ecosystem analysis- a primer, Report to Bonneville Power Administration, Project No. 199404600, BPA DOE/BP-33243-2, Portland, OR.

Lestelle, L. C., L. E. Mobrand, and W. E. McConnaha. 2004. Information structure of Ecosystem Diagnosis and Treatment (EDT) and habitat rating rules for Chinook salmon, coho salmon, and steelhead trout. Mobrand Biometrics, Vashon Island, WA.

Li, H., C. Schreck, C. Bond, and E. Rexstad. 1987. Factors influencing changes in fish assemblages of Pacific Northwest streams. Pages 193-202 *in* W. Matthews, and D. Heins, editors. Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press, Norman.

Lichatowich, J., L. E. Mobrand, L. Lestelle, and T. Vogel. 1995. An approach to the diagnosis and treatment of depleted Pacific salmon populations in freshwater ecosystems. Fisheries 20(1):10-18.

Lichatowich, J. A. 1999. Salmon without rivers. Island Press, New York.

Little, E. E., R. D. Archeski, B. A. Flerov, and V. I. Kozlovskaya. 1990. Behavioral indicators of sublethal toxicity in rainbow trout. Archives of Environmental Contamination and Toxicology 19(3).

Little, E. E., F. J. Dwyer, J. F. Fairchild, A. J. DeLonay, and J. L. Zajicek. 1993. Survival and behavioral response of bluegill during continuous and pulsed exposures to the pyrethroid insecticide ES-fenvalerate. Environmental Toxicology and Chemistry 12:871-878.

Loxterman, J. A., and S. Young. 2003. Geographic population genetic structure of steelhead in the Yakima River Basin. Pages 6-24 *in* C. Busack et al., editor. Yakima/Klickitat Fisheries Project Genetic Studies; Yakima/Klickitat Fisheries Project Monitoring and Evaluation, 2001-2 Annual Report. Project No. 199506325, BPA Report DOE/BP-00004666-1. Bonneville Power Administration, Portland, OR.

Martin, S. W., T. N. Pearsons, and S. A. Leider. 1994. Rainbow trout distribution and population abundance variation in the upper Yakima River Basin. Pages 70-104 *in* T. N. Pearsons, and coeditors, editors. Yakima River Species Interactions Studies Annual Report 1993. DOE/BP-99852-2. Bonneville Power Administration, Portland, Oregon.

Mastin, M. C. 2008. Effects of potential future warming on runoff in the Yakima River Basin, Washington. U.S. Geological Survey, Scientific Investigations Report 2008-5124.

McElhany, P., M. Ruckelshaus, M. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, NOAA Northwest Fisheries Science Center, NOAA Technical Memo NMFS-NWFSC-42, Seattle, WA.

McGinn, N. A., editor. 2002. Fisheries in a changing climate: Symposium 32 proceedings. American Fisheries Society, Bethesda, MD.

McIntosh, B. A., and coauthors. 1994. Historical changes in fish habitat for select river basins of Eastern Oregon and Washington. Northwest Science 68:36-53.

McMichael, G. A., T. N. Pearsons, and S. A. Leider. 1999. Behavioral interactions among hatchery-reared steelhead smolts and wild *Oncorhynchus mykiss* in natural streams. North American Journal of Fisheries Management 19(4):948-956.

McMichael, G. A., C. S. Sharpe, and T. N. Pearsons. 1997. Effects of residual hatchery-reared steelhead on growth of wild rainbow trout and spring Chinook salmon. Transactions of the American Fisheries Society 126(2):230-239.

Mobrand Biometrics. 1999. Phase 1 completion report: EDT analysis of the Yakima and Klickitat rivers. Mobrand Biometrics, Report prepared for the Yakama Indian Nation, Vashon Island, WA.

Mobrand, L. E., J. A. Lichatowich, L. C. Lestelle, and T. S. Vogel. 1997. An approach to describing ecosystem performance through the eyes of a salmon. Canadian Journal of Fisheries and Aquatic Sciences 54:2964-2973.

Monk, P. 2001. Fish surveys in the Roza-Sunnyside Board of Joint Control irrigation drain network: Summary of Major Findings for 2001. Roza-Sunnyside Board of Joint Control, Sunnyside, WA.

Moore, A., and C. P. Waring. 1998. Mechanistic effects of a triazine pesticide on reproductive endocrine function in mature male Atlantic salmon (*Salmo salar L.*) parr. Pesticide Biochemistry and Physiology 62(1):41-50.

Moore, A., and C. P. Waring. 2001. The effects of a synthetic pyrethroid pesticide on some aspects of reproduction in Atlantic salmon (*Salmo salar L.*). Aquatic Toxicology 52(1):1-12.

Morace, J. L., G. J. Fuhrer, and J. F. Rinella. 1999. Surface-water-quality assessment of the Yakima River Basin in Washington: Overview of major findings, 1987-91. U.S. Department of the Interior, Geological Survey, Water Resource Investigations Report 98-4113, Portland, OR.

Morgan, M. J., and J. W. Kiceniuk. 1990. Effect of fenitrothion on the foraging behavior of juvenile Atlantic salmon. Environmental Toxicology and Chemistry 9:489-495.

Muir, M. J. 2003. Evaluation of restoration projects and channel changes in the Little Naches basin, with a comparison to the American River basin. Master's thesis. University of Washington, Seattle.

National Resource Council (NRC). 1996. Upstream: Salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

NMFS (National Marine Fisheries Service). 1996. Factors contributing to the decline of West Coast steelhead. U. S. Department of Commerce, NOAA Protected Resources Division, Portland, OR.

NMFS (National Marine Fisheries Service). 2000. Predation on salmonids relative to the federal Columbia River power system. White Paper. U. S. Department of Commerce, NOAA Northwest Fisheries Science Center, Seattle, WA.

NMFS (National Marine Fisheries Service). 2004. Interim endangered and threatened species recovery planning guidance. U. S. Department of Commerce, NOAA, Silver Spring, MD.

NMFS (National Marine Fisheries Service). 2005. Draft guidelines for limiting factors and threats assessment. U. S. Department of Commerce, NOAA, Portland, OR.

NMFS (National Marine Fisheries Service). 2007. Adaptive management for ESA-listed salmon and steelhead recovery: Decision framework and monitoring guidance. U. S. Department of Commerce, NOAA Northwest Region and Northwest Fisheries Science Center, Portland, OR.

NMFS (National Marine Fisheries Service). 2008. Middle Columbia River Steelhead Recovery Plan, Portland, OR.

NMFS (National Marine Fisheries Service) Northwest Region. 2006. Supplement to the draft Yakima subbasin salmon recovery plan. U. S. Department of Commerce, NOAA, Portland, OR.

NPPC (Northwest Power Planning Council). 1986. Appendix D: Compilation of information on salmon and steelhead losses in the Columbia River basin. 1987 Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council, Portland, OR.

NPPC (Northwest Power Planning Council). 2004. Lower Middle Mainstem including Rock Creek subbasin plan. Northwest Power Planning Council, Portland, OR.

NRC (National Research Council). 1996. Upstream: Salmon and society in the Pacific Northwest. National Academy Press, Washington D.C.

ODFW (Oregon Department of Fish & Wildlife). 2005. Oregon native fish status report, volume II, Salem, OR.

Omernik, J. M. 1987. Aquatic ecoregions of the conterminous United States. Annals of the Associations of American Geographers 77:118-125.

Pacific Northwest National Laboratory, editor. 1989. Global warming: A Northwest perspective. Proceedings of the Northwest Power Planning Council conference on global warming, Portland, OR.

Palmisano, J. F., R. H. Ellis, and V. W. Kaczynski. 1993. The impact of environmental and management factors on Washington's wild anadromous salmon and trout. Washington Forest Protection Association and Washington Department of Natural Resources, Olympia.

Patten, B. 1962. Cottid predation upon salmon fry in a Washington stream. Transactions of the American Fisheries Society 91:427-429.

Patten, B. 1971a. Increased predation by the torrent sculpin (*Cottus rhotheus*) on coho salmon fry (*Oncorhynchus kisutch*) during moonlight nights. Journal of the Fisheries Research Board of Canada 28:1352-1354.

Patten, B. 1971b. Predation by sculpins on fall Chinook salmon (*Oncorhynchus tshawytscha*) fry of hatchery origin. U. S. Department of Commerce, National Marine Fisheries Service.

Pearcy, W. 1992. Ocean ecology of North Pacific salmonids. University of Washington Press, Seattle.

Pearsons, T. N., and coauthors. 2004. Yakima River species interactions studies, Yakima/Klickitat Fisheries Project Monitoring and Evaluation Report 7 of 7, 2003-2004 Annual Report, Project No. 199506325. Bonneville Power Administration, Report DOE/BP-00013756-7, Portland, OR.

Pearsons, T. N., and C. W. Hopley. 1999. A practical approach for assessing ecological risks associated with fish stocking programs. Fisheries 24(9):16-23.

Pearsons, T. N., and coauthors. 1993. Yakima River species interaction studies. Annual report for FY 1992. Bonneville Power Administration, Project Number 1989-10, DOE/BP-01483-3, Portland, OR.

Pearsons, T. N., and coauthors. 1998. Yakima River species interactions studies. Bonneville Power Administration, Progress report 1995-1997, Project No. 199506402, DOE/BP-64878-6, Portland, OR.

Pearsons, T. N., S. R. Phelps, S. W. Martin, E. L. Bartrand, and G. A. McMichael. 2007. Gene flow between resident and anadromous *Oncorhynchus mykiss* in the Yakima Basin: Ecological and genetic evidence. Pages 56-64 *in* K. Schroeder, and J. D. Hall, editors. Redband trout: Resilience and challenge in a changing landscape. Oregon Chapter, American Fisheries Society, Corvallis, Oregon.

Pearsons, T. N., and coauthors. 1996. Yakima River species interactions studies. Bonneville Power Administration, Annual Report FY 1994, Project No. 198910500, DOE/BP-99852-3, Portland, OR.

Pearsons, T. N., and J. Thomas. 2003. Pathogen screening of naturally produced Yakima River spring Chinook smolts, Yakima/Klickitat Fisheries Project Monitoring and Evaluation, Annual Report 2001. Bonneville Power Administration, Project No. 1995-06424, DOE/BP-00004666-8, Portland, OR.

Peven, C. M., R. R. Whitney, and K. R. Williams. 1994. Age and length of steelhead smolts from the mid-Columbia River basin, Washington. N. Amer. J. Fish. Management 14:77-86.

Phelps, S. R., B. M. Baker, and C. A. Busack. 2000. Genetic relationships and stock structure of Yakima River Basin and Klickitat River Basin steelhead populations. Washington Department of Fish and Wildlife, Unpublished report, Olympia.

Poff, N. L., and J. V. Ward. 1989. Implications of streamflow variability and predictability for lotic community structure: A regional analysis of streamflow patterns. Canadian Journal of Fisheries and Aquatic Science 46:1805-1817.

Reeves, G. H., F. H. Everest, and J. D. Hall. 1987. Interactions between the redside shiner (*Richardsonius balteatus*) and the steelhead trout (*Salmo gairdner*i) in western Oregon: the influence of water temperature. Canadian Journal of Fisheries and Aquatic Sciences 44:1603-1613.

Rhodes, J. D., D. McCullough, and F. A. Espinosa Jr. 1994. A coarse screening process for evaluation of the effects of land management activities on salmon spawning and rearing habitat in ESA consultations. Columbia River Inter-Tribal Fish Commission, Technical Report 94-4, Portland, OR.

Rieman, B. E., R. E. Gresswell, M. K. Young, and C. H. Luce. 2003. Introduction to the effects of wildland fire on aquatic ecosystems in the Western USA. Forest Ecology and Management 178:1-3.

Rinella, J. F., and coauthors. 1999. Surface water-quality assessment of the Yakima River Basin, Washington: Distribution of pesticides and other organic compounds in water, sediment, and aquatic biota, 1987-91. U.S. Department of the Interior, U.S. Geological Survey, Water-Supply Paper 2354-B, Denver, CO.

Rinella, J. F., S. W. McKenzie, and G. J. Fuhrer. 1992. Surface water-quality assessment of the Yakima River Basin, Washington: Analysis of available water-quality data through 1985 water year. U.S. Department of the Interior, Geological Survey, Open-File Report 91-453, Portland, OR.

Ringer, G., and T. McCoy. 1998. Satus Creek watershed analysis. U.S. Department of the Interior, Bureau of Indian Affairs, Portland, OR.

Romey, B., and S. Cramer. 2001. Aquatic habitat survey of irrigation drainage networks: Lower Yakima River Basin. Roza-Sunnyside Board of Joint Control and U. S. Bureau of Reclamation, Yakima, WA.

Saglio, P., and S. Trijasse. 1998. Behavioral responses to atrazine and diuron in goldfish. Archives of Environmental Contamination and Toxicology 35:484-491.

Salmon Recovery Science Review Panel. 2004. Report for the meeting of the Southwest Fisheries Science Center of the National Marine Fisheries Service held December 2004, Santa Cruz, CA.

Scholz, N. L., and coauthors. 2000. Diazinon disrupts antipredator and homing behaviors in chinook salmon (*Oncorhynchus tshawytscha)*. Canadian Journal of Fisheries and Aquatic Sciences 57(9):1911-1918.

Scott, J. B., and W. T. Gill. 2006. *Oncorhynchus mykiss*: Assessment of Washington State's anadromous populations and programs. Washington Department of Fish and Wildlife, Olympia.

Sherwood, C., D.A. Jay, R.B. Harvey, P. Hamilton, and C. A. Simenstad. 1990. Historical changes in the Columbia River estuary. Progressive Oceanography (25):299-352.

Siegel, J., and D. E. Fast. 2006. Monitoring and evaluation of avian predation on juvenile salmonids on the Yakima River, Washington. Annual Report 2005, Appendix I in Yakima/Klickitat Monitoring and Evaluation Project (199506325). 2005-2006 Annual Report to Bonneville Power Administration, DOE/BP 00022449-1, Portland, OR.

Small, M. P., J. L. Loxterman, and S. F. Young. 2006. Microsatellite DNA study of population genetic structure among Yakima Basin steelhead. Pages 82-113 *in* C. Busack, and coeditors, editors. Yakima/Klickitat Fisheries Project Genetic Studies: Yakima/Klickitat Fisheries Project Monitoring and Evaluation, 2005-2006 Annual Report. Bonneville Power Adminstration, Portland, OR.

Smith, D., G. Johnson, and T. Williams. 2006. Natural streamflow estimates for watersheds in the lower Yakima River. S.P. Cramer & Associates, Sandy, OR.

Snyder, E. B., and J. A. Stanford. 2001. Review and synthesis of river ecological studies in the Yakima River, Washington with emphasis on flow and salmon habitat interactions. University of Montana Flathead Lake Biological Station, Polson, MT.

Spence, B., G. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services Corp., TR-4501-96-6057, Corvallis, OR.

Stanford, J. A., and coauthors. 2002. The Reaches Project: Ecological and geomorphic studies supporting normative flows in the Yakima River basin, Washington. University of Montana Flathead Lake Biological Station, Poulson.

Stanford, J. A., and coauthors. 1996. A general protocol for restoration of regulated rivers. Regulated Rivers 12:391-413.

Stephenson, A. E., and D. E. Fast. 2005. Monitoring and evaluation of avian predation on juvenile salmonids on the Yakima River, Washington. Bonneville Power Administration, 2004 Annual Report, Portland, OR.

Thrower, F. P. H., J. J.; Joyce, J. E. 2004. Genetic architecture of growth and early life history transitions in anadromous and derived freshwater populations of steelhead. Journal of Fish Biology (65):286-307.

Tuck, R. L. 1995. The impacts of irrigation development on anadromous fish in the Yakima Basin, Washington. Master's thesis. Central Washington Univeristy, Ellensburg, WA.

Waring, C. P., and A. Moore. 1997. Sublethal effects of a carbamate pesticide on pheromonal mediated endocrine function in mature male Atlantic salmon (Salmo salar L.) parr. Fish Physiology and Biochemistry 17(1-6).

Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State salmon and steelhead stock inventory (SASSI). Washington Department of Fish and Wildlife, Olympia, WA.

Washington State Monitoring Oversight Committee. 2002. The Washington comprehensive monitoring strategy for watershed health and salmon recovery, volume 2. Washington State Recreation and Conservation Office, Olympia, WA.

WDFW (Washington Department of Fish and Wildlife). 2003. An outline for salmon recovery plans, Olympia, WA.

Weitkamp, L. A. 1994. A review of the effects of dams on the Columbia River estuarine environment, with special reference to salmonids. NOAA Northwest Fisheries Science Center, Coastal Zone and Estuarine Studies Division, Bonneville Power Administration Report, Seattle, WA.

West Coast Steelhead Biological Review Team. 1999. Updated status review of Upper Willamette and Middle Columbia River ESUs of steelhead. NOAA Fisheries, Northwest Fisheries Science Center, National Marine Fisheries Service, predecisional ESA document, Seattle, WA.

Wissmar, R. C., and coauthors. 1994. A history of resource use and disturbance in riverine basins of eastern Oregon and Washington (early 1800s-1990s). Northwest Science 68:1-35.

Yakima Indian Nation, Washington Department of Wildlife, and Washington Department of Fisheries. 1990. Yakima/Klickitat production project preliminary design report appendix A: Refined project goals and harvest management plan. Bonneville Power Administration, BPA Project No. 198904300, Report DOE/BP-00245-2, Portland, OR.

Yakima River Floodplain Mining Impact Study Team. 2004. Yakima River Floodplain Mining Impact Study, Washington Division of Geology and Earth Resources Open File Report 2004-8.

Yakima Subbasin Fish and Wildlife Planning Board. 2005. Yakima subbasin plan. Columbia River Basin Fish and Wildlife Program. Northwest Power and Conservation Council, Portland, OR.