Bull Run Water Supply Habitat Conservation Plan

For the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species

Final

October 2008

Submitted to

U.S. Department of Commerce, National Oceanic and Atmospheric Administration National Marine Fisheries Service

Submitted by
City of Portland Water Bureau

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Acronyms and Abbreviations

BLM	Bureau of Land Management
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
DBH	diameter at breast height
DPS	distinct population segment
EDT	Ecosystem Diagnosis and Treatment
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FERC	Federal Energy Regulatory Commission
FLIR	Forward Looking Infrared Radar
fps	feet per second
GIS	Geographical Information Systems
HCP	Habitat Conservation Plan
HUC	Hydrologic Unit Code
ITP	Incidental Take Permit
LCR	Lower Columbia River
LCFRB	Lower Columbia Fish Recovery Board
LRH	lower river hatchery
LRMP	Land and Resources Management Plan
LRW	lower river wild
LW	large wood
mgd	million gallons per day
MOU	Memorandum of Understanding
msl	mean sea level
NMFS	National Marine Fisheries Service
NPCC	Northwest Power Planning Council
NWI	National Wetland Inventor
ODEQ	Oregon Department of Environmental Quality

ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
ODSL	Oregon Department of State Lands
ORS	Oregon Revised Statute
OWRB	Oregon Water Resources Board
OWRD	Oregon Water Resources Department
PGE	Portland General Electric
PIG	Columbia River Basin Anadromous Fish Policy Implementation Guide
PL	Public Law
RM	river mile
RNV	range of natural variation
SMART	Stream Management, Analysis, Reporting, and Tracking
SRBA	Sandy River Basin Agreement
SRBP	Sandy River Basin Partners
SRBWC	Sandy River Basin Watershed Council
TMDL	total maximum daily load
TRT	Technical Recovery Team
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service
VSP	viable salmonid population
WLC-TRT	Willamette-Lower Columbia Technical Recovery Team
WUA	weighted usable area

Executive Summary

Executive Summary

Introduction

The Bull Run Water Supply Habitat Conservation Plan (HCP) is a 50-year plan to protect and improve aquatic habitat while continuing to manage the Bull Run River watershed as a water supply for the City of Portland, Oregon. The HCP constitutes an application for a federal incidental take permit under Section 10 of the Endangered Species Act (ESA). The primary focus of the HCP is protection for ESA-listed anadromous fish under the jurisdiction of the National Marine Fisheries Service.

The HCP is designed to respond to the City's stewardship responsibilities for the Bull Run River ecosystem and for the water supply system. Water ratepayers will bear less than $2 million in average annual costs, or about $93 million over the HCP's 50-year term. Implementing the HCP will enable the City to continue operating the Bull Run water system while also avoiding and/or minimizing impacts to covered species as required by ESA.

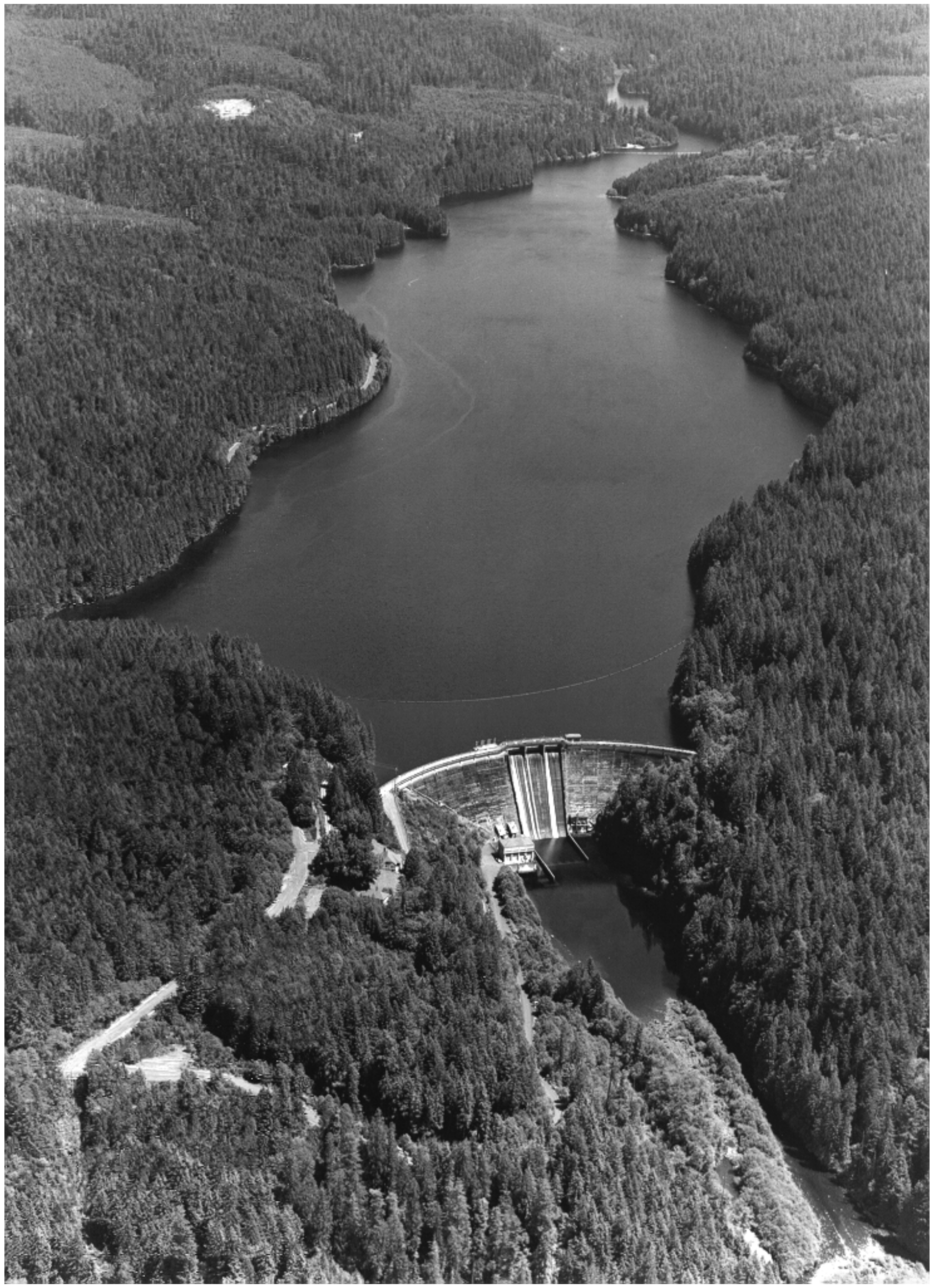
The Bull Run Watershed

The Bull Run watershed is located in the foothills of the Cascade Mountains, northwest of Mt. Hood. The Bull Run River is a major tributary of the Sandy River; the Sandy River flows into the Columbia River. The Bull Run River is approximately 25 miles long, and the related watershed drains approximately 140 square miles. Most of the watershed is located within the Mt. Hood National Forest. The City of Portland owns the majority of the riparian land along the lower 6 miles of the Bull Run River.

The Bull Run Water Supply

The Bull Run watershed has been used by the City of Portland, Oregon, for water supply since 1895. The City's water system provides water to residents and businesses within the city limits of Portland (retail supply) as well as to a number surrounding communities (wholesale supply). As of June 2008, approximately 860,000 Oregonians receive all or part of their water supply from Bull Run.

The Bull Run water supply system is the largest municipal water supply system in the state. The City's secondary supply, the Columbia South Shore Well Field, is the second-largest system. The City has a statutory water right to the full flow of the Bull Run River. When Portland General Electric's Bull Run hydroelectric project is removed (as part of a planned decommissioning), the City of Portland will be the only entity diverting water from the Bull Run River and its tributaries.



Reservoir 1 and Dam 1 in the Bull Run Watershed

Background

Three key factors helped shaped the context for the City's decision to develop an HCP: ESA species listings, Clean Water Act compliance, and water supply reliability and affordability. Foremost were the listings of the anadromous fish and the associated ESA regulatory requirements. In addition to ESA, the City also has regulatory obligations under the federal Clean Water Act that are specific to the Bull Run River for water temperature. Maintaining the reliability of the Bull Run water supply and affordability of water rates are continuing issues for local retail and wholesale customers and will be significant considerations for the Portland City Council during implementation of the HCP.

Species Listings

In 1998, the National Marine Fisheries Service (NMFS) listed winter steelhead in the lower Columbia River Basin as a threatened species under the federal Endangered Species Act. Since then, Lower Columbia River Chinook (spring and fall runs), Lower Columbia River coho, and Columbia River chum salmon have also been listed as threatened species. In March 2008, NMFS announced its decision to initiate a status review for Pacific eulachon; a decision to list will occur by November 8, 2008. These listings are the primary regulatory motivation for the City to prepare this HCP and seek an incidental take permit for the Bull Run water supply.

As required by ESA, NMFS is preparing a Recovery Plan for Chinook salmon, winter steelhead and coho salmon. The City has been in ongoing communication with NMFS staff involved in preparation of the Recovery Plan. The City anticipates that the HCP will be consistent with the Recovery Plan and will provide an important building block for Recovery Plan implementation.

Clean Water Act Compliance

In 2002, the Oregon Department of Environmental Quality (ODEQ) listed the lower Bull Run River as a "water quality limited stream" due to summer water temperatures. ODEQ subsequently prepared a Total Maximum Daily Load (TMDL), under the authority of the Clean Water Act, to define requirements for the Bull Run River and other Sandy River stream segments. Because water temperature standards for the Bull Run River are set at a level to protect cold water fish species (including the listed fish), the City concluded that a coordinated plan to address both the ESA and the Clean Water Act requirements was needed. With this in mind, the City prepared the HCP to be consistent with the CWA requirements and also prepared a temperature management plan. The temperature management plan relies on the water temperature measures included in the HCP, and is provided for reference as Appendix G of the HCP. The temperature management plan was approved by ODEQ in May 2008.

Water Supply Reliability and Affordability

From the City's point of view, a reliable and affordable water supply is a critical element in Portland's livability and economic vitality. The City's challenge is to continue to meet its safe drinking water mission while also meeting new ESA and Clean Water Act responsibilities. Careful attention was given when developing the HCP to the implications the habitat conservation commitments might pose for water supply, including day to day operation, long term supply availability, and costs to ratepayers. Proactive water conservation programs and groundwater supply play important continuing roles in ensuring the City's ability to supply enough water to meet customer needs.

Water Supply System Components and Impacts

The Bull Run water supply system comprises the most significant man-made feature affecting aquatic habitat in the Bull Run River watershed. The primary facilities covered in the HCP are introduced in this section and are described more fully in Chapters 2 and 3. The presence and operation of the water system infrastructure creates impacts on habitat for several species of listed fish as well as other aquatic and terrestrial species. The three key effects of the water system involve river flow, river temperature, and aquatic and riparian habitat, which are briefly summarized in this section along with a list of the covered species and the other species addressed in the HCP. These species and the City's impacts on them are described in more detail in Chapters 5 and 8.

Bull Run Water Supply System Components

The primary components of the water supply system are two dams and the related reservoirs, located at approximately river mile (RM) 6.0 and RM 11.1 on the Bull Run River. The HCP is primarily focused on the known or possible aquatic and riparian impacts associated with operating the dams and reservoirs. The HCP specifically excludes water system components located outside the Sandy River Basin, including the distribution portion of the system which delivers water directly to homes and businesses.

Aquatic and Riparian Impacts of the Bull Run Water Supply System

The three primary categories of water system impacts are river flow, river temperature and aquatic/riparian habitat.

Bull Run River Flow

The City diverts approximately 20 percent of the total annual flow of the Bull Run River for water supply. During the summer, the diversion has historically been almost all of the natural flow leaving little water in the river for fish. Reduced flow results in decreased habitat for spawning and rearing, as well as increased water temperatures.

Bull Run River Temperature

Although temperatures in the Bull Run River are naturally warm in the summer months due to the bedrock substrate and the east-west midday sun exposure, storage of water in the reservoirs causes further warming. The existing configuration of the infrastructure also limits the City's ability to store cold water for release later in the summer. Warm temperatures stress rearing and spawning fish.

Aquatic and Riparian Habitat

The Bull Run dams trap gravels and wood. The trapped gravel reduces the amount of gravel in the lower river that fish use for spawning. The trapped wood reduces the complexity of habitat in the lower river, reducing the ability of fish to rest and hide from predators. The dams also block access to upstream habitat for spawning and rearing.

Covered Species

The HCP requests ESA coverage for the following species:

- Lower Columbia River Chinook Salmon (Spring and Fall)
- Lower Columbia River Steelhead(Winter)
- Lower Columbia River Coho Salmon
- Columbia River Chum Salmon
- Pacific Eulachon

Photo courtesy of Bonneville Power Administration.

The HCP also includes conservation measures and effects analyses for 18 species under the jurisdiction of the US Fish and Wildlife Service. The species included are those most likely to be affected by water system operations and/or benefited by measures designed for the anadromous fish.

The 18 species are listed below. One of the species, northern spotted owl, is currently listed as threatened. The bald eagle was recently delisted under ESA but is still protected under other federal statutes. The City will not seek ESA coverage for the USFWS species at this time. However, the City believes the HCP provides protection for these species and their habitats that avoids or mitigates any significant impacts.

Fish

- Rainbow Trout
- Coastal Cutthroat Trout
- Pacific Lamprey
- River Lamprey
- Western Brook Lamprey

Amphibians and reptiles

- Cope's Giant Salamander
- Cascade Torrent Salamander
- Clouded Salamander
- Oregon Slender Salamander
- Coastal Tailed Frog
- Northern Red-legged Frog
- Cascades Frog
- Western Toad
- Western Painted Turtle
- Northwestern Pond Turtle

Birds and mammals

- Bald Eagle
- Northern Spotted Owl
- Fisher

Development of the HCP

A more than ten-year process has culminated in the HCP. This process has included a partnership effort involving a dozen or more public and private organizations and detailed technical work. The partnership approach and technical foundation are briefly introduced in this section and described further in Chapter 2. Key themes emerged from this work that guided development of the HCP. These themes are introduced in this section. More specific goals and objectives developed from these themes are described in Chapters 6 and 9.

Partnership Approach

Convening the players involved in recovering the Sandy River populations of the listed fish was a key step toward developing the HCP. The participants included staff representing NMFS, USFWS, USDA Forest Service – Mt. Hood National Forest, USDI Bureau of Land Management, Oregon Department of Fish and Wildlife, Oregon Department of

Environmental Quality, Clackamas County, Metro Regional Government, Multnomah County, Clackamas County, Oregon Trout, Northwest Steelheaders, The Nature Conservancy, Western Rivers Conservancy, East Multnomah County Soil and Water Conservation District, Portland General Electric, as well as the Portland Water Bureau. The Partners developed a vision and a basin-wide restoration strategy to guide selection and implementation of projects. The Partners continue to meet and to work together on recovering native fish in the Sandy River Basin (www.sandyriverpartners.org).

The Bull Run HCP is a significant product of this partnership effort. The Partners helped assess opportunities in the Bull Run watershed and in the larger Sandy Basin, and provided feedback on measures the City selected for the HCP. Through the actions in the HCP, the City is seeking to complement and support the restoration efforts the Partners are implementing throughout the larger Sandy River Basin.

Technical Foundation

The technical work involved in developing the HCP focused on establishing a solid foundation of scientific information. Data were collected and compiled about the habitat used by the listed fish throughout the entire Sandy River Basin. Understanding the whole Basin helped the City and the Sandy River Basin Partners to better assess the role that the Bull Run River plays in providing salmon habitat. Technical products at the basin-wide scale include the following:

- Historical and current distribution maps for the listed fish
- A geographic information system (GIS) map layer catalog covering the entire Sandy Basin
- A database of 120 stream reaches covering the extent of historical use by anadromous fish
- A 46-attribute database of habitat conditions in those reaches, based on recent stream surveys
- An assessment of productivity, abundance and diversity throughout the 120 reaches
- An assessment of reaches currently providing the greatest productivity, known as “Anchor Habitats”
- A database of more than 150 opportunities (i.e., on-the-ground projects) to improve habitat conditions

The 46-attribute database formed the foundation of the Ecosystem Diagnosis and Treatment (EDT) model. The EDT model was used to evaluate productivity, abundance, and diversity. The Bull Run River was a component of each of these basin-wide analyses.

In addition to the basin-wide analyses, the City also analyzed the following technical information for the Bull Run River:

- Temperature data measurements and temperature modeling of the reservoirs and lower Bull Run River
- Flow measurements and available fish habitat (i.e., Weighted Useable Area)
- Habitat conditions in the lower Bull Run river (e.g., gravel, wood, substrate, riparian vegetation, shade)
- Fish presence in the Bull Run reservoirs
- Location of waterfalls upstream of the Bull Run dams and the likelihood that they were passable by fish historically
- Hydrologic variability over a 60-year period of available records (e.g., changes in flow due to year-to-year weather variation)
- Productivity, abundance and diversity (using the EDT model) that would result from proposed habitat conservation measures

The results provide the basis for the analysis of biological effects likely to result from implementing the HCP, as described in Chapter 8.

Key Themes for the HCP

Key themes emerged from discussions among the Partners and from the technical results. The City and the Partners recognized the need to:

- Minimize and mitigate impacts on the covered fish species
- Choose measures that are feasible, implementable, and compatible with ongoing operation of the water system
- Improve conditions in the Bull Run River where the City has direct impacts on habitat
- Improve conditions at targeted locations elsewhere in the Sandy River Basin for three primary reasons: 1) not all of the impacts of the drinking water system on the Bull Run River can be mitigated; 2) greater benefits for the species can be achieved by habitat improvements elsewhere in the Sandy Basin for a smaller cost; and 3) cooperation with Basin partners will create better overall results than the City acting alone
- Act in a timely fashion to help reverse declining trends in the Sandy River Basin fish populations
- Plan for and manage any HCP impacts to water system customers and ratepayers

Goals and objectives for the HCP are described in Chapters 6 and 9.

Elements of the HCP

The contents of an HCP are in part prescribed by federal regulations (16 USC 1531-1544). An HCP also includes descriptive information to provide context and rationale. This executive summary does not attempt to list and summarize each and every element. The key elements are the habitat conservation measures, the measures defined to monitor the effectiveness of the HCP and adapt to change as necessary, and the analysis of the biological outcomes likely to result from implementing the HCP.

Habitat Conservation Measures

The HCP includes 49 measures to protect and improve habitat and to avoid or minimize the impacts of the Bull Run water supply system. As a whole, these measures were designed to address the flow, temperature, and habitat impacts described above. Specific performance criteria dealing with timing, location, quantity, and procedures are prescribed for each measure. The measures are listed in Table ES-1.

Table ES-1. Habitat Conservation Measures

Category	Identifying Codes[a]	Watershed Location	Measure Names[b]
Bull Run River Flow	F-1	Bull Run	Minimum Instream Flows, Normal Water Years
	F-2	Bull Run	Minimum Instream Flows, Water Years with Critical Seasons
	F-3	Bull Run	Flow Downramping
	F-4	Bull Run	Little Sandy Flow Agreement
Bull Run River Temperature	T-1	Bull Run	Pre-Infrastructure Temperature Management
	T-2	Bull Run	Post-Infrastructure Temperature Management
Bull Run River Habitat	H-1	Bull Run	Spawning Gravel Placement
	H-2	Bull Run	Riparian Land Protection
	P-1	Bull Run	Walker Creek Fish Passage
	R-1	Bull Run	Reservoir Operations
	R-2	Bull Run	Cutthroat Trout Rescue
	R-3	Bull Run	Reed Canarygrass Removal

Table continued on next page.

Table ES-1. Habitat Conservation Measures, continued

Category	Identifying Codes[a]	Watershed Location	Measure Names[b]
Water System Operation and Maintenance	WS O&M-1	Bull Run	Bull Run Infrastructure Operation and Maintenance
	WS O&M-2	Bull Run	Bull Run Spill Prevention
Offsite Sandy Basin Aquatic and Riparian Habitat	H-3	Bull Run (Little Sandy)	Little Sandy 1 and 2 Large Wood Placement
	H-4	Lower Sandy	Sandy 1 and 2 Log Jams
	H-5	Lower Sandy	Gordon 1A and 1B Large Wood Placement
	H-6	Lower Sandy	Trout 1A Large Wood Placement
	H-7	Lower Sandy	Trout 2A Large Wood Placement
	H-8	Lower Sandy	Sandy 1 Reestablishment of River Mouth
	H-9	Lower Sandy	Sandy 1 Channel Reconstruction
	H-10	Lower Sandy	Turtle Survey and Relocation
	H-11	Lower Sandy	Sandy 1 Riparian Easement and Improvement
	H-12	Lower Sandy	Sandy 2 Riparian Easement and Improvement
	H-13	Lower Sandy	Gordon 1A/1B Riparian Easement and Improvement
	F-5	Middle Sandy	Cedar Creek Purchase Water Rights
	H-14	Middle Sandy	Sandy 3 Riparian Easement and Improvement
	H-15	Middle Sandy	Cedar 2 and 3 Riparian Easement and Improvement
	H-16	Middle Sandy	Alder 1A and 2 Riparian Easement
	H-17	Middle Sandy	Cedar 2 and 3 Large Wood Placement
	P-2	Middle Sandy	Alder 1 Fish Passage
	P-3	Middle Sandy	Alder 1A Fish Passage
	P-4	Middle Sandy	Cedar Creek 1 Fish Passage

Table continued on next page.

Table ES-1. Habitat Conservation Measures, continued

Category	Identifying Codes[a]	Watershed Location	Measure Names[b]
Offsite Sandy Basin Aquatic and Riparian Habitat	H-18	Upper Sandy	Sandy 8 Riparian Easement and Improvement
	H-19	Salmon	Salmon 1 Riparian Easement and Improvement
	H-20	Salmon	Salmon 2 Riparian Easement and Improvement
	H-21	Salmon	Salmon 3 Riparian Easement and Improvement
	H-22	Salmon	Boulder 1 Riparian Easement and Improvement
	H-23	Salmon	Salmon 2 Miller Quarry Acquisition
	H-24	Salmon	Salmon 2 Miller Quarry Restoration
	H-25	Salmon	Salmon 2 Carcass Placement
	H-26	Salmon	Boulder 0 and 1 Large Wood Placement
	H-27	Zigzag	Zigzag 1A Channel Design
	H-28	Zigzag	Zigzag 1A and 1B Riparian Easement and Improvement
	H-29	Zigzag	Zigzag 1A, 1B, and 1C Carcass Placement
	H-30	Multiple	Habitat Fund
Terrestrial Habitat	W-1	Multiple	Minimize Impacts to Spotted Owls
	W-2	Multiple	Minimize Impacts to Bald Eagles
	W-3	Multiple	Minimize Impacts to Fishers

[a] The code letters refer to flow (F), temperature (T), habitat (H), passage (P), reservoir operations (R), water system operation and maintenance (WS O&M), and wildlife (W).

[b] The numbers in the measure names refer to the river “reach” where the measure will be implemented. See Appendix B for definitions of these river reaches.

Monitoring, Research and Adaptive Management Programs

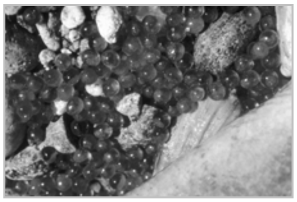


Photo courtesy of Bonneville Power Administration.

The HCP includes monitoring measures to track the implementation and effectiveness of the habitat conservation measures described above. Monitoring will include the preparation of annual reports as well as data collection efforts tied to specific performance objectives ("measurable habitat objectives"). The research effort includes four habitat and population studies in the lower Bull Run River as well as participation in a partnership research effort on juvenile salmonids in the larger Sandy River Basin.

The HCP also incorporates a framework for responding to new information and the likelihood that some reconsideration and adaptation will be necessary over the 50-year term. The Adaptive Management program involves the basin-wide restoration strategy developed by the Sandy River Basin Partners, an HCP Implementation Committee, and a framework to guide decision-making. The Adaptive Management program incorporates two dedicated sources of funding: $4 million from the Habitat Fund and a separate $3 million Insurance Fund to address adaptive management needs, if necessary.

In addition, the HCP also includes provisions (Changed Circumstances, Chapter 10) for dealing with changes that might occur over the 50-year term of the HCP, including the potential impacts of climate change.

Analysis of Biological Outcomes

The HCP provides a detailed analysis of the effects likely to result from implementing the habitat conservation measures. The most detailed analyses are provided for the "four primary covered species" (fall Chinook, spring Chinook, winter steelhead, and coho) for which the City had the most available information. Effects for these species are presented in terms of the lower Bull Run River habitat conservation measures, the offsite Sandy Basin habitat conservation measures, and the Sandy River Basin populations. Effects analyses are also provided for each of the other species listed above, including the three listed species: Columbia River chum, eulachon (smelt), and the northern spotted owl. In each case, the City concludes that the HCP measures, taken as a whole, will avoid or minimize impacts to the degree required by ESA.

Alternatives to the HCP

The HCP represents the City's approach for achieving ESA and CWA compliance. The City considered two primary alternatives to the HCP and dismissed those alternatives because they did not offer the combination of resource benefit, regulatory certainty and cost-effectiveness provided by the HCP. The No Action alternative would continue a limited number of actions to comply with Clean Water Act temperature requirements in the lower Bull Run River. No other actions would be taken. The Fish Passage alternative would provide new facilities to enable fish to reach habitat upstream of the Bull Run dams but would not include the offsite Sandy Basin measures described in the HCP. Both of these alternatives are evaluated in detail in the accompanying environmental impact statement (EIS).

Funding the HCP

The HCP is anticipated to cost about $93 million to implement over the 50-year term, which is equivalent to less than $2 million per year on average. These costs will be paid by water system ratepayers. The costs are for implementing the variety of habitat conservation measures and the associated monitoring. Some of the measures include installation of new infrastructure; the largest and most expensive of these are the proposed new multiple level intakes at Dam 2 to better manage water temperatures in the Bull Run River below the dams. Approximately one-third of the estimated total costs of the HCP are related to pumping groundwater from the Columbia South Shore Well Field. As has been the case since the City began providing fish flows in 2000, groundwater will be necessary in some years to enable the City to meet customer demands and release water into the Bull Run River for fish. Only the anticipated groundwater costs directly related to the release of water for fish are included in the HCP.

Chapter 1. Acknowledgments

1. Acknowledgments

The City of Portland would like to acknowledge the many dedicated individuals and organizations that have contributed to the development of the Habitat Conservation Plan (HCP) for the Bull Run Water Supply.

1.1 Sandy River Basin Agreement Policy Committee and Technical Team (Now Sandy River Basin Partners)

Two committees were formed under auspices of the 1999 memorandum of understanding known as the Sandy River Basin Agreement, a Policy Committee and a Technical Team. The Policy Committee represented policymakers in the represented organizations. The Technical Team was composed of staff scientists and resource planners. The mission of these two committees was to collaboratively develop strategies for recovering native fish species in the entire Sandy River as well as to assist the City of Portland to develop a draft strategy for the Bull Run HCP. Over time, the number of organizations involved has grown. The group is now known as the Sandy River Basin Partners (SRBP, **www.sandyriverpartners.org**).

1.1.1 SRBP Membership

Over the almost 10-year period since work began, individuals involved in the Partners and the predecessor committees have included the following (by organization):

Clackamas County: Commissioner Larry Sowa, Karen Streeter, Ginny Van Loo, Bob Storer and John Borge

Columbia Land Trust: Dan Roix

Multnomah County: Virginia Bowers, Kim Peoples and Roy Iwai

East Multnomah Soil and Water Conservation District: Jean Fike

Metro: Charlie Ciecko, David Moskowitz and Angie Kimpo

NOAA National Marine Fisheries Service: John Volkman, Michelle Day, Melissa Jundt, Michael Tehan, Ben Meyer, Dan Tonnes, and Nancy Munn

The Nature Conservancy: Jonathan Soll

Northwest Steelheaders: Mike Myrick, Gary Benson, and Phil Donovan

Oregon Dept. of Environmental Quality: Andy Schaedel, Greg Geist, Karen Williams, Avis Newell and Manette Simpson

Oregon Dept. of Fish and Wildlife: Al Smith, Greg Robart, Jim Muck, Dick Caldwell, Jeff Boechler, Todd Alsbury, Jim Brick, and Danette Ehlers

Oregon Trout: Jim Myron, Jason Miner, Brett Brownscombe, and Mark McCollister

Portland General Electric: Julie Keil, John Esler, and Doug Cramer

Portland Water Bureau: Rosemary Menard, Eddie Campbell, Steve Kucas, Janet Senior, Sarah Santner, Terry Black, and Jessica Letteney

Sandy River Basin Watershed Council: Russ Plaeger and George Hoyt

USDI Bureau of Land Management: Scott Abdon, Rudy Hefter, Dave Roberts, Laura Dowlan, Mark Brown, John Barber, and Dick Todd

USDA Forest Service, Mt. Hood National Forest: Lisa Norris, Dan Shively, Duane Bishop, Ivars Steinblums, and Todd Parker

USDI Fish and Wildlife Service: Gary Miller, Ron Garst, Ann Gray, Stephen Zylstra, Joe Zisa, Timmie Mandish, Kemper McMaster, and Janine Castro

Western Rivers Conservancy: Sue Doroff and Josh Kling

Note: Our apologies to any of our colleagues who may have been inadvertently left off this list.

1.1.2 USFWS Grant

One of the Partners' early accomplishments was receiving a $459,000 Habitat Conservation Planning Grant (Section 6) from the U.S. Fish and Wildlife Service (USFWS). This grant funded a video about the Sandy River, a characterization report about resource conditions in the basin, an on-line atlas of maps, initial work on a coordinated monitoring strategy, as well as a facilitator for the early Partners' meetings. The atlas is available on the Partner's website. Copies of the characterization report and video are available through the Portland Water Bureau.

The products of this grant have been useful during development of the HCP and will continue to be valuable during implementation. The City appreciates the administrative assistance of Rachel Miller and Heather Hollis at USFWS and of the following ODFW staff: Martin Nugent, Charlie Corrarino, Gail Samura, and Diana Butts. The Section 6 grant is administered through the Oregon Dept. of Fish and Wildlife.

1.2 Sandy River Working Group

In 2004, a group of fish biologists affiliated with the SRBA Technical Committee decided to form a separate working group to identify and evaluate anchor habitats for salmonids in the Sandy River Basin. Anchor habitats are defined as distinct stream reaches that currently harbor specific life stages of salmon and steelhead to a greater extent than the stream system at large. The resulting Anchor Habitats report is available on the Partners' website.

As a second step, the working group developed a hierarchical framework for restoring habitat in the basin. The framework is based on the latest available scientific literature and is consistent with direction provided in the Oregon Plan for Salmon and Watersheds. The framework report is in final editing and will be posted on the Partners' website when complete.

Both of these products have been instrumental in guiding the ongoing work of the Partners and have contributed to choices the City made when developing the HCP. The working group was led by Dan Shively from the Mt. Hood National Forest and by Jason Miner and

Mark McCollister from Oregon Trout. Members of the working group also included the following:

Northwest Steelheaders, Sandy Chapter: Mike Myrick

Bureau of Land Management, Salem District: Dave Roberts

Clackamas County: Mark Mouser

East Multnomah County Soil and Water Conservation District: Julie Dileone

National Marine Fisheries Service: Rob Markle

Oregon Department of Fish and Wildlife: Todd Alsbury and Danette Ehlers

Sandy River Basin Watershed Council: Russ Plaeger and George Hoyt

The Nature Conservancy: Jonathan Soll

U.S. Fish and Wildlife Service: Brad Goerhring

Mt. Hood National Forest: Duane Bishop and Todd Parker

Portland Water Bureau: Steve Kucas

1.3 Sandy River Monitoring

Fish population monitoring elements of the HCP (see Chapter 9) are designed to be part of a larger cooperative basin-wide effort. The approach was developed by fish biologists from key participating agencies with help from a variety of monitoring experts. Participants included the following:

Oregon Department of Fish and Wildlife: Todd Alsbury, Danette Ehlers, Kirk Schroeder, Jeff Rogers, and Julie Firman

National Marine Fisheries Service: Dan Tonnes and Rich Turner

Mt. Hood National Forest: Duane Bishop, Dan Shively, and David Saiget

USFS Pacific Northwest Research Station (Corvallis): Gordon Reeves

Bureau of Land Management: Dave Roberts

Oregon Department of Environmental Quality: Mike Mulvey

Portland Water Bureau: Steve Kucas and Burke Strobel

1.4 Community Involvement in Portland and in the Sandy River Basin

Since 1999, the City of Portland has reached out to the broader community to provide information and to seek input and ideas as we developed the HCP. Water Bureau staff sponsored numerous field trips, half-day classes, and open houses attended by residents of both Portland and of the Sandy River Basin. Staff also consulted with the Portland Utility Review Board and with a variety of government agencies, university researchers and non-profit organizations involved in salmon recovery.

1.5 Consulting Team

The City would also like to thank the consulting staff who contributed time, technical and regulatory expertise, facilitation support, and project experience to the City's work on the HCP. Individuals who made major contributions include:

CH2M Hill: Bill Blosser and Ken Carlson

Biota Pacific: Marty Vaughn

R2 Resources: Ron Campbell and Phil Hilgert

Mobrand Biometrics (now Jones & Stokes): Kevin Malone

Portland State University: Scott Wells and Rob Annear

Thompson/Smitch Consulting Group: Tim Thompson

Resolve: Deb Nudelman

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1.6 Staff of the City of Portland

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Chapter 2. Introduction and Background

2. Introduction and Background

The Bull Run Water Supply Habitat Conservation Plan (HCP) has been prepared in support of the City of Portland's application to the National Marine Fisheries Service (NMFS) for an Incidental Take Permit (ITP) to cover the continued operation and maintenance of the Bull Run water supply system. The City of Portland (City) prepared the HCP in accordance with Section 10(a)(2)(A) of the federal Endangered Species Act (ESA), which allows for the approval of incidental take of threatened and endangered fish and wildlife species during the performance of otherwise lawful activities, provided certain conditions are met. One of those conditions is the preparation of an HCP. The City's HCP describes actions the City will take to improve habitat conditions in the Bull Run and Sandy rivers and thereby contribute to the recovery of native fish populations.

The City prepared this HCP in coordination with NMFS and the U.S. Fish and Wildlife Service (USFWS), the federal agencies responsible for implementation and enforcement of the ESA. The City is confident that this HCP satisfies the requirements of Section 10 and appropriately addresses the habitat conservation needs of the species for which the City seeks coverage.

This chapter provides background information on recent history leading to the HCP, the Bull Run water system, the need for an ITP, related laws and regulations, and the City's habitat conservation approach for the HCP. The effectiveness of the HCP and the content of the HCP chapters are also briefly introduced.

2.1 Recent History Leading to the HCP

The Bull Run watershed has provided water to the Portland metropolitan area since 1895. Only recently, however, has the City begun to fully understand the role that the Bull Run River plays in supporting the larger aquatic ecosystem of the Sandy River Basin (Figure 2-1). The listings of Chinook salmon, coho salmon, and steelhead as threatened species under the federal ESA were key indicators that the Sandy River Basin is facing challenges. The Oregon Department of Environmental Quality (ODEQ) also designated several segments of the Sandy River, including six miles of the lower Bull Run River, as "water quality limited" because summer water temperatures are too high for salmon and steelhead. These regulatory decisions recognized problems that have developed over decades and continue to threaten the sustainability of the native fish populations. These decisions also made it clear that the City needed to assess conditions in the Bull Run River and develop a proposal to meet the requirements of the law, secure the continued availability of the water supply, and make a responsible contribution to sustaining the aquatic ecosystem on which both people and salmon depend.

In 1998, the City began discussions with other public and private organizations involved in salmon recovery in the Sandy River Basin. Those discussions resulted in a Memorandum of Understanding (MOU) signed by NMFS and USFWS (collectively, the Services), the Mt. Hood National Forest, the U.S. Department of the Interior's Bureau of Land Management,

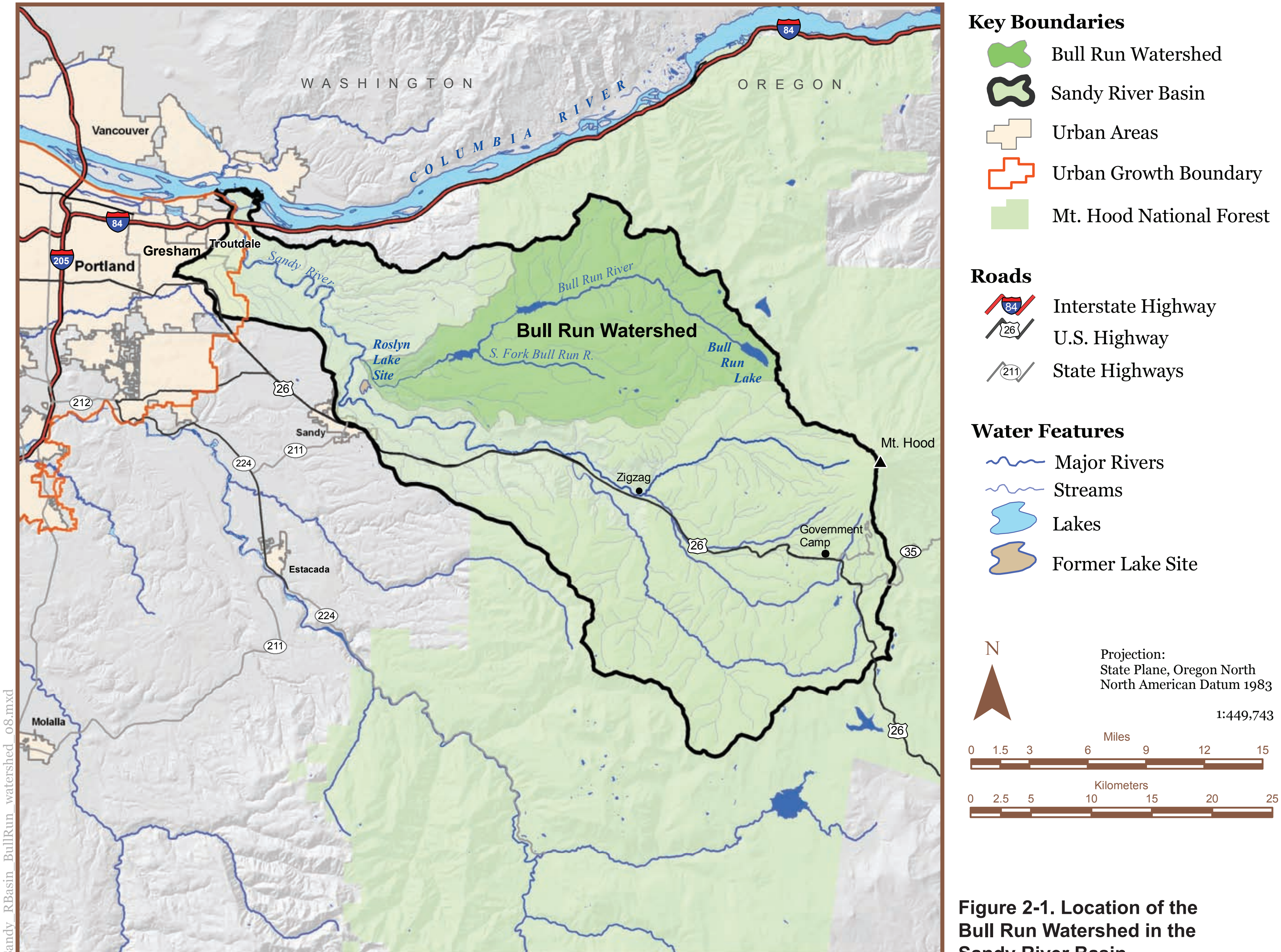


Figure 2-1. Location of the Bull Run Watershed in the Sandy River Basin

Sandy_RBasin_BullRun_watershed_08.mxd

the Oregon Department of Fish and Wildlife (ODFW), Portland General Electric (PGE), and the Portland Water Bureau. The MOU signers pledged to work together to recover wild fish populations in the whole of the Sandy River Basin. Since 1999, more than a dozen organizations have joined in the effort and are now known as the Sandy River Basin Partners.

The City developed this HCP in the spirit of the 1999 MOU and with the help of many dedicated individuals, both members of the Sandy River Basin Partners and others engaged in related salmon recovery work.

2.2 Overview of the Bull Run Water System

The Bull Run water system infrastructure consists of three major components: storage, transmission, and distribution. Storage includes the dams and reservoirs located in the Bull Run watershed. Transmission includes the facilities that transport water from the Bull Run watershed into the City. Distribution includes the facilities involved in delivering water supply directly to homes and businesses.

The Bull Run water system is one of only a few large unfiltered water systems in the United States. This is a reflection of the very high quality water available from Bull Run, as well as the unusually high level of protection of the watershed from pollution sources. The watershed has been closed to public access for more than 100 years. Recreation, commercial uses, and residential development are not allowed in the watershed.

The Portland Water Bureau provides both retail and wholesale water service. Retail service provides water supply to homes and businesses within the incorporated city limits of Portland (Figure 2-2). Wholesale service provides water supply to 19 cities and water districts in the Portland area, which in turn sell and distribute the water to their own customers. Some of these wholesale customers rely entirely on the City supply, and some have other sources in addition to the supply they purchase from the City. The Bull Run water system is the largest water supply in the state of Oregon and serves approximately one-quarter of the state's population.

In addition to the water supply facilities in Bull Run, the City also owns a groundwater supply system that is located adjacent to the Columbia River and near the Portland International Airport. This supplemental supply provides an additional source of water in dry summers and during circumstances, such as a strong winter storm, when turbidity in the Bull Run increases above U.S. Environmental Protection Agency (EPA) drinking water standards.

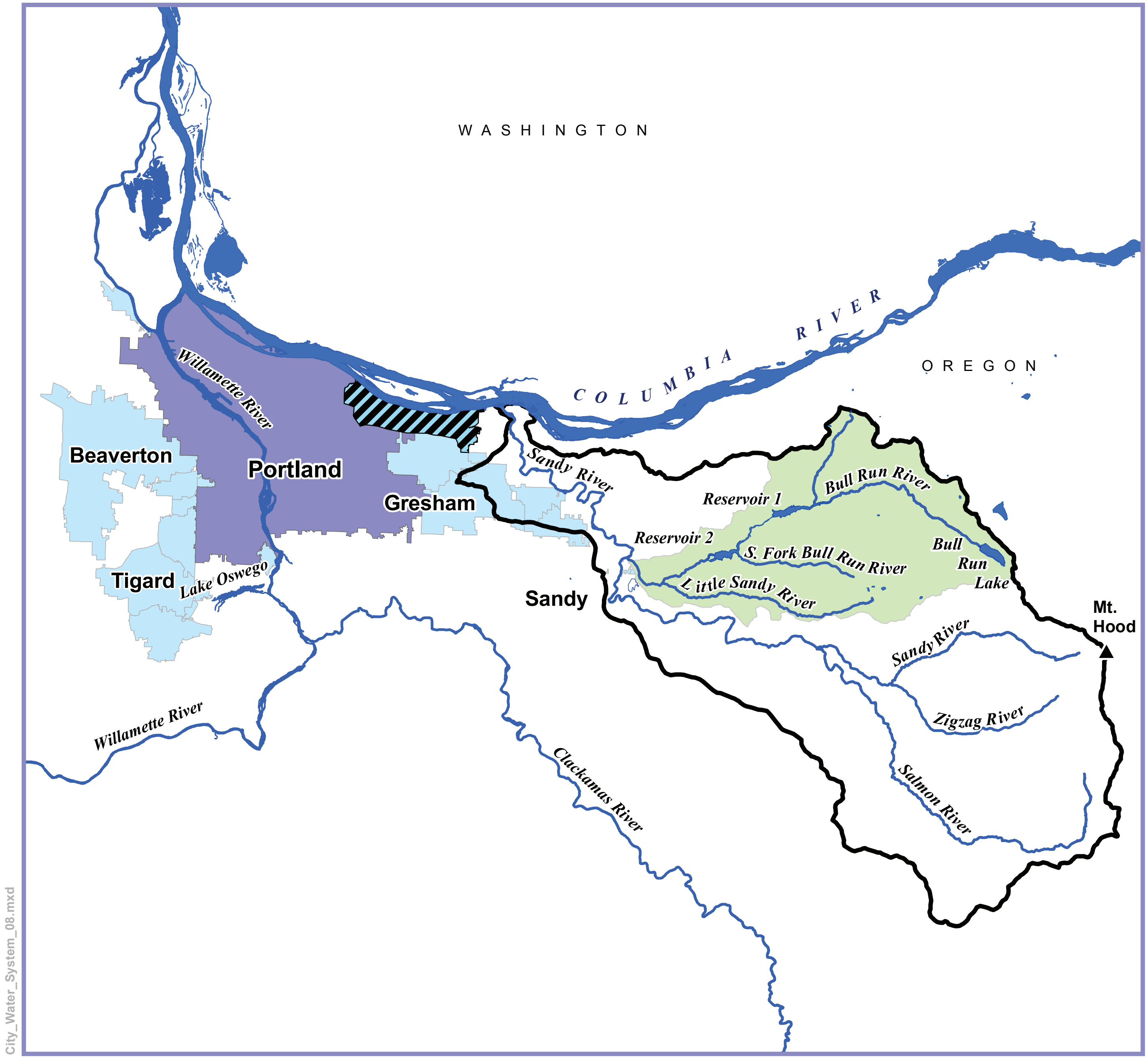


Figure 2-2. City of Portland Water System and Service Area

2.2.1 Storage

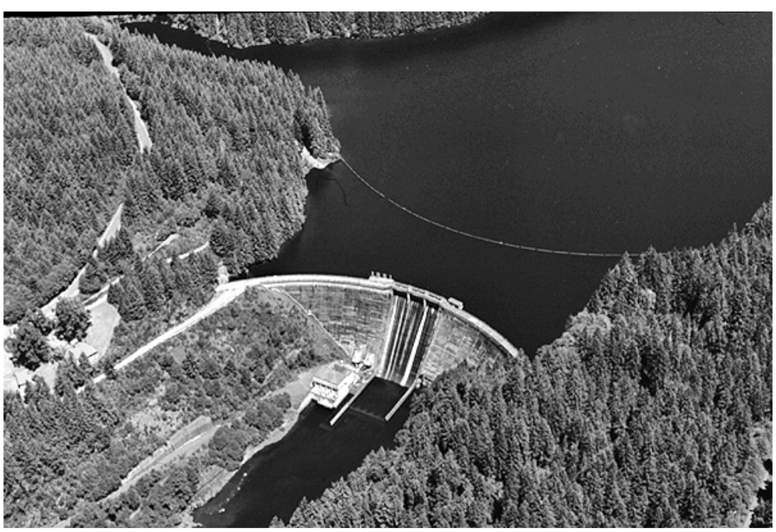
Storage facilities in the Bull Run include the reservoirs behind Dam 1, completed in 1929, and Dam 2, completed in 1962, as well as Bull Run Lake. The combined capacity of the reservoirs in Bull Run is approximately 17 billion gallons. Approximately 10 billion gallons of that capacity is usable storage. Bull Run Lake is used periodically as a supplemental source.

The City relies most heavily on the storage in the reservoir behind Dam 1. The maximum capacity of the reservoir is 10 billion gallons. The surface elevation is raised in the spring by dropping gates in the spillway opening. This occurs after the winter storms are over because the gates are not sturdy enough to withstand overtopping. During the dry season, typically early July to mid-October, the City draws the reservoir down as much as 75 feet. The surface elevation in Reservoir 1 varies between 970 and 1,045 feet above mean sea level. When storms return in the fall, the reservoirs refill—often very quickly (within a few days) but sometimes slowly (over several months). The City attempts to refill the reservoirs before the most intense storms begin in November because sediment accumulated at tributary deltas can be disturbed by high flows and cause turbidity problems.

Bull Run Dam 1, a concrete gravity arch dam, is located at river mile (RM) 11.1. The reservoir behind the dam is about 4 miles long and as much as 190 feet deep. Water passes Dam 1 in one of three ways: through the penstocks in the powerhouse, through needle valves at the bottom of the dam, or over the spillway. Most of the time, flow is through the powerhouse. The needle valves are old and infrequently used. Water flows over the spillway during the few large winter storms that exceed the capacity of the powerhouse. Water that passes Dam 1 flows into the river for a short distance before it pools again in the reservoir behind Dam 2.

Dam 1 is equipped with an intake structure that allows selective withdrawal at different water elevations in the reservoir. This structure enables the City to avoid turbid water near the bottom of the reservoir, and also permits more managed use of cold water to meet downstream objectives.

Dam 2, an earthfill dam, is located at RM 6.5. The reservoir behind the dam is about 4.5 miles long and as much as 130 feet deep. Maximum capacity is 6.8 billion gallons. Water is



withdrawn from elevations close to the bottom of Dam 2 at two intake towers, north and south. The current structures of these intakes do not allow for selective withdrawal at multiple elevations, which results in rapid loss of temperature stratification of this reservoir.

Water passes from the intake towers in one of three ways: through the penstocks in the powerhouse into the diversion pool, through two Howell-Bunger valves into the diversion pool, or over the spillway bypass into the lower river. Water in the diversion pool is directed through the Headworks facility and into the transmission system, or it flows over the diversion dam into the lower Bull Run River.

Figure 2-3 is a simplified illustration of the infrastructure and land features in the Bull Run watershed.

Figure 2-3. Infrastructure and Land Features in the Bull Run Watershed

The Water Bureau attempts to keep the reservoir at Dam 2 as full as possible throughout the year, including the summer months. The surface elevation varies between 840 and 860 feet above mean sea level. This strategy allows for any upstream turbidity to dilute and settle out before the water is diverted for water supply.

Bull Run facilities related to Dam 2 include a spillway structure to bypass winter storm flows past Dam 2, a diversion dam below Dam 2, and a rock weir and pool below the Dam 2 spillway used for energy dissipation. At the Headworks, the water is screened to remove debris, and chlorine is added to the water supply for disinfection. Operators staff the Headworks facility 24 hours a day/seven days a week, and they make the operational adjustments necessary to manage downstream river flows and temperatures.

The original man-made barrier to anadromous fish in the Bull Run River was the diversion dam completed in 1921. The diversion dam, located below Dam 2 at RM 5.9, is 37 feet high. The current lowermost barrier is the spillway weir at RM 5.8. This weir forms a pool and helps dissipate the energy of the flow over the spillway. The spillway weir was completed in 1965 and is 15 feet high.

Hydropower

The City owns hydropower facilities that generate electricity as a byproduct of water supply operations. These facilities are licensed (License No. 2821) by the Federal Energy Regulatory Commission (FERC) and are operated, under a long-term power sales agreement, by PGE. Powerhouse 1 is located immediately downstream of Dam 1 and has an installed capacity of 24 megawatts. Powerhouse 2 is located immediately downstream of Dam 2 and has an installed capacity of 12 megawatts. Electric power generated by these facilities is sold directly to PGE. The City's current hydropower license is valid until 2029. The hydropower facilities are not included as covered facilities in the HCP (see Chapter 3).

Bull Run Lake

Bull Run Lake (see Figure 2-1) does not have a surface connection to the Bull Run River. Because the lake is formed in part by a porous landslide that occurred thousands of years ago, its surface elevation declines every summer as water seeps through the landslide and emerges at springs to form the headwaters of the mainstem Bull Run River. The City maintains a small dam at Bull Run Lake that raised the level of the natural lake approximately 10 feet.

Bull Run Lake represents a supplemental water supply that can be used in unusually dry years. Water supply discharges from the lake, which occur occasionally, primarily change the timing of water availability in the Bull Run River, rather than add to the total amount. None of the covered species (Chinook, steelhead, coho, chum, and eulachon) is found at the lake. Facilities at Bull Run Lake are operated under the terms of a U.S. Forest Service (USFS) easement and are not included as a covered facility in the HCP (see Chapter 3).

2.2.2 Transmission

The Bull Run water system includes three transmission pipelines (known as conduits) that carry water from Headworks to a reservoir at Powell Butte in east Portland and to wholesale connections located to the west. These conduits are buried in a right-of-way, but in some locations they are hung on trestles and bridges (e.g., across the Bull Run River and the Sandy River). At two locations, water can be transferred from one conduit to another. Facilities at these locations are known as interties. The conduits have a combined total capacity of approximately 210 million gallons per day (mgd). At approximately 120 locations, at low points on the conduit corridor, water can be drained from the conduits for maintenance reasons. Chlorinated water is dechlorinated before discharge into storm drains or waterways.

2.2.3 Distribution

The distribution system includes more than 2,100 miles of pipes that carry water to customers, as well as in-town reservoirs, tanks, and pump stations. The distribution portion of the system is located entirely outside the Sandy River Basin, and therefore is not evaluated in the HCP and no ESA coverage is requested in the HCP.

2.2.4 Water Supply, Demand, and Related Operations

Yield from the watershed varies annually and seasonally, as does water demand. Both factors are driven primarily by weather. In warm dry summers, yield tends to be lower and water demand tends to be higher. Conversely, in cool wet summers, yield tends to be higher and water demand is lower. The duration of the dry season is also important because it determines the time period during which the City will rely on the limited storage in the reservoirs. Long dry seasons make it more challenging to provide reliable water supply and increase the probability of needing groundwater to supplement the amount available before fall rains return. During the winter, the Bull Run system is operated as “run of the river.” The reservoirs are kept full and the amount of water not needed for water supply is released into the lower river. The Bull Run reservoirs have no flood control capacity.

Figure 2-4 illustrates seasonal water supply and water demand in the Bull Run—for the drawdown period of June to October—since the mid-1940s.

Water Supply

Approximate median annual water yield from the Bull Run watershed (measured at Headworks, RM 6.5) is 180 billion gallons. Annual yield, 1940 to 2000, ranged from 98 to 258 billion gallons. The median annual diversion for water supply over the same period was about 36 billion gallons, or approximately 20 percent of the total yield. Monthly and daily yields (and diversion percentages) vary seasonally. The two Bull Run reservoirs are relatively small in comparison to precipitation and stream discharge in the watershed. The reservoirs are not large enough to provide a multi-year water supply. Refill each winter is necessary to ensure supply for the following summer.

Figure 2-4 indicates a declining trend in reservoir supply since 1946. The City is monitoring this trend to determine whether it continues and to assess the implications it might have for supply availability into the future. Chapter 10 (Section 10.2.1) describes the City's approach for monitoring and responding to changes in the hydrology of the Bull Run River during the term of the HCP.

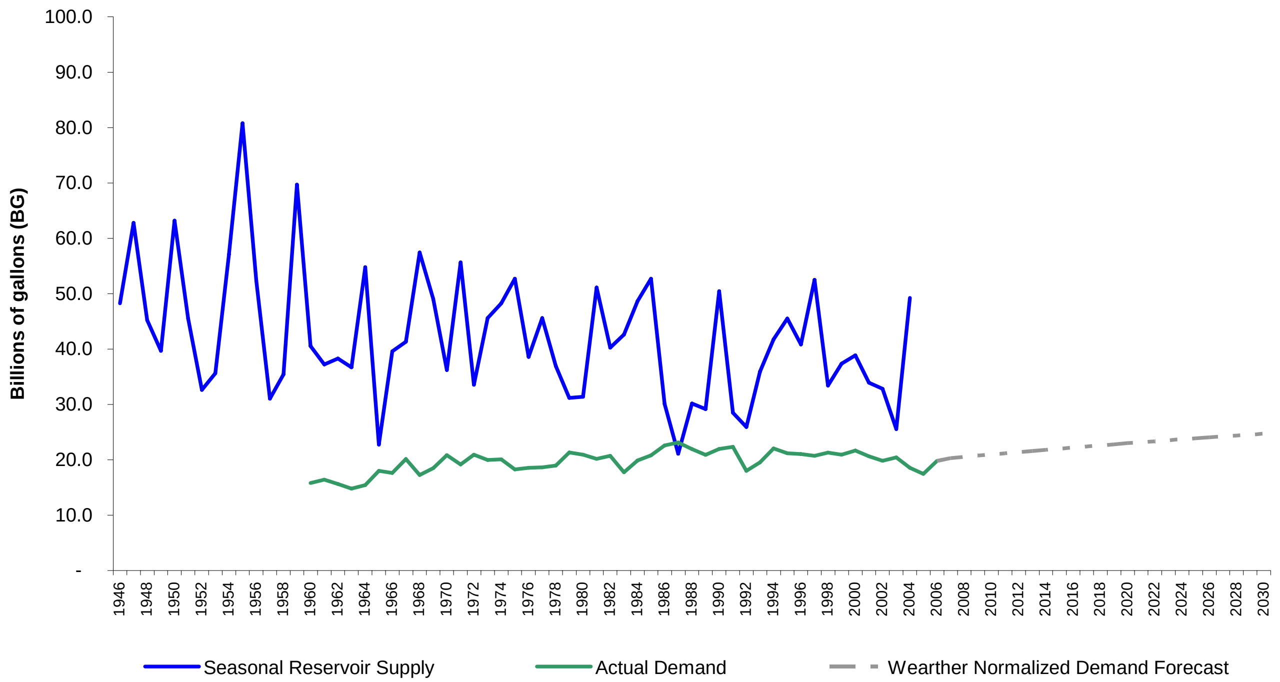


Figure 2-4. Seasonal Reservoir Supply, Actual Demand, and Weather-Normalized Demand Forecast

Sources: Seasonal reservoir supply is total reservoir inflow plus 9.9 BG reservoir supply with no groundwater (for June–October 1946–2004). Total reservoir inflow is the total of the daily mean flows of four gauges (USGS Gauges No. 14138850, Bull Run River at RM 14.8; No. 14138870, Fir Creek at RM 0.6; No. 14138900, North Fork Bull Run River at approximately RM 0.2; and No. 14139800, South Fork Bull Run River at RM 0.6) multiplied by 1.2, to account for the ungauged area of reservoir inflows in the Bull Run watershed. Actual demand data are from Water Bureau consumption data (1960–2005). Weather-normalized demand forecasts (2006–2030) were created using weather patterns from 1940–2005 weather data measured at Portland International Airport and Metro Regional Government population projections.

Groundwater

The City's Columbia South Shore Well Field provides a supplemental supply to the Bull Run watershed. This groundwater supply is used to provide water when the Bull Run supply is shut down and in years when the Bull Run supply is not enough to meet demand. The well field will play a key role in implementing the HCP by providing an additional reliable source of water to meet water demand when needed.

The Bull Run supply is occasionally shut down to avoid serving water to customers that exceeds EPA standards for turbidity in drinking water. These shutdowns have occurred periodically since the wellfield became operational in the mid-1980s. The most notable shutdown occurred in 1996 during a large-scale regional flood event. As of June 2008, turbidity-related shutdowns and related groundwater pumping have occurred six times since 1984 and have varied in duration from 3 to 23 days.

Groundwater also provides capacity to augment Bull Run supplies. In 1987, the City pumped approximately 5.3 billion gallons during the summer months to help meet water demand. As of June 2008, the City has used the well field 13 times for summer season supply since 1984. The duration of use has varied from 12 to 89 days.

The marginal cost of groundwater is substantially greater than the marginal cost of Bull Run surface water. The two most significant groundwater-related costs are electricity to pump water out of the ground and up to the reservoir at the top of Powell Butte, and maintenance and repair of all the moving parts in the wells and pump station.

The well field has a role in meeting increasing water demand resulting from population growth. The well field infrastructure represents supply capacity already in place and ready to use. Other options at similar magnitudes will not be available until demand (as moderated by conservation programs) grows enough to enable financing and construction of new storage or supply. Given uncertainties about the pace of urban growth and future wholesale water customer behavior, the City is likely to need groundwater capacity to meet its responsibilities to customers as demand on the system increases.

Future Water Storage in the Bull Run

Over the last 20 years, the City has examined a number of options for increasing water storage in the Bull Run system. In the future, the City will continue to explore these and other options to meet long-term water supply needs. These options are speculative at this time, so they are not addressed in this HCP, and the City will not seek coverage for them in the ITP.

Water Demand

During fiscal year 2005-2006 the Bull Run water system served a population of approximately 800,000 people. Retail water demand was approximately 60 percent, and wholesale demand was 40 percent. Per capita daily water demand has hovered around approximately 115 gallons per day since fiscal year 2004-2005. Water demand during the summer months (median 140 mgd) is typically about 1.5 to 2 times the winter season demand (median 94 mgd), primarily due to outdoor landscape irrigation.

Figure 2-4 shows measured water demand from the Water Bureau's service area. The data reflect interim reductions in demand that have occurred due to changes in state plumbing codes, land use, and water-use behavior, as well as shifts in the regional economy. Although the population of the area that the Water Bureau serves has grown since 1992, per capita demand has gone down by approximately 20 percent during the same period.

Projected demands to 2030, as shown in Figure 2-4, are based on an econometric model forecast using Metro population projections. Uncertainties in the demand projections include wholesale water customers' future decisions about developing other water sources in the region, as well as future economic and social shifts that may affect water use behaviors and level of use.

Water Conservation

Demand data shown in Figure 2-4 incorporate the effects of the City's ongoing water conservation programs. These programs are implemented by the Water Bureau and the Regional Water Provider's Consortium (City of Portland, Seasonal Water Supply Augmentation and Contingency Plan, 2006) and include media campaigns during the summer season, partnerships and programs focused on outdoor irrigation and landscaping, education and outreach programs for both children and adults (including multiple brochures and web pages), and pilot testing of water-efficient technology. The City also works with business customers, including outreach programs, water audits to guide operation and equipment improvements to save water, and technology studies. In 2005, for example, resulting water savings by businesses approached 10 million gallons for the year.

Water conservation will continue to be a key tool for the City to use in responding to population growth and associated potential increases in water demand. Water conservation programs need to be adaptable over time to target specific changes in residential and business/industrial water use behaviors and technologies, and to respond to changes in conditions and available incentives. Targeted conservations programs will moderate water use, delay the time when the City will need to develop new water supplies, and enable the City to implement the HCP.

2.2.5 Water Rights

The State Legislature enacted ORS 538.420 in 1909. This statute grants to the City "the exclusive rights to the use of waters of the Bull Run and Little Sandy Rivers." The City also has filed claims to pre-1909 water rights, with a priority date of 1886 on the Bull Run River and a priority date of 1892 on the Little Sandy River. The City currently diverts about 20 percent of the annual flow of the Bull Run River, but it has not made use of its water right on the Little Sandy River. The City and PGE are the only entities with water claims or rights on the Little Sandy River. PGE's pre-1909 water claim for diversion from the Little Sandy River will be converted to instream use when the Little Sandy Dam is decommissioned in 2008.

2.2.6 Land Ownership and Land Use Permits

The City owns about 5,000 acres of land in the Bull Run watershed, most of which is located around Reservoir 2 and downstream along the Bull Run River. Approximately 90 percent of the watershed is federally owned land administered by the Mt. Hood National Forest. Management of the national forest land is governed by a variety of federal forest management statutes, the Northwest Forest Plan, and the Bull Run Act (P.L. 95-200) enacted in 1977 and amended in 1996 and 2001.

The City holds multiple special-use permits and easements to allow operation of water system related facilities on federal land. The City and the USFS signed a new Bull Run Watershed Management Unit (BRMWU) Agreement in late 2007. The agreement outlines a framework for roles and responsibilities, provides a model for joint operations, and lays the groundwork for supplemental functional plans for managing the BRMWU.

As part of the partnership agreement, the City and USFS are considering a land exchange that would trade approximately 2,500 acres of City-owned land for comparable acres of federal land in the watershed. If this exchange is implemented, the ownership changes might require minor modification, and/or an amendment, of the HCP to incorporate new covered lands. The land exchange is not expected, however, to change the habitat conservation measures in the HCP or change the nature of activities that affect aquatic and riparian habitat. The amendment, if needed, would likely apply the existing measures to additional lands.

2.3 Need for the Incidental Take Permit (ITP)

Section 9 of the ESA prohibits the ''taking'' of listed species. NMFS may, however, issue permits to take federal listed species when such a taking is incidental to, and not the purpose of, otherwise lawful activities. As defined there, the term ''take'' means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. The term can also include modification to the habitat of a listed species that results in the death or injury of that species, or the impairment of essential life functions. While the City does not intentionally "take" listed species, ongoing impacts of the water supply system can affect the habitat of these species.

The City is seeking an ITP from NMFS. Section 10(a)(1)(B) of the ESA, and regulations at 50 CFR 17.32, contain provisions that allow issuance of ITPs to nonfederal entities. To issue a permit, NMFS must determine that the following criteria are met:

1. The taking will be incidental to otherwise lawful activities.
2. The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking.
3. The applicant will develop an HCP and ensure that adequate funding for the HCP will be provided.
4. The taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild.
5. The applicant will comply with any other measures that NMFS may require as being necessary or appropriate.

The City's purposes in preparing this HCP are twofold: to comply with the ESA and to manage the Bull Run water supply system on a long-term basis. More specific goals and objectives toward achieving these purposes are described in Chapter 6. The habitat conservation measures in Chapter 7 (along with related monitoring and adaptive management measures in Chapter 9) describe the manner in which the City intends to meet the ITP issuance criteria.

2.4 Relationship to Other Laws and Regulations

The habitat conservation measures described in this HCP will be implemented in the context of several other federal laws and regulations. The most directly related of these is the Clean Water Act (CWA) requirement to manage water temperature in the Bull Run River to meet ODEQ standards and protect cold water fish. Appendix G provides the ODEQ approved Temperature Management Plan, which describes the ODEQ requirements and how the HCP water temperature measures will be used to also achieve CWA compliance.

The Bull Run water supply reservoirs are equipped with hydropower generation facilities under the authority of FERC. As mitigation required under the license, the City annually provides funding to ODFW to support hatchery production of spring Chinook salmon and winter steelhead. Production of hatchery salmon and steelhead helps ensure sport fishing opportunities in the lower Sandy River Basin, while the HCP is focused on improving habitat that will benefit naturally producing salmon and trout. The City's HCP measures are compatible with the City's FERC license and are not expected to require a FERC license amendment. Neither the City's FERC-regulated hydropower facilities in Bull Run nor the related funding for the ODFW hatchery facilities are included as covered in the HCP (see Chapter 3).

Some of the facilities and activities affected by the HCP are located on national forest land and subject to federal forest management laws, regulations, and permits, as described above (see Section 2.2.6, Land Ownership and Land Use Permits). Additional information about land management and regulation, especially on nonfederal land, is provided in Chapter 4.

A variety of other permits (federal, state and local) may be required as part of implementing the HCP. The City will obtain permits as needed and will work to ensure compatibility of the permit terms with the HCP.

2.5 Approach to Habitat Conservation Planning

This HCP represents a new and important milestone in the City's 100-year history of Bull Run watershed stewardship. Protecting species affected by the water supply system is a necessary extension of these stewardship responsibilities. The HCP provides a framework and a set of specific habitat conservation commitments that will guide the City's work for 50 years.

When developing the HCP, the City looked first at the habitat conservation measures that could be feasibly implemented in the Bull Run watershed while also continuing to operate the City's primary water supply. The Bull Run measures described in the HCP substantially improve conditions for fish in the lower Bull Run River. Some impacts in the Bull Run River could not feasibly be avoided, however, so the City also evaluated opportunities to improve conditions for ESA-listed fish in the larger Sandy River Basin. In selecting offsite measures, the City considered the impacts not fully mitigated in Bull Run, the regional importance of the Sandy River fish populations, and the limiting factors affecting productivity of those populations. The limiting factors analysis was derived from a basin-wide assessment of habitat conditions generated from empirical data, the judgment of field biologists familiar with the Sandy River, and application of the Ecosystem Diagnosis and Treatment (EDT) methodology used widely across the Columbia River Basin.

From the very early stages, the City also sought the participation of others involved in protecting and restoring fish populations in the Sandy River Basin. Since 1999, more than a dozen organizations have joined together as the Sandy River Basin Partners (Partners). The Partners played a key role in helping the City identify measures for the HCP that could complement and leverage the ongoing basin-wide restoration effort.

The City's habitat conservation planning approach is described in more detail below. The City is confident that this approach has helped to prepare an HCP that will meet Section 10 requirements for ITP coverage, will fully address the impacts of the Bull Run water supply system, and will be an important part of the partnership effort to protect and restore habitat conditions in the Sandy River.

2.5.1 Sharing the Bull Run River

Both people and fish depend on the Bull Run River. This HCP reflects the actions the City will take to protect and improve habitat for fish and other species, while also ensuring that the City can continue to use water from the Bull Run watershed for generations to come. Sharing the water to meet both needs is a key element of the HCP.

Because the water system is located on the Bull Run River, the HCP is focused on addressing the impacts of system operations on fish in this particular river. Chapter 8 describes in detail how the flow, temperature, and habitat measures will improve habitat and fish population conditions in the Bull Run River. The City's intent is to provide biological improvements commensurate with water system impacts.

Water system operations in the future will be different from those in the past. The City's obligation as a water supplier is to ensure that future changes will be both practical and feasible, and will allow for ongoing operation of the water system to meet customer needs. Clarifying the amount of water needed to meet ESA requirements in the HCP helps the City plan more effectively for water supply. Chapter 7 describes the individual measures the City will take to ensure that it meets both the regulatory and the water supply requirements. Defining the City's financial obligation for habitat conservation and species protection also helps the City plan for and manage the associated financial impacts to ratepayers.

The HCP was designed to retain tools to meet future demand for water without compromising the City's ability to provide instream flows for fish. Water conservation and groundwater use provide flexible and cost-effective means to meet increased human needs over time. These tools will also help the City deal with year-to-year weather variability.

The HCP does not include measures to provide fish passage into Bull Run River habitat above the dams. The City has concluded that the investment required to provide passage is too much when compared to the amount of habitat available above the Bull Run dams and the productivity that would result from access to that habitat. This conclusion is based on the EDT model analysis of the habitat available above the dams (Mobrand Biometrics 2005) and estimates of what would be required financially and operationally (Tappel 1998, CH2M Hill

2008a) to provide such passage. In lieu of fish passage, the HCP compensates for lost habitat in the Bull Run by implementing measures elsewhere in the Sandy Basin.

Sharing the Bull Run River with people means that impacts of the water system on fish are not entirely offset by the HCP measures for the Bull Run River alone. This HCP therefore includes habitat conservation measures that will be implemented elsewhere within the Sandy River Basin. These measures will enable the City to address the effects of the Bull Run water supply on ESA-listed fish species and provide a meaningful contribution to the eventual recovery of those species. Because the fish that use the Bull Run River are part of larger populations in the Sandy River Basin, it makes sense for the City to join in a larger effort to help restore habitat in the Sandy River and its tributaries.

2.5.2 Stewardship of the Sandy River Basin

The offsite measures described in Chapter 7 of the HCP were selected to provide improved habitat conditions for ESA-listed fish species in the larger Sandy River Basin. Three key factors in this analysis were the regional importance of protecting the Sandy River populations of fall Chinook, coho, and steelhead; the difficulty involved in supporting spring Chinook spawning in the Bull Run River; and the City's intent is to take action in locations the Partners have identified as important for sustaining native fish populations.

NMFS has concluded that only two potentially viable populations of native fall Chinook remain in the Lower Columbia River Ecologically Significant Unit (ESU). One of these populations persists in the Sandy River and one in the Lewis River (McElhany et al. 2003). For this reason, the City has included measures in the HCP to benefit the Sandy River population of fall Chinook.

The coho salmon population in the Sandy River Basin is one of only two known self-sustaining populations in the Lower Columbia River ESU (Iwamoto et. al. 2003). HCP measures in the Bull Run Watershed substantially minimize impacts of the water system on coho, but do not avoid all impacts on coho. Additional measures located in the Upper Sandy River, the lower Salmon River, and the Zigzag River are designed to improve habitat conditions for coho.

Photo courtesy of Char Corkran.

NMFS Willamette Lower Columbia Technical Recovery Team (WLCTRT) has classified the Sandy River winter steelhead run as a core population and stated that this run currently offers one of the most likely paths to recovery in the Lower Columbia Steelhead ESU (McElhany et al. 2003). HCP measures in the lower Bull Run River will greatly improve conditions for steelhead, but will not avoid all impacts associated with operating the water supply system. Additional HCP measures to benefit steelhead are located primarily in the upper Sandy River, the Salmon and Zigzag rivers, and smaller tributary streams that are favored by steelhead.

Providing favorable water temperatures for spring Chinook spawning emerged as an objective difficult, if not impossible, to achieve in the lower Bull Run River. Even natural (pre-dam and pre-water system) temperature conditions in the Bull Run River were too warm when spring Chinook are spawning in the late summer/early fall (ODEQ 2005). This limitation results from the east-west orientation of the watershed and the resulting exposure to summer sun. Warming that occurs in the reservoirs exacerbates this problem. The HCP includes measures in other Sandy River Basin locations (upper Sandy River near Salmon River confluence, lower Salmon River, and Zigzag River) targeted to benefit spring Chinook.

2.5.3 Solid Technical Foundation

The selection of Bull Run measures and offsite measures to include in the HCP was informed by a series of technical evaluations conducted jointly by the Partners and others between 1999 and 2006. Coordinated technical information at the basin scale provides a solid technical foundation for coordinated restoration throughout the habitat used by the Sandy River Basin fish populations.

The Partners' first step was to compile a habitat database for 120 stream reaches throughout the Sandy River Basin, including the Bull Run River. Data types (45 attributes) were selected based on EDT methodology. Most of these data already existed, but the data files were dispersed and had not been compiled into a comprehensive basin-wide analysis. The database is made up of recent stream survey data collected using standard methodology (Moore et al. 2002). Where data gaps existed, extrapolations were made by biologists familiar with the stream reaches in question. The Partners took the extra step of reconciling data from adjacent stream reaches for consistency and so whole tributaries could be evaluated. An EDT model, built on the habitat database, was used to assess the habitat factors limiting the productivity of fish populations. The Partners then used the limiting factors analysis results to identify 150 habitat conservation measures that could be implemented to strategically improve habitat conditions and fish population productivity.

The Partners, with others, also identified anchor habitats currently existing throughout the Sandy River Basin. Anchor habitats are defined as stream reaches that are currently providing the largest numbers of fish (productivity). The results of this analysis provided valuable information for development of the HCP, as well as for parallel work by other Partner organizations.

In addition, the Partners and affiliated organizations have developed a coordinated population monitoring program for adult and juvenile fish, and a conservation and restoration strategy based on project type and location. The habitat conservation and restoration strategy is a scientifically based approach to conserving streams currently in good condition and restoring impaired streams to improve fish habitat and salmonid populations in the Sandy River Basin. The strategy identifies priority locations and priority action types for the short-term (5-10 years) and a framework for long-term planning and implementation. The HCP is designed to be consistent with these basin-wide strategies.

2.5.4 A Partnership Approach

As noted above, the City has worked collaboratively with the Partners since 1999 to assess conditions and plan a strategic basin-wide approach for restoration in the Sandy River Basin. The Partners were also directly involved in identifying measures to include in the HCP. One of the HCP strategies was to use the City's investments in the HCP to complement and leverage the resources and capabilities of all the Partners.

Working relationships have been created and improved among the organizations and individuals involved in the Partners. These relationships provide an institutional framework to sustain a coordinated basin-wide recovery effort for the 50-year term of the HCP, if not longer. This framework helps increase the probability that the City's work implementing the HCP will proceed in the context of a coordinated effort by federal, state, and local agencies; nonprofit organizations; and a variety of private landowners and businesses. The ongoing participation of the Partners and the basin-wide restoration strategy developed by the Partners will help guide the direction of HCP implementation.

2.6 Effectiveness of the HCP

The HCP includes a diverse set of habitat conservation measures in multiple locations throughout the Sandy River Basin. Demonstrating the effectiveness of these measures in meeting ESA requirements is an important element of the HCP. To assist in the evaluation of effectiveness of the habitat conservation measures, the City has provided in the HCP a reference condition for each measure. These reference conditions are drawn from the technical foundation described above, and in the Bull Run River include a comparison to the conditions that existed in the Bull Run watershed prior to development of the City's water system in the late nineteenth century. The reference conditions are described in Chapter 8. In addition, the HCP draws on the capabilities of the EDT model to assess the overall effect of the HCP on the key parameters used to judge fish population performance, specifically the Viable Salmonid Population (VSP) metrics of productivity, diversity, abundance, and spatial structure (McElhany et al. 2003). The VSP analyses are also provided in Chapter 8. The City is confident that, when taken as a whole, the HCP conservation measures meet the requirements of the law and make a meaningful contribution to the basin-wide restoration effort described above.

2.7 Content of the HCP

This chapter has provided an introduction for the HCP, including background information on the Bull Run water system and the City's habitat conservation approach. Chapter 3 describes the species, lands, facilities, and activities for which the City seeks Section 10 coverage in an ITP. Chapter 4 provides contextual information about landscape conditions in the Sandy River Basin. Chapter 5 provides information about the current conditions for the covered species in the basin as well as the 18 other fish and wildlife species addressed in the HCP. Chapter 6 outlines the City's goals and objectives, and Chapter 7 defines the habitat conservation measures. Chapter 8 describes the outcomes expected for each of the species and is also referred to as the effects analysis. Chapter 9 describes the City's monitoring and adaptive management programs. Chapter 10 provides contingency plans for potential changed conditions during the term of the HCP. Chapter 11 describes the costs anticipated to implement the habitat conservation measures, as well as monitoring and adaptive management, and describes how those costs will be paid. Chapter 12 provides alternatives to implementing the HCP. A series of appendixes provide additional detail for some sections.

Chapter 3. Scope of the Habitat Conservation Plan

3. Scope of the Habitat Conservation Plan

3.1 Species Covered and Addressed

3.1.1 Species Covered by the HCP

This Habitat Conservation Plan (HCP) requests ESA coverage for six species of fish, as listed in Table 3-1. Each of these species meets all of the following criteria:

- The species is known to be present or has the potential to be present within the Sandy River Basin during the term of the Incidental Take Permit (ITP).
- The species is currently listed or has the potential to be listed under the federal Endangered Species Act (ESA) as threatened or endangered during the term of the ITP.
- The species has the potential to be affected by one or more of the covered activities described in Section 3.4.

The ecology, current status, and distribution of each covered species in the Sandy River Basin are described in Chapter 5 of this HCP. The City of Portland (City) seeks coverage for each of these species in an ITP.

Table 3-1. Fish Species Covered by the HCP

Common Name	Scientific Name	Status[a]	
		Federal	State
Lower Columbia River Chinook Salmon (Spring and Fall)[b]	*Oncorhynchus tshawytscha*	T	S
Lower Columbia River Steelhead	*Oncorhynchus mykiss*	T	S
Lower Columbia River Coho Salmon	*Oncorhynchus kisutch*	T	E
Columbia River Chum Salmon	*Oncorhynchus keta*	T	S
Pacific Eulachon	*Thaleichthys pacificus*	C	none

[a]Status Codes: E = Endangered; T = Threatened; C= Candidate; S = Sensitive
[b]Fall and spring Chinook are separate races of the same species *(O. tshawytscha)*. In this HCP, the City refers to them as two species. Fall and spring Chinook, steelhead, and coho are therefore referred to as the four primary covered species.

3.1.2 Species Addressed by the HCP

The HCP also includes conservation measures and effects analyses for 18 fish and wildlife species under the jurisdiction of the U.S. Fish and Wildlife Service. The species included were those most likely to be affected by water system operations and/or benefited by measures designed for the anadromous fish. The 18 species are listed in Table 3-2. One of the species, northern spotted owl, is currently listed as threatened. The bald eagle was recently delisted under ESA but is still protected under other federal statutes. The City does not seek ESA coverage for the USFWS species at this time. However, the City believes the HCP provides protection for these species and their habitats that avoids or mitigates any significant impacts.

Table 3-2. Additional Species to Benefit from the HCP Measures

Common Name	Scientific Name	Status[a]	
		Federal	State
Fish			
Rainbow Trout	*Oncorhynchus mykiss*	none[b]	S
Coastal Cutthroat Trout	*Oncorhynchus clarki clarki*	SOC	S
Pacific Lamprey	*Lampetra tridentata*	SOC	S
River Lamprey	*Lampetra ayresi*	SOC	none
Western Brook Lamprey	*Lampetra richardsoni*	none	none
Amphibians and Reptiles			
Cope's Giant Salamander	*Dicamptodon copei*	none	S
Cascade Torrent Salamander	*Rhyacotriton cascadae*	none	S
Clouded Salamander	*Aneides ferreus*	none	S
Oregon Slender Salamander	*Batrachoseps wrighti*	SOC	S
Coastal Tailed Frog	*Ascaphus truei*	SOC	S
Northern Red-legged Frog	*Rana aurora aurora*	SOC	S
Cascades Frog	*Rana cascadae*	SOC	S
Western Toad	*Bufo boreas*	none	S
Western Painted Turtle	*Chrysemys picta belli*	none	S
Northwestern Pond Turtle	*Clemmys marmorata marmorata*	SOC	S
Birds and Mammal			
Bald Eagle	*Haliaeetus leucocephalus*	none[c]	T
Northern Spotted Owl	*Strix occidentalis caurina*	T	T
Fisher	*Martes pennanti*	C	S

[a]Status Codes: T = Threatened; S = Sensitive; C = Candidate; SOC = Species of Concern

[b]The resident form of Lower Columbia River rainbow trout, *O. mykiss,* is not listed under the Endangered Species Act.

[c]The bald eagle was delisted as a threatened species on the Endangered Species List on July 9, 2007 (USFWS 2007a). The City has prepared its bald eagle measure according to the National Bald Eagle Management Guidelines (USFWS 2007b).

3.2 Covered Lands

The City seeks coverage in the ITP for all lands associated with, and/or potentially affected by, covered activities located within the hydrologic boundary of the Sandy River Basin (except as specifically excluded in this chapter). The boundaries of the Sandy River Basin are shown in Figure 2-1. Covered lands include lands owned by the City and lands owned by others on which the City operates its water supply system or on which the City will implement habitat conservation measures. On these lands, the City seeks coverage for the activities listed in Section 3.4, but only to the extent that those activities affect the covered species.

3.3 Covered Facilities

The City seeks coverage for all facilities owned, operated, and/or used by the City as part of the Bull Run water supply system within the hydrologic boundary of the Sandy River Basin (unless specifically excluded in this chapter), but only to the extent these facilities are affected by the covered activities. Covered facilities are the following:

- Bull Run Dam 1 and Dam 2, and associated structures
- Reservoir 1 (Lake Ben Morrow) and Reservoir 2
- Reservoir 2 spillway approach canal
- Diversion dam and pool below Dam 2
- Spillway weir and pool below Dam 2
- Reservoir log booms and other reservoir structures
- Headworks facility (screens, chlorination facility, operation equipment)
- Water supply conduits (including interties and blowoffs), bridges, and trestles
- Water quality monitoring stations and flow gauges in the lower Bull Run River and the Little Sandy River
- Microwave communication towers located adjacent to waterways or reservoirs
- Sandy River Station maintenance facility
- City-owned or maintained roads and other paved/graveled surfaces on nonfederal lands
- City-owned or maintained easements on nonfederal lands owned by others (e.g., water supply conduit easements on private land)
- Easements owned or maintained by others on City-owned land (e.g., Bonneville Power Administration powerline easements on City land)

Facilities specifically excluded from the City's request for Section 10 coverage include water system facilities at Bull Run Lake, hydroelectric facilities at Dam 1 and Dam 2, the Lusted Hill Treatment Facility, Dodge Park at the confluence of the Bull Run and Sandy rivers, water supply conduits crossing the mainstem Sandy River, roads on federal land, minor facilities on national forest land upstream of Dam 2 and outside the riparian area surrounding the reservoirs, and all water supply facilities located outside the Sandy River Basin.

ESA coverage is available for facilities on federal lands through ESA Section 7 procedures, so the City has chosen to exclude some of them in the HCP (e.g., Bull Run Lake and federal roads).

3.4 Covered Activities

The City seeks coverage for City-implemented or City-authorized activities associated with the lands and facilities listed in Sections 3.2 and 3.3 to the extent that they affect covered species in Section 3.1. Covered activities are the following:

- Operation, maintenance, and repair of the water system
- Implementation of habitat conservation, research and monitoring measures
- Incidental land management

Each of these categories of covered activities is described in greater detail below.

Water system activities specifically excluded from the request for coverage include operation and maintenance of City facilities at Bull Run Lake; operation and maintenance of the Lusted Road Treatment Facility; operation and maintenance of Dodge Park; operation, maintenance, and replacement of conduits crossing the mainstem Sandy River; operation and maintenance of hydroelectric facilities at Dam 1 and Dam 2; operation and maintenance of minor facilities on national forest lands that are upstream of Dam 2 and outside the riparian area surrounding the reservoirs; maintenance and repair of roads on federal land; all aspects of the water supply system located outside of the Sandy River Basin; and activities by others in the Bull Run River watershed not specifically mentioned here. City funding of ODFW fish hatchery operations under the City's pre-existing federal hydropower license is also excluded (see Chapter 2).

During the term of the HCP, water supply facilities within the Bull Run and Sandy River Basin might be modified, constructed, or reconstructed by the City for reasons that are currently not anticipated and/or are not described in the HCP. The City will notify the NMFS prior to such currently undescribed activities if there is a potential for take of covered species and will consult with NMFS about measures to avoid or mitigate take. The HCP will be amended if necessary.

3.4.1 Operation, Maintenance, and Repair of the Water System

The City will continue to operate, maintain, and repair the Bull Run water supply system to provide a safe and reliable supply of water, satisfy the habitat conservation requirements of this HCP, comply with other pertinent laws and regulations, ensure the safety of its employees and of the general public, and protect the physical integrity of the water supply system structures. Covered activities are the following:

- Storage of water in system reservoirs and regulation of reservoir surface elevations
- Diversion of water for water supply
- Alteration of flows downstream from the water supply dams and diversion
- Release of water from reservoirs into the Bull Run River
- Adjustment of water intake depth to regulate temperature, turbidity, and color
- Seasonal closure of gates at the Dam 1 spillway to store additional water
- Removal of debris (including logs) from reservoirs

- Operation of boats and barges on reservoirs
- Delivery and storage of fuel and lubricants for water supply system vehicles and equipment
- Delivery and storage of chlorine gas for water supply disinfection
- Draining of water supply conduits
- General landscape maintenance within and around facilities
- Operation, maintenance, and repair of all facilities listed in Section 3.3

See description of these activities in Chapter 8, Section 8.7, for further information.

3.4.2 Habitat Conservation, Research, and Monitoring Measures

The City seeks coverage for implementation of habitat conservation measures described in Chapter 7, the research and monitoring measures described in Chapter 9, as well as any additional habitat conservation measures and monitoring measures implemented as part of adaptive management.

3.4.3 Incidental Land Management Activities

The City also seeks coverage for the following activities in the Sandy River Basin that are incidental to the operation of the water supply system:

- Management of City-owned riparian lands in the Bull Run watershed
- Maintenance and repair of roads, bridges, culverts, parking lots, easements and rights-of way on nonfederal lands in the Bull Run watershed
- Operation and maintenance of the Sandy River Station maintenance facility

See description of these activities in Chapter 8, Section 8.7, for further information.

3.5 Term of the HCP

The City seeks a 50-year term for the HCP and ITP.

Chapter 4. Landscape Conditions

4. Landscape Conditions

4.1 Environmental Setting

This chapter provides a general description of environmental and cultural conditions in the Sandy River Basin (Figure 4-1) as context for the Habitat Conservation Plan (HCP). For each topic discussed, the larger Sandy River Basin is described first, followed by a section specific to the Bull Run watershed. In addition, Section 4.3 provides a detailed description of the current habitat conditions in each of the six watersheds within the Sandy River Basin, including fish distribution (habitat access) and channel conditions. The descriptions and maps in this chapter are primarily based on the information appearing in the *Sandy River Basin Characterization Report* (Sandy River Basin Partners 2005).

Figure 4-1. Watersheds of the Sandy River Basin

4.1.1 Climate

Sandy River Basin

The Sandy River Basin has a maritime climate characterized by seasonally mild temperatures, wet winters, a long frost-free period, dry summers, and narrow daily fluctuations in temperature (Sandy River Basin Partners 2005).

Annual precipitation generally increases from west to east and with elevation, ranging from 30 inches near the mouth of the Sandy River at Troutdale (elevation 30 feet) to 140 inches at Mount Hood (elevation 11,237 feet). Table 4-1 summarizes precipitation variations within the Basin's watersheds. The heaviest precipitation occurs from November through January, and the lowest in July and August.

Table 4-1. Precipitation in the Sandy River Basin

Watershed	Annual Precipitation Range (inches)	
	Low	High
Lower Sandy River[a]	45 (at Troutdale)	62
Middle Sandy River[b]	91	127
Upper Sandy River[c]	70 (at west end of watershed)	~140 (near summit of Mount Hood)
Bull Run River[d]	52	143
Zigzag River[c]	65 (at the upper Still Creek drainage)	130
Salmon River [c]	35 (at east end of watershed)	130 (at source)

Sources:

[a] Oregon Climate Service – Troutdale Airport.

[b] Natural Resource Conservation Service – South Fork Bull Run River SNOTEL site.

[c] U.S. Forest Service Watershed Analysis documents—low at west end of watershed; high near Mount Hood summit.

[d] Represents long-term average of Bull Run station (Robbins 2004, personal communication; cited in Sandy River Basin Partners 2005).

Both temperature and precipitation vary with altitude, with higher elevations receiving much of the precipitation as snow (Oregon Department of Environmental Quality [ODEQ] 2005). Snowfall on Mount Hood averages more than 300 inches a year. High elevation snow often does not completely thaw until the end of summer. Snow accumulations, combined with stored glacier ice, act as reservoirs that release cool water flows throughout the summer. Snow and glacier melt improve summer base flows and reduce water temperatures in some of the Basin's watersheds.

Recorded air temperatures in the Sandy River Basin area (as a 30-year monthly average for January) range from a low of about 33 °F in Portland (measured at Portland International Airport, approximately 10 miles west of Troutdale) to a low of 22 °F in Government Camp. Average monthly highs are 81 °F (in July/August) in Troutdale (measured at the Portland International Airport and 70 °F (July) in Government Camp (Loy et al. 2001).

Bull Run

The Bull Run watershed is located at low to middle elevations in the Basin (260 to 4,750 feet). Most precipitation falls as rain, not snow. Snow accumulations are rare below 2,000 feet. Average maximum accumulations (measured as water equivalent) at the two higher-elevation SNOTEL sites are 13.4 inches (North Fork, 320-foot elevation) and 25.5 inches (Blazed Alder, 3,650-foot elevation), respectively.

Spring rains in the watershed last into June. Summers are mild and dry. Fall rains typically begin in September but can be sporadic, with limited precipitation until mid-October. Significant fall rains sometimes hold off until as late as December. Mean annual precipitation is 80 inches at the Headworks and 140 inches at the North Fork SNOTEL site.

Winter storms can be intense, dropping as much as 6.8 inches of rain in a 24-hour period (e.g., the 1994 Thanksgiving storm) and 10 to 15 inches in multi-day storms (e.g., 1994 and 1996). Storm tracks across the watershed are affected by prevailing winds and the topographic effects of the Columbia Gorge, Mount Hood, and other surrounding ridges oriented predominantly east-west.

See also Section 4.1.5 and Chapter 10 for information about potential impacts of climate change in Bull Run.

4.1.2 Topography and Geomorphology

Sandy River Basin

The topography of the Sandy River Basin is varied, with high-gradient relief in the upper reaches of the Basin, moderate gradients in the middle reaches, and relatively low gradients in the lower reaches (Table 4-2). The average gradient in the upper Basin is about 288 feet per mile (5.5 percent slope), but it may exceed 1,000 feet per mile (19 percent slope) (Oregon Department of Fish and Wildlife [ODFW] 2002). Elevations in the Basin range from a high of 11,240 feet above sea level at the glaciers of Mount Hood, to a low of 40 feet at the confluence with the Columbia River.

Table 4-2. Elevation Ranges in the Sandy River Basin

Watershed	Elevation Range (feet)
Lower Sandy River	40–3,920
Middle Sandy River	240–4,160
Upper Sandy River	554–11,047
Bull Run River	240–4,680
Zigzag River	1,400–11,240
Salmon River	1,100–10,000

Source: 2003 SCSGIS file 1:100k Sandy Basin streams with EDT reach delineation.

Along its route to the Columbia River, the Sandy River cuts through a series of formations consisting primarily of basalt and andesite flows, pyroclastics, landslide and/or mudflow material, and glacial deposits. Because much of this material is relatively stable yet somewhat easy to erode, the Sandy River has cut deep narrow canyons along many of its segments. The river is relatively confined within these canyons and exhibits little lateral movement. However, in moderate or gentle stream gradient areas, such as near the mouth (River Mile [RM] 0—RM 2.5) and in the vicinity of Mensinger Bottom (approximately RM 32.0 – RM 35.5), the Sandy River has been known to change its course, often rapidly (Oregon Division of State Lands [ODSL] 2002).

Bull Run

The mainstem Bull Run River is about 25 miles long. With the exception of the reservoirs, the river flows mostly through confined and moderately confined basalt canyons to its mouth at the Sandy River. Overall, the stream gradient is fairly low and averages approximately 1.5 to 2.5 percent (U.S. Forest Service [USFS] 1999). Riffles dominate the mainstem Bull Run channels. The USFS (1997) concluded that anadromous fish-bearing streams in the watershed exhibited a high percentage of riffle and large pool habitat but were limited in side-channel habitat. The USFS also hypothesized that habitat conditions in the watershed favored steelhead and Chinook salmon more than coho salmon.

The lower Bull Run River (RM 0–RM 5.8), which is currently accessible to anadromous fish, is dominated by bedrock and large boulders. Spawning gravels are scarce and probably limit the production of anadromous salmonids. Much of the lower river is riffle habitat but the pools are large in volume. Habitat conditions for juvenile salmonids in this section of the river are only fair due to the lack of habitat structure and cover (R2 Resource Consultants 1998b).

4.1.3 Geologic Landscape and Geologic Hazards

Sandy River Basin

The Sandy River Basin is composed of two major geologic provinces: the geologically young High Cascades Province and the older Western Cascades Province (USFS 1979). The Basin has been formed by a sequence of volcanic eruptions, uplifting, bedrock deformations, weathering, and erosion, with more volcanic eruptions followed by glaciation, and finally, more weathering and erosion. These geologic processes have left behind a mixed and highly varied combination of bedrock covered by equally varied surficial materials (USFS 1979). Lava flows and pyroclastic rock make up most of the bedrock found in the Basin.

Geologic hazards in the Sandy River Basin include volcanic eruption, earthquakes, and landslides. Mount Hood is an active volcano that, like other Cascade volcanoes, may only be resting. Were Mount Hood to erupt, it could trigger landslides, mudflows, and lava flows that could inundate stream habitat and create barriers to fish migration.

The topography of most of the present-day valley bottom throughout the Sandy River Basin is a product of three significant eruptive events from Crater Rock on Mount Hood. These eruptions occurred within the last 10,000 to 15,000 years and produced lahars. Lahars are fast-moving mudflows that result when hot volcanic material melts snow and ice from the slopes of the volcano. Past lahars have traveled as far as the confluence of the Columbia River, leaving terraces up to 150 meters deep. One such major event occurred in the late 1700s and created the Old Maid Flat area, together with deep silt deposits at the mouth of the Sandy River. The deposits were so extensive that when Lewis and Clark came upon them during their expedition years later, they named the river “Quicksand” River. Another large-scale, lahar-related sediment release was observed as recently as June 2002. This release, likely caused by rapid snowmelt, dramatically increased turbidity levels throughout the mainstem Sandy River (ODEQ 2005).

The ongoing influence of past laharic events, Mount Hood glaciers, and the Basin’s underlying lithology result in naturally high sediment loading in the Sandy River. Tributaries to the upper Sandy and Zigzag rivers receive large amounts of sediment, particularly during spring and summer months, from glaciers and steep unstable slopes on the western flank of Mount Hood. Fine suspended sediment, known as glacial silt or flour, is particularly noticeable in the Sandy River mainstem during mid-to-late summer. The Sandy River has one of the highest percentages of glacial melt of all major Oregon rivers (see additional information on Sandy River Basin glacial conditions in Section 4.1.4).

Seismic hazard within the Sandy River Basin is relatively low compared to the rest of western Oregon (Loy et al. 2001). The U. S. Geological Survey (USGS) has mapped faults in the Sandy River Basin. These traverse the Basin in a northeast-southwest position and are located within the Bull Run (upper portion), upper Sandy River, and Salmon River (lower portion) watersheds.

Bull Run

Protected from glacial and laharic influences, the Bull Run watershed has a more stable valley floor and reduced sediment yields. Columbia River Basalts form much of the bedrock layer. The Troutdale Formation (sedimentary, 200-foot thickness) is present west of the confluence of the Bull Run and Little Sandy rivers. Quarternary landslide deposits are present in the northern valley walls of the lower river. The Rhododendron Formation is also present in the lower Bull Run area and the Little Sandy. This formation is subject to erosion, though it is well cemented in some cases. Less than 2 percent of the total watershed area has been identified as highly susceptible to landslides (USFS 1997).

4.1.4 Hydrography

Sandy River Basin

The Sandy River Basin drains approximately 508 square miles (325,000 acres), flowing generally east to west. The mainstem Sandy River travels 56 miles before flowing into the Columbia River at RM 120.5 near the City of Troutdale. The Basin consists of five USGS fifth-field Hydrologic Unit Code watersheds: the upper Sandy River, middle Sandy River, lower Sandy River, Bull Run River, and Salmon River. The fifth-field Salmon River watershed encompasses the Zigzag River and Salmon River watersheds. Approximately 680 miles of streams have been mapped within the Basin.

The Sandy River and several of its major tributaries originate from the Sandy, Palmer, Reid, and Zigzag glaciers on the western slopes of Mount Hood at an approximate elevation of 6,200 feet above sea level. Glacial streams receive substantial coarse and fine sediment loads and exhibit turbid conditions, due to suspended glacial flour during the summer months. These types of streams feature “flashy” hydrologic regimes, dynamic stream channels, and cold summer stream temperatures. Some of these factors offer less stable habitat conditions for fish production than nonglacial streams, but the influence of glacial conditions on fish production in the Sandy River Basin is as yet unknown. Glacial tributaries in the Basin include Sandy River, Muddy Fork of the Sandy River, and Zigzag River. Clearwater tributaries include Salmon River, South Fork Salmon River, Boulder Creek, Bull Run River, Clear Creek, Camp Creek, Lost Creek, Still Creek, and Sandy River Clear Fork.[1]

The Zigzag and Salmon rivers are the two glacial-origin rivers in the Basin where habitat conservation measures will be implemented. The Zigzag River is a steep-gradient stream from the headwaters at Zigzag Glacier to the lower two miles, where it transforms to a more moderate gradient depositional area for sediment. Most glaciers on the south-facing slopes have largely vanished as a result of climatic changes over the past several thousand years. The associated streams are not glacially influenced at present and do not receive sediment loads similar to other glacial streams. The Salmon River originates from the Palmer Glacier on the south slope of Mount Hood and empties into the Sandy River at RM 38. The Salmon

[1] The Salmon River is a glacial-origin river that, unlike many other streams in the upper Sandy River Basin, does not receive large amounts of glacial sedimentation and remains clear throughout the summer.

River usually runs clear all year and provides miles of spawning and rearing habitat for both anadromous and resident fish species.

Following a major flood in 1964, the Army Corps of Engineers and local communities combined efforts to create artificial channels in several miles of the lower reaches of the Salmon, Zigzag, and Sandy rivers, and Still Creek. Heavy equipment was used to reconfigure and straighten the stream channels and remove most large obstructions and boulders from the streambeds. Large woody debris was cut up and removed. Berms were built with rocks to harden and contain the stream banks.

Though well intended, the channelization projects affected the timing, variability, and duration of floodplain and wetland inundation in the area. The berms and instream channelization work affected riparian vegetation, reduced instream habitat complexity, and blocked many side channels. The side channels and associated backwater areas were especially important as refuge for winter-rearing juvenile anadromous fish. Channelization also increased flow velocities, which scoured spawning gravels from portions of the streambed (ODFW 1997).

Bull Run

Bull Run River enters the Sandy River at Dodge Park (RM 18.5) near the City of Sandy. The mainstem Bull Run River is approximately 25 miles long and originates from springs below Bull Run Lake (elevation 3,180 feet), a large natural lake to the northwest of Mount Hood. The watershed drains approximately 140 square miles, or about one-fifth of the Sandy River Basin land area. The Little Sandy River is a large tributary stream that empties into the Bull Run River at about RM 2.9 (3.4 miles below the diversion dam at the Headworks).

4.1.5 Water Quantity and Water Rights

Sandy River Basin

The Sandy River is similar to many other western Cascade Mountain streams. Flow varies greatly on a daily and seasonal basis, depending on the amount of rain falling, the rate of snowpack and glacier melt, and the rate of withdrawal or diversion for a variety of uses. Minimum stream flows generally occur during September or October. Peak flows in the Basin most often occur in December and January and are often associated with rain-on-snow events (ODFW 2002).

Seasonal high and low stream flows vary throughout the Basin and are generally influenced by storm events and snowmelt. Streamflow in the upper Sandy River and Bull Run River watersheds is characterized by low flows in the late summer (August and September) and high flows from storm events from October through April. Highest stream flows in the Zigzag River watershed occur in May and June from snowmelt runoff (USFS 1995b, 1996, 1997). Average discharges in the Salmon River are also substantially influenced by rates of snow accumulation and snowmelt. Rain-on-snow events occur in transitional snow zone elevations of the Basin (typically in December and January) and can also occur in the Zigzag

River watershed. Peak flows in the mainstem Sandy River generally happen during major rain-on-snow storm events, as was true for the flood of December 1964.

USGS measures discharge at many locations in the Sandy River Basin. Key USGS measurement stations provide real-time data available via the USGS web site (http://waterdata.usgs.gov/nwis/rt). These stations include the following:

- USGS 14137000: Sandy River near Marmot
- USGS 14137001: Sandy River Diversion above Marmot Dam site
- USGS 14137002: Sandy River below Marmot Dam site
- USGS 14141500: Little Sandy River near Bull Run River
- USGS 14142500: Sandy River below the Bull Run River

The primary sources of measured flow data for the Sandy River are USGS Gauge No. 14142500 (0.1 mile downstream from the confluence of Bull Run River and the Sandy River) and USGS Gauge No. 14137000 (0.3 mile above the Marmot Dam site). Both gauges provide data on daily mean discharge in cubic feet per second (cfs). The monthly averages of daily mean flows at these two stations for the period from 1911 to 2002 are depicted in Figures 4-2 and 4-3. Gauge No. 14142500 reflects cumulative discharge for most of the Sandy River Basin (some tributaries such as Beaver, Gordon, and Trout creeks are downstream of the gauge and are not represented in the data).

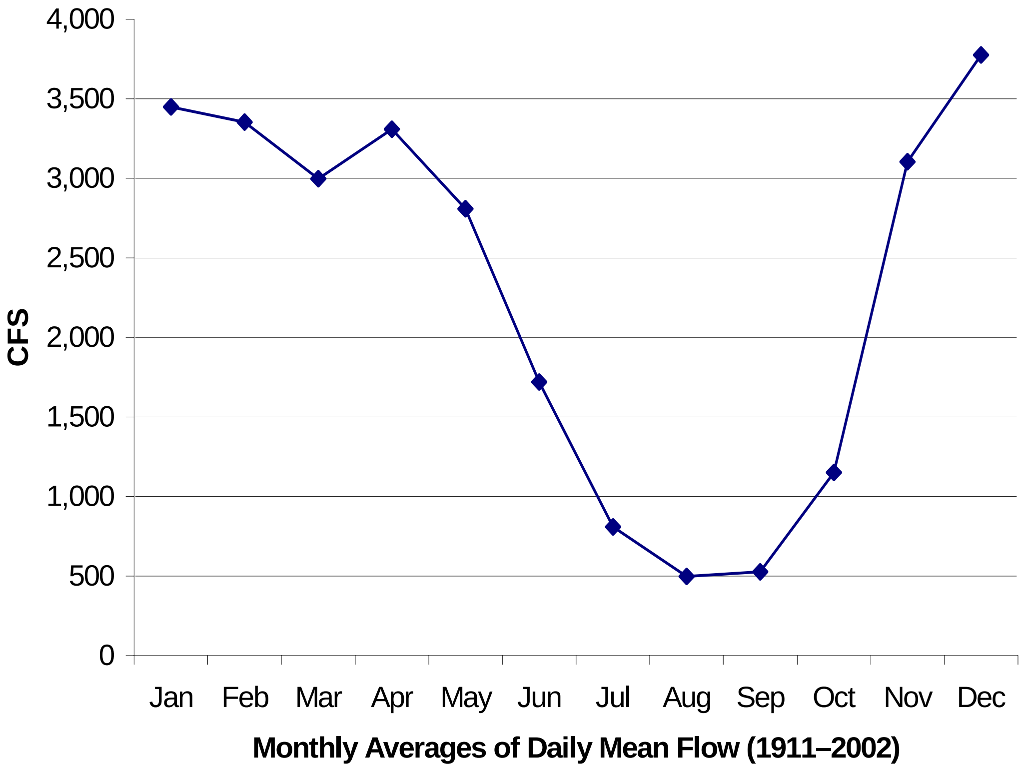


Figure 4-2. Monthly Averages of Daily Mean Flow in the Sandy River Below the Bull Run Confluence, 1911–2002 (USGS Gauge No. 14142500)

Source: USGS 2004a

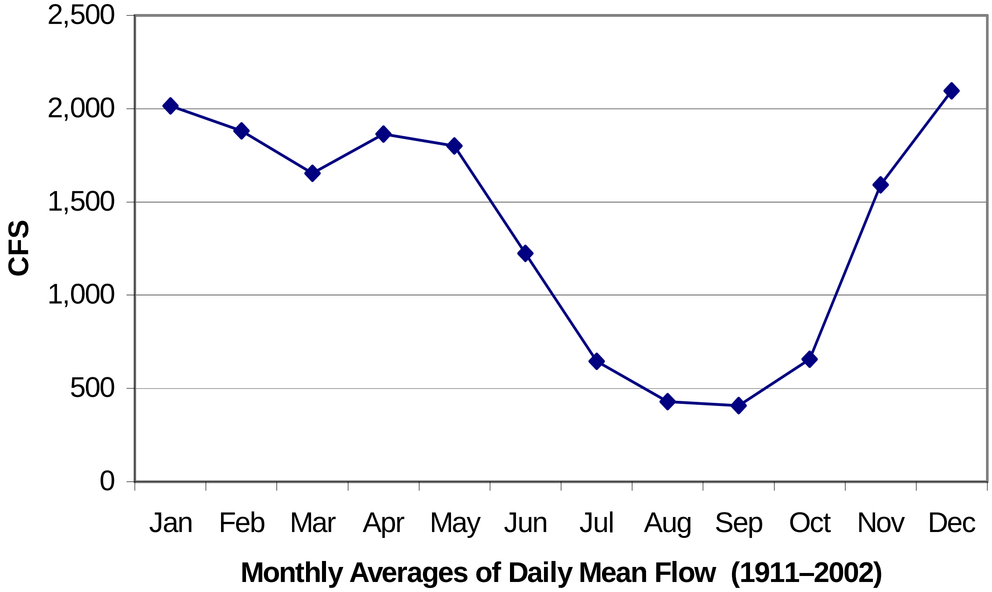


Figure 4-3. Monthly Averages of Daily Mean Flow in the Sandy River Above Marmot Dam Site, 1911–2002 (USGS Gauge No. 14137000)

Source: USGS 2004b

Flows in the Sandy River are variable, ranging widely between days and months within water years. The minimum instantaneous flow was 45 cfs in September 1962. The maximum was 84,400 cfs, which occurred in December 1964 (ODSL 2002). The next four highest flood flows were 65,800 cfs in February 1996, 58,000 cfs in March 1931, 57,600 cfs in November 1999, and 52,700 cfs in February 1986.

Flows during the dry period, occurring from June to October, are similar at stations 14142500 and 14137000. Discharge at the lower gauge (14142500) is greater than at the upper gauge (14137000) during the rainy period from November to May. Daily mean flow exceedences, by month, for Gauge Nos. 14142500 and 14137000 are listed in Table 4-3.

Table 4-3. Likelihood the Sandy River Flow Will Equal or Exceed the Flow Projections at USGS Gauge Nos. 14142500 and 14137000

	Gauge No. 14142500[a]			Gauge No. 14137000[b]		
Month	**10%**	**50%**	**90%**	**10%**	**50%**	**90%**
January	6,740	2,450	1,110	3,910	1,400	700
February	6,680	2,370	1,210	3,570	1,380	730
March	5,330	2,520	1,370	2,730	1,390	875
April	4,960	3,000	1,700	2,810	1,710	1,020
May	4,500	2,590	1,270	2,800	1,660	948
June	3,130	1,420	769	1,940	1,020	631
July	1,250	702	464	932	584	420
August	678	476	347	560	406	314
September	782	429	302	540	360	281
October	2,610	571	295	1,290	400	265
November	6,870	1,930	456	3,370	1,020	357
December	7,500	2,440	1,060	4,100	1,400	625

Note: Percentages indicate the percent of the time that flows are estimated to equal or exceed the specified flow amount.

[a] Gauge No. 14142500 is on the Sandy River, 0.1 mile downstream of the mouth of the Bull Run River.

[b] Gauge No. 14137000 is on the Sandy River, 0.3 mile upstream of Marmot Dam site.

The Oregon Water Resources Department (OWRD) modeled natural flows for the Sandy River Basin. Modeled natural flows (at a 50-percent and 80-percent exceedence level) at four locations on the Sandy River are presented in Table 4-4.

Table 4-4. Modeled Natural Average Monthly Flows at Four Locations on the Sandy River (cfs)[a,b]

	Below Confluence of Salmon River (+/- RM 37.5)		Above Confluence of Bull Run River (+/- RM 19.0)		Below Confluence of Bull Run River (+/- RM 18.0)		At Confluence of Columbia River (+/- RM 1.0)	
Month	**50%**	**80%**	**50%**	**80%**	**50%**	**80%**	**50%**	**80%**
Jan	1,412	823	1,720	989	2,780	1,536	3,190	1,810
Feb	1,411	959	1,680	1,120	2,720	1,745	3,130	2,040
Mar	1,293	968	1,500	1,110	2,450	1,750	2,760	2,000
Apr	1,561	1,097	1,770	1,240	2,880	1,961	3,120	2,190
May	1,507	1,129	1,680	1,230	2,649	1,900	2,740	1,940
Jun	955	716	1,030	772	1,519	1,075	1,620	1,190
Jul	567	447	608	490	830	650	950	726
Aug	416	344	424	364	562	487	633	539
Sep	394	311	406	331	594	458	682	503
Oct	413	328	449	339	766	510	843	561
Nov	940	536	1,190	609	2,126	1,062	2,210	1,160
Dec	1,466	880	1,740	1,010	2,830	1,625	3,230	1,880

Source: Oregon Department of State Lands 2002.

[a]Flow estimates are based on model developed by the Oregon Water Resources Department.
[b]Model assumes no consumptive uses or flow regulation and normal rainfall conditions.

Flow regimes in the Sandy River Basin have been affected by land use practices as well as by dams and diversion structures built over the past century. Natural discharge patterns in the Sandy River Basin have been altered primarily by the following:

- Diversion of water from the Sandy River (Marmot Dam at RM 30) and Little Sandy River (Little Sandy Diversion Dam at RM 1.7) for hydropower
- Storage and diversion of water from the Bull Run River for City of Portland's (City's) municipal water supply (Headworks Dam at RM 6)
- Diversion of water from the Sandy Hatchery weir on Cedar Creek at RM 0.05
- Withdrawal of water from Alder Creek to partially supply the City of Sandy's municipal requirements

Under Oregon State law, the storage of water by an impoundment and the diversion of water from a stream or groundwater aquifer must be permitted and must be put to beneficial use. State records (OWRD 2004) indicate a total of 7,880 cfs of appropriated water in the Sandy River Basin (not including the City's statutory right described below). The three largest uses for this water (all three non-consumptive) are power production, anadromous and resident fish rearing, and recreational boating (Sandy River Basin Partners 2005).

Bull Run

Table 4-5 lists estimated natural flows in the lower Bull Run River. The natural flows are defined as the monthly median Bull Run base flows that would have been in the river if no dams or diversions existed in the Bull Run. The City estimated the natural flows by using gauged tributary inflows to the reservoirs and then increasing them by 20 percent to account for the additional drainage areas not represented by the gauges. The resulting flow estimate was then increased by 4.9 percent to account for the drainage area from Bull Run Dam 2 to USGS Gauge No. 14140000 on the lower Bull Run River.

Table 4-5. Estimated Natural Flows in the Lower Bull Run River at USGS Gauge No. 14140000 (RM 4.7)

	Percentage[a]										
Month	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
January	19,821	2905	1,817	1,277	974	782	657	518	430	341	169
February	16,072	2420	1,529	1,186	955	785	667	558	469	368	159
March	9,560	1774	1,292	1,067	901	780	675	574	492	409	180
April	12,828	1620	1,283	1,119	991	896	803	710	596	493	175
May	6,340	1478	1,186	1,006	867	755	657	568	467	357	128
June	5,224	1040	749	599	486	408	354	303	255	201	91
July	2,465	362	274	232	203	180	164	148	131	117	73
August	2,382	216	164	144	131	122	110	105	97	88	52
September	6,214	427	266	196	156	128	112	101	91	84	42
October	9,696	1258	737	491	346	255	200	149	122	89	60
November	15,964	2620	1,711	1,261	980	771	619	479	355	243	65
December	22,327	2,947	1,877	1,316	1,053	857	709	586	488	362	110

Source: Monthly flows for the upper reach of the lower Bull Run River (1940-2004).
[a]Percent of the time flows are estimated to equal or exceed the specified flow amount.

Recent operation of the Bull Run water supply system has affected the magnitude and pattern of flow in the lower river, particularly during the summer and early fall. From early July to mid-October, most of the water entering the Bull Run reservoirs is diverted through Portland's water supply conduits. During the late fall and winter months, after the Bull Run reservoirs are filled, surplus water is spilled. There are currently no minimum instream flows in the lower Bull Run River.

Until early 2008, flow from the Little Sandy River was diverted at the Little Sandy Dam and then through a flume to Roslyn Lake, the forebay to the Portland General Electric (PGE) Bull Run Powerhouse at RM 1.5 on the Bull Run River. The Little Sandy Dam is scheduled for decommissioning and removal in 2008, which will restore natural flow conditions to the full length of the Little Sandy River and will add flow to the lower Bull Run River below the Little Sandy confluence.

In 1909, the state legislature enacted ORS 538.420, which states that “the exclusive rights to the use of waters of the Bull Run and Little Sandy Rivers are granted to the City of Portland.” PGE’s pre-1909 claim to water from the Little Sandy River will be converted to instream use, per state statute, after the Little Sandy Dam is decommissioned. See Chapter 2 for additional background on Bull Run and Little Sandy water rights.

Climate Change

The City has designed its HCP to take into account reasonably predicted climate changes and potential changes in the precipitation patterns and streamflow in the Bull Run watershed. The City has kept climate records for more than 60 years and continues to assess climate data and related research. University of Washington climate researchers recently evaluated effects of climate change on the Bull Run watershed and the city’s water supply (University of Washington 2002). They concluded that, over the long term, winter precipitation will likely increase and effects on flow from spring snowmelt will likely decrease. They also concluded that the average duration of reservoir drawdown was likely to increase. Over the next several decades, however, the Bull Run hydrograph will probably not change significantly. See Chapter 10 for additional information on climate change in Bull Run.

4.1.6 Water Quality

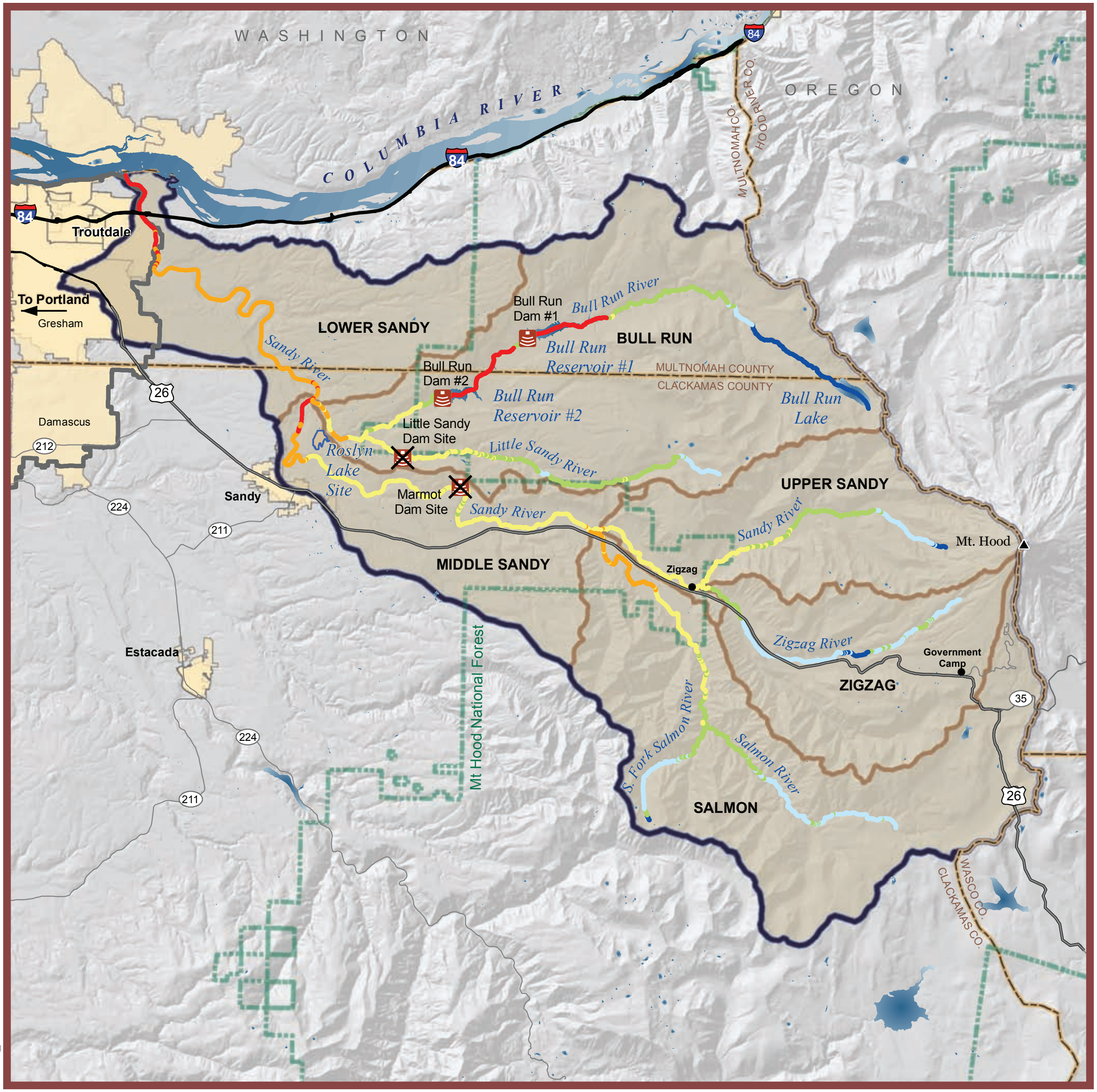
Sandy River Basin

Collection of water quality data for the Sandy River Basin has been sporadic. The exceptions are the Bull Run River watershed (where water quality is extensively monitored as a municipal water source) and an ambient water quality sampling site near the mouth of the Sandy River (at Troutdale Bridge, monitored by ODEQ bimonthly). Water quality conditions in the Sandy River Basin are generally good, and are suitable to support salmonids (ODEQ 2005; and Sandy River Basin Partners 2005).

In general, tributaries in the upper portion of the Sandy River Basin maintain cooler temperatures than the mainstems of the major rivers (Salmon, Sandy, and Bull Run). Air temperatures are cooler at higher elevations, and narrower channel widths afford more shade from riparian trees. Lower elevation tributaries undergo warmer air temperatures, lower gradients and slower flows, and wider channels.

ODEQ collected instream monitoring data and Forward Looking Infrared Radar (FLIR) data in 2001. According to the data, water temperatures in four river segments (totaling 45.9 river miles) exceed numeric criteria of the state temperature water quality standard (16 °C for rearing; 13 °C for spawning) and are therefore considered water quality limited. The FLIR water temperature data (ODEQ 2005) are presented in Figure 4.4.

ODEQ completed a Water Quality Management Plan in 2005 (ODEQ 2005). The plan provides a strategy for reducing pollutant discharges to comply with the total maximum



Key Boundaries
- Sandy River Basin
- Watershed Boundaries
- County Boundaries
- City Limits
- Urban Growth Boundary
- Mt. Hood National Forest

Roads
- Interstate Highway
- U.S. Highways
- State Highways

Site Features
- Dam
- Former Dam Site
- Lakes
- Former Lake Site

Water Temperatures (FLIR)
- Less than 10 ° C
- 10 - 13 ° C
- 13 - 16 ° C
- 16 - 18 ° C
- 18 - 21 ° C
- Greater than 21 ° C

N

Projection:
State Plane Oregon North
North American Datum 1983

Scale = 1:371,700

Miles 0 1 2 4 6 8

Kilometers 0 1.5 3 6 9 12 15

Figure 4-4. Relative Water Temperatures in Sandy River Basin Streams and Tributaries

daily load (TMDL) allocations determined for the Sandy River and required by the federal Clean Water Act. Water temperature measures in the plan include (but are not limited to) temperature control in permitted discharges and riparian area enhancement and protection (i.e., shading).

Bull Run

Water temperature conditions in the lower Bull Run River are within the suitable range for most of the year. Bull Run is, however, naturally warm during the summer and early fall months, and of limited suitability for some fish species (City of Portland 2004b, ODEQ 2005). Warm conditions occur because of the east-west orientation of the channel (resulting in prolonged sun exposure despite good-quality riparian conditions) and the lack of glacial influence and related cooling. The degree of groundwater-related cooling in the watershed is not known, although subsurface flow from Bull Run Lake to the springs forming the mainstem Bull Run River has a demonstrated cooling effect on upper (above dam) river temperatures. Bedrock-dominated channels in the lower river likely limit groundwater exchange, and the channel width, shallow cross-sectional depth, elevation, and overall distance from the topographic divide likely contribute to naturally warm conditions.

ODEQ has listed the lower Bull River as water quality limited for summer water temperatures. Maximum daily water temperatures in recent decades have routinely exceeded temperatures preferred for salmonid rearing and spawning in the late summer and fall. Figure 4-5 shows the trend in the daily mean, maximum, and minimum water temperatures measured in the lower Bull Run River during 2001 and 2002. The horizontal lines delineate the ODEQ current water temperature criteria for salmonids.

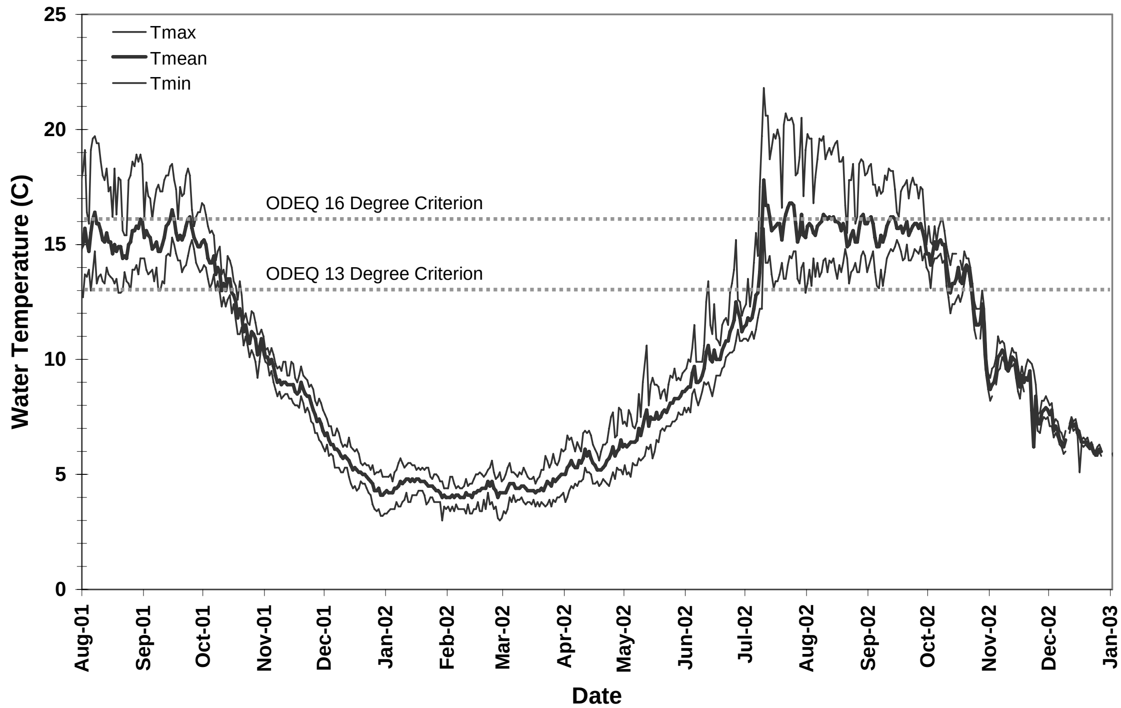


Figure 4-5. Lower Bull Run Water Temperatures, 2001–2002

Source: CH2M HILL 2003a

The Oregon statewide, biologically based (numeric) criteria for water temperature are 16 °C for salmonid rearing and 13 °C for salmonid spawning (ODEQ 2005). The physical characteristics of the lower Bull Run watershed (east-west orientation and bedrock substrate) accentuate solar heating in mid-summer and make these numeric temperature criteria unattainable, even without the influence of the City's water supply operation (Leighton 2002). In anticipation of this type of situation, the Oregon standard includes a "natural conditions" provision. The natural conditions standard (OAR 340-041-028) states:

"Where DEQ determines that the natural conditions of all or a portion of a subbasin exceed the biologically-based criteria, the natural condition supersedes the biologically based criteria, and the natural condition is deemed to be the applicable temperature criteria for that water body."

Natural conditions in the Bull Run River were analyzed by ODEQ and the City to assist in the development of a TMDL for the Sandy River and tributaries (ODEQ 2005). Portland State University and the City used a model of river flow and temperature conditions to characterize thermal conditions in the absence of the City's water system. Actual water temperatures in the lower Bull Run River were also measured over a range of conditions, and regression models were created based on those data.

ODEQ reviewed available USFS stream temperature data for the adjacent Little Sandy River and then measured water temperatures to confirm the USFS data. The City also collected Little Sandy River temperature data. These analyses indicated that natural Bull Run temperatures (at Larson's Bridge) and Little Sandy temperatures follow a similar pattern in response to weather and suggested the Little Sandy could serve as a real-time surrogate for water temperature compliance for the lower Bull Run. ODEQ developed a “correction factor” to account for the physical differences between the Bull Run and Little Sandy rivers (e.g., smaller basin size in the Little Sandy and faster temperature travel times).

Appendix G provides the Temperature Management Plan (TMP) required by DEQ to demonstrate compliance with the Sandy River TMDL. The TMP relies on the flow and temperature-related conservation measures included in Chapter 7.

4.1.7 Wetlands

Sandy River Basin

Wetlands are an important resource that provide cover and food sources for fish and filter pollutants. National Wetland Inventory (NWI) mapping reveals there are roughly 6,439 acres of wetlands in the Sandy River Basin, representing only about 2 percent of the Basin area. Eroded by abundant rainfall and dissected by numerous streams, the majority of the Basin has moderately steep topographic relief. Exceptions are the spring-created meadows on gentle slopes at the headwaters of the Salmon River and the riparian wetlands where the gradient lessens along the lower Sandy River, particularly the delta at its confluence with the Columbia River. The distribution of wetland areas among the six watersheds is indicated in Table 4-6.

Table 4-6. Wetland Distribution in the Sandy River Basin

Watershed	Wetland Acres	Wetland Acres as Percentage of Each Watershed
Upper Sandy River	427	1
Middle Sandy River	844	2
Lower Sandy River	1,534	3
Bull Run River	2,100	2
Zigzag River	349	1
Salmon River	1,185	2
Total	6,439	

Source: GIS calculations based on National Wetland Inventory mapping.

The Sandy River delta and several other sites along the lower Sandy River contain extensive areas of wet meadow, small ponds, and riparian forest. These are watered by rainfall and river overflow, and are maintained by subsurface river flow. They are classified as riverine wetlands, with some areas classified as palustrine emergent wetlands (Cowardin et al. 1979). Gallery forests of black cottonwood (*Populus trichocarpa*) predominate in some sections, but the majority of wetland acreage at the Sandy River delta is now covered with introduced reed canarygrass (*Phalaris arundinacea*), native sedges, and other herbaceous plants, as well as some willows and shrubs still abundant (CH2M HILL 2005).

Bull Run

The Bull Run River watershed has the largest number of NWI wetlands mapped in the Sandy River Basin due to its areas of moderately gentle topography. The largest wetland complexes are at the head of the Little Sandy River, the head of the North Fork Bull Run River, and around Big Bend Mountain in the Blazed Alder Creek drainage. Most of these wetlands are in areas where springs emerge on topographic benches. Water from the springs collects, is augmented by rainfall and snowmelt, and forms wet meadows or ponds before running off steeper slopes to form streams.

Scrub-shrub and riverine wetlands also occur in the upper Bull Run watershed, but they only cover small acreages. Scattered pockets of palustrine scrub-shrub wetlands or forested wetlands occur in the Camp Creek drainage, and one wetland is at Walker Prairie. These wetlands are on flat terrain in conifer forest, particularly where seeps emerge at the base of steeper slopes. They are dominated by shrubs, with sedges and other herbaceous plants present. Riverine wetlands are found on several old river benches that are now inundated when reservoirs 1 and 2 are full, as well as depositional bars of silt and fine woody debris at the heads of the reservoirs. These wetlands are dominated by sedges and other herbaceous plants, with willow (*Salix* spp.) in some sections.

NWI lists one freshwater forested/scrub wetland in the lower Bull Run watershed. It is a six-acre wetland at the mouth of the Bull Run River on the north side of the river across from Dodge Park.

4.1.8 Vegetation

Sandy River Basin

Over 86 percent of the Sandy River Basin is forested, either deciduous or coniferous. Coniferous forests are more prevalent. The remaining area of the Basin is urban, agricultural, or nonvegetated. The vegetative cover of the Basin is characterized by 12 cover-type categories, as defined by the Oregon Natural Heritage Program. These vegetative cover types are shown where they occur throughout the Basin in Figure 4-6.

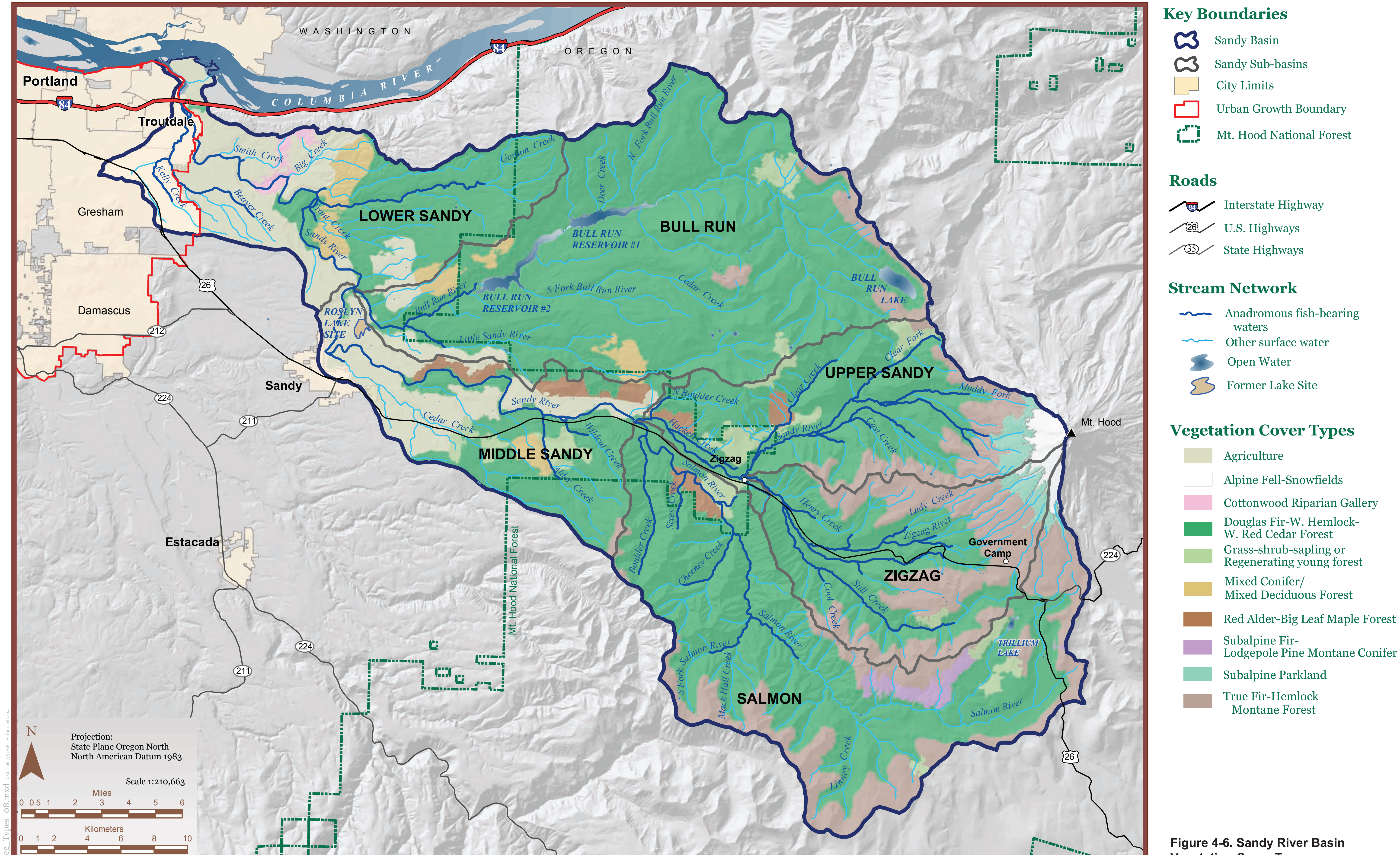


Figure 4-6. Sandy River Basin Vegetation Cover Types

The type and condition of riparian forests vary among the Basin's watersheds and river reaches. The typical riparian species in the Sandy River Basin include willow, alder, maple, cedar, hemlock, Douglas-fir, and true firs; all are species that thrive along stream bank riparian zones (Franklin and Dyrness 1973). Willow and alder are the predominant pioneering species on gravel bars and disturbed stream bank sites. Douglas-fir, cedar, hemlock, and true firs are key transition and climax species that provide stabilizing streamside structure, large wood (LW) recruitment, and stream shading.

Riparian conditions on forestlands in the Basin are generally in good condition (see Sandy River Basin Characterization Report, 2005, for additional information). Stream shading is good in the middle and upper reaches of the Sandy River, keeping temperatures down and providing habitat for fish and wildlife. The Salmon-Huckleberry Wilderness area covers approximately 36,000 acres of the Salmon River watershed; the Mt. Hood Wilderness area (approximately 36,000 acres) spans the watershed boundary of the upper Sandy and Zigzag river watersheds.

The riparian habitat in the Basin has been affected by human influences. Situated within minutes of the Portland metropolitan area, the lower river is heavily used for recreation. Agriculture and residential development have altered or disturbed some riparian habitat areas and also caused stream bank erosion.

Bull Run

The Bull Run watershed is largely coniferous forest, and much of it is more than 150 years old. Limited timber harvest began in the Bull Run watershed in the 1800s near the headwaters of Bear Creek (USFS 1997). Prior to 1958, approximately 1,200 acres were cleared for the sites of Bull Run Reservoirs No. 1 and No. 2 (USFS 1997). From 1958 to 1973, timber on 15,980 acres of the watershed (about 20 percent) was harvested (USFS 1997). Timber harvest was subsequently limited to salvage logging after a large windstorm in 1983. During the period 1900–1997, 110 fires were recorded in the watershed (USFS 1997). None of the fires exceeded 1,000 acres. The largest one, the 1971 Linket Fire, burned 960 acres (USFS 1997).

The narrow floodplains along the Bull Run river channel, resulting from the confined basalt canyons, have produced riparian zones that are dominated by conifers with some bigleaf and vine maple, alder, and willow (USFS 1999). The riparian zones of the Bull Run River are usually dominated by hemlock, Douglas-fir, and cedar.

4.1.9 Fish and Wildlife

Sandy River Basin

The Sandy River Basin supports a diverse assemblage of native and introduced fish species from its headwaters to its mouth. The native species of Chinook and coho salmon, steelhead, eulachon (also called smelt), coastal cutthroat trout, and lamprey are known to occur in the Basin. These species are described in detail in Chapter 5 along with maps of current and historical distribution of the four primary covered species. Other native fish species of ecological or cultural significance that may be found in the Sandy River Basin include chum salmon (*Oncorhynchus keta),* mountain whitefish (*Prosopium williamsoni*), eulachon (*Thaleichthys pacificus),* resident rainbow trout (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*).

Historically, annual Columbia River harvest of chum salmon reached 500,000 fish; but today, populations in Oregon tributaries to the Columbia, including those in the Sandy River Basin, are extinct (ODFW 2005). The few fish observed in Oregon are probably strays from runs returning to the Washington tributaries of the lower Columbia. Estuarine and lower river habitat degradation have been implicated as likely causes (ODFW 2005).

Mountain whitefish are ecologically important to the health of the Sandy River Basin and its fish resources (ODFW 1997). Whitefish eggs and fry provide a food source for overwintering native fish stocks. Although biological information about whitefish is limited, they are most commonly found in mainstem rivers and large tributaries. According to ODFW (1997), whitefish populations in the Basin appear to be healthy.

Eulachon (smelt) historically ascended the Columbia River by the millions to spawn in the lower mainstem and tributaries, including the Sandy River. Smelt returns to the Sandy River are inconsistent, with large runs in some years and no smelt observed in others (ODFW 1997). When present, the smelt return to spawn in the Sandy River between February and April. They spawn in sandy-silty substrates commonly found in the lower river near the mouth.

Resident rainbow trout are indigenous to the Sandy River, and important populations are documented as existing above anadromous barriers in the Little Sandy River and upper Gordon Creek (ODFW 1997). Rainbow trout are also found throughout the middle and lower reaches of the mainstem Sandy, Bull Run, Salmon, and Little Sandy rivers. Rainbow trout have not been documented above Final Falls (near RM 14) on the Salmon River or above the falls at RM 21 on the Bull Run River. Historically, ODFW stocked rainbow trout in the upper Sandy River watershed. Stocking was discontinued in 1995 to reduce competition with native fish stocks.

Bull trout were historically documented in the Clackamas River Basin and are currently found in the Hood River watershed. The historical presence of bull trout in the Sandy River Basin has been debated. Confirmed sightings of bull trout have occurred in the Sandy River Basin (Bachmann, pers. comm., 2002). Photographs were taken of an angler-caught bull trout on January 23, 2002, and ODFW staff reported a bull trout in the Marmot Dam fish trap in May 2000 (Schneider, pers. comm., 2002). A 1960 report (Leonards 1960; cited in USFS 1996) also refers to bull trout in the Sandy River Basin, but documented proof is lacking.

The Columbia River bull trout distinct population segment (DPS) was federally listed as threatened on June 10, 1998, by the U.S. Fish and Wildlife Service (USFWS). The Columbia River bull trout DPS includes all bull trout populations located within the Columbia River Basin and its tributaries in the United States (excluding bull trout found in the Jarbidge River, Nevada). The Sandy River was not identified in this listing as supporting a bull trout population (National Marine Fisheries Service [NMFS] 1998b).

ODFW introduced brook trout (*Salvelinus fontinalis*) into high elevation lakes (e.g., Cast, Dumbbell, Palmer, and Blue lakes) via airplane back in the late 1950s and early 1960s. ODFW also introduced grayling into Goodfellow Lakes, although the planting was unsuccessful. The bulk of nonsalmonid game fish found in the Sandy River Basin were introduced in the late 1800s to early 1900s except for white sturgeon (*Acipenser transmontanus*), which are indigenous to the Columbia River system.

The majority of the introduced species are found in the lower Sandy River near the delta, where velocities are typically slower and water temperatures are generally warmer than other locations in the Basin. ODFW (1997) describes the major management concern associated with introduced fish as predation on native fish stocks. Physical attributes of the Sandy River (i.e., high velocity and cool water temperatures) appear to be limiting the colonization of warm-water predatory fish introduced to the lowermost reaches of the Basin.

In addition to fish, the Sandy River Basin also provides diverse habitats for a wide variety of wildlife species. The Basin is located in the Pacific flyway and is used by migratory birds as resting or nesting grounds during migration. A rich diversity of amphibian and reptile species is found in the Basin's rivers, streams, marshes, and ponds. Mammal species living in the Basin include Roosevelt elk, black-tailed deer, black bear, coyote, cougar, bobcat, otter, raccoon, beaver, mink, and wolverine. The habitats adjacent to the rivers and tributaries provide important travel corridors for wildlife movement and dispersal.

Bull Run

The Bull Run watershed supports fall and spring Chinook, coho salmon, steelhead, rainbow trout, cutthroat trout, and various other fish species. Anadromous fish are limited in their distribution to the lower Bull Run River downstream of Dam 2. Pacific lamprey have been observed in the lower river while the reservoirs support cutthroat and rainbow trout, and cutthroat/rainbow hybrids. Cutthroat trout are also found in Bull Run Lake, which is isolated from the headwaters of the Bull Run River by a landslide that occurred approximately 15,000 years ago. Because the population of cutthroat is isolated, the City is not requesting coverage for the Bull Run Lake cutthroat in this HCP.

Several other species addressed in the HCP utilize habitats in the Bull Run watershed. Various amphibians such as the northern red-legged frog, the coastal tailed frog, Cope's giant salamander, Cascade torrent salamander, and the Oregon slender salamander rely on habitat in the Bull Run. The watershed also has important upland habitat for bald eagles and spotted owls.

4.2 Cultural Setting

Early human activity in the Sandy River Basin was largely limited to subsistence living, travel, and dispersed hunting and gathering. By the middle of the 1800s, the majority of human activity in the area concentrated on agriculture, timber production, and fish harvest. Dams were constructed in the early 1900s to provide municipal water supply and generate hydropower. Communities near the mouth of the Sandy (Troutdale and Gresham) and along the Highway 26 corridor continue to grow today.

4.2.1 Current Land Use

Sandy River Basin

The overwhelming majority of the Sandy River Basin is covered by private and public forests, with federal forests constituting about 75 percent of the Basin. Urban and agricultural areas are concentrated at the lower part of the Basin, including portions of the incorporated cities of Sandy, Troutdale, and Gresham. Agricultural areas are used to grow row crops, berries, and nursery stock, and to support livestock. Land cover is generally indicated by the satellite photo provided in Figure 4-7. Land ownership is listed in Table 4-7.

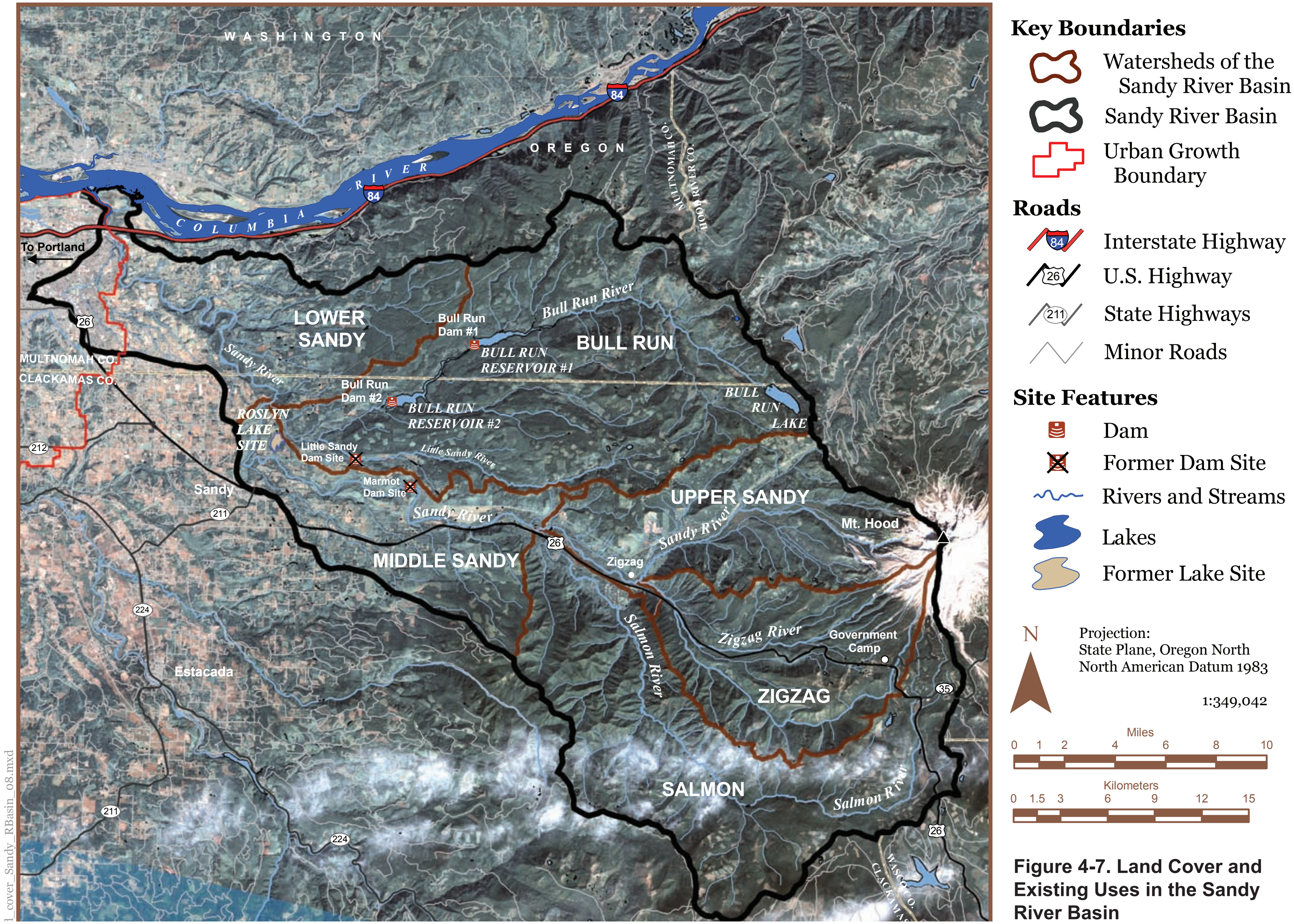


Figure 4-7. Land Cover and Existing Uses in the Sandy River Basin

Table 4-7. Land Ownership in the Sandy River Basin

Ownership Type	Total Acres	Percent Composition
Federal		
Bureau of Land Management	13,666	4
U. S. Forest Service	221,428	70
State		
State of Oregon	845	< 1
Local/Regional		
City	264	> 1
County	1,714	> 1
Portland Water Bureau	5,108	2
Metro	1,622	> 1
Private Lands		
Conservation Group	684	< 1
Portland General Electric	1,466	< 1
Other Private Owners	68,713	22

Source: Metro tax lot information, 2003

The Basin is used as a water supply source, an electric power source, and a recreational haven for hikers, skiers, fishing and camping enthusiasts, boaters, swimmers, and mountain bicyclists. More than 58 miles of streams within the Basin are designated Wild, Scenic, or Recreational under the federal Wild and Scenic Rivers Act. Almost 20,000 acres of land are protected within these river corridors (USFS 1989).

Salmon and steelhead runs support popular sport fisheries in the Sandy River Basin. Fishing regulations put special emphasis on the survival of wild fish in the Basin. The mainstem Sandy River upstream to the Marmot Dam site is open for harvest of adipose-fin-clipped steelhead year-round, adipose-fin-clipped Chinook salmon from February 1 to October 31, and adipose-fin-clipped coho salmon from August 1 to October 31.

Winter steelhead are the most popular game fish in the Sandy River. Before catch-and-release regulations were started in 1990, in-basin harvest of winter steelhead significantly affected spawning and escapement of wild winter steelhead into the upper Basin. The spring Chinook salmon run also supports a substantial sport fishery in the river below the Marmot Dam site. Spring Chinook are a large-bodied, high-quality food fish. They are caught in the early part of their run when the fish are still in good physical condition. Fall Chinook fishing is generally limited by natural conditions, since by the time the adults return to the Sandy River to spawn their condition and meat quality have deteriorated.

Hatchery fish are no longer planted in the upper Basin above the Marmot Dam site (RM 30). In 2006, a trap at the dam’s fish ladder prevented hatchery steelhead and coho salmon from entering the river above Marmot Dam. With the decommissioning and removal of Marmot Dam, ODFW changed practices for releasing juvenile hatchery fish to control straying of returning adults. For example, hatchery winter steelhead are released at popular angling spots such as Oxbow and Dabney parks on the lower river.

Bull Run

President Benjamin Harrison designated the Bull Run watershed as a national forest reserve in 1892, anticipating development of the water supply for the City. Water from the Bull Run River was first diverted to Portland in 1895. Since the turn of the twentieth century, the water system has been developed to serve the water needs of the Portland metropolitan area. Two large dams were constructed for water storage—the first in 1929 and the second in 1964. In the 1980s, the dams were retrofitted to generate hydropower.

Access to the Bull Run Watershed Management Unit is restricted by federal law. Recreational uses (e.g., fishing and boating) are not allowed. Facilities include water system infrastructure, access roads, and a variety of monitoring and communication equipment installations related to water system operation. No private residences or commercial facilities exist inside the management unit boundary.

Land uses downstream of the management unit boundary include a small number of private residences, the PGE Bull Run Powerhouse, Camp Namanu (a residential summer camp), and Dodge Park (a picnic and fishing area owned and operated by the City).

4.2.2 Land Management and Regulation

Sandy River Basin

More than 70 percent of the Sandy River Basin is national forest land, under the jurisdiction of the Mt. Hood National Forest. Some checkerboard lands in the middle Basin are administered by the Bureau of Land Management (BLM). All of these federal lands are managed according to the Northwest Forest Plan. Unincorporated private land along the Highway 26 corridor and middle mainstem Sandy River as far upstream as Zigzag is in Clackamas County. Unincorporated private land along the lower mainstem Sandy River and related tributaries is in Multnomah County. Management of nonfederal forestlands is regulated by the Oregon Department of Forestry (ODF). Portions of the cities of Sandy, Troutdale, and Gresham are also located in the Basin.

USFS Land Management

Management activities in the Mt. Hood National Forest are guided by the Northwest Forest Plan (USFS 1994b) and the Mt. Hood National Forest Land and Resource Management Plan (LRMP) (USFS 1990). A reconciliation document drafted in 1995 indicates that all standards and guidelines in the Mt. Hood National Forest LRMP apply unless superseded by the Northwest Forest Plan standards. When standards and guidelines from both documents apply, the more restrictive applies or one that provides greater benefits to late-successional forest-related species. Late Successional Reserve is the dominant land allocation within Mt. Hood National Forest lands located in the Sandy River Basin.

BLM Land Management

BLM land management activities comply with Northwest Forest Plan requirements, and are also managed according to the Salem District BLM Resources Management Plan. BLM, in conjunction with private organizations such as Western Rivers Conservancy and The Nature Conservancy, manages about 20 miles of Wild and Scenic Rivers within the Sandy River and Salmon River watersheds, in addition to 9,000 acres in the Highway 26 corridor (ODEQ 2005). BLM is proceeding to acquire land in the middle Sandy River/ Salmon River corridors under the direction of The Conservation and Land Tenure Strategy for the Sandy River and Mt. Hood Corridor and the Oregon Resources Conservation Act of 1996.

Nonfederal Forest Lands (State Forest Practices Rules)

ODF regulates the management of riparian and upland forest on nonfederal lands. The Oregon Forest Practices Act (ORS Chapter 527) and associated rules prescribe measures intended to protect natural resources. Riparian management requirements are based on the type, size, and beneficial use of a water body. Stream size is classified as small, medium, or large based on average annual flow. Buffer widths vary from 50 to 100 feet.

Best management practices for riparian management areas include tree harvest prohibitions; understory vegetation retention; snags and downed wood retention; basal area retention targets; live conifers retention; precommercial thinning, and other activities to maintain the growth and survival of conifers; and stream buffers. Restrictions are also imposed on the application of chemicals (e.g., pesticides, herbicides, fertilizers).

Nonforested Riparian Lands (County and Municipal Zoning)

Local government land use regulations are in place to protect rivers, streams, and water quality in the Sandy River Basin. Regulations vary by jurisdiction, but all the cities and counties have regulations that govern how development occurs in riparian areas. The following jurisdictions have land use authorities within the Basin: cities of Sandy, Troutdale, and Gresham; and Multnomah and Clackamas counties. The urban growth boundary also extends into the Basin and is managed by Metro, a directly elected regional government.

Land use regulations are governed by Oregon's statewide land use goals. Programs to comply with these land use goals are developed and codified in comprehensive plans and zoning ordinances adopted by the jurisdictions. Goal 5 deals with protection of natural resources, scenic and historic areas, and open spaces. Goal 6 deals with the quality of air, water, and land resources of the state. Floodplain management and other natural hazards are included in Goal 7.

While all the jurisdictions have different plans and ordinances, the objectives in each case are to protect the riparian resources in the Basin and maintain water quality. The primary mechanisms are establishing development setbacks based on stream size and slope, maintaining trees, controlling erosion, and planting native vegetation.

Bull Run

Approximately 90 percent of the Bull Run watershed is on national forest land and is managed in accordance with Northwest Forest Plan provisions, as well as statutes specifically applicable to Bull Run that strictly regulate timber harvest. A federal law, Public Law 95-200, was passed in 1977 as a result of public controversies about timber harvest that took place primarily between 1958 and 1973. PL 95-200 restricts access to the watershed and restricts forest management practices. Federal lands in the Bull Run and Little Sandy watersheds are also subject to the provisions of two recent statutes—the 1996 Oregon Resource Conservation Act (ORCA) and the 2001 Little Sandy Protection Act. ORCA amended P.L. 95-200 and prohibited timber cutting except as needed in two cases: to protect water quality and quantity, and to operate the City’s water supply and hydropower facilities. The Little Sandy Protection Act added 2,550 acres of federal land to the Bull Run Watershed Management Unit and extended the watershed protections that apply in the unit to these acres. These statutes supersede the direction provided in the Northwest Forest Plan.

City-owned lands along the lower Bull Run River, together with downstream private lands, are managed in compliance with Clackamas County laws and ordinances and State of Oregon laws and regulations. City-owned land is also managed according to City Council ordinances and policies. The City limits tree harvest on its lands to that necessary for the maintenance and protection of the water system. The City has not allowed commercial timber harvest on its lands for over 30 years.

4.3 Current Habitat Conditions in the HCP Area

Habitat information in this section is organized according to the six watersheds in the Sandy River Basin.

- Lower Sandy River
- Middle Sandy River
- Upper Sandy River
- Salmon River
- Zigzag River
- Bull Run River

Much of the following text comes from ODFW's Sandy River Fish Management Plan (ODFW 2001), Stillwater Sciences (2000), the Sandy River Basin Characterization Report (Sandy River Basin Partners 2005), and various watershed analyses completed by USFS for the Mt. Hood National Forest (Zigzag Watershed Analysis: USFS 1995b; upper Sandy Watershed Analysis: USFS 1996; Salmon River Watershed Analysis: USFS 1995a, Bull Run Watershed Analysis: USFS 1997).

Habitat information in each of the six watersheds is provided as context for the habitat conservation measures in Chapter 7 and the analysis of effects in Chapter 8. Land-use patterns, habitat access, and channel conditions are described as well as the current and historical distribution of fall Chinook, spring Chinook, winter steelhead, and coho salmon. Table 4-8 provides an estimate of the current and historical distribution of fall and spring Chinook, winter steelhead, and coho.[2] The stream miles listed in this table are derived from a geographic information system (GIS) interpretation of a 1:100,000-scale map. The species distribution used in the current conditions described in Chapter 5 is by individual stream reach; the stream reach mileages are based on stream surveys and are therefore more detailed than the stream miles by watershed listed in Table 4-8. The detailed stream reach mileages were used in the analysis of effects that appears in Chapter 8. Appendix C shows the distribution of the four primary salmonids species on a reach-by-reach basis.

The current habitat conditions information also provides the broad context for the species-specific information and maps in Chapter 5.

[2] The stream miles are an estimate because not all of the culvert information in the Basin was available.

Table 4-8. Estimated Stream Miles for Current and Historical Anadromous Fish Distribution in the Sandy River Basin[a,b]

Watershed	Total Stream Miles in Watershed	Current Anadromous Fish Distribution	Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
			Current	Historical	Current	Historical	Current	Historical	Current	Historical
Lower Sandy River	107	36	20	20	20	20	36	36	35	35
Middle Sandy River	65	24	12	20	20	20	24	37	24	37
Upper Sandy River	107	44	0	23	29	29	44	44	30	30
Salmon River	130	28	0	21	22	22	28	28	28	28
Zigzag River	100	30	0	18	23	23	30	30	23	23
Bull Run	170	8	8	40	8	40	8	49	8	40
Basin Total	679	170	40	142	122	154	170	224	148	193

Source: Sandy River Basin Characterization Report 2005.

[a]These stream mile designations were made by the Sandy River technical team composed of staff from the Sandy River Basin Partners.

[b]The team made the designations during the development of the Sandy River stream reach database and by GIS interpretation of a 1:100,000-scale map. These estimates of mileage might not be correct. If data were unavailable on the presence of fish barriers or the passability of juveniles and adults to migrate past known barriers, the technical team assumed complete passage because the analysis was focused on estimating the quality and quantity of stream habitat in the Basin. Historical distribution of each species was based on the known habitat preferences of each species and the professional opinion of the technical team.

4.3.1 Lower Sandy River Watershed

The lower Sandy River watershed (Figure 4-8) is the most urbanized of the six watersheds in the Sandy River Basin, and it contains the most agricultural lands (Sandy River Basin Watershed Council 1999). Aquatic habitat degradation is widespread in the lower watershed. Although some natural channel conditions persist, much of the stream banks of the mainstem lower Sandy River are armored with riprap to prevent erosion of private property and roads. Channel modifications are evident along the west bank of the lower Sandy River near Troutdale. The mouth of the Sandy River was channelized and rerouted in the past, but agencies are now undertaking efforts to return the lower Sandy River to its original channel at the mouth of the river (Virginia Kelly, USFS, pers. comm., May 2006). Substantial habitat diversity and complexity were lost in the lower Sandy River as meanders, oxbows, and side channels were disconnected and LW was removed.

Lower Basin tributaries have also been heavily influenced by ongoing development. Buck Creek was affected by debris flows during major floods in 1964 and 1996. Additionally, a poorly designed culvert on Buck Creek has been considered a partial passage barrier to upstream migrating fish since the 1950s (ODFW 1997). Beaver Creek has been heavily impacted by urbanization and nursery stock production facilities (ODFW 1997).

Gordon and Trout creeks are still in relatively good shape. These tributaries are utilized by steelhead, coho, and fall Chinook for spawning and rearing.

Habitat Access

The mainstem Sandy River in this watershed is unobstructed for fish passage. Several tributaries, notably Beaver and Buck creeks, contain culverts that affect fish passage.

The Sandy River and its tributaries in the lower Sandy River watershed support the bulk of the fall Chinook salmon productivity in the Sandy River Basin. The lower Sandy River also functions as an important migration corridor for juvenile and adult salmonid fishes. Gordon Creek is the only remaining free-flowing, unobstructed tributary in this watershed. It is an important spawning tributary for threatened Lower River Wild Sandy River fall Chinook and winter steelhead trout (ODFW 1997). Trout Creek has a natural barrier to fish passage (four-meter-high falls) about 1,500 meters from the mouth (SRBWC 1999). Trout, Buck, and Beaver creeks are important to anadromous fish productivity in the lower Sandy River watershed.

It is difficult to assess the number of stream miles in the lower Sandy River watershed currently used by anadromous fish compared with what was available historically. For Table 4-8, the Sandy River Basin Agreement Technical Team (SRBTT) assumed that all 36 stream miles in the lower Sandy River watershed currently utilized by anadromous fish are used by steelhead and coho salmon. Historically, both species used the same number of stream miles in the watershed (See Appendix C for the full current and historical distribution). Fall and spring Chinook currently use about 20 stream miles in the lower Sandy River watershed, the

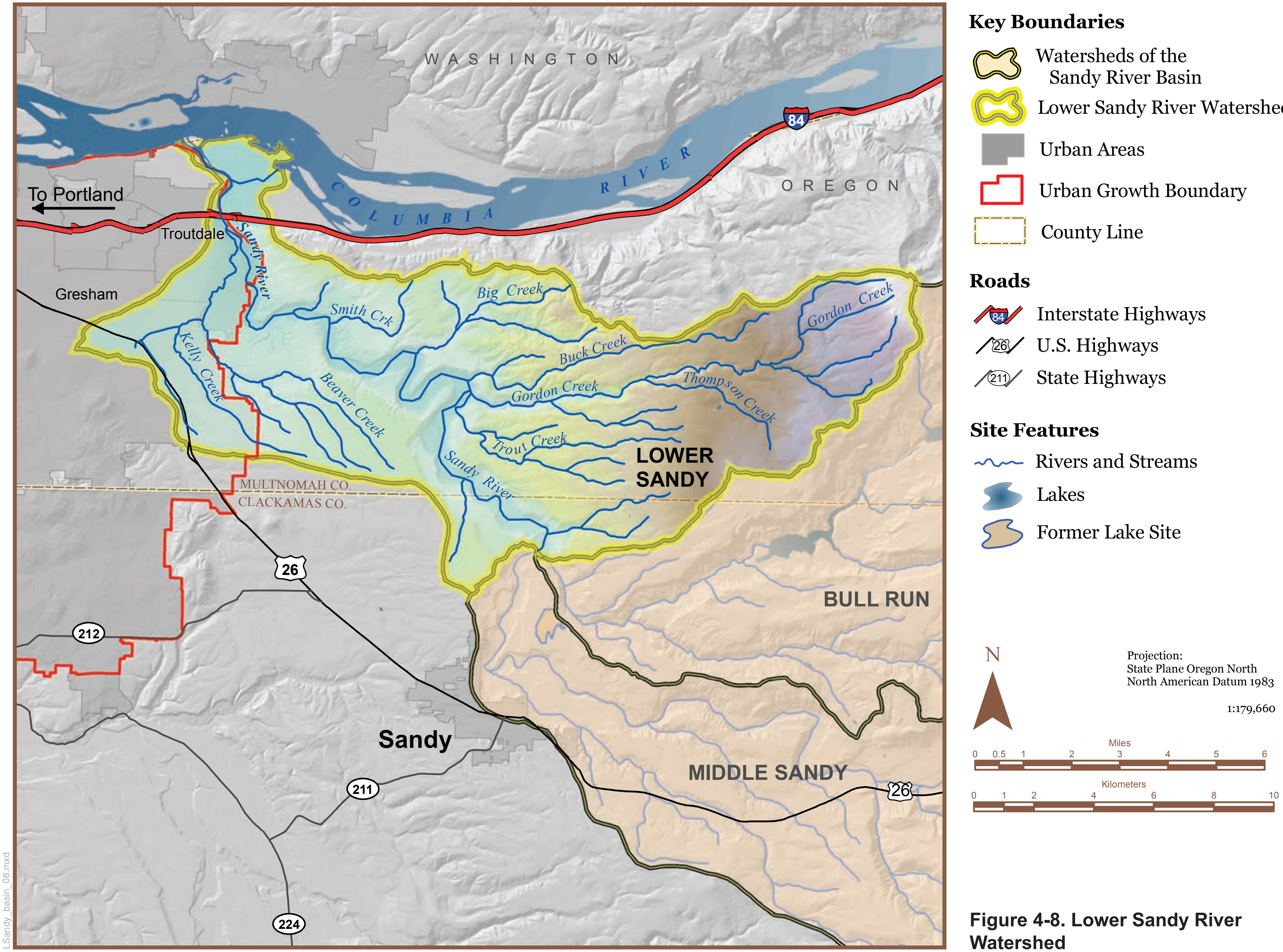


Figure 4-8. Lower Sandy River Watershed

same number of miles used historically. Anadromous cutthroat trout are assumed to use the lower Sandy River (below the Marmot Dam site), although there have been few recent observations. Resident cutthroat trout are well distributed throughout the watershed.

Channel Conditions

PGE (2002) conducted an evaluation of habitat elements and channel conditions in portions of the lower Sandy River watershed. Indicators of properly functioning habitat elements evaluated included substrate, LW, pool frequency, pool quality, and off-channel habitats. The lower Sandy River watershed was divided into two reaches for this evaluation: the Sandy River from Dabney Park to Dodge Park (RM 6.6 --RM 18.5), and the reach from the mouth to Dabney Park (RM 0—RM 6.6).

The reach from RM 6.6—RM 18.5 begins at Dabney Park and extends to Dodge Park at the Bull Run River confluence. This reach is characterized by a low-channel gradient relative to other reaches upstream. The dominant habitat types in this reach are pools and riffles. Streambed substrates are composed primarily of cobbles, gravels, and sand. Cobble/gravel bars, side channels, overflow channels, and island features are more abundant and of larger magnitude compared to upstream reaches in the river. The percentage of channels and bars with sand accumulations is also much higher in the low-gradient lower Sandy River mainstem than it is farther upstream. In some portions of the reach, the active bed is saturated with sand and the potential for additional fine sediment storage is low (PGE 2002). The reach provides the majority of suitable mainstem spawning habitat for fall Chinook salmon in the Sandy River Basin (PGE 2002). An abundance of pool, riffle, and side-channel habitats provides good summer and winter rearing conditions for juvenile steelhead trout, Chinook, and coho salmon.

The reach from the mouth of the Sandy River to Dabney Park (RM 0--RM 6.6) has the lowest channel gradient within the mainstem Sandy River. The dominant habitat types are pools and riffles. Channel substrates are composed primarily of sand and gravel. Bed mobility is high, and the sand content in the subsurface is very high (PGE 2002). The mouth of the Sandy River forms a broad shallow delta at its confluence with the Columbia River. Depositional dynamics of the delta are strongly influenced by the backwater effect of the Columbia River and by a lack of high-water events in the spring caused by dam operations on the Columbia (PGE 2002; SRBWC 1999).

Concerns about fish passage into the Sandy River during seasonal low-flow periods led to alterations in the natural stream channel throughout the 1900s. A rock dam and a levee were constructed in the 1930s to provide fish passage that was often considered restricted during periods of low flow. Dredging of the main channel has also been conducted periodically to facilitate fish passage. This reach contains limited spawning habitat for Chinook salmon and steelhead trout near Lewis and Clark State Park. Suitable rearing habitat exists for steelhead trout, Chinook, and coho salmon, primarily in the uppermost portions of the reach. The lowermost portions of the Sandy River and delta are used as a migration corridor for salmonid fishes, and spawning and rearing habitat is limited. Historically, however, the Sandy River delta probably provided excellent off-channel rearing habitat for most of the salmonids that utilize the watershed.

Two important tributaries to the lower Sandy River also support anadromous salmonids that have been targeted by the City for conservation measures. Gordon Creek has well-vegetated side slopes, a bottom composition dominated by cobbles and gravel, but little large wood in the active stream channel. The lower end of Trout Creek has a very low stream gradient, and the creek parallels the mainstem Sandy River for approximately one-quarter mile. The lower stream provides good low-velocity habitat for salmonids.

4.3.2 Middle Sandy River Watershed

The middle Sandy River watershed (Figure 4-9) begins near the confluence with the Salmon River at about RM 37.5 and continues downstream to RM 18.5 at the confluence with the Bull Run River (Dodge Park). Major tributaries in the watershed include Alder and Cedar creeks. The watershed is located entirely in Clackamas County. Land ownership in the watershed includes USFS (Mt. Hood National Forest), BLM, State of Oregon, Clackamas County, and private holdings.

Land and water use in the watershed varies widely, including timber harvest, agriculture, rural residential home sites, transportation, power generation and transmission, recreation, and municipal water supply.

Habitat Access

The middle Sandy River watershed functions primarily as a migration corridor for juvenile and adult salmonid fishes, but it also provides spawning habitat for Chinook salmon and rearing habitat for a variety of resident and anadromous salmonids (S.P. Cramer & Associates Inc. 1998). Until Marmot Dam (RM 30) was decommissioned in the summer of 2007, it was the only dam located in the middle Sandy River. Fish passage facilities were provided at Marmot Dam for migratory fish to have access to the upper watershed.

Tributaries supporting anadromous fish species in the middle Sandy River watershed are limited. Portions of Cedar Creek, Wildcat Creek, and Alder Creek, which are accessible to migratory salmonids, support natural production of steelhead, salmon (primarily coho), and resident trout. Resident trout are likely present in Cedar Creek, Alder Creek, and other small streams above barriers to anadromous fish, although their abundance is not well documented.

Passage barriers in the middle Sandy River watershed limit fish habitat. Sandy Hatchery, the only fish hatchery in the Sandy River Basin, is located on Cedar Creek. Significant reductions in aquatic habitat have occurred as a result of hatchery construction and operation. A weir constructed at the Sandy Hatchery about 0.5 mile upstream from the mouth of Cedar Creek has prevented upstream fish passage since the early 1950s. Approximately 12 miles of upper Cedar Creek are blocked from fish usage. USFS (1996) identified a partial artificial barrier on Alder Creek under the U.S. Highway 26 bridge, although steelhead have been documented upstream of this barrier. At least one other passage barrier exists on Alder Creek at the City of Sandy's water diversion. USFS (1996) also identified a passage barrier on an unnamed tributary in the Mensinger Bottom area of the Sandy River. In 1997 ODFW concluded that the juvenile fish screens and bypass facility at Marmot Dam were below agency criteria and that some impingement, entrainment, and migration delay was probably continuing to occur (ODFW 1997).

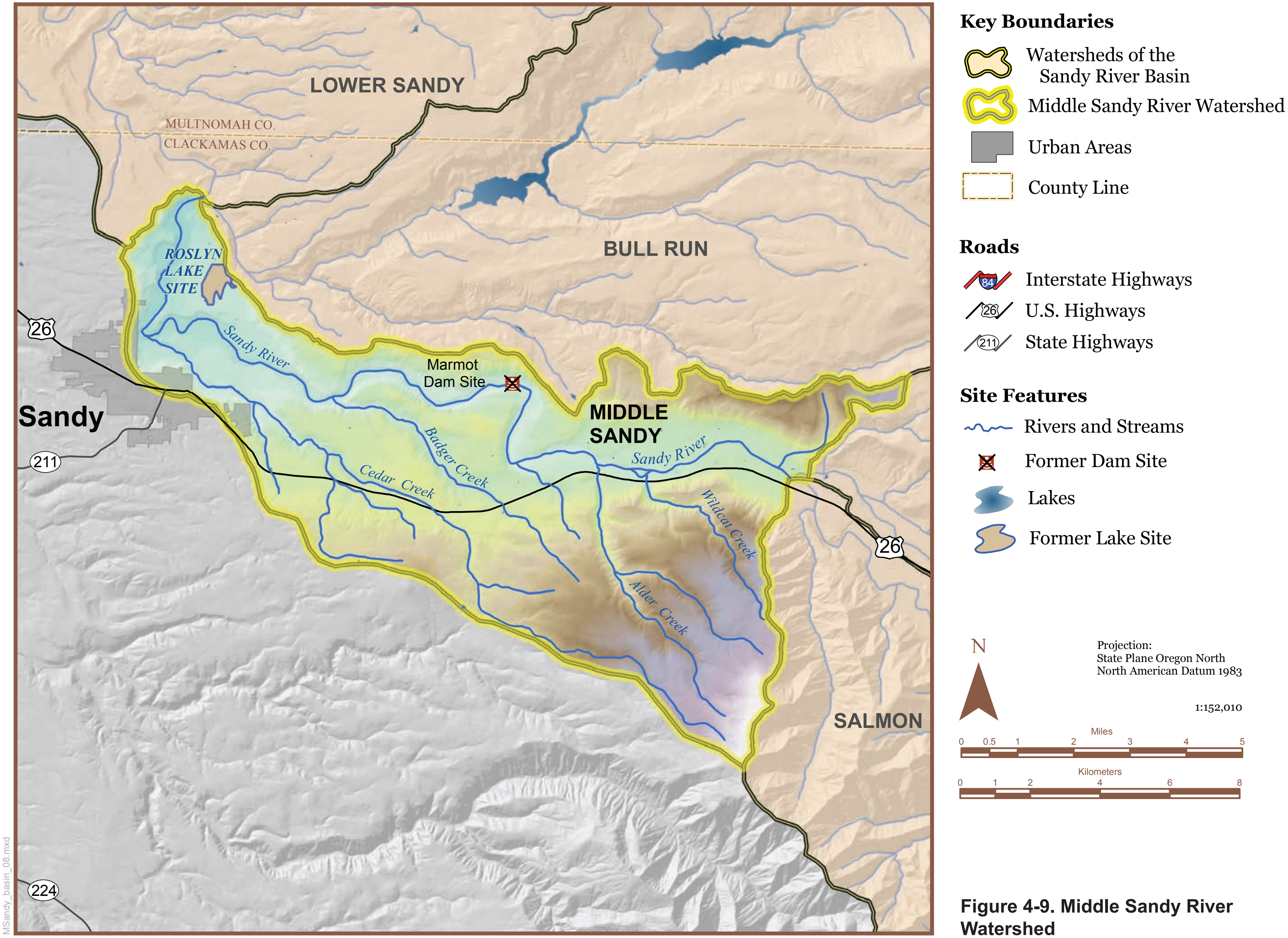


Figure 4-9. Middle Sandy River Watershed

The SRBTT estimated anadromous fish currently use about 24 stream miles of habitat in the middle Sandy River Watershed (see Table 5-1). This total represents about 14 percent of the total stream miles (170 miles) currently used by anadromous fish in the Sandy River Basin. Anadromous fish in the middle Sandy River watershed historically used about 37 stream miles of habitat. The stream mileage estimates for this watershed do not reflect the latest passage improvements made by the Mt. Hood National Forest and other agencies.

Steelhead trout and coho salmon utilize all 24 of the accessible stream miles in the watershed. Both species used about 37 stream miles in the watershed historically. Fall Chinook currently use about 12 stream miles in the middle Sandy River watershed, compared to about 20 miles used historically. Spring Chinook currently use about 20 stream miles in the middle Sandy River watershed, approximately the same number of miles used historically. Anadromous cutthroat trout are assumed to use only the portion of the middle Sandy River watershed below the Marmot Dam site, but resident cutthroat trout are well distributed throughout the watershed.

Channel Conditions

Fish habitat has been altered in some areas of the middle Sandy River watershed. Following the flood of 1964, federal, state, and many other public and private entities worked cooperatively to straighten and deepen the channel along portions of the middle Sandy River. Some habitat diversity and complexity were lost as meanders, oxbows, and side channels were disconnected and remaining LW was removed.

Habitat types for the middle Sandy River watershed were evaluated in detail by USFS (1996) for those areas located within the boundaries of the Mt. Hood National Forest. This area primarily included the upper stream reaches of Alder and Cedar creeks above potential passage barriers to anadromous salmonid fishes. Aquatic habitat data for the portions of the middle Sandy River watershed located outside of the Mt. Hood National Forest were briefly summarized by USFS (1996), SRBWC (1999), and PGE (2002). A detailed study of physical habitat features was conducted by S.P. Cramer & Associates Inc. (1998) for portions of the mainstem Sandy River.

S.P. Cramer & Associates (1998) divided the mainstem Sandy River into four river reaches based on differences in habitat features and stream flow. The reaches are described below in a downstream direction.

The uppermost reach of the middle Sandy River (mouth of the Salmon River to the mouth of Whiskey Creek, RM 37.4—RM 31.8) was predominantly riffle habitat (69 percent), followed by glide habitat (21 percent), pool habitat (10 percent), and side-channel habitat (0.52 percent). The stream gradient averaged 0.9 percent and the substrate was mostly rock and sand. LW (defined by S.P. Cramer & Associates as being greater than 12 inches in diameter, 25 feet from the base) abundance was less than 2.5 pieces per mile. Based on aquatic habitat characteristics, anadromous fish use in this reach is primarily limited to migration, although S.P. Cramer & Associates documented unspecified juvenile salmonid fishes holding behind boulders.

Photo courtesy of Ethan Jewett, Oregon Trout.

The middle Sandy River from Whiskey Creek to the Marmot Dam site (RM 31.8—RM 30.1), was influenced by the presence of the dam. Stream gradient was only 0.2 percent compared with 0.9 and 0.8 percent, respectively, in adjacent upstream and downstream reaches. This reach had the highest percentage of pool (53 percent) and side-channel habitat (17 percent) and the lowest gradient of all reaches in the middle Sandy River watershed. This reach also had the greatest large wood abundance, averaging 22.5 pieces per mile. The majority of Chinook salmon production in the mainstem Sandy River above Marmot Dam was estimated to occur in this reach due to its shallow stream gradients, high percentage of pool and side-channel habitat, and high abundance of available spawning gravels.

S.P. Cramer Associates did not survey the Marmot gorge reach of the middle Sandy River from RM 30.1—RM 24.5 due to safety concerns; however, information for this reach does exist (Stillwater Sciences 2002; ODFW 2001). Downstream of the Marmot Dam site, the Sandy River flows for about five miles through a scenic narrow gorge that has steep canyon walls, constrained chutes, and deep trench-like pools. Human access to this section of the river is limited to only a few places where steep trails drop down to the river. The canyon walls consist primarily of basalts, sandstone sediments, and compacted volcanic ash conglomerates. The hard banks are usually welded volcanic bedrock of the Rhododendron Formation (Stillwater Sciences 2000). The reach is characterized by a one percent gradient, high confinement, and step-pool morphology, with only patch cobble/boulder deposits and long, deep bedrock pools that are separated by coarse-bedded riffles and boulder rapids. Large (house-sized) boulders are present in the channel, likely originating from the canyon walls. The stream channel is mainly composed of large and small boulders because the narrow channel likely transports the smaller sediments and cobbles. Even though spawning habitat is probably limited in the canyon reach, deep pools provide late-migrating spring Chinook with good summer holding habitat. Pools may also be used for juvenile rearing. Riffles with coarse bed material also may provide rearing habitat for steelhead, but winter rearing is likely limited because of the high flows and shear stresses in the gorge.

The lowermost reach of the middle Sandy River (Revenue Bridge to the mouth of the Bull Run River, RM 24.5—RM 18.5) has an average gradient of 0.8 percent. Riffles were the dominant habitat type (52 percent), followed by pools (35 percent), and glides (13 percent). Side channels represented nine percent of the channel length. LW abundance in this reach was the lowest of all the reaches surveyed by S.P. Cramer & Associates (1998), averaging less than two pieces per mile. Gravels suitable for spawning substrate were limited in this reach because of high water velocities (PGE 2002). Cobble/boulder and cobble/gravel were the dominant substrates, reflecting the wide active channel and increased depositional potential over this reach (PGE 2002). A variety of species probably utilize this reach for various spawning, rearing, and migration strategies.

ODEQ assessed stream structure as part of the 1988 non-point source assessment (USFS 1996). Stream structure problems in the 1988 assessment were identified as moderate or severe for the portion of the mainstem Sandy River located in the middle Sandy River watershed. Insufficient stream structure, defined as the inadequacy of one or more physical components of a stream (e.g., stream bank, LW, pools, gravels), was anticipated to reduce channel stability, habitat, or flow-regulating characteristics (USFS 1996).

Several important tributaries flow into the Sandy River in the middle portion of the Basin, and the City is planning to implement conservation measures in several of them. The tributaries are Cedar, Alder, and Wildcat creeks. Cedar Creek is one of the largest low-gradient tributaries to the middle Sandy River and historically probably provided important habitat for several anadromous fish species. Alder and Wildcat creeks currently are utilized by steelhead and coho, and perhaps other species such as cutthroat.

USFS (1996) assessed habitat types for surveyed reaches of Alder and Cedar creeks using queries from the SMART database. Riffle habitat was the dominant habitat type for Cedar Creek (60 percent); pools made up approximately 25 percent of the stream length surveyed; and side channels accounted for about 10 percent of the area surveyed. Alder Creek was approximately 80 percent riffle, 15 percent pool, and less than 10 percent side-channel habitat. Based on this assessment, if anadromous fish passage was available in the upper reaches of Alder Creek, riffle habitat would favor steelhead and resident trout use over Chinook and coho salmon.

Pool frequency (number of pools per mile of stream) and pool area (square feet of pools per mile of stream) were calculated for the upper reaches of Alder and Cedar creeks by USFS (1996) from queries of the Stream Management, Analysis, and Tracking (SMART) database. Pool frequency and area were compared to the range of natural variation (established from unmanaged areas in the Mt. Hood Wilderness and Fir Creek subwatershed of the Bull Run watershed), and USFS Policy Implementation Guide (PIG) standards were used to assess habitat quality. [3] Pool frequency in Alder Creek was within the range of natural variation

[3] USFS compared habitat conditions to the range of variability in such conditions observed at reference sites in the region that were considered representative of relatively natural, undisturbed, or unmanaged conditions. USFS used habitat

(RNV), but below PIG standards. Pool volume was also within the RNV, but below the median value. Therefore, pools appeared to be relatively abundant in Alder Creek but were small on average. Pool frequency in Cedar Creek was above the RNV and PIG standards, and pool volume was well above the median RNV. Pool habitat appears to be high quality in Cedar Creek within the boundaries of the Mt. Hood National Forest.

4.3.3 Upper Sandy River Watershed

The upper Sandy River watershed (Figure 4-10) begins at an elevation of 11,047 feet at its eastern border on Mount Hood's summit and descends to an elevation of about 1,100 feet at its western border near the mouth of the Salmon River at RM 37.5. The upper Sandy River from its headwaters to the boundary of the Mt. Hood National Forest (12.4 miles) was designated as a National Wild and Scenic River in 1988 (USFS 1996). The upper Sandy River drops quickly in elevation as it flows through unstable volcanic rock and ash deposits in its upper reaches. According to the USFS (1996), 14,944 acres in the upper watershed are located in the Mt. Hood Wilderness Area.

Primary sources of surface water in the watershed include glacial melt, spring-fed tributaries, and several high Cascade lakes. Large tributaries in the watershed include Muddy and Clear forks of the Sandy River, and Rushing Water, Lost, Cast, Clear, and Hackett creeks. Land ownership in the watershed includes private holdings and land owned by USFS (Mt. Hood National Forest), BLM, and Clackamas County.

According to USFS (1996), portions of the upper Sandy River have been straightened, channelized, and armored following extensive flood damage caused by the 1964 flood and due to development that has occurred along the reach from Zigzag to Brightwood.[4] USFS (1996) also identified structures placed in Clear Creek by private landowners to armor the stream banks from erosion. As a result of these activities and others, the lower 3.2 miles have been channelized, and subsequent down-cutting of the channel has been observed.

Sediment sources vary by location within the watershed. Mass wasting, surface erosion, stream channels, and glacier melt are principal sources of sediment production. Streams originating from the northwest, west, and southwest facing slopes of Mount Hood typically are glacial-fed. Glacial streams receive substantial coarse and fine sediment loads and exhibit turbid conditions due to suspended glacial flour, particularly during the summer months. Hillslope and channel erosion in some tributaries in the steeply sloping upper reaches of the Basin have been attributed to mass wasting and debris torrents, primarily in the Muddy Fork drainage (USFS 1996). Such erosion has been generally attributed to timber harvest, fire burn, and road construction (USFS 1996), although such activities have been minimal in the past decade (Shively, USFS, pers. comm., 2003). Clear Creek, Clear Fork, Horseshoe Creek, and the upper Sandy River have the highest potential sediment production, primarily as a result of roads. Sediment inputs from stream channels are high in most streams in the upper

standards based on *Columbia River Basin Anadromous Fish Policy Implementation Guide* (PIG) objectives. These include habitat standards to aid selection on habitat enhancement projects for streams used by anadromous fish (USFS 1991).

[4] In November 2006, the Sandy River also experienced a flood event. As a result, several areas in the Sandy River Basin are under review by ODFW to determine the extent of the changes to the habitat.

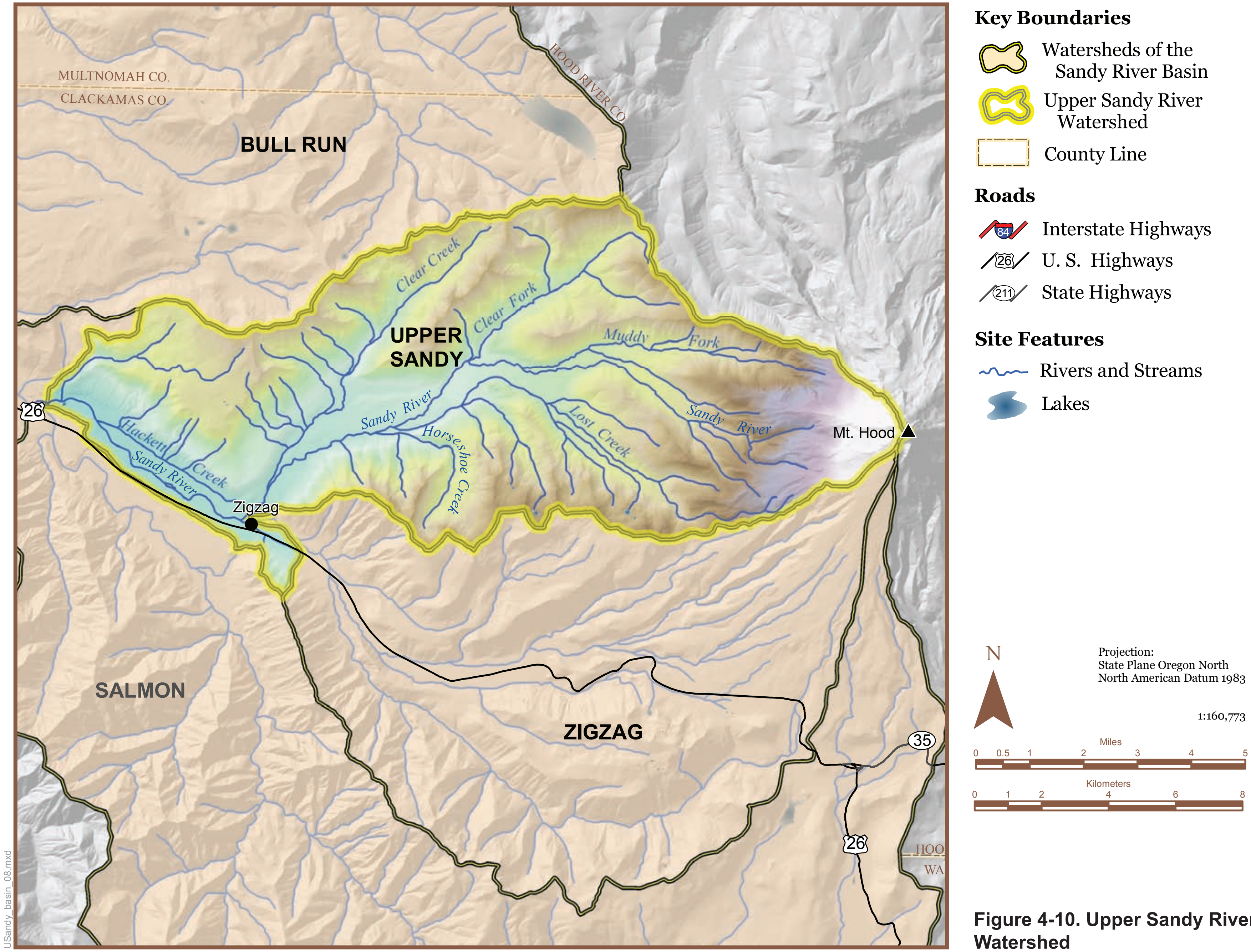


Figure 4-10. Upper Sandy River Watershed

Sandy River watershed. The high stream bank failure potential is evident in the mudflow deposits that the Sandy River and Muddy Fork Sandy River pass through in the upper reaches of the watershed (USFS 1996).

Habitat Access

Stream passage barriers in the upper Sandy River and tributaries are primarily of natural origin (i.e., barrier falls), but one small hydropower facility built on Minikahda Creek (a tributary of Clear Creek) is a passage barrier to anadromous fish (USFS 1996). The SRBTT estimated that the upper Sandy River watershed contains about 44 stream miles of habitat that are currently used by anadromous fish (Table 4-8), the most of any watershed in the Sandy River Basin. This total represents about 26 percent of the total stream miles (170 miles) currently used by anadromous fish in the Basin. However, the stream mileage estimates for this watershed probably do not reflect the latest passage improvements made by the Mt. Hood National Forest or other agencies.

Of the 44 stream miles, all are used by steelhead—about the same number of miles as the species used historically. Spring Chinook and coho salmon currently use about 29 and 30 stream miles, respectively, in the upper Sandy River watershed—also about the same number of miles as used historically. Fall Chinook do not currently use areas in this watershed, although historically the habitat might have supported use of about 23 stream miles. Anadromous (sea-run) cutthroat trout are assumed no longer to occur in the upper Sandy River watershed, but resident cutthroat trout are well distributed throughout the watershed.

Channel Conditions

The upper Sandy River travels from its source at elevation 6,200 feet on the western flank of Mount Hood to an elevation of 1,600 feet at its confluence with the Salmon River, which is 13 miles downstream (Northwest Power Planning Council [NWPPC] 1990). The upper Sandy River has a high stream gradient and carves through unstable volcanic ash and rock deposits. The average gradient in the upper Basin is about 10 percent. The headwaters of the Sandy River are above tree line, where there is little vegetation to stabilize stream banks, and sediment inputs and bedload movement are high. Fish production in these high-elevation stream reaches is limited by a high gradient and water turbidity.

Farther down the Sandy River, near the towns of Rhododendron and Zigzag (RM 38—RM 43), the stream substrates are typically composed of loose alluvial rock. The stream gradient is moderate and consistent, averaging about 1.3 percent from the Zigzag River downstream to Sleepy Hollow Bridge, which is slightly downstream of the Salmon River. The bottom substrates in this stream reach are mostly small boulders, cobbles, and gravel. Glacial sediment deposits may be thick where the stream gradient lessens, and spawning gravels are often embedded with fine sediments at those locations. In this reach, high flows still significantly affect channel form. In contrast, the adjacent Salmon River is dominated by mostly basaltic lava rock and channels are generally more constrained and less prone to lateral scour during floods (NWPPC 1990; USFS 1999).

During the summer dry season, glacial runoff releases large quantities of sediments into the upper Sandy River and Muddy Fork, resulting in increased turbidity downstream. However, streamflow releases from high-elevation glaciers and snowpack provide cool water temperatures and adequate flows for summer and fall migratory fish seeking clear-water spawning tributaries upstream, such as the Clear Fork of the Sandy River, Lost Creek, Clear Creek, and Hackett Creek; all are important spawning and rearing tributaries in the upper Sandy River watershed. Many other small tributaries located in the upper watershed contribute to the overall natural production of anadromous and resident fish in the Sandy River Basin.

North Boulder Creek is also an important tributary to the upper Sandy River, and the City is proposing to implement conservation measures in this stream. The stream channel averages seven percent gradient in the lower reach, and the bottom substrate is dominated by boulders. The stream channel is also lacking large wood, and sedimentation levels are high due to road runoff and poor riparian conditions.

Data on aquatic habitat types, pool abundance, LW in the upper Sandy River watershed are available from the Stream Management, Analysis, Reporting, and Tracking (SMART) database for streams within the boundaries of the Mt. Hood National Forest. USFS (1996) conducted queries of the SMART database to establish the dominant habitat types present in the upper Sandy River watershed. The upper Sandy River and Muddy Fork have little to no pool habitat and are predominantly riffle habitat, with limited side channels. Clear Fork, Lost Creek, and Clear Creek are all similar in vegetation type and stream order stratification. Habitat types in these streams are approximately 70 percent riffle, with generally 25 percent or less pool habitat and 15 percent or less side-channel habitat.

Pool frequency was calculated by USFS (1996) using the SMART database. The assessment was used to compare pool quantity to RNV and PIG standards. Stream reaches from unmanaged areas in the Mt. Hood Wilderness and the Fir Creek subwatershed of the Bull Run were used to establish the RNV for pools and LW. Pool frequency was within or above the RNV for all streams in the upper Sandy River watershed, with the exception of the mainstem upper Sandy River. However, all of the streams in the upper Sandy River watershed were below the standards. The upper Sandy River is located in the Mt. Hood Wilderness Area, so it is likely that the present state of the stream is representative of relatively natural, undisturbed conditions. A lack of pool habitat could be attributed to the natural geology of this section of stream. The upper Sandy River flows through extensive mudflow deposits, leaving little opportunity for pool formation (USFS 1996).

To further evaluate the availability of pool habitat in the upper Sandy River watershed, pool volume was assessed as a measure of square feet of pools per mile of stream. Pool volume was determined by USFS (1996) to be above the median for RNV or above the RNV for nearly all streams assessed in the Sandy River Basin. The exceptions were Muddy Fork and the upper Sandy River mainstem. Muddy Fork was at the low end of the RNV; the upper Sandy River was outside and below the RNV. The lack of abundance of pool habitat and pool area in larger streams in the upper Sandy River watershed probably indicates limited suitable habitat for Chinook salmon. The pool frequency and pool area in smaller tributaries appear to be suitable for habitat requirements of coho salmon, steelhead, and resident trout.

4.3.4 Salmon River Watershed

The Salmon River originates from the Palmer Glacier on the south slope of Mount Hood and empties into the Sandy River at RM 38. Since glaciers on the south-facing slopes have mostly vanished as a result of climate changes over the past several thousand years, streams in the watershed are not currently glacially influenced. Consequently, Salmon River watershed streams do not receive sediment loads similar to glacial streams. The Salmon River usually runs clear all year and provides significant miles of spawning and rearing habitat for both anadromous and resident fish species. Figure 4-11, on the following page, is a map of the Salmon River watershed.

The Salmon River watershed encompasses approximately 74,240 acres (116 square miles) in Clackamas County (USFS 1995a). Elevations within the watershed range from about 10,000 feet at its headwaters on the south slope of Mount Hood to 1,100 feet at its confluence with the Sandy River at Brightwood. From its headwaters on the Palmer Snowfield, the river flows for 33 miles, through the Salmon-Huckleberry Wilderness and through a mix of BLM, Clackamas County, and private lands. USFS manages the upper 25 miles within the Mt. Hood National Forest. The lowermost eight miles are managed by BLM. Major tributary streams in the watershed include the West Fork and South Fork Salmon River, and Mud, Linney, Cheeney, Mack Hall, and Boulder creeks.

Habitat Access

The Salmon River is free-flowing throughout its entire length and was designated a Federal Wild and Scenic River in 1988. Final Falls, a 60-foot-high cascade located at about RM 14 on the Salmon River, is the upstream limit of anadromous fish distribution. The lower 14 miles of the Salmon River provide some of the most diverse and productive salmon and steelhead habitat in the Sandy River Basin. The lower Salmon River also serves as an important migration corridor for upstream migrating adults and downstream migrating juveniles. Important tributaries to the lower Salmon River that support anadromous fish include the South Fork Salmon River and Boulder, Cheeney, and Mack Hall creeks. The uppermost 20 miles above Final Falls contains excellent habitat conditions for resident salmonids.

Anadromous fish, including spring Chinook, coho salmon, and winter steelhead trout, currently use about 28 stream miles of habitat in the Salmon River watershed. This total represents about 16 percent of the stream miles (170 miles) in the Sandy River Basin accessible to anadromous fish species. Historically, anadromous fish used approximately the same number of stream miles of habitat in the watershed.

Currently, fall Chinook salmon do not use the Salmon River watershed. It is estimated that fall Chinook used about 21 miles historically (CH2M HILL 2005). Coastal cutthroat trout are assumed no longer to occur in the Salmon River watershed, but resident cutthroat trout are well distributed throughout the watershed.

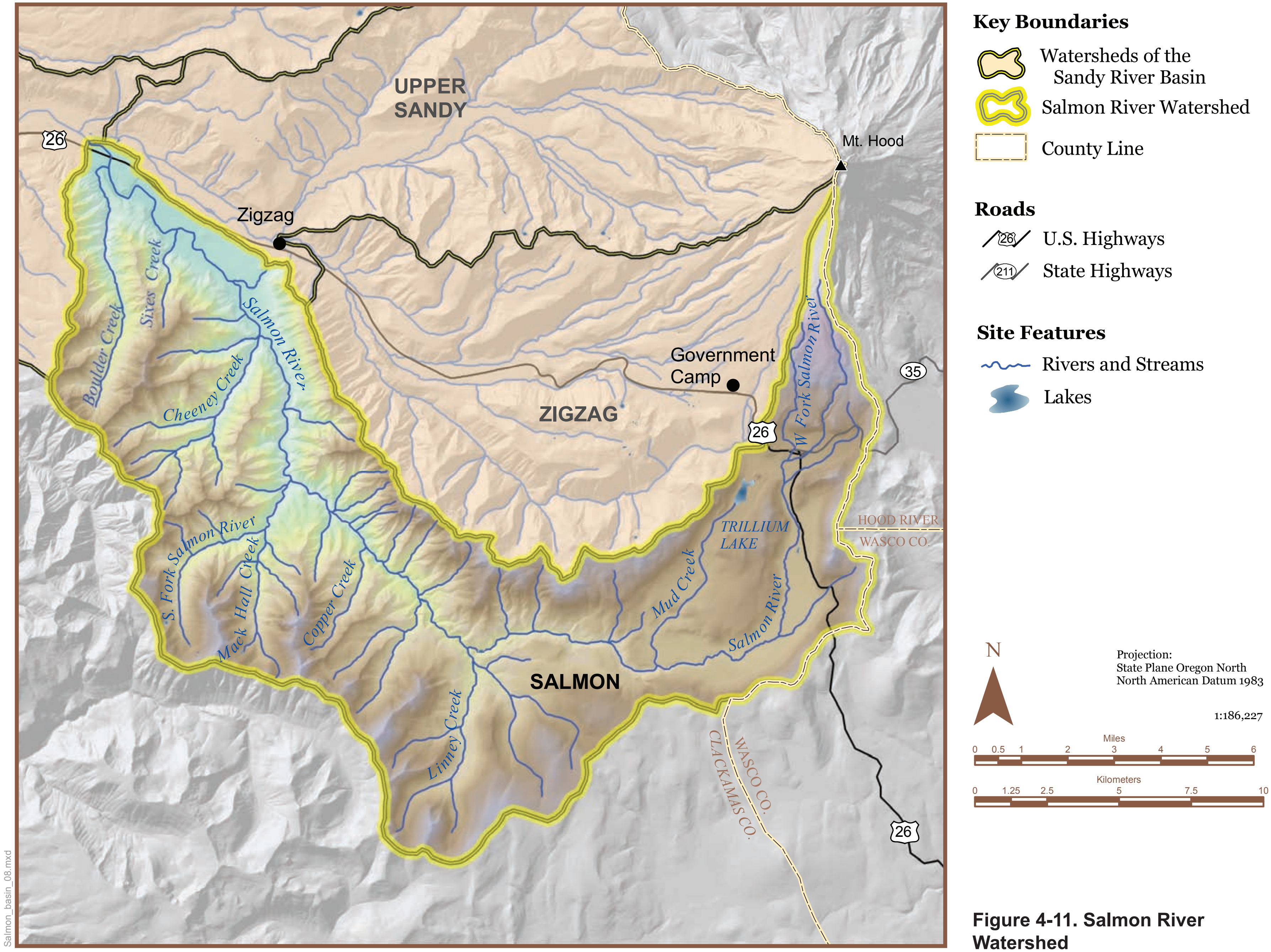


Figure 4-11. Salmon River Watershed

Channel Conditions

USFS (1995a) has rated the habitat conditions for the lower 14 miles of the Salmon River as generally good. Water quality is excellent for the production of salmonids because the river is usually clear and cool in the summer. This is in contrast to some of the other large tributaries to the Sandy River that transport large amounts of glacial flour in the summer. The Salmon River and its tributaries have a great diversity of habitat types, ranging from low-gradient, wide meandering river channels to small high-gradient creeks. Most of the Salmon River watershed is dominated by moderate-sized stream reaches with boulder and rubble substrate, riffle-dominated, with frequent large pools due to the presence of bedrock outcrops, large boulders, or old-growth trees that have fallen into the stream. The various habitat types support the production of steelhead and trout, coho, and Chinook salmon.

Large floods have degraded the habitat in recent years. Floods in 1964, the 1970s, and the late 1990s scoured the channel and removed much of the LW from the system.[5] Following some of these floods, the Army Corps of Engineers, USFS, and other agencies and private individuals removed any remaining logs and boulders from the mainstem Sandy River channel from its mouth to the confluence with the South Fork of the Salmon River (USFS 1995a). The channel was also deepened and straightened throughout this area, which cut off meanders, oxbows, and side channels. Very important habitat was lost, and those actions still affect the mainstem Salmon River today.

The first 7.4 miles of the Salmon River are on private land. Approximately 50 percent of the banks have been stabilized with riprap by landowners in this reach, which has a stream gradient of approximately one percent. Because of the channelization, the stream is characterized by long stretches of relatively deep riffle habitat.

From RM 7.4—RM 14.3 (Final Falls), the Salmon River is on federal land (Mt. Hood National Forest). The average stream gradient is about 1.6 percent and the dominant stream substrate is small cobbles.

As described by USFS (1995a), the typical habitat for the watershed is a moderate-sized stream with boulder and rubble substrate. The streams are riffle-dominated, with frequent large pools created by bedrock outcrops, large boulders, or old-growth trees in the stream. Aquatic habitat types were evaluated to assess habitat quality for anadromous and resident fish using information from the SMART database. Based on USFS (1995a) assessments, riffle habitat was the dominant habitat type in the Salmon River watershed. Habitat types in the watershed accessible to anadromous salmonid fishes were compared with habitat types in the South Fork of the McKenzie River to establish RNV. Side-channel frequency was lower on the Salmon River from the mouth upstream to the South Fork Salmon River compared to RNV. However, riffles and pools were in the same range for the two basins. Side channels were more prevalent in the lower Salmon River prior to habitat alterations following the floods of 1964 and 1974. For the portions of the watershed supporting resident fish, a diversity of adequate habitats exists for all life stages of the species.

[5] Flooding occurred in tributaries in the Sandy River Basin in November 2006. As of February 2007, the area is under review by ODFW to assess the habitat changes that resulted from this event.

USFS (1995a) conducted an assessment of pool frequency in terms of the number of pools per mile of stream for the Salmon River and major tributaries within the watershed. Pool frequencies were compared to the RNV and PIG standards. RNV was approximated from data about the Lewis River in the Gifford Pinchot National Forest, which USFS (1995a) concluded was the closest approximation to pool conditions in the Salmon River.

For the purpose of the assessment, the watershed was divided into three major reaches (USFS 1995a). The lower reach consisted of the lower Salmon River from RM 0.0—RM 7.2. The middle reach consisted of the mainstem Salmon River from RM 7.2—RM 18.2, including Boulder, Cheeney, and Mack Hall creeks, and the South Fork Salmon River. The upper reach consisted entirely of resident fish habitat, including the Salmon River from RM 18.2—RM 26.9, as well as Linney, Draw, Inch, String, and Mud creeks. Pool frequency in the lower, middle, and upper reaches was determined to lie outside the RNV and below PIG standards, with two exceptions: Boulder Creek, which was within the RNV and just below PIG standards; and Mud Creek, which met both standards. In general, USFS (1995a) attributed substandard pool frequencies throughout most of the middle and lower reaches of the watershed to channelization efforts following large-scale floods in the 1960s and 1970s. Substandard frequencies in the middle and upper reaches, not impacted by channelization efforts, were attributed to the presence of high channel gradients throughout most of the upper watershed.

USFS (1995a) suggested that sediment delivery from existing roads, highway sanding, and mass wasting were the largest contributors to potential sediment in the Salmon River Watershed. However, mass wasting was considered to be the primary source of sediment delivery exclusively in the lower watershed. The West Fork and East Fork Salmon River subwatersheds have the highest potential for sediment delivery from highway sanding, at over 2,000 tons per year, while the upper Salmon River watershed has a potential sediment delivery of about 377 tons per year (USFS 1995a). Specifically, Highway 35 from the junction with Highway 26 to the watershed boundary has the highest potential for sediment delivery of any road in the watershed.

Over the years, many small low-gradient tributaries and wetlands located on private land in the watershed have been channelized, drained, and filled (USFS 1995a). Historically, these streams and wetlands were important to coho salmon spawning and rearing in the Salmon River watershed. At least one significant wetland complex exists in the Welches area at the Wildwood Recreation Site (USFS 1995a). Timber harvest, fire, recreation, urbanization, livestock grazing, and sediment inputs from road sanding have all impacted aquatic habitat in the watershed.

4.3.5 Zigzag River Watershed

The Zigzag River watershed (Figure 4-12) covers about 37,730 acres in Clackamas County (USFS 1995b). Most of the watershed is in the Mt. Hood National Forest, and about 11,216 acres are wilderness areas and 1,690 acres are alpine areas. About 1,248 acres are developed and 988 acres are in private ownership. Highway 26 essentially bisects the watershed. Elevations in the watershed range from 1,400 to 10,000 feet.

The Zigzag River originates from Zigzag Glacier, carves its way through volcanic mudflow deposits, and terminates in alluvium near its confluence with the Sandy River. The Zigzag River is a steep-gradient stream from the headwaters to the lower two miles, where it transforms to a more moderate-gradient sediment depositional area. Large tributary streams in the watershed include the Little Zigzag River and Lady, Devils, Camp, Henry, and Still creeks.

Only about three percent of the watershed area is developed. However, developments such as the Highway 26 corridor, several small towns (e.g., Welches, Rhododendron, Zigzag), summer homes, and ski areas occur in concentrated areas near or adjacent to the Zigzag River. River and floodplain habitat in these areas has been affected by development-related factors such as channelization, road sediment, highway sanding, and recreation activities.

Habitat Access

The SRBTT estimated anadromous fish currently use about 30 stream miles of habitat the Zigzag River watershed (see Table 4-8). This total represents about 18 percent of the total stream miles (170 miles) currently used in the Sandy River Basin. Historically, anadromous fish likely had access to more stream miles in the watershed. Human-made structures have blocked access to some streams. USFS (1995b) reported that access to fish habitat in the watershed was blocked at various locations by migration barriers. Some of these barriers have since been corrected. Culvert barriers remain at Henry Creek and the upper Little Zigzag River. Lady Creek is partially blocked by old dams and fill material at its mouth (one mile), although fish passage has been improved in the area by adding step pools. The Oregon Department of Transportation (ODOT) identified several road culverts in need of repair to allow for improved fish passage conditions. The Mt. Hood National Forest has an ongoing program to improve these fish passage problems.

The Zigzag River and its tributaries provide important and productive spawning and rearing habitat for native salmon and steelhead in the watershed. The Zigzag River also serves as an important migratory corridor for anadromous fish to reach tributary habitats. Still and Camp creeks are recognized for providing high quality spawning and rearing habitat for salmon and steelhead and are important natural production areas (ODFW 1997). Smaller tributaries in the watershed also make a significant contribution to overall natural fish production (ODFW 1997).

All 30 miles of habitat currently utilized in the Zigzag River watershed are used by steelhead trout. This total is the same number of stream miles in the watershed used historically by steelhead. Spring Chinook and coho currently use about 23 stream miles in the Zigzag River watershed, which is also the same number of miles as used historically. Fall Chinook do not currently utilize the Zigzag River watershed. Fall Chinook are estimated to have used about 18 miles historically. Anadromous cutthroat trout are assumed no longer to occur in the Zigzag River, but resident cutthroat trout are well distributed throughout the watershed.

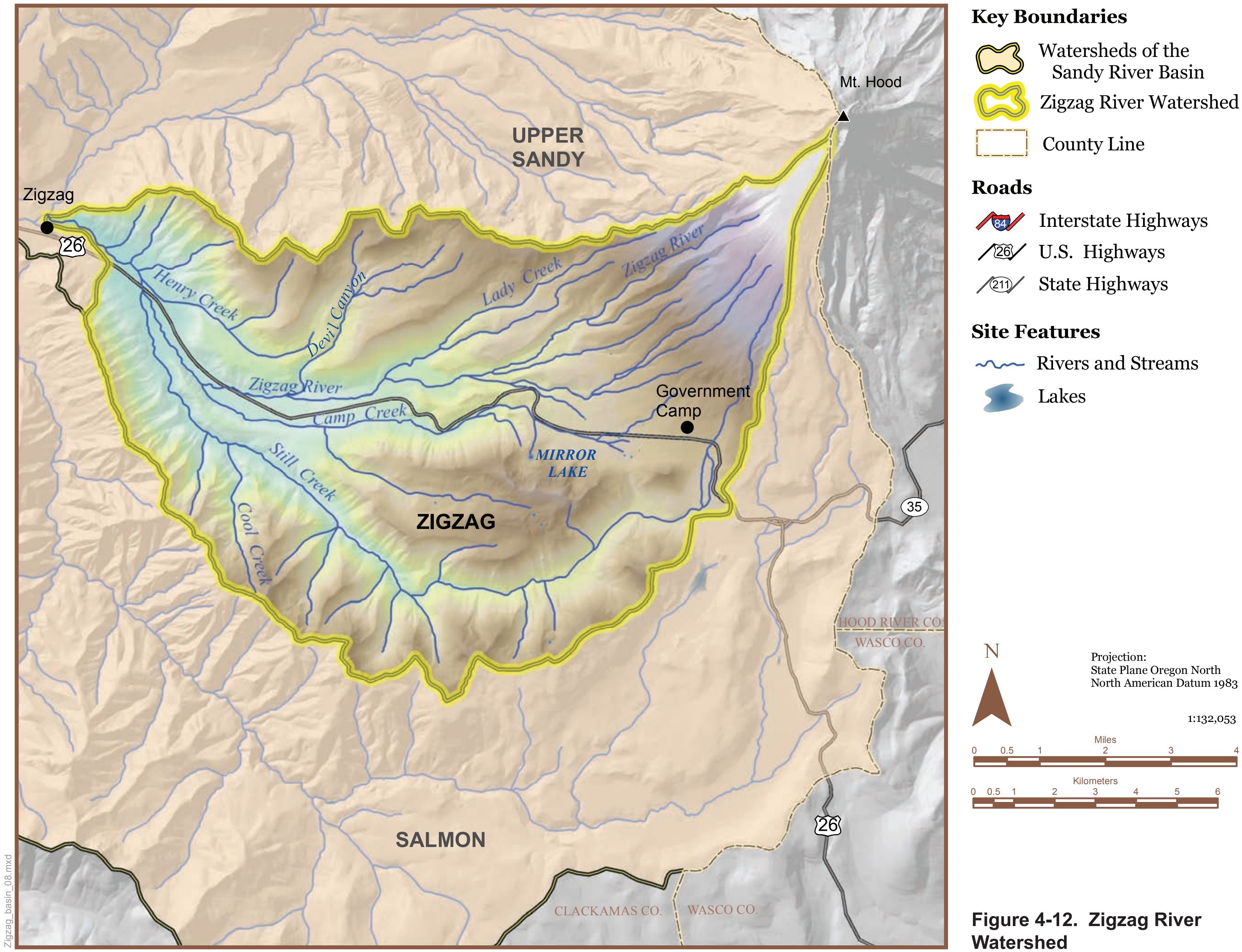


Figure 4-12. Zigzag River Watershed

Channel Conditions

Habitat conditions for salmonids in the Zigzag River watershed range from low to high quality (USFS 1995a). The mainstem Zigzag River and its tributaries have a broad diversity of habitat types, ranging from low-gradient, wide, meandering river channels to small, high-gradient, glacier-fed creeks. The typical habitat for the watershed is a moderate to small-sized stream with boulder and rubble substrate, moderate to steep gradients, moderate to low levels of pools, and in-channel large woody debris.

The 1964 flood scoured channels and swept much of the large woody material out of the Zigzag system (USFS 1995b). After the flood, the Army Corps of Engineers, USFS, other public agencies, and private individuals removed remaining large logs and boulders from sections of Still Creek, Camp Creek, and the Zigzag River. The Zigzag River was deepened and straightened, which cut off meanders, oxbows, and side channels. Substantial amounts of aquatic habitat were lost, and the diversity and quality of aquatic habitat were reduced by these actions.

USFS (1995b) calculated sediment sources in the watershed with a high potential for delivery to perennial streams. These sources included road sediment, highway sanding, recreation activities, and timber harvest. Existing roads and highway sanding were found to be the largest contributors of potential sediment in the watershed. Though overall road density appears low, most roads have been placed directly adjacent to major streams and tributaries. Highway 26 and Still Creek Road (FS 2612) have the highest potential for sediment delivery in the watershed. Many unstable stream reaches in lower Camp Creek and the lower Zigzag River are high-risk areas for bank erosion and channel migration (USFS 1995b).

Fish habitat has been degraded in some areas. RM 2.2—RM 7.3 on the Zigzag River is a stream reach with high potential for disturbance, sediment supply, and/or bank erosion potential. This reach is located immediately upstream of an area of high quality habitat for anadromous fish (USFS 1995b). Timber harvest, fire, recreation, and sediment from roads and highway sanding have all affected aquatic habitat in the watershed.

Habitat types for the Zigzag River watershed were evaluated by USFS (1995b) using data from the SMART database relating to the presence and quantity of mesohabitat types (e.g., riffles, glides, pools, side channels). Riffle habitat was the dominant habitat type throughout the watershed. The mix of habitat types was similar to the relatively undisturbed Bull Run River watershed (USFS 1995b). The major difference between the watersheds was lower levels of pool habitat in the anadromous reaches of the Zigzag River compared with those in the Bull Run River watershed. USFS (1995b) concluded that the lower levels of pool habitat in the anadromous reaches favor steelhead trout in the Zigzag River over both coho and Chinook salmon. A mixture of habitat types in the portion of the watershed supporting resident fish provided adequate habitat for existing species. For instance, there were plenty of riffles and glides for resident rainbow trout, and glides and pools for cutthroat and brook trout.

Pool frequency (number of pools per mile of stream) calculated from queries of the SMART database were compared with pool frequency using the RNV and PIG standards (USFS 1995b). Of the watersheds assessed in the Regional Ecosystem Assessment Project, USFS

(1995b) concluded that the RNV for the Lewis River in the Gifford Pinchot National Forest in southwest Washington was the best approximation for stream type and vegetation conditions in the Zigzag River watershed. Excluding Wind Creek, the frequency of pools in the Zigzag River watershed was at or below the RNV. The frequency of pools was at the lower end of the RNV in Camp Creek and below the range in Cool, Lady, and Still creeks and the Little Zigzag and Zigzag rivers, as well as below PIG standards.

To further assess the quantity of pool habitat in the Zigzag River watershed, USFS (1995b) also determined total area of pools (square feet of pools per mile of stream) for various stream reaches. The pool areas were greatest in the large stream reaches (the lower portions of Camp Creek, Still Creek, and the Zigzag River). The small, steep gradient reaches in the watershed (Cool Creek, Little Zigzag River, Henry Creek, and Wind Creek) had the lower pool areas. Wind Creek exhibited the highest frequency of pools in the watershed, yet one of the lowest with respect to pool area. USFS (1995b) attributed the low level of pool habitat in much of the Zigzag River watershed to the transport of pool-forming LW out of the system by large floods in 1964 and 1972. Shortly after the flooding, USFS, the Army Corps of Engineers, and other entities removed remaining LW and boulders to improve stream flow capacity.

4.3.6 Bull Run River Watershed

The Bull Run River watershed (Figure 4-13) encompasses 88,962 acres (139 square miles) and includes nine subwatersheds (USFS 1997). A total of 78,899 acres of the watershed is under federal (USFS and BLM) ownership; 4,426 acres are owned by the City of Portland; 595 acres are owned by PGE until the planned dam decommissioning is complete; and 5,042 acres of the watershed are owned by private entities. Elevations in the watershed range from 260 to 4,750 feet. Annual precipitation ranges from 52 to 143 inches; however, snowfall is rare below 2,000 feet (USFS 1997).

Bull Run River is a large, clear-water tributary, unaffected by Mount Hood glaciers, that enters the Sandy River at Dodge Park (RM 18.5) near the City of Sandy. The mainstem is approximately 25 miles long and originates from springs below Bull Run Lake (elevation 3,180 feet), a large natural lake to the northwest of Mount Hood. Many large tributary streams also contribute significantly to the flows produced in the Bull Run watershed. Historically, flows from the Bull Run watershed represented approximately a third of the average annual flow in the Sandy River entering the Columbia River.

Important tributary streams draining into the Bull Run River watershed include the North and South forks of the Bull Run River, the Little Sandy River, and Blazed Alder, Fir, Cougar, and Camp creeks. The Little Sandy River is a large tributary stream emptying into the Bull Run River at RM 3 (four miles below the City’s Headworks Dam).

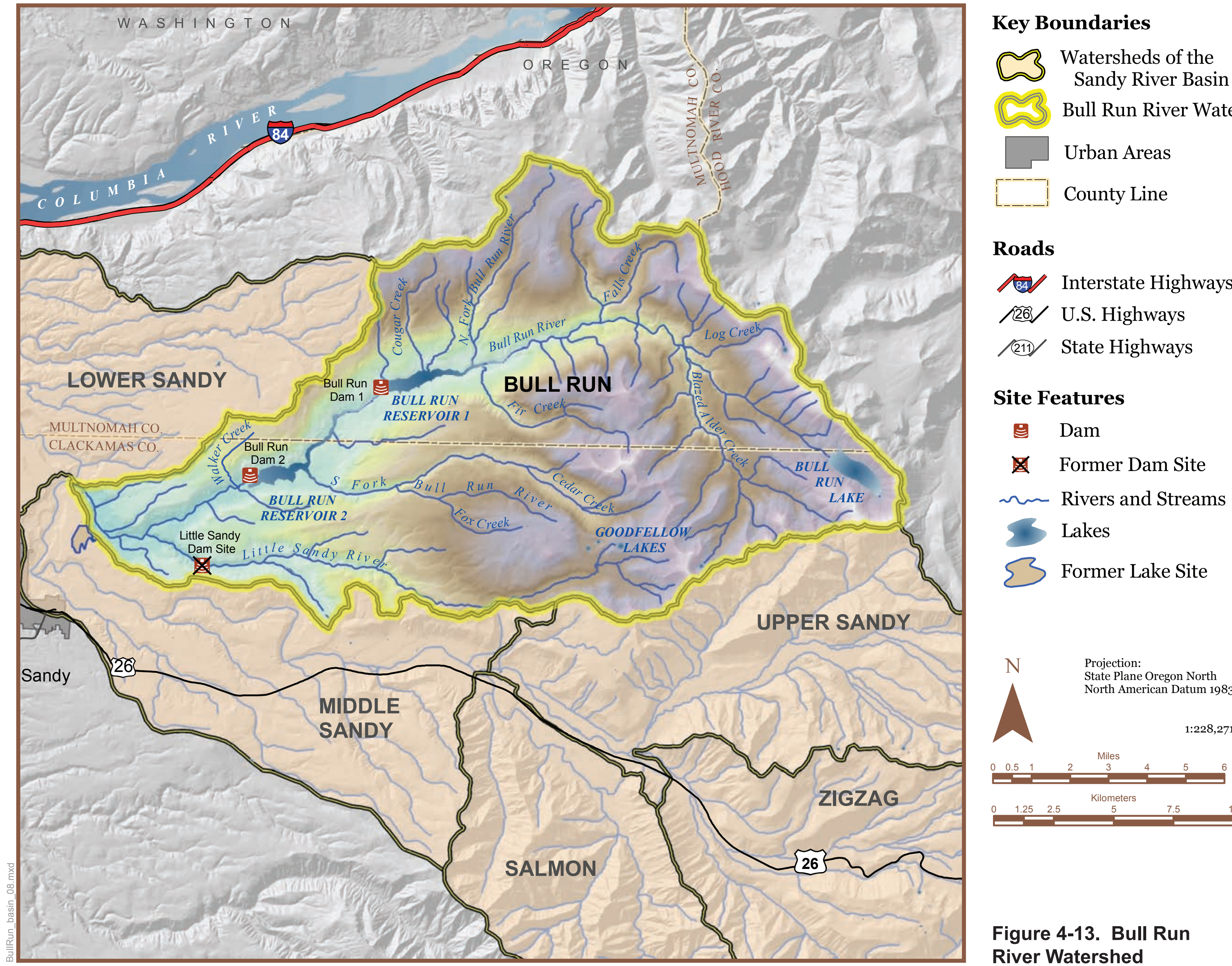


Figure 4-13. Bull Run River Watershed

Habitat Access

Anadromous fish historically used about 49 stream miles in the Bull Run River watershed, which includes 10 miles of stream for the Little Sandy River (see Table 4-8). Of the 39 stream miles for the Bull Run River portion, approximately nine miles are now inundated by Bull Run reservoirs. Steelhead and lamprey probably had access to all 49 miles of streams. Coho, Chinook (spring and fall) salmon, and coastal cutthroat trout probably had access to approximately 40 out of the 49 miles in the watershed.

Anadromous fish currently use about 7.5 stream miles of stream habitat in the Bull Run River watershed. Of this total, approximately 5.8 miles are in the lower Bull Run River downstream of the Headworks, with an additional 1.7 miles in the Little Sandy River. This distance represents about 4.7 percent of the total stream miles (170 miles) currently used by anadromous fish in the Sandy River Basin.

The Bull Run and Little Sandy rivers provide limited migration, spawning, and rearing habitat for anadromous and resident fish species in the Bull Run River watershed downstream of hydroelectric and water diversion projects. Fish passage is blocked at RM 5.8 on the lower Bull Run River and at RM 1.7 on the Little Sandy River. Other tributaries to the lower Bull Run River have limited productivity potential for anadromous fish due to steep gradients or natural waterfalls (City of Portland 2002). Additionally, a culvert in Walker Creek blocks access to about 500 feet of this lower Bull Run River tributary (City of Portland 2002).

Fall and spring Chinook, coho, and steelhead currently use all of the accessible 7.5 stream miles in the Bull Run River watershed. Anadromous cutthroat trout are assumed to use the lower Sandy River (below the Marmot Dam site), including the lower Bull Run River, although there have been few recent observations. Resident cutthroat trout are well distributed throughout the watershed.

Important habitat for resident, fluvial, and adfluvial forms of coastal cutthroat trout is known to exist upstream of dams in the upper Bull Run and Little Sandy rivers. These cutthroat trout populations have been protected by the lack of competition from anadromous fish in both subwatersheds and the curtailment of recreational fishing since the late 1800s in the upper Bull Run River watershed.

Channel Conditions

USFS (1997) evaluated habitat types for the Bull Run River watershed using data from the SMART database relating to the presence and quantity of channel habitat types (e.g., riffles, glides, pools, side channels). With the exception of the upper Little Sandy River, riffles dominated the habitat composition for mainstem channels in the watershed. USFS (1997) concluded that anadromous fish-bearing streams in the watershed exhibited a high percentage of riffle and large pool habitat but were limited in side-channel habitat. The agency hypothesized that habitat conditions favored steelhead trout and Chinook salmon over coho salmon. Suitable habitat for rainbow trout and other resident fish species appeared to exist in the Little Sandy River, where riffle, pool, and glide habitats account for 43, 33, and 15 percent of total habitat, respectively. The upper Bull Run River exhibited a high percentage of riffle habitat suitable for resident cutthroat trout, but it lacks adequate pool and glide habitat for other species. The habitat in the upper Bull Run, with the exception of the inundated area, is close to historical condition.

Sediment production in the watershed was assessed by USFS (1997) and attributed to three principal causes: mass wasting, land disturbances, and stream channel geomorphic processes (e.g., flow-induced channel erosion and sediment transport). Landslide mapping in the Bull Run River watershed identified less than two percent of the total watershed area as highly susceptible to landslides. Land disturbances in the Bull Run River watershed were not found to be large contributors to the watershed’s sediment budget. USFS (1997) concluded stream channel geomorphic processes were the dominant source of sediment in the watershed.

Spawning gravels are scarce in the lower Bull Run River and probably limit the production of anadromous salmonid fishes in the river (R2 Resource Consultants 1998b). High water velocities occurring during peak flow periods reduce gravel quantity. Much of the river is situated in a canyon, and it is confined to a relatively narrow channel by steep bedrock walls. River velocities can become high enough to mobilize and transport gravel and larger streambed materials.

River discharge and depth also influence the availability of spawning gravels because the number of gravel patches with sufficient spawning depth increases directly with stream flow. As an example, in 1997 a total of 21 gravel patches in the lower Bull Run River were predicted to be suitable for steelhead spawning under early spring flow conditions (R2 Resource Consultants 1998b). A total surface area of 3,580 square feet of suitable gravel was estimated to support up to 96 steelhead redds under median flow conditions during the spring spawning period. However, many of these redds were likely subject to desiccation due to subsequent dewatering during low flow periods. R2 Resource Consultants (1998b) predicted only 15 of these redds would be viable throughout the fry emergence period. Although subsequent provisional minimum flow release for the lower Bull Run River and a gravel supplementation by the City have dramatically increased the available spawning gravels and likelihood of fry recruitment from anadromous fish spawning, the quantity of gravel may still limit the production potential of the lower reaches.

USFS (1997) calculated pool frequencies as a measure of the number of pools per mile of stream. Pool frequency in the Bull Run River watershed was obtained from queries of the SMART database and then compared to the RNV and PIG standards. The RNV was approximated from unmanaged stream reaches by stream order across the Sandy River Basin (USFS 1997). Of the 11 streams assessed, only Blazed Alder Creek and the South Fork Bull Run River met PIG standards. All streams assessed were within the RNV for pool frequency except for the upper Bull Run River. The Little Sandy River and lower Bull Run River were within the RNV, but at the low end.

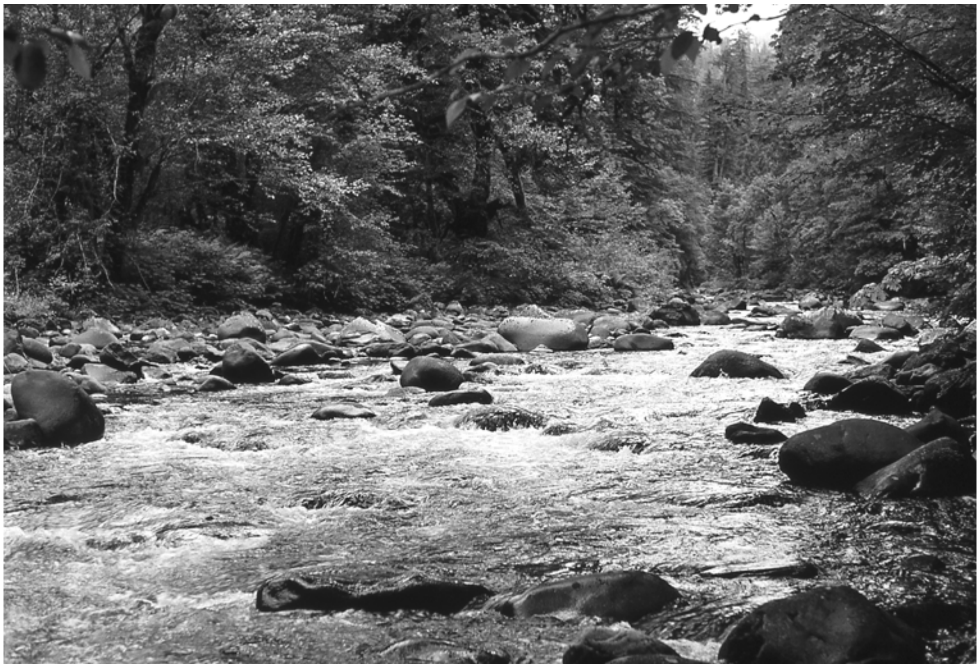


Photo courtesy of Char Corkran.

To further quantify pool habitat in the Bull Run River watershed, USFS (1997) assessed pool volume as a measure of square feet of pools per mile of stream. The upper and lower Bull Run River and the Little Sandy River were at the low end or outside of the RNV for pool frequency. However, they were at the high end or above the RNV for pool volume. This result indicates pool frequency is low but pools are large in volume and presumably of high quality (USFS 1997). Of the other nine streams assessed for pool volume, only two (Fir Creek and Otter Creek) were below the RNV.

The portion of the watershed accessible to anadromous salmonid fishes generally has low pool counts but high pool volumes. This situation typically provides good habitat for Chinook salmon because of the presence of large mainstem pools. The portion of the watershed utilized by resident fish appears to have adequate pool habitat for rainbow (upper Little Sandy River) and cutthroat (upper Bull Run River) trout.

Water management in the Bull Run River watershed has altered the hydrological profile of both the 5.8-mile reach of the lower Bull Run River downstream of Headworks Dam and the 1.7-mile reach of the Little Sandy River downstream of the Little Sandy Diversion Dam. PGE limits spill events in the Little Sandy River to the greatest extent possible (PGE 2002). Spilling water over the dam drastically increases flows and can attract anadromous fish into the Little Sandy River. When flows subsequently decrease, the channel is dewatered and fish can become stranded.

Water diverted from the Sandy River was combined with Little Sandy River water and transported through a series of canals and flumes into Roslyn Lake for power generation at PGE's Bull Run Hydroelectric Project (RM 1.7). Because the combined Sandy/Little Sandy water source was discharged to the lower Bull Run River, anadromous salmonids initially homing to the Sandy River may have been attracted to the Bull Run River. Straying due to false attraction could adversely influence spawning success if fish migrate upstream past

PGE's Bull Run Powerhouse in spring or early summer months. These fish may be exposed to reduced summer base flows, high water temperatures, and limited spawning habitat (PGE 2002). Fish migrating back downstream in search of suitable spawning habitat can experience migration delay and lost fitness. As noted elsewhere in the HCP, PGE's hydroelectric project is being decommissioned and this diversion of water from the Sandy River to the Bull Run River will no longer occur after early 2008.

In the Bull Run River, approximately 20 percent of the water annually draining to Headworks Dam is transported out of the watershed for municipal water supply (SRBWC 1999). Consumptive water use reduces base stream flows in the Bull Run River, thereby affecting habitat during the summer and fall when adult and juvenile steelhead trout and Chinook salmon are present in the river. In 2002, the lower Bull Run River from the mouth to RM 5 was included on the ODEQ 303(d) list as water quality limited for water temperatures exceeding summer salmonid fish-rearing standards, and mentioned in the Water Quality Management Plan mentioned previously (ODEQ 2005).

Streamflow in the lower Bull Run River is largely controlled by water releases from both the Headworks (RM 5.8) and PGE's Bull Run Powerhouse (RM 1.6). Flows between the Headworks and the powerhouse (4.2 miles) are reduced by the diversion of water for municipal use and by storage of water in the two Bull Run reservoirs. The diversions have their greatest influence on hydrological conditions in this section of the river during the low flow season (July through October) annually. River flow between the PGE Bull Run Powerhouse and the confluence of the Bull Run and Sandy rivers is generally higher than flows expected to occur under natural conditions, and it is subject to wide flow variation resulting from hydropower peaking operations. When PGE's hydroelectric project is decommissioned, flows will be affected only by the City's upstream water supply operations.

Streamflows in the lower Bull Run River affect fish production in several ways. Low flows increase water temperatures for fish rearing in the summer months. Low flows also affect habitat availability. However, juvenile survey data suggest that habitat availability related to flow might not be the key factor limiting juvenile production in the lower Bull Run River. Rearing densities of juvenile fish are low in the lower Bull Run River. Based on data collected for three years (Clearwater BioStudies 1997; Beak 2000b), juvenile steelhead densities were only 20 percent of those from other comparable streams in the region. These data were collected from 1997 to 1999 when base flow conditions in the summer were 5 to 7 cfs. Very few fish were present to fill the available habitat. These results may indicate that either the habitat is underseeded or combinations of other environmental variables, such as water temperature, are controlling fish production.

R2 Resource Consultants (1998b) evaluated spawning flows for anadromous salmonids in the lower Bull Run River and found that flows during the winter and spring are generally within or exceed the range of flows predicted to provide optimal available spawning habitat for steelhead and cutthroat trout. An analysis of spawning gravel in the lower Bull Run River (R2 Resource Consultants 1998b), however, indicated that lack of suitable spawning gravel may be limiting production of steelhead. A gravel supplementation program to further increase spawning production potential was recommended for consideration.

Chapter 5. Current Condition of the Species Covered or Addressed in the HCP

5. Current Condition of the Species Covered or Addressed in the HCP

The species that are covered or addressed in this Habitat Conservation Plan (HCP) were defined in Chapter 3. This chapter presents the current condition of the species and their habitats in the Sandy River Basin, including information on life histories, distribution and abundance, habitat needs, and threats to survival. As in Chapter 3, the species are divided into three general categories: fish, including covered species and other fish species; amphibians and reptiles; and birds and mammal.

5.1 Fish Species Selected for HCP Coverage

The Sandy River Basin supports a diverse assemblage of native and introduced fish species from its headwaters to its mouth. The native fish species include Chinook (fall and spring run), coho salmon, and steelhead.[1] These four species are the primary focus of the HCP, and there is good information available to describe their habitat needs and current status, as detailed in the following subsections. The other native fish species covered under the HCP are chum salmon and eulachon. Less information is available about chum and eulachon, which necessitated a different analysis approach. Table 3-1 lists the other aquatic species covered under the HCP and their state and federal Endangered Species Act (ESA) status.

Chinook salmon and winter steelhead were selected for coverage because they have been listed as threatened under the authority of the federal ESA. Lower Columbia River (LCR) Chinook (*Oncorhynchus tshawytscha*) were first listed in March 1999 and that ruling was reaffirmed in June 2005. Both the fall and spring races of Chinook that utilize the Sandy and Bull Run rivers are listed threatened species. LCR steelhead (*O. mykiss*) were first listed as a threatened species in March 1998, and that ruling was reaffirmed in January 2006. The LCR steelhead distinct population segment (DPS) was also identified in the January 2006 determination.

Coho salmon (*O. kisutch*) were included as covered species because of both state and federal analyses and decisions. In 2000, the Oregon Department of Fish and Wildlife (ODFW) listed LCR coho salmon as endangered under the state's Endangered Species Act.[2] LCR coho were listed as a federally threatened species in June 2005.

Columbia River chum (*O. keta*) were listed as a threatened species in March 1999. Most chum in the lower Columbia River prefer habitats in the mainstem Columbia. However, it is believed that the species could also use the lower Sandy River in the vicinity of the areas that will be affected by some of the City's HCP measures. For those reasons, the City decided to include chum salmon as a covered species.

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[1] Fall and spring Chinook are separate races of the same species *(O. tshawytscha)*. In this HCP, the City refers to them as two species. Fall and spring Chinook, steelhead, and coho are therefore referred to as the four primary species.

[2] The state of Oregon has listed some salmonid fishes under the state Endangered Species Act. However, that law applies only to actions of state agencies on state-owned or state-leased lands.

Pacific eulachon (*Thaleichthys pacificus*) was designated as a candidate species in March 2008. Eulachon, or smelt, are endemic to the eastern Pacific Ocean with a major and consistent spawning run in the mainstem Columbia River. In some years, eulachon spawn in the lower Sandy River in the vicinity of the area that will be affect by some of the City's HCP measures. Consequently, the City will include eulachon as a covered species.

5.2 Other Fish Species Addressed in the HCP

Other fish species addressed in this HCP include cutthroat trout, rainbow trout, Pacific lamprey, brook lamprey, and river lamprey. All of the fish species addressed in this HCP will benefit from the implementation of the measures for the primary covered species (fall and spring Chinook, winter steelhead, and coho salmon). Less is known about the other aquatic species in the Sandy River Basin. The available biological information for each species is summarized in this chapter.

Resident rainbow trout have the same scientific classification as steelhead and similar habitat requirements. Rainbow trout occur throughout the Sandy River watershed, including the two Bull Run reservoirs. Rainbow trout might be affected by both the City's water supply operations and implementation of the HCP conservation measures.

Coastal cutthroat trout (*O. clarki clarki*) was proposed for listing in March 1999 but was never officially listed for several reasons (U.S. Fish and Wildlife Service [USFWS] 2002):

- The states of Oregon and Washington took steps to reduce mortality caused by direct and incidental harvest and to reduce hatchery production of anadromous life history forms in the lower Columbia River.
- Local conservation and recovery work and changes in forest management regulations reduced the risks to the species.
- The latest information indicated that there were relatively healthy-sized total populations in a large portion of the DPS.
- USFWS gained an improved understanding of the ability of freshwater forms to produce anadromous progeny.

Nevertheless, cutthroat trout remain a species of interest in the Sandy River Basin.

Three lamprey species will benefit from the HCP measures: Pacific lamprey (*Lampetra tridentata)*, western brook lamprey (*L. richardsoni*), and river lamprey (*L. ayresi*)). Pacific lamprey were listed as an Oregon state sensitive species in 1993 and were given further legal protection status by the state in 1996. Less information exists for western brook or river lamprey, but ODFW suspects these two fish have declined precipitously in recent decades (ODFW 2002). All three lamprey species could use habitat in the Bull Run and Sandy rivers.

5.3 Tools Used to Investigate Current Conditions for the Primary Covered Species

In addition to current research and publications, three tools were used to investigate current conditions for the species listed as endangered under the ESA: periodicity tables, the Ecosystem Diagnosis and Treatment (EDT) model, and the Physical Habitat Simulation (PHABSIM) model. Periodicity charts show the periods during the calendar year when fish are present in a particular life stage. The EDT model compares current conditions with estimated historical conditions. The PHABSIM model estimates the weighted usable area for spawning and rearing from the amount of flow in a stream.

Note: The HCP relies on the best and most complete data available at the time the document was drafted. In most cases, these data are from 2003. The City's understanding is that NMFS will use the most current available data about the species, including recovery planning documents, when evaluating the adequacy of the HCP.

5.3.1 Periodicity Charts

The periodicity charts for fall and spring Chinook, coho salmon, and steelhead in the Sandy River Basin were developed by the Sandy River Basin Agreement Technical Team (SRBTT) in December 2002. The figures were derived from several periodicity tables, including:

- Portland General Electric's (PGE's) ESA draft consultation documents related to their dam decommissioning process
- Oregon Department of Environmental Quality's (ODEQ's) draft total maximum daily load documents for the Sandy River Basin
- ODFW's 1997 Sandy River Fish Management Plan
- Portland Water Bureau's draft periodicity tables for the lower Bull Run River

5.3.2 EDT Modeling

The EDT model compares current conditions with historical conditions to determine

- which habitat attributes (called Level 2 environmental attributes in EDT) have degraded or improved over time.
- the relative effect each attribute has had on species performance across its historical distribution in the Sandy River Basin.
- the limiting factors (named Level 3 survival factors in EDT) for the species in the Sandy River Basin.

Historical conditions are defined as those existing prior to European settlement.

The EDT model expresses the interaction of 46 habitat attributes as the limiting factors that most affect a particular life stage. For example, the primary attribute that influences the spawning life stage as key habitat is the quantity of small cobble/gravel riffles. However, in the fry colonization stage, the amount of backwater pool habitat is the primary influence.

The SRBTT, from August through December 2000, entered all habitat data for each stream reach of the Sandy River Basin. Appendix B shows each stream reach length in miles and river miles. These data were used to create the habitat attribute ratings that are in the EDT model.

The first EDT modeling results for the Sandy River were completed in 2001. The model has been updated since then as new information about mortality influences, fish distribution, and other information became available. The limiting factors for each species are presented for watersheds for the Sandy River Basin from analyses using the EDT model. In addition, a matrix of limiting factors is provided for individual reaches in the Bull Run River watershed. Both show the potential effects of limiting factors as dots of different sizes. The dots represent EDT model estimates of the degree of habitat change from historical to current conditions. The values assigned to the dots differ for the Sandy River Basin and the reaches in the Bull Run watershed. The different scales are explained below.

Limiting Factors in the Sandy River Basin

The limiting factors in the Sandy River Basin are expressed as the degree to which species survival is reduced under current habitat conditions compared with historical conditions. Dots of different sizes show the estimated reductions in survival for each species by watershed. An empty cell shows a less than 1 percent change from historical conditions. The scale of the degree of change from historical to current conditions is shown in Figure 5-1 below.

Percentage change from historical conditions	Worse
Less than 1%	
Between 1 and 5%	•
Between 5 and 20%	●
More than 20%	⬤

Figure 5-1. Scale for Limiting Factors in the Sandy River Basin Watersheds

Limiting Factors in the Bull Run Watershed

EDT model results for Bull Run are shown for the life stages of each species. The numbers in the "life stage most affected" columns show the top three most affected life stages in the reach.[3] The most affected life stages are those that would be most accountable for the overall decline in species productivity in that reach. The numbers rank the accountability for the decline in productivity from 1, most accountable, to 3, least accountable.

The dots compare the life-stage survival under current conditions to survival under historical conditions for the attribute. The dot size indicates the proportional reduction or

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[3] EDT models habitat conditions in reaches of the Bull Run watershed in which the species are not present (such as reaches above Dam 2) to determine the expected relative use of the reach by each life stage.

improvement in survival of the life stage indicated as the number 1 life stage most affected. An empty cell indicates negligible change (less than 0.2 percent) from historical conditions.

The scale of the degree of change from historical to current conditions is shown in Figure 5-2, below.

Percentage change from historical conditions	Worse	Better
Less than 0.2 %		
Between 1.0 and 0.2%	•	○
Between 5 and 1%	●	○
Between 25 and 5%	●	○
More than 25%	●	○

Figure 5-2. Scale Explanation for Limiting Factors in the Bull Run Watershed

For example, in Figure 5-3, the dots under channel stability, competition from species, flow, food, habitat diversity, and key habitat diversity indicate the degree to which current conditions are worse than (solid circles) or better than (open circles) historical conditions for the fry colonization life stage. The circles for flow, food, and habitat diversity indicate that current conditions are between 5 and 25 percent worse than historical conditions. The circle for key habitat quantity indicates that current conditions are between 5 and 25 percent better than historical conditions.

	Life Stage Most Affected													Limiting Factors															
	Spawning	Egg incubation	Fry colonization	0-age migrant	0-age active rearing	0,1-age inactive	1-age migrant	1-age active rearing	2+-age active rearing	2+-age migrant	2+-age transient rearing	Prespawning migrant	Prespawning holding	Channel stability	Chemicals	Competition (w/hatch)	Competition (other species)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Bull Run Bear 1		2	1			3								●			•	●	●	●									○

Figure 5-3. Sample Matrix for Coho

The effects represented by the dots are weighted according to the expected relative use of the reach by each life stage (as if the species were present in the reach). For example, rearing juvenile steelhead are more affected by water temperature than are migrating steelhead smolts. If reach A has the potential to provide habitat for more rearing juveniles than reach B, the dot size under temperature will be larger for reach A than for reach B. However, if reach C has the potential to support only a few rearing juveniles and no emigrating smolts, and reach D cannot potentially support rearing juveniles but can provide habitat for large numbers of smolts, reaches C and D might have the same dot size under temperature.

Appendix D, EDT Information Structure, provides an introduction to the EDT model as well as tables with definitions of the habitat attributes, the limiting factors, and how habitat attributes are combined to estimate limiting factors. For more information on the EDT model and definitions of the limiting factors, see Appendix D, or Lestelle et al. 2004; City of Portland Bureau of Water Works 2004a; and Lestelle et al. 1996.

5.3.4 PHABSIM Modeling

R2 Resource Consultants (1998) used the PHABSIM model to estimate the habitat-flow relationships of the HCP measures on spawning and juvenile rearing habitat in the lower Bull Run River. The results are expressed as weighted usable area (WUA), an index of available instream habitat at various increments of flow. Using median flows up to 500 cubic feet per second (cfs) for segments of the lower Bull Run River, R2 Resource Consultants determined WUA estimates for natural flow conditions (no dams and no diversions) and estimates of HCP flows, both upstream and downstream of the Little Sandy River. For flows greater than 500 cfs, goodness-of-fit curves were used to extrapolate WUA values.

5.4 The Covered Species

The four primary covered fish species are fall Chinook, spring Chinook, winter steelhead and coho. The additional covered fish species are chum and eulachon.

5.4.1 The Four Primary Covered Species

Among fish species, the species listed under the ESA—Chinook (fall and spring races), steelhead, and coho—are the primary focus of attention for the HCP.[4] For these primary covered fish species, conditions are first described for the entire Sandy River Basin and then for the Bull Run River watershed. Information about current conditions for the other species is limited and is described primarily at the Sandy River Basin scale.

The topics covered under the Sandy River Basin and Bull Run subsections differ slightly, as shown below:

Sandy River Basin	**Bull Run Watershed**
Life history and diversity	Distribution
Distribution	Abundance
Abundance	Habitat conditions
Hatchery production and plantings	Limiting factors
Harvest in the basin	Flow and habitat preferences
Reasons for listing and/or threats to survival	

The status of salmonids in the Sandy River Basin is monitored by both the National Marine Fisheries Service (NMFS) and ODFW. This HCP uses reports and documents published by NMFS and ODFW, as well as EDT modeling results, as source information for reasons for decline and limiting factors for the species in the Sandy River Basin.

Because the Bull Run watershed is a subregion of the Sandy River Basin, some overlap between reasons for listing or limiting factors may occur between the larger Basin and the Bull Run watershed.

[4] Fall and spring Chinook are separate races of the same species (*O. tshawytscha*). In this HCP, the City refers to them as two species. Fall and spring Chinook, steelhead, and coho are therefore referred to as the four primary species.

Fall Chinook in the Sandy River Basin

Life History and Diversity

Fall Chinook salmon (*O. tshawytscha*) in the Sandy River Basin are included in the Lower Columbia River Evolutionarily Significant Unit (ESU) and in 1999 were listed as "threatened," under the federal ESA (NMFS and USDFWS 1999). Adult fall Chinook salmon begin to enter the Sandy River Basin in August and are probably present through February in small numbers. Peak spawning occurs from October through December, and spawning distribution appears to be controlled by flow conditions in the Basin (ODFW 1997). Estimated periods of occurrence of fall Chinook life stages in the lower portion of the Sandy River Basin (below the Marmot Dam site) are shown in Figure 5-4.

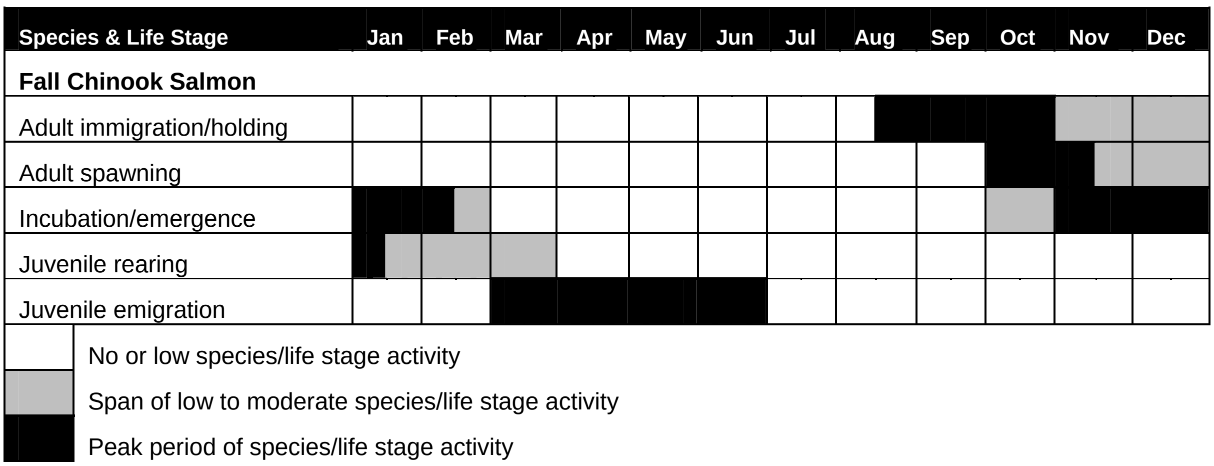


Figure 5-4. Estimated Periods of Occurrence for Fall Chinook in the Lower Sandy River Basin Below Marmot Dam Site

Source: Sandy River Basin Agreement Technical Team 2002.

Historically, fall Chinook were distributed in the Basin upstream to the Salmon River. They are now assumed to be present only below the Marmot Dam site.

Fall Chinook salmon in the Sandy River Basin are ocean-type fish, meaning they typically spend one year or less rearing in fresh water (NMFS 2003). Ocean-type Chinook salmon juveniles migrate to the ocean in the late summer or autumn of their first year as fry or fingerling migrants (Myers et al. 1998). If environmental conditions are not conducive to subyearling outmigration, however, ocean-type Chinook salmon juveniles may remain in fresh water for the entire first year after hatching (Myers et al. 1998; NMFS 2003).

Juvenile fall Chinook salmon are dependent on estuaries and their associated wetlands as nurseries before they migrate to the open ocean. Wetlands play a vital role in providing feeding opportunities and offering protection from predators. Juvenile Chinook salmon often rear up to six months in estuarine environments before spending the majority of their life in the ocean. Ocean residence varies, but most Chinook salmon spend between three and four years in saltwater before returning to spawn in fresh water.

Size, age, and run timing of adult fall Chinook vary by stock in the Sandy River Basin. ODFW currently recognizes two run components. The first, an early maturing tule stock, is also referred to as the lower river hatchery (LRH) stock. The second, the late maturing Lower River Wild (LRW) stock, shows run timing and genetic characteristics similar to the late wild stock in the Lewis River in Washington (NMFS 2003).

The early maturing tule fall Chinook are believed to be a mix of three groups: naturally produced fish that originated from hatchery releases made in the Sandy River prior to 1977; the progeny of successful spawning stray hatchery fall Chinook; and, to a lesser extent, stray hatchery fall Chinook adults originating from hatcheries in both Washington and Oregon (ODFW 1997). Tule fall Chinook begin entering the Sandy River in August, and spawning occurs in late September through mid-October. ODFW established the early maturing tule fall Chinook population as a component of the Tule Gene Conservation Group.

The late maturing LRW stock is indigenous to the Sandy River Basin and typically enters the Sandy River in October, with spawning occurring from late October through December. An additional component to the LRW stock is referred to as the Winter or Late Bright stock. The winter Chinook stock typically returns from December to early February. Recently, ODFW included the winter Chinook stock as a subcomponent of the Sandy River LRW stock (ODFW 1997). Together, they form the Sandy Fall Chinook Gene Conservation Group as established by ODFW.

The NMFS Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) classified the late-run Sandy River brights (LRW stock) as both a “core” and a “genetic integrity” population in their recovery planning efforts. These designations mean that the population historically was abundant and productive; the current population resembles the historical life histories and genetic types in the Sandy River Basin; and the population currently offers one of the most likely paths to recovery in the Lower Columbia Chinook ESU (McElhany et al. 2003). Two states, Washington and Oregon, are preparing plans to address recovery in the Lower Columbia Chinook ESU. The Lower Columbia River Fish Recovery Board (LCRFRB), which is a Washington group, determined the priority for contribution of this stock to recovery goals in the ESU as “primary.” This classification means the Sandy River late fall Chinook stock is targeted for recovery as one of the stocks desired to achieve viable population levels with a greater than 95 percent probability of persistence (negligible extinction risk) within 100 years (LCRFRB 2004; McElhany et al. 2003; McElhany et al. 2004). Oregon is now in the process of developing a Lower Columbia River recovery plan for streams in Oregon.

The early fall run tule stock (LRH) did not receive a similar designation as either a core or genetic integrity population. The LCRFRB designated the priority for contribution of this stock to recovery goals as “stabilizing,” which focuses on maintaining the current population structure of this stock (LCRFRB 2004).

Distribution

The SRBTT developed a completed list of the reaches in which each natural population of anadromous salmonids was known or assumed to spawn, either currently or historically (City of Portland 2004a). For streams in which data were not available to determine species use, the SRBTT assumed that Chinook (spring and fall) would not utilize streams with a minimum width less than 15 feet or a gradient higher than 8 percent. After initial EDT model runs were completed in 2001, the SRBTT met again to review the results and re-examine spawning distribution in the Sandy River Basin. Based on this review, several spawning reaches were excluded for some species and added for others. This distribution information was used to develop Figures 5-5 and 5-6.

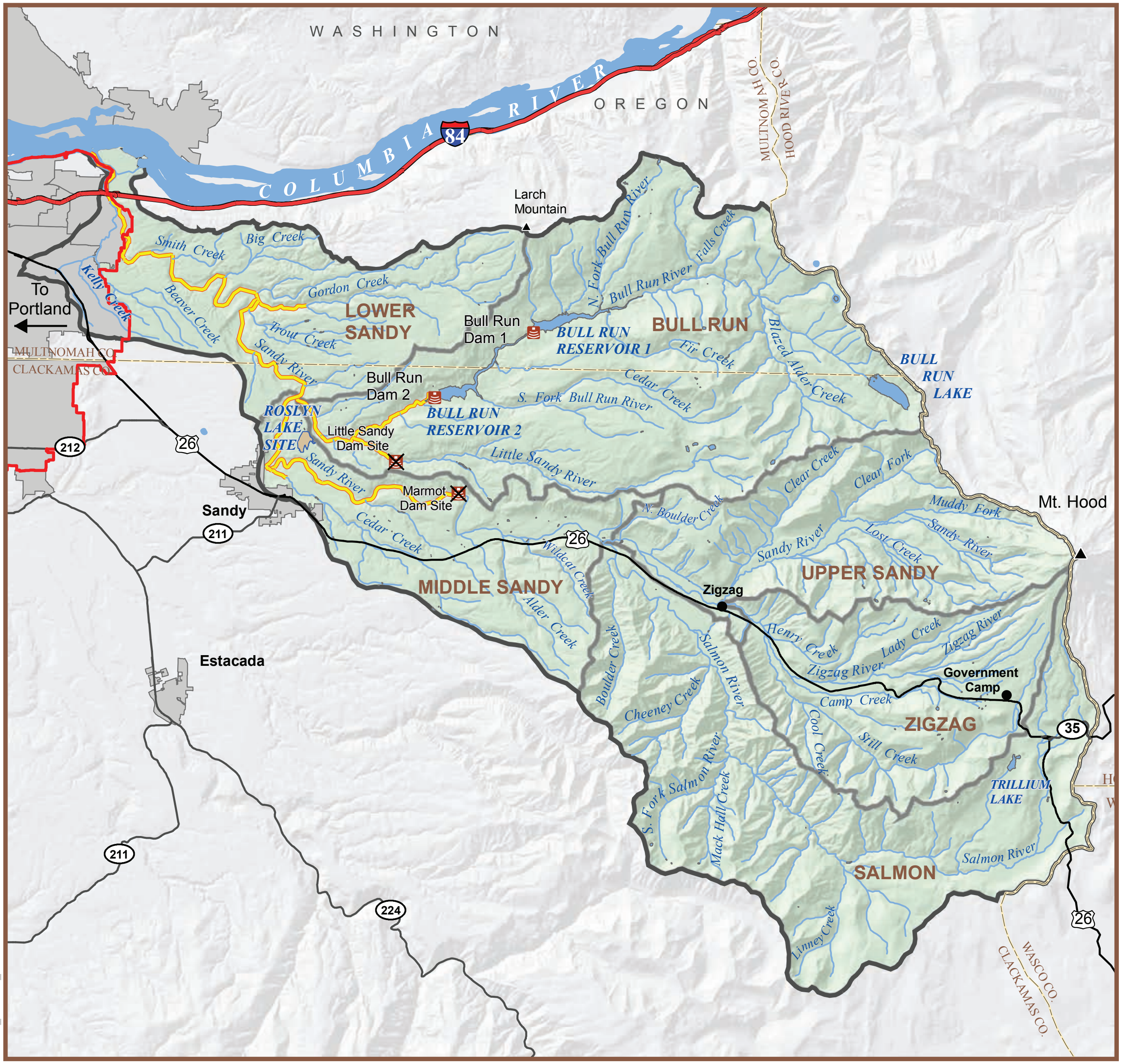
Current. The SRBTT determined the current fall Chinook distribution in the Sandy River Basin, as shown in Figure 5-5. Because fall Chinook were not observed upstream of Marmot Dam in the years prior to 2006, the SRBTT determined that the species is concentrated primarily in the mainstem Sandy River below the Marmot Dam site. The current distribution has probably been affected by several factors, such as ineffectiveness of the Marmot Dam fish ladder (from about 1913 to 1933), seasonal low flows in the Sandy River below Marmot Dam and in the Bull Run River, and ODFW egg-taking at Marmot Dam.

Available spawning habitat for tule fall Chinook is usually limited by low flow conditions characteristic of the Sandy River in early fall. Spawning generally occurs in the mainstem from Lewis and Clark State Park to the upstream boundary of Oxbow Park (ODFW 2002). Spawning may have occur in tributaries and side channels downstream of Marmot Dam if significant early season rainfall occurred.

Sandy River LRW fall Chinook utilize much of the same spawning habitat as tule fall Chinook, but due to their run timing they usually have more tributary and side-channel habitat available for spawning. For instance, Gordon and Trout creeks are important lower Basin tributaries used for fall Chinook spawning when flows increase (ODFW 2002).

Historical. The historical fall Chinook distribution assumed in the Sandy River Basin is shown in Figure 5-6. Though most spawning of fall Chinook now occurs in the mainstem and tributaries of the lower Basin near Oxbow Park, historical spawning distribution occurred both in the Bull Run River and above the Marmot Dam site in the Salmon River and Sixes Creek, a Salmon River tributary (ODFW 2002).

A table of current and historical distribution for all species and all watersheds in the Sandy River Basin is available as Appendix C.



Key Boundaries

- Sandy River Basin
- Watersheds of the Sandy River Basin
- Urban Areas
- Urban Growth Boundary
- County Line

Roads

- Interstate Highways
- U.S. Highways
- State Highways

Site Features

- Dam
- Former Dam Site
- Lakes
- Former Lake Site

Current Fall Chinook Distribution

- Present
- Not Present

N

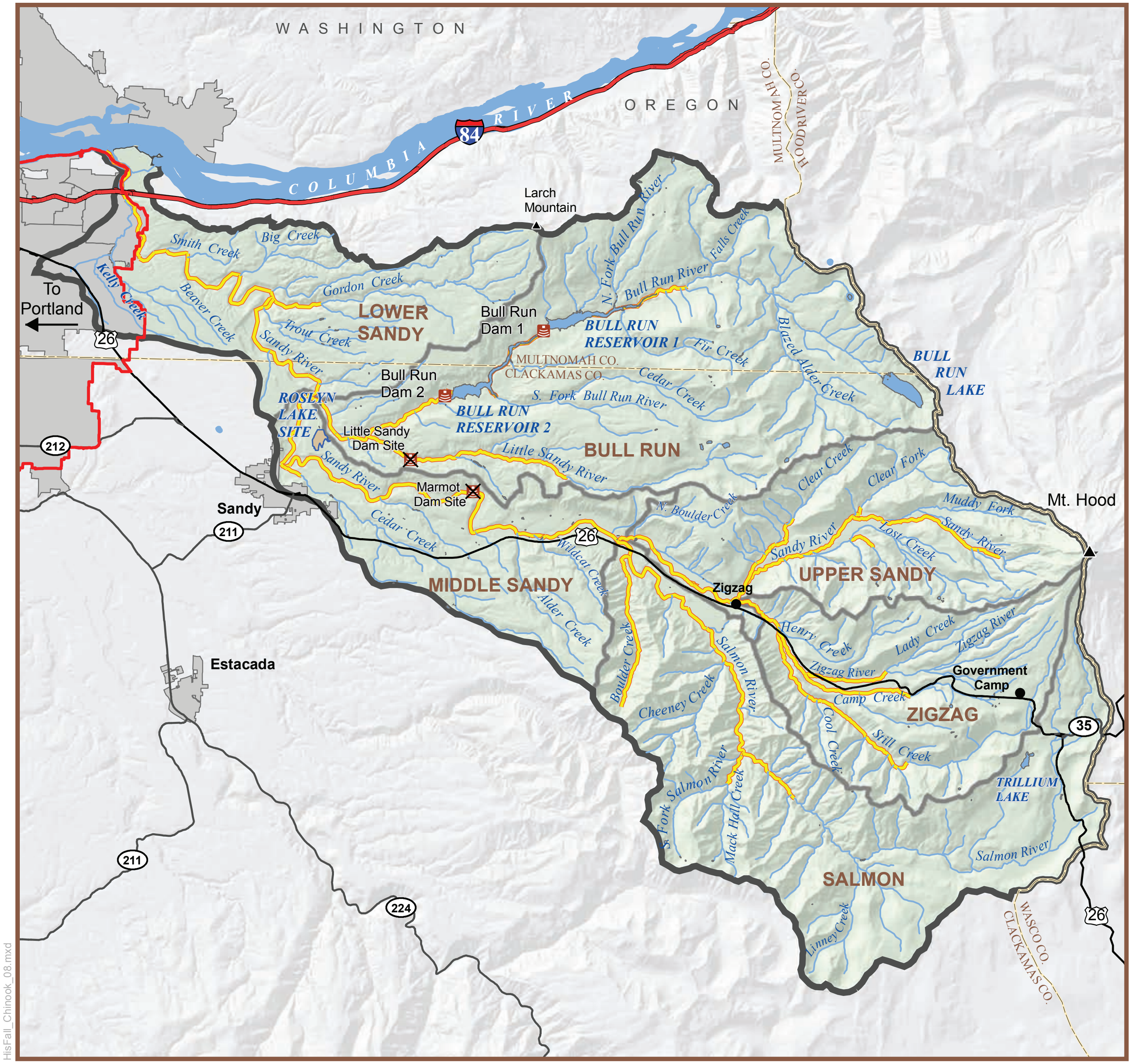
Projection:
State Plane Oregon North
North American Datum 1983

1:330,931

Miles: 0 1 2 4 6 8

Kilometers: 0 1.5 3 6 9 12 15

Figure 5-5. Current Fall Chinook Distribution



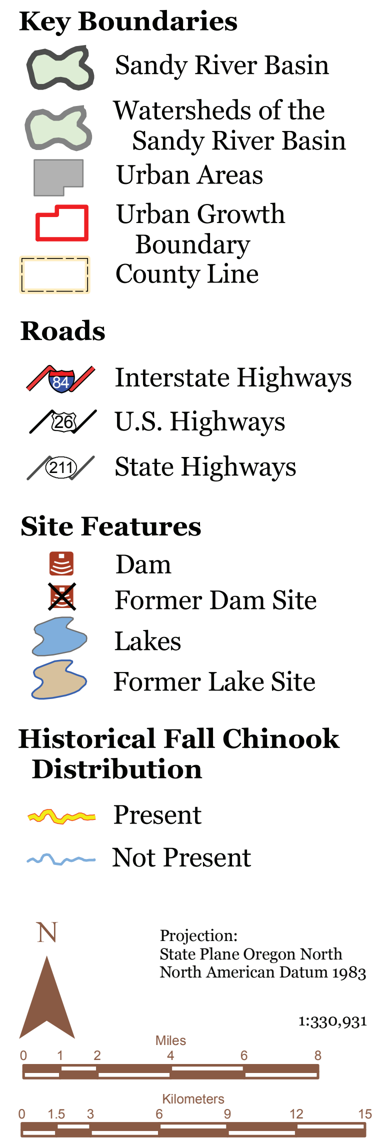


Figure 5-6. Historical Fall Chinook Distribution

Anchor Habitat. The Sandy River Basin Working Group (SRBWG), which is composed of agencies and nongovernmental groups interested in restoring fish runs in the Sandy River watershed, has identified anchor habitats for salmon and steelhead populations (SRBWG 2006). Anchor habitats are defined as distinct stream reaches that currently harbor specific life-history stages of salmon and steelhead to a greater extent than the stream system at large. Anchor habitats are usually not at capacity for fish production; they are areas that currently have the greatest fish densities. The SRBWG identified anchor habitat by evaluating empirical data, professional judgment data, and EDT model data of current conditions. The SRBWG believes a successful habitat restoration strategy for the Sandy River Basin should focus on the remaining, relatively intact riverine habitat that currently supports a disproportionate share of wild salmon and steelhead. The City considered the anchor habitat reaches for fall Chinook when choosing habitat conservation measures (see Chapter 7).

All five anchor habitat reaches for fall Chinook are located in the lower Sandy River watershed, with three on the mainstem Sandy River and two on the lower ends of Trout and Gordon creeks. Fall Chinook spawning generally occurs from late October to early December, and it is concentrated in the lower Sandy River near Oxbow Park. Trout and Gordon creeks also support fall Chinook spawning and may serve as refuge areas for adult fish during high-flow events (ODFW 2001).

Abundance

Tule fall Chinook abundance and escapement are rarely documented in the Sandy River because this stock is believed to be an introduced run. It is unknown, however, whether the population is sustaining itself since hatchery plantings were curtailed in 1977. In October 1988, surveyors counted 828 redds and 920 fish, indicating tule escapement may be high in some years (ODFW 2002). In recent years, the mean abundance estimate of the fall Chinook tule stock was 183 adult fish in the Sandy River (NMFS 2003).

Various sources provide run estimates for the Sandy LRW fall Chinook stock. Though the numbers vary somewhat, depending on the years considered, most agree the stock is depressed. The average annual run estimate for returns to the Sandy River in 1984–1994 was 1,503 (ODFW 2002). Another estimate, for 1984–2001, was 504 individuals (NMFS 2003). Spawning escapement in 2000 reached a record low of only 88 individuals (ODFW 2003a). The winter subcomponent appears to be severely depressed based on declining spawner counts at index sites in Gordon and Trout creeks (ODFW 1997). In most years, only a handful of these fish have been observed or caught by anglers in the Sandy River.

More recently, Mobrand Biometrics (2004) summarized Sandy LRW fall Chinook stocks estimates for 1990–2000 from several sources. Three different estimates of LRW fall Chinook abundance for the Sandy River Basin are presented graphically in Figure 5-7 (Mobrand Biometrics, Inc. 2004). The information comes from ODFW's Fisheries Management and Evaluation Plan (2003a). The highest, lowest, and average run sizes between 1990 and 2000 are 2,060, 708, and 1,166 fish, respectively.

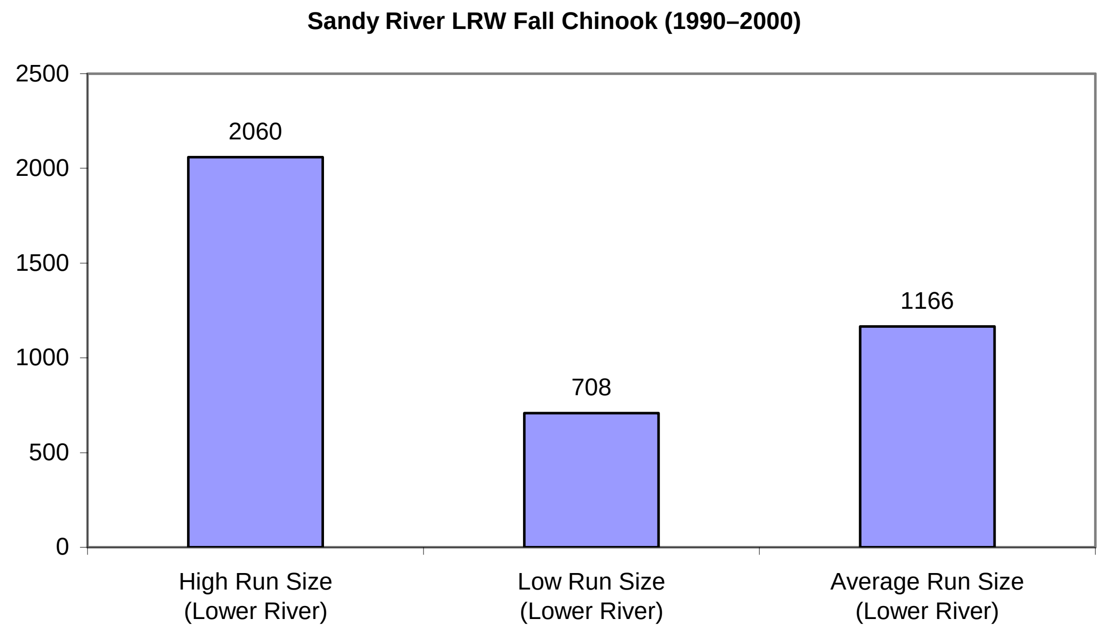


Figure 5-7. Estimates of Fall Chinook Abundance in the Lower Sandy River Below Marmot Dam

Source: ODFW 2003a

The ODFW Fisheries Management and Evaluation Plan (2003a) also established a critical abundance threshold[5] level of 300 natural-origin LRW spawners (to avoid short-term deleterious genetic and demographic effects). A viable abundance threshold[6] for Sandy LRW fall Chinook was set at 1,500 natural origin spawners (ODFW 2003a). The objective in the Oregon Administrative Rules (OAR 635-500-3470) is to maintain an annual average escapement of 1,500 wild late maturing fall Chinook to the standard survey spawning reach in the Sandy River Basin (river mile (RM) 6 to 13). A recovery goal has not yet been set by the WLC-TRT for the Sandy River Basin.

EDT modeling also provided an estimate of the current fall Chinook habitat conditions for producing 1,700 returns to lower Sandy River reaches 1 and 2. The estimate assumes an adult harvest rate of 33 percent, which approximates current conditions. Under fully restored freshwater habitat conditions, EDT estimates fall Chinook abundance would be approximately 3,000 adult spawners.

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[5] Critical abundance thresholds are those below which populations are at relatively high risk of extinction. Critical population size guidelines are reached if a population is low enough to be subject to risks from depensatory processes; genetic effects of inbreeding depression or fixation of deleterious mutations; demographic stochasticity; or uncertainty in status evaluations. If a population meets one critical threshold, it would be considered to be at a critically low level. Source: McElhany et al. 2000 (as cited in ODFW 2003a).

[6] Viability abundance thresholds are those above which populations have negligible risk of extinction due to local factors. Viable population size guidelines are reached when a population is large enough to survive normal environmental variation; allow compensatory processes to provide resilience to perturbation; maintain genetic diversity; provide important ecological functions; and not risk effects of uncertainty in status evaluations. A population must meet all viability population guidelines to be considered viable. Source: McElhany et al. 2000 (as cited in ODFW 2003a).

The EDT estimate for current conditions with harvest is higher than the average adult index count for the lower river (1,166).[7] However, the difference in the EDT adult abundance estimate compared to the index counts is expected because the EDT value is based on an additional 8.5 miles of spawning habitat. Because some fall Chinook spawning takes place outside the index area, ODFW considers the index count the minimum number of fall Chinook adults returning to the Basin each year.

The fall Chinook adult counts shown in Figure 5-7 indicate that the critical abundance threshold of 300 adults has consistently been met during the last decade and that the ODFW escapement target threshold of 1,500 adults has been met occasionally since 1990.[8]

Hatchery Production and Plantings

Current. Hatchery plantings of fall Chinook currently do not occur in the Sandy River. Hatchery straying has been confirmed through coded wire tag recoveries (ODFW 1997). Washougal Hatchery (located on the Washougal River, a tributary of the Columbia River, north of the mouth of the Sandy River) annually releases nearly six million fall Chinook fingerlings (ODFW 1997). Hatchery tule fall Chinook releases in years 1995–2001 totaled 32,878,694 in the Washougal River (NMFS 2003). It is possible the stray rate of hatchery tule fall Chinook in the Sandy River is moderated to some degree by low flows and relatively warm water in the lower Sandy River during August and September, and because the broad shallow conditions that exist at the confluence with the Columbia River during this period may deter entry of strays (ODFW 1997). Any influence on Sandy River fall Chinook is believed to be greatest on the early maturing tule stock, with little to no influence on the late-maturing stock (ODFW 1997).

Historical. Various hatchery plantings of primarily tule fall Chinook occurred intermittently in the Sandy River prior to 1977; since that time, no releases have been documented. Fall Chinook eggs were initially taken between 1903 and 1912 by the Oregon Fish Commission Hatchery located at the confluence of Boulder Creek and the Salmon River. Following construction of Marmot Dam in 1912, hatchery operations were moved to a station just downstream of the dam (ODFW 1997). Limited data from the 1913–1960 period indicate fall Chinook were also trapped at racks in the lower Sandy River, Bull Run River, Cedar Creek, and Gordon Creek for various releases in the Sandy River Basin and release sites in other basins (ODFW 1997). Sandy Hatchery produced Sandy stock fall Chinook between 1954 and 1976 for release into the Sandy River Basin and in support of other fall Chinook programs outside the Basin (ODFW 1997).

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[7] Fall Chinook numbers are based on index counts (1989–1995) and adult age composition data presented in Table 4 of the Chinook Fisheries Management and Evaluation Plan (ODFW 2003a).

[8] The low run size value is the minimum number of adults counted during the period of record. High run size is the largest number of adults counted during this same time period.

Photo courtesy of Bonneville Power Administration.

Harvest in the Basin

Current. Sport angling of fall Chinook in the Sandy River is limited to adipose-fin-clipped fish of hatchery origin. Since late maturing Sandy River stock fish are primarily wild, no harvest is allowed of LRW fall Chinook in the Sandy River Basin. ODFW estimates the current impact rate on LRW fall Chinook to be in the range of 2—4 percent, as incidental catch in the coho and winter steelhead fisheries (ODFW 2003a). The Sandy River is closed to angling of coho salmon on October 31 to protect spawning LRW fall Chinook. No angling is allowed for Chinook or coho salmon from November through January.

Ocean distribution of Sandy River LRW fall Chinook is unknown. Based on coded wire tag studies, however, LCR fall Chinook stocks generally migrate north (ODFW 1997). Harvest data on LRW fall Chinook generally come from Lewis River LRW fall Chinook, which are believed to be very similar in genetic makeup and run timing. Commercial ocean harvest proportions of Lewis River LRW fall Chinook (brood years 1985–1988) averaged about 9 percent in Oregon and 19 percent in Washington, whereas about 57 percent and 15 percent of the harvest occurred in British Columbia and Alaska, respectively (ODFW 1997). Commercial and sports fisheries outside the Basin, including ocean fisheries, may harvest up to 50 percent of the native fall Chinook run destined for the Sandy River based on harvest rates reported for Lewis River LRW stock fall Chinook (adult return years 1984–1993) (ODFW 1997). Harvest in the Sandy River has averaged 383 individuals annually for run years 1985–1994 based on salmon tag returns that are corrected for nonresponse bias. This estimate translates to an in-basin harvest rate of about 25 percent for the 10-year period

(ODFW 2002). Recent harvest rates from both ocean and freshwater fisheries for Sandy River LRW Chinook ranged from 25 to 51 percent (ODFW 2003a).

The EDT assessment for the Sandy River used an average harvest rate of 33 percent, citing ODFW's Fisheries Management and Evaluation Plan (2003a).

Historical. Sport angling harvest of fall Chinook in the Sandy River has always been limited. By the time adults enter the Sandy River, their body condition and flesh quality generally have deteriorated (ODFW 1997). Until recently, harvest was allowed on all fall Chinook stocks; however, effort was generally low because of fish condition. Though little historical harvest data exist, it is assumed that historical commercial and recreational ocean harvest levels were equal to or greater than the harvest rate currently exhibited today.

Reasons for Listing/Threats to Survival

Three principal sources of information are available to help explain why fall Chinook salmon have decreased in abundance in the Sandy River Basin: NMFS documents, ODFW reports, and EDT model results, as discussed below.

National Marine Fisheries Service. NMFS cites several factors for decline across the range of Chinook salmon. Water diversions for agriculture, flood control, domestic use, and hydropower purposes have greatly reduced, eliminated, and degraded suitable habitat. Additionally, forestry, agriculture, mining, and urbanization have degraded, simplified, and fragmented habitat.

Overexploitation of Chinook salmon has been considered a factor of decline even before extensive habitat degradation. Exploitation rates that have occurred after widespread aquatic and terrestrial habitat degradation have continued to be higher than most populations could sustain. Predation and disease have increased from introductions of nonnative species and artificially propagated salmonid fishes. Natural climatic conditions, including drought and poor ocean productivity, have further reduced natural production. Increased hatchery supplementation has led to increased competition and genetic introgression[9] between hatchery and naturally produced fish stocks.

In its decision to list the LCR ESU for Chinook, NMFS (1998a) indicated that major habitat problems are primarily related to blockages, forest practices, urbanization in the Portland and Vancouver areas, and agriculture in floodplains and low-gradient tributaries. They also stated that substantial Chinook salmon spawning habitat has been blocked (or passage substantially impaired) at several locations in the ESU. In the Sandy River Basin specifically, NMFS (1998a) listed Marmot Dam and the Bull Run dams as substantially impairing passage to historical spawning habitat.

Oregon Department of Fish and Wildlife. The Sandy River Subbasin Salmon and Steelhead Production Plan (ODFW 1990) and the Sandy Basin Management Plan (ODFW 1997 and

[9] Genetic introgression is the movement of genes from one population or taxon into another via hybridization. ESA typically recognizes that small amounts of genetic introgression do not disqualify individuals or populations from "species membership'' or ESA protections, if those individuals or populations conform to the scientific taxonomic description of that species. A natural population of a particular species that possesses genes from another taxon at low frequency, yet retains the distinguishing morphological, behavioral, and ecological characters of the native species, may remain very valuable to the overall conservation and survival of that species.

2001) identify several factors that have reduced the production potential of native fall Chinook in the Sandy River Basin:

- Construction of Marmot Dam reduced the passage and natural production of fall Chinook upstream.
- Flow diversion at Marmot Dam reduced attraction water below the dam, and reduced spawning and rearing habitat in the 11-mile section down to the Bull Run River mouth.
- Much of the lower Sandy River below the Marmot Dam site is silted with sand and sediment eroded from the upper drainage when the snow melts in the late spring and summer. Siltation reduces the quality and quantity of fall Chinook spawning habitat.
- Construction of the Bull Run dams inundated historically accessible habitat and eliminated access above the dams.
- Snagging, poaching, and general harassment of fall Chinook spawners can be a problem on the redds in the lower Sandy River.
- Current sport and commercial fisheries may harvest up to 50 percent of the native Sandy River fall Chinook. The harvest on fall Chinook is a mixed-stock fishery, and the native late-run stock appears to be reduced to a remnant of past levels.
- LCR hatchery stock is known for its propensity to stray, and mixing of these fish with native Sandy River fall Chinook may detrimentally affect native stock. In addition, tule stock of fall Chinook in the Sandy River Basin may be mixing with and replacing the native stock.

EDT Modeling. Results from EDT modeling for the the Sandy River Basin estimate that the primary limiting factors for fall Chinook are the following:

- Habitat diversity. Habitat diversity has been lost throughout the Basin, although losses in the Bull Run and lower Sandy rivers are thought to have a large impact on fall Chinook.
- Key habitat quantity. Key habitat has decreased due to changes in habitat composition (pools, riffles, and glides) between current and historical conditions. The changes in habitat types are due to simplification of the stream channel, loss of large woody debris, increased confinement, and changes in low flow.
- Channel stability. The stream channel has become less stable in most of the Basin, due to a loss of large woody debris, impaired riparian function, and high streamflow.
- Obstructions. The two Bull Run dams have blocked fall Chinook passage.

Other minor limiting factors include changes in flow (primarily low flow in the Bull Run River), maximum stream temperature (from low flow), fine sediment (loss of riparian habitat and landslides), and food (decreased salmon carcass abundance). Figure 5-8 shows the limiting factors for fall Chinook in the Sandy River Basin by watershed.

Geographic Area	Channel Stability	Chemicals	Competition (hatch)	Competition (other species)	Flow	Food	Habitat diversity	Hasassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
	Limiting Factors															
Bull Run River	●				●	●	⬤		⬤				●	●		●
Columbia River			•				•					•				⬤
Lower Sandy River	•				•	•	●	•				•	●			•
Middle Sandy River					•	•	•						•			•
Upper Sandy River	•				•	•	●						●			•
Salmon River	•				•	•	●									●
Zigzag River	•				•		●						•			•

Figure 5-8. Limiting Factors for Fall Chinook in the Sandy River Basin[a,b]

Percentage change from historical conditions	Worse
Less than 1%	
Between 1 and 5%	•
Between 5 and 20%	●
More than 20%	⬤

Source: EDT model run 10/20/2005.

[a]Appendix D provides definitions of the limiting factors (level 3 survival factors) and the habitat attributes (level 2 environmental attributes) and a matrix showing the relationship between them.

[b]The habitat attributes are also used in Chapter 8 and Appendix E to define the reference condition for the habitat benefits that arise from the City's HCP measures.

At least 50 percent of the loss in fall Chinook production for all reaches combined is due to degraded conditions throughout the Basin as a result of the following five habitat attributes:

- Increase in stream temperature
- Decrease in low streamflow
- Loss of riparian function
- Loss of large woody debris
- Increase in fish pathogens

These habitat attributes are shown as the reference condition in the effects chapter (Chapter 8). The relationship between the limiting factors and the habitat variables, as well as detailed definitions of the factors and attributes, are presented in Appendix D.

Fall Chinook in the Bull Run Watershed

Distribution

Anadromous fish historically used about 49 stream miles in the Bull Run River watershed, which includes 10 miles of stream for the Little Sandy River (see Table 4-8). Of the 39 stream miles in the Bull Run River (excluding the Little Sandy River), fall Chinook had access to approximately 10.5 miles upstream of Bull Run Dam 2. Of that area historically available to fall Chinook, all but approximately 1.5 miles are now inundated by Bull Run reservoirs. Figure 5-9 shows the estimated periods of occurrence for fall Chinook life stages in the lower Bull Run River.

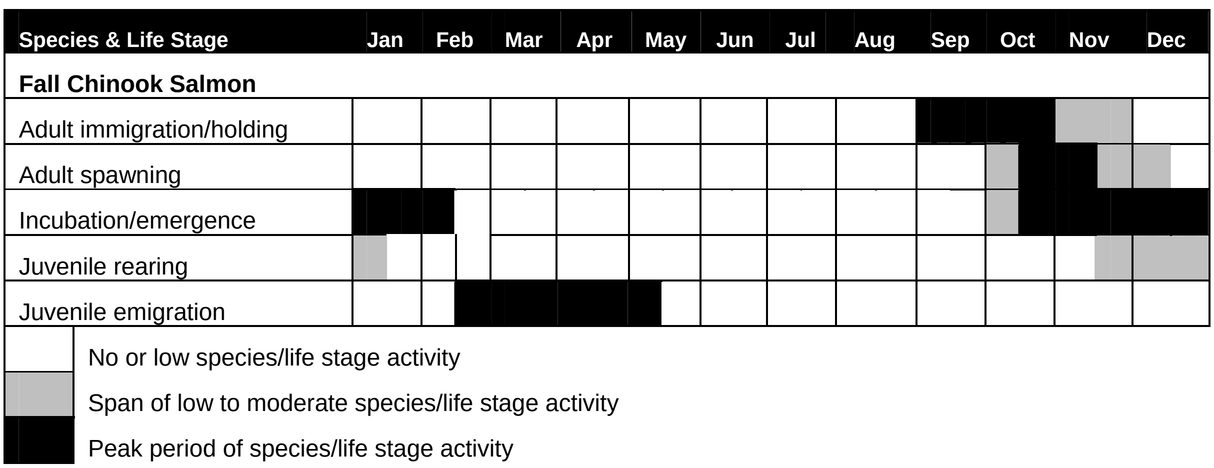


Figure 5-9. Estimated Periods of Occurrence for Fall Chinook in the Lower Bull Run River

Source: Sandy River Basin Agreement Technical Team 2002.

Table 5-1 shows the river segments and historical distribution of fall Chinook in the Bull Run River. Figure 5-6 on page 5-12 shows historical fall Chinook distribution throughout the Sandy River Basin.

Table 5-1. Historical Distribution of Fall Chinook in the Bull Run River

River Segment	River Miles
Lower Bull Run River	
Bull Run River (mouth to Dam 2 spillway weir)	5.8
Little Sandy River (mouth to Little Sandy Dam site)	1.7
Little Sandy River (Little Sandy Dam site to middle waterfalls)	5.6
Upper Bull Run River	
Bull Run River (Dam 2 spillway weir up through reservoirs)	9.2
Bull Run River (free-flowing river to waterfall at RM 16.3)	1.3

Source: USFS, 1999

Fall Chinook currently can use about 7.5 stream miles of habitat in the Bull Run River watershed. Of this total, approximately 5.8 miles occur in the lower Bull Run River downstream of the Headworks, with an additional 1.7 miles in the Little Sandy River.

Abundance

EDT modeling also provided an estimate of abundance based on the current fall Chinook habitat conditions for fall Chinook. The estimated production in the lower Bull Run and Little Sandy rivers was 178 and 1,598 adults, respectively.[10] Juvenile production was estimated at approximately 11,000 for the current condition and about 50,000 for the historical condition.

EDT estimates are similar to recent empirical data for Chinook salmon abundance in the lower Bull Run River. The City completed adult Chinook surveys in the late 1990s and in 2005 (Clearwater BioStudies 2006) for an index reach of the Bull Run River (RM 1.5—RM 3.9), while the EDT estimates are for all of the lower Bull Run and Little Sandy rivers. The total number of Chinook salmon redds was 27, 34, and 68 for the 1998, 1999, and 2005 surveys, respectively. In those years, the peak number of live and dead Chinook salmon ranged from 49 to 165 adult fish. However, it was not possible to differentiate between the spring and fall Chinook salmon redds. New Chinook redds have been observed in the lower Bull Run River through late November, a pattern that could reflect late spawning by a few spring Chinook salmon, but it is also consistent with the spawn timing of the Sandy River's late-run fall Chinook (Clearwater BioStudies 2006).

Habitat Conditions

The Portland Water Bureau, U.S. Forest Service (USFS), and other agencies have been studying the aquatic habitat of the lower Bull Run River since the mid-1990s. From about

[10] Historical fish numbers as defined in EDT assume pristine habitat conditions in the Bull Run, Sandy, and Little Sandy rivers, but current habitat conditions in the Columbia River and estuary. The numbers therefore do not reflect the true historical production potential of the species.

1997, the City has conducted a number of studies aimed at determining current conditions and factors affecting abundance and production of fall Chinook in the Bull Run River watershed. In particular, the City's studies have focused on current habitat conditions and use by anadromous species, primarily Chinook salmon and steelhead, in the lower 5.8 miles of the Bull Run River (Clearwater BioStudies 1997; R2 Resource Consultants 1998a,b; Beak 1999, 2000a,b,c). The studies indicate that the following key environmental factors may have affected abundance and productivity of fall Chinook salmon:

- Low flows may reduce the amount of instream habitat suitable for use by spawning fall Chinook.
- Gravel in the lower river suitable for spawning and construction of redds is lacking or absent.
- Trapping of large woody debris in the upper reservoirs does not allow the wood to pass through the lower Bull Run River, and beneficial habitat may be lost as a result.
- Dams block access to potential upstream spawning habitat.
- Rapid, short-term flow fluctuations may strand or displace Chinook fry.

Management of the Bull Run River water supply has affected the flow patterns of the lower Bull Run River. The City stores water behind its dams and diverts a portion of the Bull Run River watershed yield for municipal and industrial uses. The greatest impact on fall Chinook caused by low streamflows in the lower Bull Run River is from mid-October to the end of December, which is the primary spawning time for Lower River Wild fall Chinook. The impact of water diversions on the lower Bull Run River is substantially smaller during the winter and spring when incubation and fry emergence for fall Chinook occurs. The reservoirs are usually full during this period, and municipal demand is much lower than in the summer.

An analysis of gravel availability and spawning use in the lower Bull Run River by Beak Consultants (2000a) indicates that lack of suitable spawning gravel may be limiting production of Chinook salmon. Beak Consultants (2000a) counted Chinook spawning redds in the lower river and estimated the total quantity and distribution of gravel suitable for Chinook spawning in the lower river. The similarity in estimated number of suitable redd patches and actual redd counts suggest that available suitable gravel area in the lower river downstream of Larson's Bridge is probably fully utilized. On this basis, it was concluded that suitable gravel is in very low supply in the lower river and is likely limiting Chinook salmon production.

Limiting Factors

Reach-specific results for fall Chinook salmon in the Bull Run River watershed are summarized in Figure 5-10. This summary indicates that the most affected life stages among the reaches in the watershed are emerging fry (fry colonization), incubating eggs (egg incubation), migrating adults (prespawning migrant), and holding adults (prespawning holding), followed by spawning adults (spawning) and subyearling rearing (0-age active rearing).

Ten limiting factors affect fall Chinook survival in the watershed. Of these, habitat diversity, key habitat quantity, flow, and food have a high effect in depressing productivity in several reaches. In addition, channel stability has a high effect in lower Bull Run River reaches (Bull Run 1 through Bull Run 4), and obstructions have a high effect on reaches of the Bull Run River above RM 5.8. This is, of course, because Bull Run Dam 2 blocks all anadromous fish access into the upper Bull Run watershed at RM 5.8. Water temperature also has a moderate effect in lower Bull Run River reaches (Bull Run 1 through Bull Run 4).

	Life Stage Most Affected											
	Spawning	Egg incubation	Fry colonization	0-age active rearing	0,1-age inactive	1-age migrant	1-age active rearing	2+-age active rearing	2+-age migrant	2+-age transient rearing	Prespawning migrant	Prespawning holding
Bull Run Dam 1			3								1	
Bull Run Dam 2			3								1	
Bull Run Spillway Weir			3								1	
Bull Run 1		1	2									3
Bull Run 2	2	1	3									
Bull Run 3	2	1										3
Bull Run 4	3	1	2									
Bull Run 5			3								1	
Bull Run 6			1	3								2
Bull Run 6a		1	3									2
Bull Run 7	3		1	2								
Little Sandy 1		2	1									3
Little Sandy 2		2	1									3
S.F. Bull Run 1	3		2									1

	Limiting Factors																
	Channel stability	Chemicals	Competition (w/hatch)	Competition (other species)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Bull Run Dam 1									⬤							
Bull Run Dam 2									⬤							
Bull Run Spillway Weir									⬤							
Bull Run 1	⬤				·	•	•						•	·		●
Bull Run 2	⬤				●	·	•						·	•		•
Bull Run 3	⬤				●		·						·	•		•
Bull Run 4	⬤			·	●	●	⬤						·	•		●
Bull Run 5									⬤							
Bull Run 6	•		·	·	•	●	⬤						●			◯
Bull Run 6a	•			·		●	⬤						⬤			⬤
Bull Run 7						•										
Little Sandy 1	·				·	•	●									●
Little Sandy 2	·				●	•	⬤						●			
S.F. Bull Run 1	•			·	●	●	⬤						●			◯

Figure 5-10. Limiting Factors for Fall Chinook in the Bull Run River Watershed[a,b]

Percentage change from historical conditions	Worse	Better
Less than 0.2 %		
Between 1.0 and 0.2%	·	◦
Between 5 and 1%	•	○
Between 25 and 5%	●	◯
More than 25%	⬤	❍

Source: EDT model run 10/20/2005.

[a]Appendix D provides definitions of the limiting factors (level 3 survival factors) and the habitat attributes (level 2 environmental attributes) and a matrix showing the relationship between them.

[a]Bull Run reaches 5 and higher are the reaches at or above the Dam 2 diversion pool and include the reservoirs. The limiting factors in this figure for Bull Run reaches 5 and above are primarily the results of inundation of the Bull Run River by the reservoirs.

Flow and Fall Chinook Habitat Preferences

Because City operations in the Bull Run divert flow from the watershed and that effect is a focus of this HCP, additional information on the relationship between streamflow and fish habitat preferences is provided below for Chinook salmon.

Spawning Flow-Habitat Relationships. Figure 5-11 shows the relationship between total usable habitat and flow for spawning Chinook salmon in the lower Bull Run River between Dam 2 (approximately RM 5.8) and PGE's powerhouse at RM 1.5. These relationships were developed for Chinook salmon and are applicable for both the fall and spring runs of Chinook.

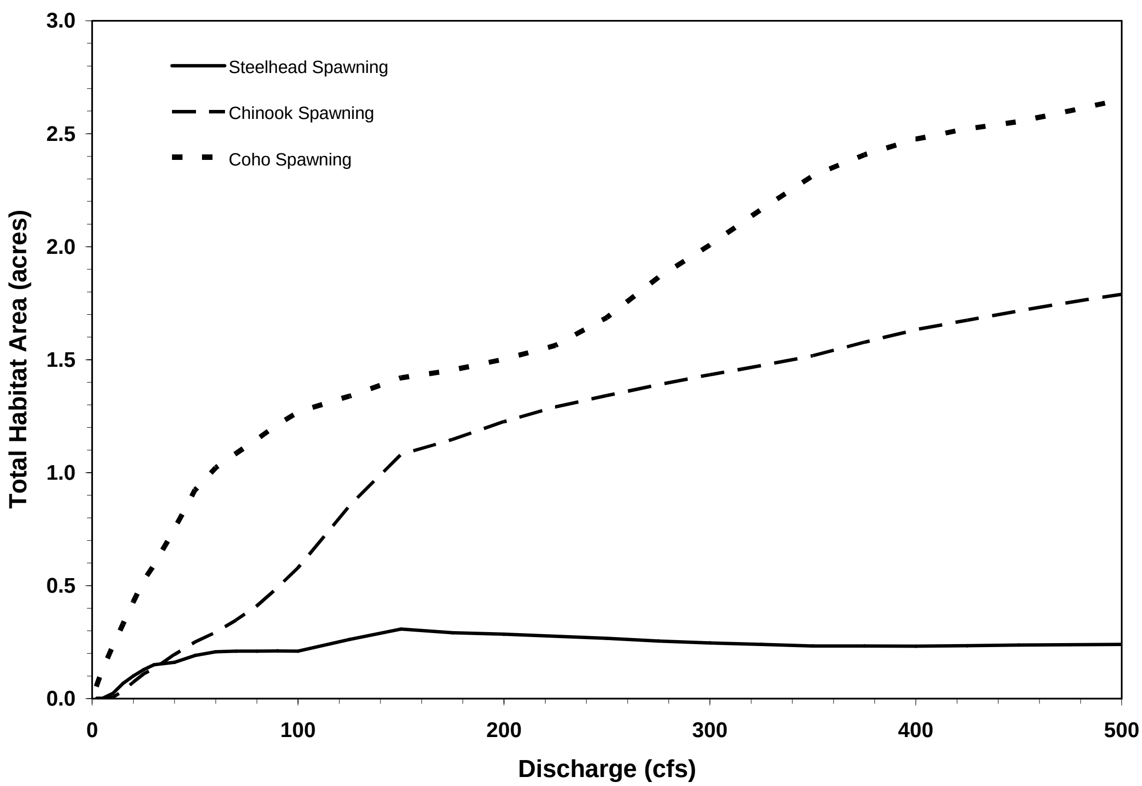


Figure 5-11. Relationship Between Flows in the Lower Bull Run River and Available Spawning Habitat for Chinook, Coho Salmon, and Steelhead

Source: R2 Resource Consultants 1998a.

Within the flow range modeled (0–500 cfs), the relationship for Chinook indicates that spawning habitat increases with increasing discharge.

Juvenile Rearing Flow-Habitat Relationships. Figure 5-12 shows the relationship between total usable habitat and flow for rearing juvenile Chinook in the lower Bull Run River.

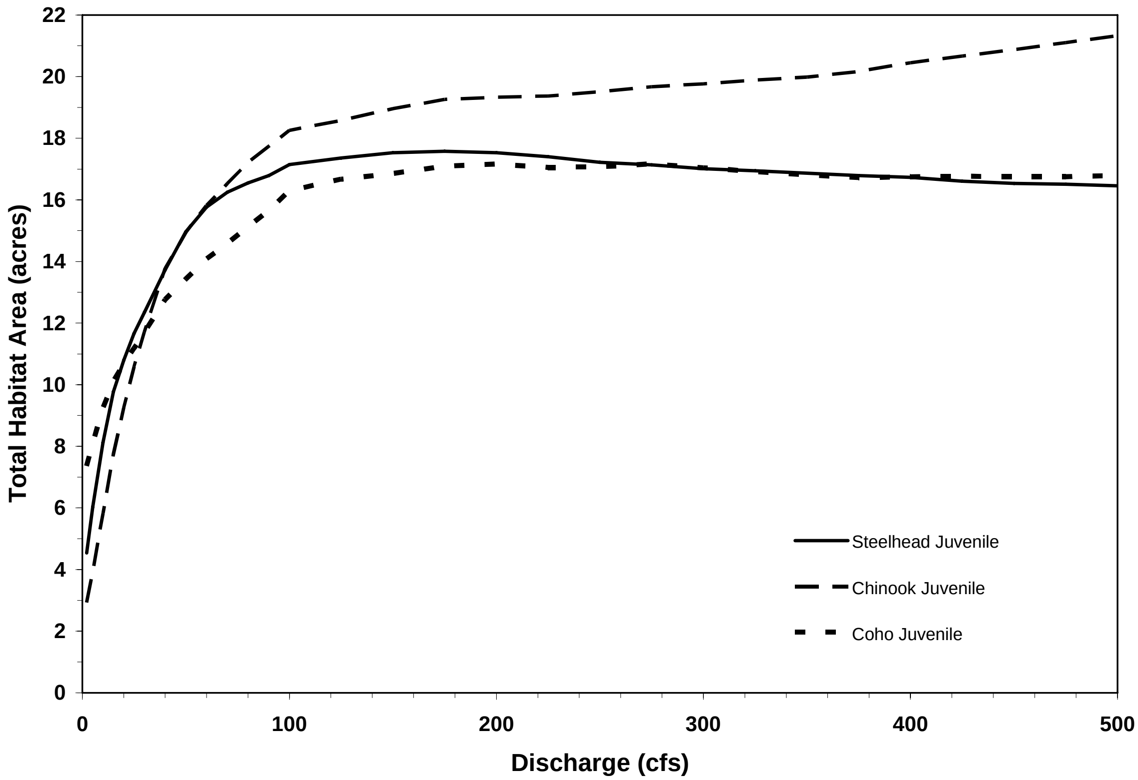


Figure 5-12. Relationship between Total Usable Habitat and Flow for Rearing Juvenile Chinook in the Lower Bull Run River

Source: R2 Resource Consultants 1998a.

Results of PHABSIM modeling indicate that habitat conditions for juvenile Chinook salmon increase at a rapid rate between 0 and 100 cfs, with most of the rapid increase occurring between 0 and 20 cfs (R2 Resource Consultants 1998a). Habitat conditions for juvenile Chinook and other salmonids become near constant at flows above 100 cfs.

The results of the PHABSIM modeling are expressed as weighted usable area (WUA), an index of available instream habitat at various increments of flow. R2 Resources Consultants estimated WUA for a number of flows in various reaches of the lower Bull Run River by (1998a) using the PHABSIM model. The WUA estimates for each species are shown in Chapter 8, Effects of the HCP.

Spring Chinook in the Sandy River Basin

Life History and Diversity

Natural origin spring Chinook salmon (*O. tshawytscha)* belong to the LCR ESU and are currently listed as threatened under the federal ESA. Available information suggests that spring Chinook salmon currently present in the Clackamas and Sandy rivers are predominantly the result of introductions from the Willamette River ESU, and thus are probably not representative of spring Chinook salmon found historically (NMFS 1998a). Genetic analysis suggests that naturally reproducing spring Chinook salmon in the upper Sandy River have retained at least a low level of genetic differentiation from upper Willamette River stock spring Chinook salmon propagated in the Clackamas Hatchery (Bentzen 1998). The current spring Chinook salmon stock using the Bull Run River could have been derived from either the Sandy "native" population or the Clackamas "hatchery" population. The NMFS WLC-TRT classifies the Sandy River spring Chinook stock as a population of "genetic integrity," meaning it resembles the historical life histories and genetic types in the Sandy River Basin (McElhany et al. 2003).

Adult spring Chinook salmon enter the mouth of the Columbia River as early as late January and early February in preparation for their spawning run, which can take six months or longer and cover a distance of several hundred miles. Columbia River spring Chinook salmon bound for the Sandy River begin entering the Sandy River delta as early as February, but more commonly in April and May. Peak migration over Marmot Dam into the upper Sandy River Basin has usually occurred in June, with a smaller peak occurring in September. Migration into the upper Basin subsides in July and August, probably due to a seasonal increase in water temperature and decrease in instream flow (ODFW 1997). Figure 5-13 shows estimated periods of occurrence of spring Chinook life stages in the upper portions of the Sandy River Basin.

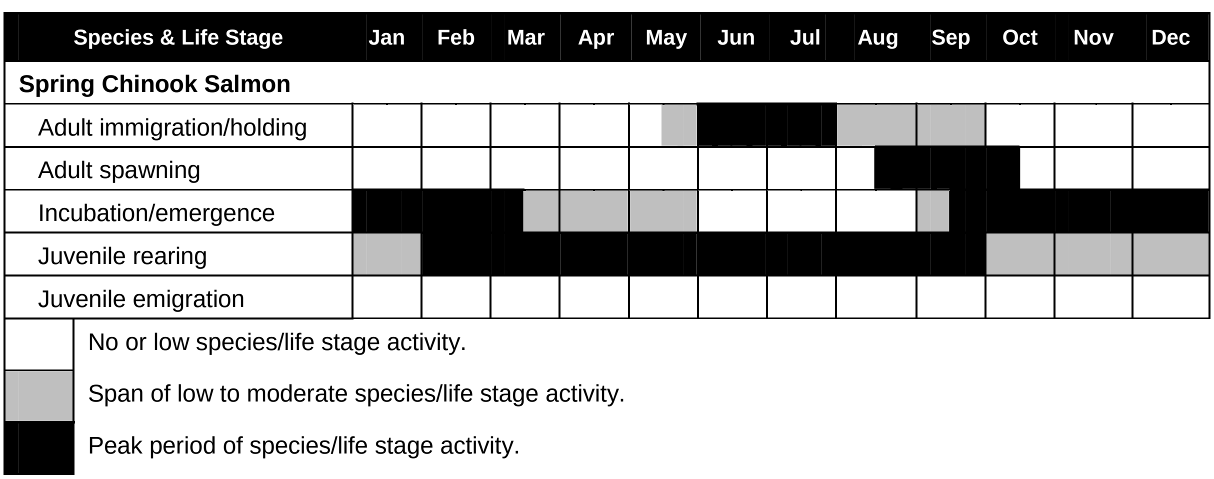


Figure 5-13. Estimated Periods of Occurrence for Spring Chinook in the Upper Sandy River Basin Above the Marmot Dam Site

ODFW currently lists spring Chinook returning to the Sandy River Basin in the Willamette Spring Chinook Gene Conservation Group, which includes populations returning to the


Photo courtesy of Bonneville Power Administration.

McKenzie, Santiam, Molalla, and Clackamas rivers. All of these rivers are major tributaries to the Willamette River (ODFW 1997). Life-history data from the Sandy River are limited, and transplantation records indicate the Sandy River Basin has received overwhelmingly large numbers of upper Willamette River spring-run Chinook salmon (Myers et al. 1998).

Spawning occurs primarily in August through October, peaking in September. Fry emergence typically occurs in middle to late winter, followed by a downstream migration to large mainstem areas for rearing. Juvenile spring Chinook rearing distribution is not well documented in the Sandy River Basin (ODFW 1997). Natural origin Sandy River juvenile spring Chinook primarily exhibit two outmigration strategies. The majority of smolts migrate to the ocean in the spring of their second year (at age 1+ as stream-type fish); however, a significant portion may outmigrate in the fall as subyearlings. The percent of subyearling smolts in the population depends upon the annual variability of habitat conditions that might facilitate rapid growth. Once Willamette stock spring Chinook enter the ocean, they typically migrate north to British Columbia and Alaska (ODFW 1997). Willamette River spring Chinook typically mature in their fourth and fifth year of life, with the majority maturing at age four (ODFW 2001).

The NMFS WLC-TRT classified the spring run as both a "core" and a "genetic integrity" population in their recovery planning efforts. These designations mean that the population historically was abundant and productive; the current population resembles the historical life histories and genetic types in the Sandy River Basin; and the population presently offers one of the most likely paths to recovery in the Lower Columbia Chinook ESU (McElhany et al. 2003). The LCRFRB designated the priority for contribution of this stock to recovery goals in the ESU as "primary." This classification means the Sandy River spring Chinook stock is targeted for recovery as one of four stocks in the Cascade "stratum" to achieve viable population levels with greater than 95 percent probability of persistence (i.e., negligible extinction risk within 100 years) (LCRFRB 2004; McElhany et al. 2003; McElhany et al. 2004).

Distribution

The SRBTT developed a completed list of the reaches in which each natural population of anadromous salmonids was known or assumed to spawn, either currently or historically (Mobrand Biometrics 2004). For streams in which data were not available to determine species use, the SRBTT assumed that Chinook (spring and fall) would not utilize streams with a minimum width less than 15 feet or a gradient higher than 8 percent. After initial EDT model runs were completed in 2001, the SRBTT met again to review the results and re-examine spawning distribution in the Sandy River Basin. Based on this review, several spawning reaches were excluded for some species and added for others. This distribution information was used to develop Figures 5-14 and 5-15.

Current. Current spring Chinook distribution in the Sandy River Basin is shown in Figure 5-14. Spring Chinook in the Basin have utilized the mainstem Sandy River from the mouth upstream to Marmot Dam for migration and rearing (SRBP 2005). Recent data also show spring Chinook use in the lower Sandy River (Tonnes, pers. comm., 2005). Sandy River spring Chinook salmon have spawned primarily upstream of Marmot Dam, with most spawning occurring in the Salmon River up to Final Falls (near RM 14) and in Still Creek from its confluence upstream about 3 miles (ODFW 1997). Spawning also occurs in the Zigzag River, in the upper Sandy River (mostly above Clear Creek), and in the lower reaches of Clear Creek and Lost Creek (ODFW 1997). Spawning has also been documented in the lower Bull Run and Little Sandy rivers (R2 Resource Consultants 1998a). Spawning probably occurs in the mainstem Sandy River side channels and tributaries when sufficient flows exist. Additionally, the Sandy River and associated tributaries above the Marmot Dam site support migration and rearing of juvenile and adult life forms.

Historical. Historical spring Chinook distribution assumed in the Sandy River Basin is shown in Figure 5-15. Upstream of the Marmot Dam site on the mainstem Sandy River, most of the habitat historically utilized by spring Chinook is largely intact, except for the habitat affected by the channelization efforts in the Salmon and Zigzag rivers following the 1964 flood (ODFW 1997). Approximately 24 miles of streams in the Bull Run River watershed (above the dams) were historically available to Chinook (City of Portland 2002), plus six miles of the lower watershed that are currently accessible. Spring Chinook were also likely endemic to the Little Sandy River.

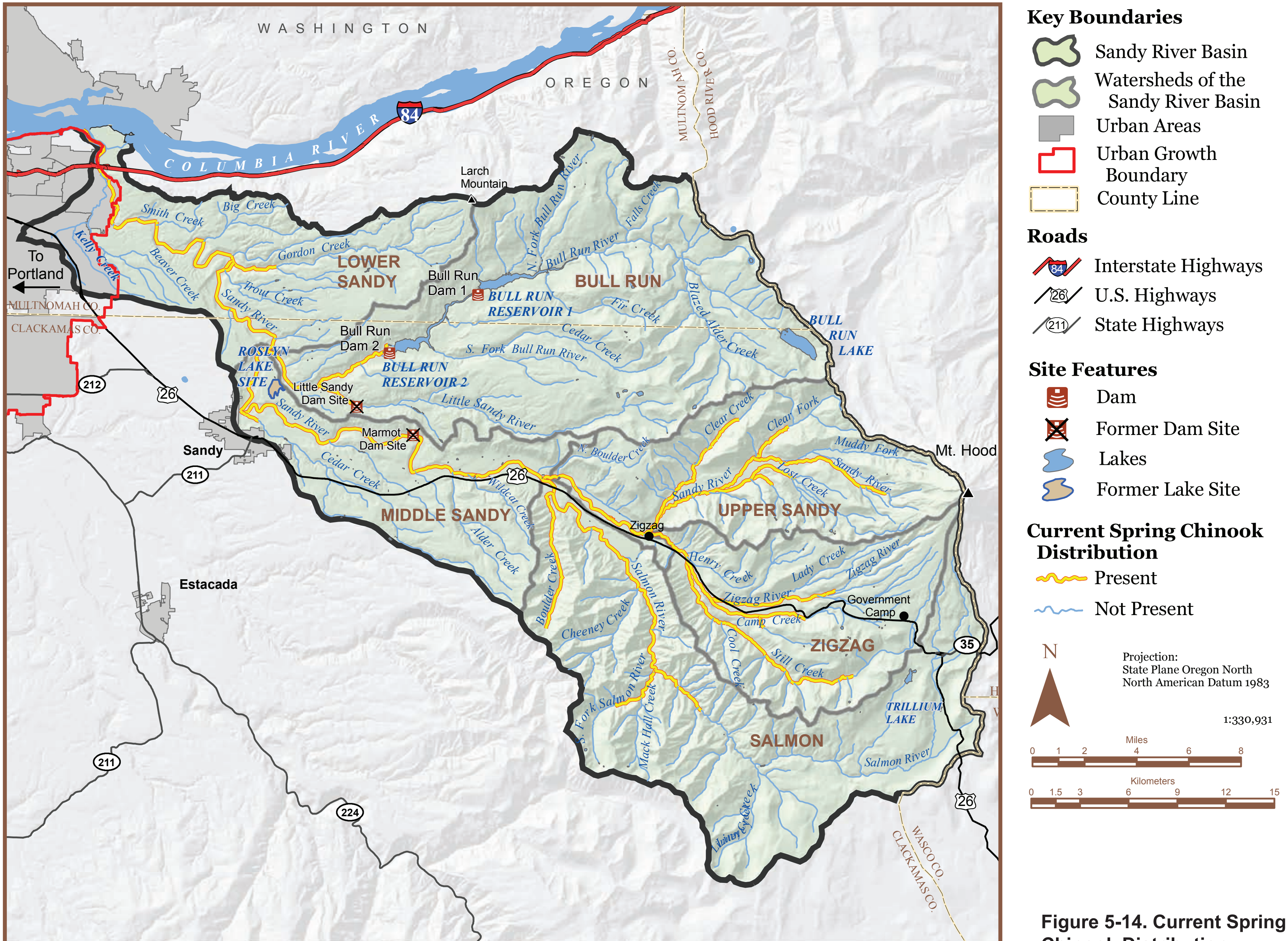


Figure 5-14. Current Spring Chinook Distribution

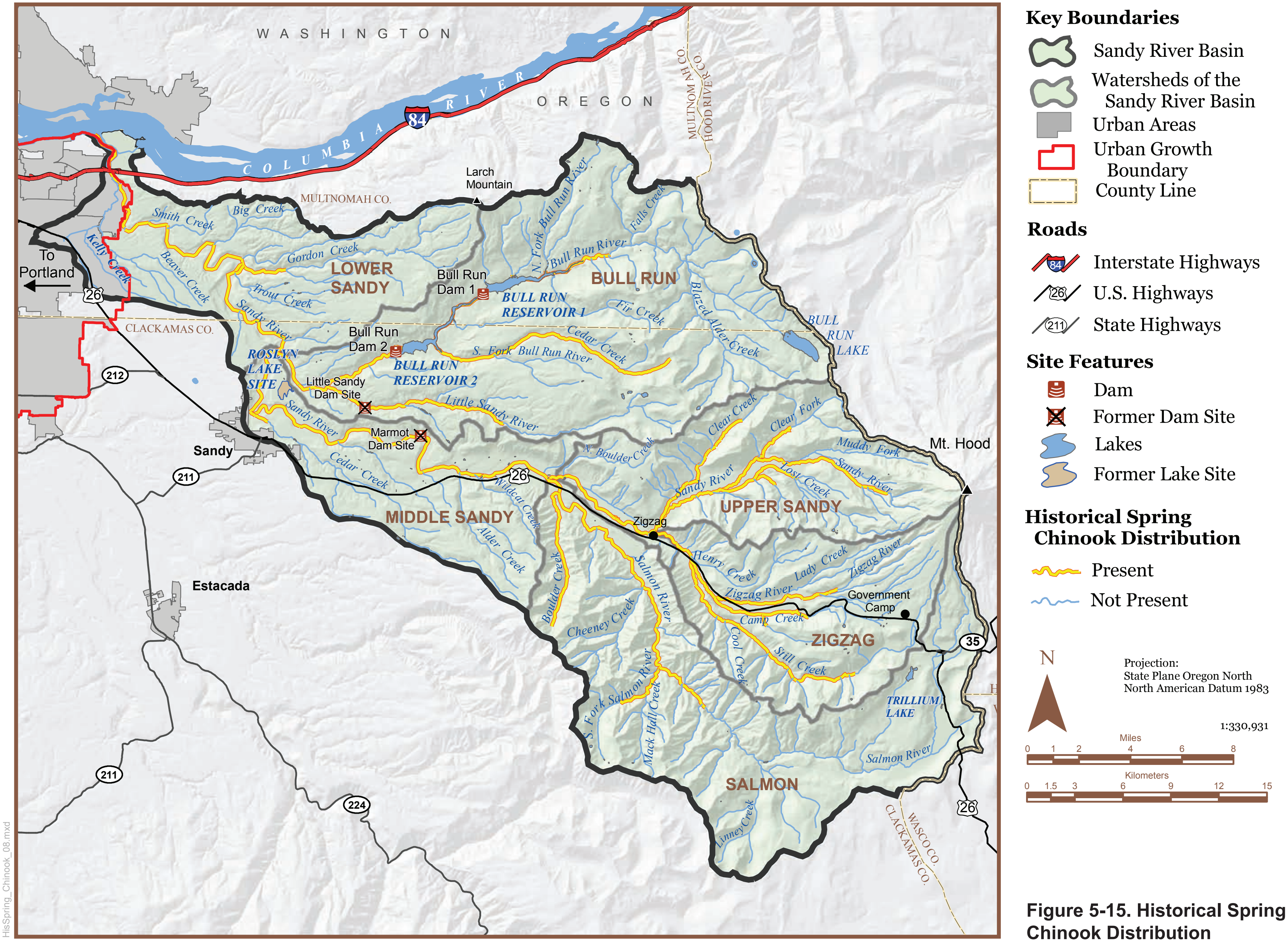


Figure 5-15. Historical Spring Chinook Distribution

Anchor Habitat. The City considered the anchor habitat reaches for spring Chinook when choosing off-site areas (non-Bull Run) that should be emphasized for HCP conservation measures (see Chapter 7). Spring Chinook anchor habitat is generally located in the upper Sandy River Basin upstream of Cedar Creek. The anchor habitat analysis, which is based on current conditions, identified several anchor habitat reaches for spring Chinook (SRBWG 2006). Two reaches in the mainstem Sandy River from approximately RM 24 (two miles upstream from the confluence with Cedar Creek) to the Salmon River confluence were identified as anchor habitat. These reaches are in the middle Sandy River watershed. All of the mainstem Salmon River up to Final Falls (RM 14), the Sandy River from the Salmon River confluence to the Zigzag River, the lower end of Clear Fork in the upper Sandy River watershed, and the lower end (downstream of Cool Creek) of Still Creek were also identified as anchor habitats for spring Chinook.

Abundance

The abundance of Sandy River spring Chinook salmon has increased dramatically since the 1970s, probably due to increased hatchery smolt releases and the establishment of minimum flow requirements in the mainstem Sandy River below Marmot Dam. Although little historical data exist, minimum run estimates during the 1950s and 1960s varied from a low of 51 adults in 1965 to a high of 689 adults in 1964 (ODFW 1997). Minimum run estimates were based on Marmot Dam fish counts and ODFW sport catch counts derived from angler punch cards. Marmot Dam fish counts were not conducted from 1971 through 1977, but were reestablished in 1978. Minimum run estimates from 1978 through 1995 varied from a low of 735 adults in 1978 to a high of 8,551 in 1992 (ODFW 1997).

Most spring Chinook returning to the Sandy River Basin are believed to be of hatchery origin, though natural production continues to occur primarily above the Marmot Dam site (ODFW 2002). Sandy stock spring Chinook were primarily used for hatchery supplementation from the early 1900s through 1969. Beginning in the 1970s, a program was initiated to supplement the depleted native run with Willamette stock spring Chinook (ODFW 2002). It is likely that genetic introgression between native Sandy spring Chinook and Willamette stock spring Chinook occurred; however, the upper Sandy River retains at least a low level of genetic differentiation from upper Willamette River stock (Bentzen 1998).

Between 1997 and 2007 when Marmot Dam was decommissioned, fin-clipped hatchery and wild spring Chinook were separated at the Marmot Dam fish ladder to obtain information on hatchery and wild fish in spawning populations. Beginning with the 1997 brood, the intent was to mark all hatchery Chinook. However, until 2002, about three percent of hatchery fry and pre-smolts have been released in the Basin without fin clips. Given the large numbers of hatchery fish released, even this small percentage of unmarked hatchery fish biased the estimates of wild spawners until 2002, especially because the number of wild fish in the Basin was low.

Sandy stock spring Chinook were primarily used for hatchery supplementation from the early 1900s through 1969. Beginning in the 1970s, a program was initiated to supplement the depleted native run with Willamette stock spring Chinook (ODFW 2002) and most spring Chinook returning to the Sandy River Basin are believed to be of hatchery origin. A genetic analysis (Bentzen 1998) determined that naturally spawning spring Chinook were intermediate to Clackamas River (i.e., Willamette stock) spring Chinook and LCR spring Chinook stocks. The analysis also determined there was little genetic resemblance to the fall Chinook of the Sandy River, which is counter to trends in other lower Columbia River watersheds. Therefore, the naturally spawning spring Chinook stock retains some original genetic characteristics (WLC-TRT 2003).

Three different estimates of adult spring Chinook abundance are graphically displayed in Figure 5-16. The data were taken from ODFW's Fisheries Management and Evaluation Plan (ODFW 2003a). The fish were sampled from the fish trap/ladder at Marmot Dam so they do not include adult fish that would have spawned below the dam in the lower Sandy River Basin. The highest, lowest, and average run sizes between 1990 and 2000 were 4,451, 1,503, and 2,810 fish, respectively. These counts include hatchery and wild fish.

The ODFW Fisheries Management and Evaluation Plan (2003a) states that a viable abundance threshold of Sandy River spring Chinook is 2,000 natural origin spawners, which is identical to the ODFW spring Chinook escapement goal of 2,000 adults for the Sandy River Basin (ODFW 2001). The objective in the Oregon Administrative Rules (OAR 635-500-3460) is to achieve an average annual spawning escapement of 2,000 wild spring Chinook into the Sandy River Basin. Beginning in 2002, all hatchery-reared spring Chinook returning to the Sandy River Basin have been distinguished from wild fish by an adipose fin clip. In run years 2002–2003, an average of 1,229 natural origin spawners passed the Marmot Dam fish ladder. The critical abundance threshold (set to avoid short-term deleterious genetic and demographic effects) was set at 300 natural origin spawners (ODFW 2003a).

EDT estimates of adult spring Chinook production were also determined based on the same geographic point of reference used for the empirical abundance estimates in ODFW (2003a) and on the same harvest rate. EDT estimates of adult abundance include all spawning areas upstream of Marmot Dam. The estimates do not include production occurring from mainstem Sandy River reaches downstream of Marmot Dam or lower river tributaries, including the Bull Run River.

EDT estimates that the current habitat conditions for stream reaches above Marmot Dam could produce approximately 1,400 spring Chinook adults annually. The number of adults returning each year assumes an ocean and freshwater fisheries harvest of 39 percent of all adults (Mobrand Biometrics 2004). The EDT estimate based on current conditions is lower than the average number of adults counted at Marmot Dam from 1990–2000 (2,229).

The Marmot Dam counts indicate adult returns to the Basin exceed both the critical and viable threshold levels defined by ODFW.

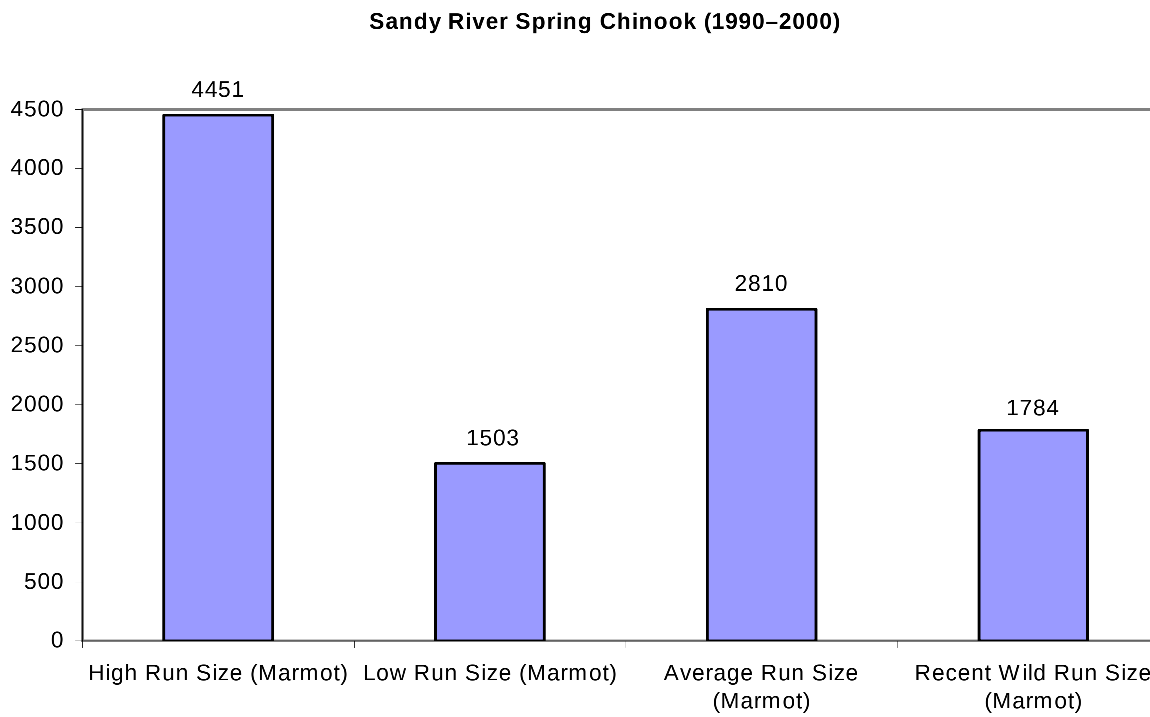


Figure 5-16. Estimates of Spring Chinook Abundance Upstream of Marmot Dam

Source: ODFW 2003a.

Hatchery Production and Plantings

Current. Beginning in 2002, adult spring Chinook brood stock collection occurred exclusively at the Marmot Dam fish trap with the intent of collecting natural-origin Sandy River spring Chinook for hatchery supplementation. Brood stock were collected and transferred to the Clackamas Hatchery for egg-take, incubation, and rearing (Bourne, pers. comm., 2004). Pre-smolts were transferred to the Sandy Hatchery on Cedar Creek for acclimation prior to release (Bourne 2004). In 2006, 300,000 Sandy stock spring Chinook smolts were released annually from Sandy Hatchery (ODFW 2006). The City funds the production of about 160,000 spring Chinook smolts under Federal Energy Regulatory Agency (FERC) license 2821. PGE funds the production of 100,000 spring Chinook smolts under FERC license 477.

Historical. Sandy River stock spring Chinook were primarily used for hatchery supplementation from the early 1900s through 1969. Spring Chinook smolt releases began to increase substantially in the 1970s with the introduction of Willamette stock spring Chinook reared at Clackamas Hatchery. Willamette stock spring Chinook were released in the Sandy River Basin exclusively through 2001, except in 1977 and 1978 when Carson Hatchery stock (Washington) was released (ODFW 1997). Hatchery releases averaged about 200,000 smolts for release years 1977–1985 and increased to an annual average of 420,985 for release years

1986–1996 (ODFW 1997). Increased smolt releases in the mid-1980s were primarily a result of mitigation to compensate for lost natural production in the Bull Run watershed.

Harvest in the Basin

Current. The Sandy River recreational spring Chinook fishery is important economically to local communities. Sandy River spring Chinook support a substantial sport fishery in the lower river (Taylor 1998), and the fish from this hatchery are highly desirable because their flesh is in peak condition and they are fairly large fish. Beginning in 2002, harvest of spring Chinook salmon in the Sandy River Basin was limited to adipose-fin-clipped fish of hatchery origin. All wild fish are required to be released. By implementing a selective fishery for hatchery spring Chinook in the Sandy River Basin, harvest rates are estimated to be reduced by more than 85 percent from historical levels (NMFS 2003). Before selective fishing regulations were implemented in 2002, harvest rates on naturally produced spring Chinook in the Sandy River were approximately 40 percent (NMFS 2003). Since 2002, cumulative fishery harvest impacts on wild spring Chinook salmon have not been expected to exceed 18.3 percent in ocean, mainstem Columbia River, and Sandy River fisheries (ODFW 2003a). In-basin sport fishing impacts are projected to be in the range of 4.2 to 6.1 percent per year (ODFW 2003a).

Historical. Recreational spring Chinook harvest dates back to 1956, based on estimates derived from ODFW punch card returns. Low harvest levels from 1956 through 1978 paralleled trends in low returns to the Basin. Average sport catch in the Basin was approximately 120 fish per year during the period 1956–1978. During run years 1979–1994 average sport catch harvest in the Basin increased to an average of 1,193 fish per year. Harvest goals in the Basin were set in 1990 by the Sandy Fish Management Plan (ODFW 1997). The total run goal of 4,500 spring Chinook allocated an in-basin harvest of 2,000 and a spawner escapement of 2,500 adults (ODFW 1990). The 1990–1994, on average, the in-basin harvest goals and spawning escapement goals were met for the Sandy River (ODFW 1997). The 1990 management goals did not differentiate between native and hatchery adults in the runs. Cumulative fishery impacts on natural origin Sandy River spring Chinook in ocean, mainstem Columbia River, and Sandy River fisheries ranged from 50 percent in 1984–1993, to 39 percent in 1994–1998, and to 40 percent in 1999 (SRBP 2005).

Reasons for Listing/Threats to Survival

The factors of decline and reasons for listing of spring Chinook are similar to those previously described for fall Chinook. Descriptions are available from ODFW and EDT results, as presented below.

Oregon Department of Fish and Wildlife. The Sandy River Subbasin Salmon and Steelhead Production Plan (ODFW 1990) and the Sandy Basin Management Plan (ODFW 1997 and 2001) identify several factors that have reduced the production potential of native spring Chinook in the Sandy River Basin:

- In the mainstem Sandy River, spring Chinook spawn above Cedar Creek. Above the Salmon River, sedimentation from snowmelt silt, a lack of gravel, channelization, and the low pool-to-riffle ratio limit spring Chinook production in most reaches.

- In the upper tributaries, a lack of pools, a lack of gravel, and sedimentation limit the production of spring Chinook smolts.
- Before minimum flows were maintained below Marmot Dam, low flow conditions from the dam to the Bull Run River confluence hindered the upstream passage of salmon and steelhead and probably contributed to the decline of spring Chinook salmon.
- Prior to the screening in 1951, PGE's unscreened diversions of water to Roslyn Lake and the turbines of the Bull Run powerhouse are believed to have contributed to a decline of smolts produced in the upper Basin.
- Originally, hatchery smolts were released in the middle and upper reaches of the Sandy River, and competed with naturally produced spring Chinook in the upper Basin. From 1994-2007 when Marmot Dam was decommissioned, all hatchery smolts were released downstream of Marmot Dam.
- Spring Chinook spawning habitat in the Bull Run system is limited to the short reaches below the dams on the Bull Run and Little Sandy rivers. At times, the streamflows in these reaches were low and may have limited spawning habitat.

EDT Modeling. Results from EDT modeling for the the Sandy River Basin estimate that the primary limiting factors for fall Chinook are as follows:

- <u>Habitat diversity</u>. Habitat diversity has decreased throughout the Basin, but the primary effects are found in the Bull Run and Zigzag rivers. The decrease has been caused by loss of large woody debris, artificial confinement of the stream channel, and degraded riparian condition.
- <u>Key habitat quantity</u>. Key habitat quantity has decreased due to changes in habitat composition (pools, riffles, and glide) between the current and historical conditions in the Bull Run River watershed, the lower Columbia River, and the Salmon River Watershed. The change in habitat types is due to the simplification of the stream channel caused by loss of large woody debris, increased confinement, and changes in low flow.
- <u>Maximum stream temperature</u>. Higher stream temperatures in the Sandy River mainstem and Bull Run River have reduced spring Chinook productivity compared with historical conditions.
- <u>Obstructions</u>. The Bull Run dams block spring Chinook access, and Marmot Dam has affected the downstream survival of juvenile fish.

Other minor limiting factors include changes in high and low flow, channel stability, and sediment throughout the Basin. The factors limiting spring Chinook production are shown in Figure 5-17.

Geographic Area	Channel Stability	Chemicals	Competition (hatch)	Competition (other species)	Flow	Food	Habitat diversity	Hasassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
	Limiting Factors															
Bull Run River	●				•	•	⬤		⬤				●	●		●
Columbia River			•				•					●				⬤
Lower Sandy River	•				•	•	●	•					●	⬤		•
Middle Sandy River	•				•	•	•						•	•		•
Upper Sandy River	•				•	•	●						●	•		•
Salmon River	•				•	•	●							•		●
Zigzag River	•				•	•	⬤						•			•

Figure 5-17. Limiting Factors for Spring Chinook in the Sandy River Basin[a,b]

Percentage change from historical conditions	Worse
Less than 1%	
Between 1 and 5%	•
Between 5 and 20%	●
More than 20%	⬤

Source: EDT model run 10/20/2005.

[a]Appendix D provides definitions of the limiting factors (level 3 survival factors) and the habitat attributes (level 2 environmental attributes) and a matrix showing the relationship between them.

[b]The habitat attributes are also used in Chapter 8 and Appendix E to define the reference condition for the habitat benefits that arise from the City's HCP measures.

Spring Chinook in the Bull Run Watershed

Distribution

Spring Chinook currently have access to approximately 7.5 stream miles in the Bull Run watershed. Of this total, approximately 5.8 miles occur in the lower Bull Run River downstream of Headworks, with an additional 1.7 miles in the Little Sandy River downstream of the Little Sandy Dam site. Figure 5-18 shows the occurrence of spring Chinook life stages in the lower Bull Run River.

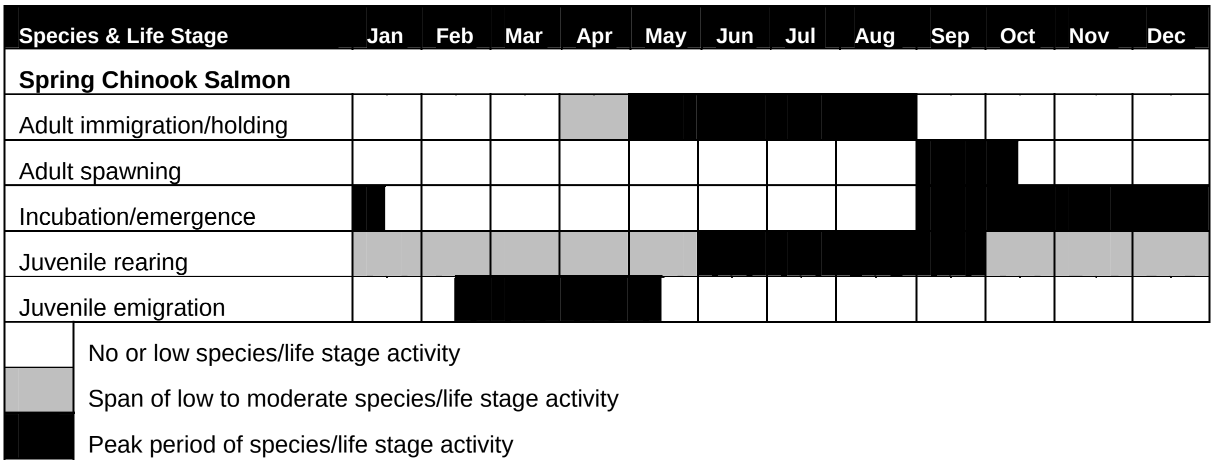


Figure 5-18. Estimated Periods of Occurrence for Spring Chinook in the Lower Bull Run River

Table 5-2 summarizes the river segments and historical distribution of spring Chinook in the Bull Run watershed. Figure 5-15 on page 5-30 shows historical spring Chinook distribution throughout the Sandy River Basin.

Table 5-2. Historical Distribution of Spring Chinook in the Bull Run and Little Sandy Rivers

River Segment	River Miles
Lower Bull Run River	
Bull Run River (mouth to Dam 2 spillway weir)	5.8
Upper Bull Run River	
Bull Run River (Dam 2 spillway weir up through reservoirs)	9.2
Bull Run River (free-flowing river to waterfall at RM 16.3)	1.3
South Fork Bull Run River	2.7
Cedar Creek (tributary to South Fork Bull Run River)	8.1
Little Sandy River	
Little Sandy River (mouth to Little Sandy Dam site)	1.7
Little Sandy River (Little Sandy Dam site to middle waterfalls)	5.6

Source: USFS, 1999

Even though 7.5 stream miles are accessible in the Bull Run watershed, spring Chinook do not currently use all of the habitat. On the mainstem Bull Run, Chinook (both spring and fall) have not been observed upstream of Larson's falls at RM 4.3 on the Bull Run River. The falls are passable at relatively small flows, but spring Chinook tend to stay in the lower river.

For the lower Little Sandy River downstream of the Little Sandy Dam site, current PGE operations significantly reduce base flows and little fish production occurs in this stream reach. With dam removal planned for 2008, base flows will revert to historical levels, but it is not known whether spring Chinook will use the Little Sandy River. The channel size, geomorphology, base flows, and other conditions may favor other fish species such as steelhead or coho salmon.

Abundance

Under current habitat conditions and access limitations, the EDT model estimates that the habitat in the Bull Run and Little Sandy rivers could produce approximately 60 spring Chinook adults annually assuming no harvest or hatchery fish influences. The EDT estimates of adult spring Chinook production are close to the numbers of fish observed in the Bull Run watershed. Clearwater Biostudies (2006) surveyed a total of 68 redds and estimated the minimum spawning escapement for the lower Bull Run River during the 2005 spawning period to be 232 adults. This total included primarily spring Chinook and perhaps some early fall Chinook salmon in a 2.4-mile reach between Larson's Bridge and the Bull Run Hydroelectric Project Powerhouse. The 2005 survey provided adult Chinook salmon abundances that exceeded the range of minimum spawning escapements of between 78 and 89 Chinook salmon spawners collected in the late 1990s (Beak 2000a; ODFW 2002). However, many of the spring Chinook observed in the lower Bull Run River were likely of hatchery origin, thus biasing upward the estimated spring Chinook production potential of the Bull Run watershed.

If habitat in the lower Bull Run and Little Sandy rivers were restored to historical habitat conditions (mid-1800s) and fish access above the Little Sandy Dam were restored, EDT projections indicate that spring Chinook adult and juvenile abundance could be increased to 1,785 adult spring Chinook and approximately 66,000 juvenile fish, respectively. This assumes, however, that environmental conditions (including harvest) in the lower Sandy River, lower Columbia River and estuary, and ocean have not been further degraded.

Habitat Conditions

The current habitat conditions of the lower Bull Run River do not favor utilization by spring Chinook. Various studies (Clearwater BioStudies 1997; R2 Resource Consultants 1998a,b; Beak 1999, 2000a) indicate that the following key environmental factors may have affected abundance and productivity of spring Chinook in the lower Bull Run River:

- Dams block access to potential upstream spawning habitat.
- High water temperatures during summer may affect juvenile fish growth and survival.
- High water temperatures during primary spawning time may affect adult spawning.

- Sustained summer low flows may reduce the amount of instream habitat suitable for use by juvenile spring Chinook.
- Gravel in the lower river suitable for spawning and construction of redds is lacking or absent.
- Rapid, short-term flow fluctuations may cause stranding or displacement of juvenile spring Chinook.

Several of the factors listed above result from the City's water supply operations in the Bull Run. However, some of the factors occur naturally and indicate spring Chinook production was likely limited historically by habitat conditions in the lower Bull Run. As an example, the summer and early fall water temperatures in the lower Bull Run River were high before the City constructed the dams (Leighton 2002). These high water temperatures probably limited the success of spring Chinook spawning and rearing in this portion of the Bull Run. Currently, it is not known whether significant spring Chinook production occurs. Spring Chinook adults are observed every year, but their spawning and rearing success have not been evaluated.

The presence of adult spring Chinook may be attributable to how PGE operates its Bull Run Hydroelectric Project. Many spring Chinook are probably drawn into the Bull Run because PGE diverts Sandy River water and puts it into the Bull Run River at RM 1.5. These operations may create false attraction for the adult spring Chinook and may explain the yearly observations of salmon in the lower Bull Run River.

Limiting Factors

Reach-specific results for spring Chinook salmon in the Bull Run River watershed are summarized in Figure 5-19. This summary indicates that the most affected life stages among the reaches in the watershed are emerging and dispersing fry (fry colonization), developing eggs (incubating eggs), and migrating adults (prespawning migrant), followed by holding adults (prespawning holding) and subyearling rearing (0-age active rearing).

Twelve of the 16 limiting factors affect spring Chinook survival in the watershed. Of these factors, channel stability, flow, food, habitat diversity, obstructions, sediment load, temperature, and key habitat quantity have a high to extreme effect in depressing productivity in most reaches of the Bull Run River watershed, excluding reach South Fork Bull Run 2.

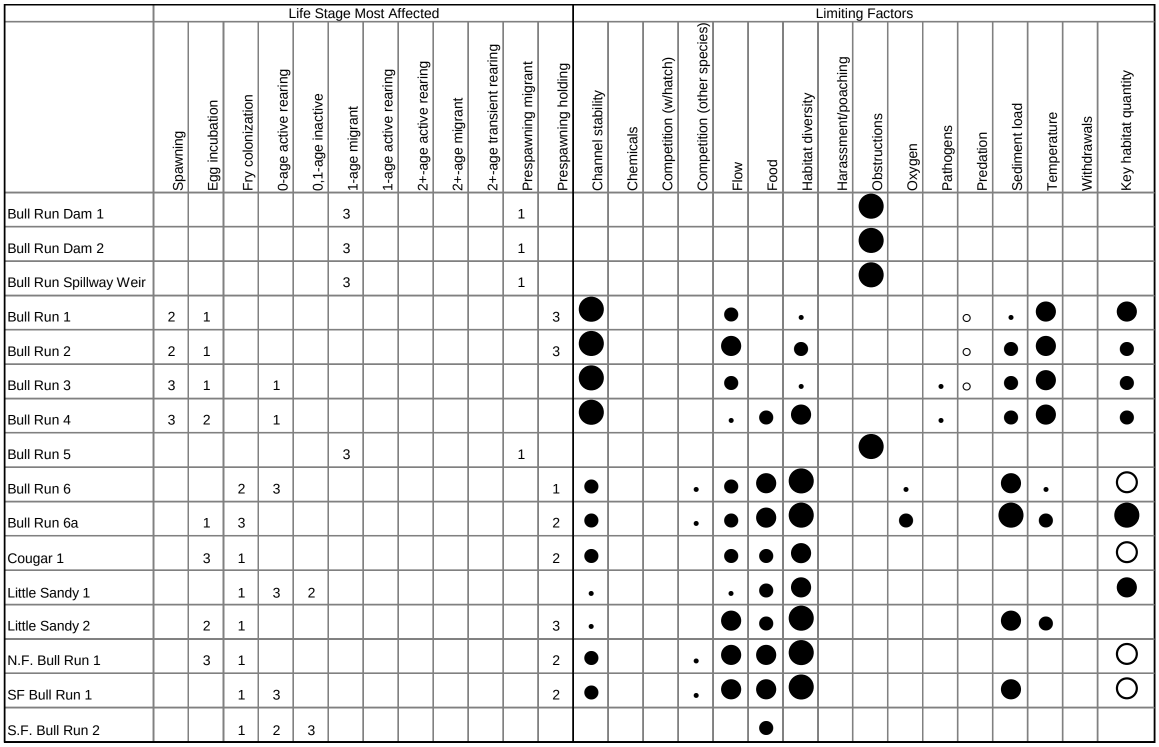
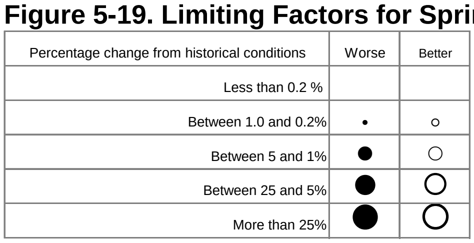


Figure 5-19. Limiting Factors for Spring Chinook in the Bull Run River Watershed[a,b]



Source: EDT model run 10/20/2005.

[a]Appendix D provides definitions of the limiting factors (level 3 survival factors) and the habitat attributes (level 2 environmental attributes) and a matrix showing the relationship between them.

[a]Bull Run reaches 5 and higher are the reaches at or above the Dam 2 diversion pool and include the reservoirs. The limiting factors in this figure for Bull Run reaches 5 and above are primarily the results of inundation of the Bull Run River by the reservoirs.

Flow and Spring Chinook Habitat Preferences

Because City operations in the Bull Run divert flow from the watershed, and that effect is a focus of this HCP, additional information on the relationship between streamflow and fish habitat preferences is provided below for Chinook salmon.

Spawning Flow-Habitat Relationships. Figure 5-20 shows the relationship between total usable habitat and flow for spawning Chinook salmon in the lower Bull Run River between Dam 2 (approximately RM 5.8) and PGE's powerhouse at RM 1.5. These relationships were developed for Chinook salmon and are applicable for both the fall and spring races of Chinook.

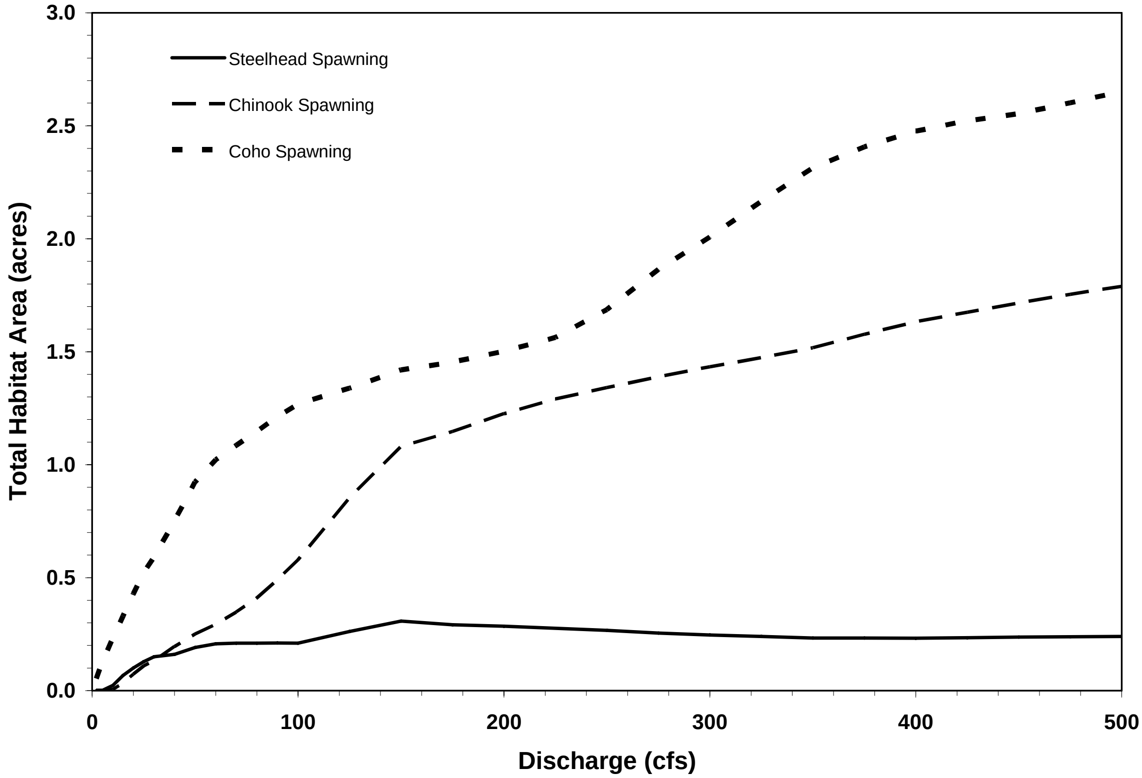


Figure 5-20. Relationship Between Flows in the Lower Bull Run River and Available Spawning Habitat for Chinook, Coho Salmon, and Steelhead

Source: R2 Resource Consultants 1998a.

Within the flow range modeled (0–500 cfs), the relationship for Chinook indicates that spawning habitat increases with increasing discharge.

Juvenile Rearing Flow-Habitat Relationships. Figure 5-21 shows the relationship between total usable habitat and flow for rearing juvenile Chinook in the lower Bull Run River.

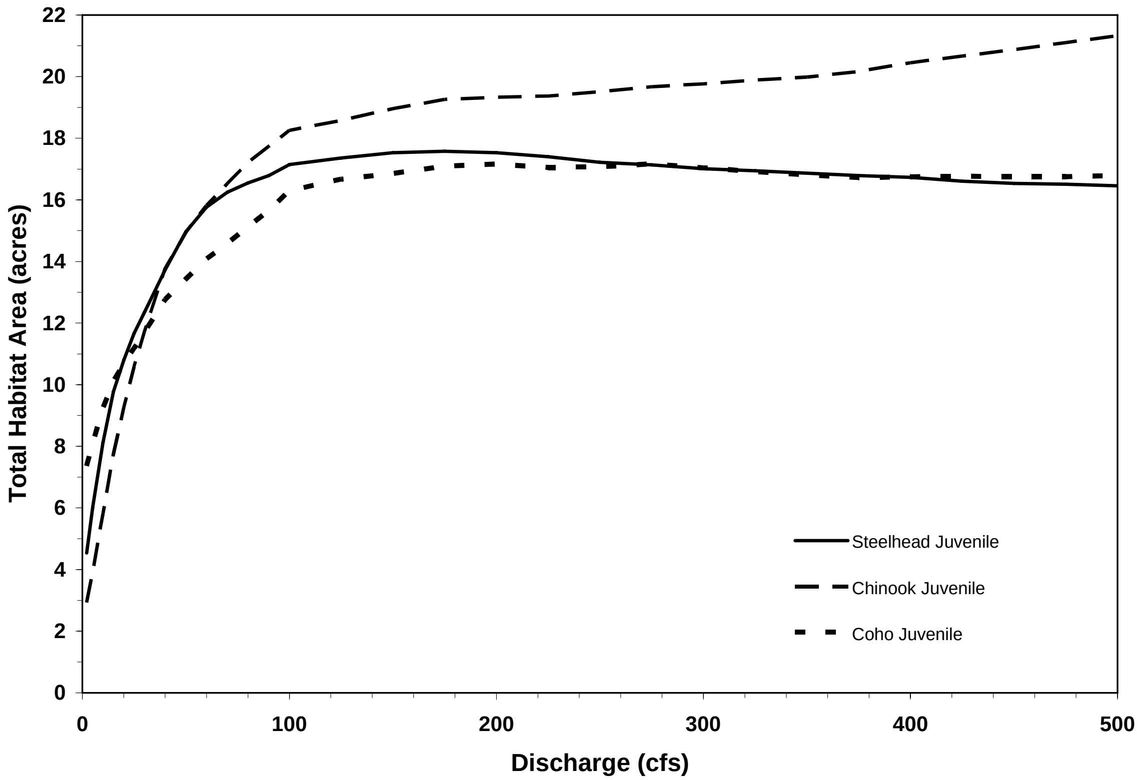


Figure 5-21. Relationship between Total Usable Habitat and Flow for Rearing Juvenile Chinook, Coho Salmon, and Steelhead in the Lower Bull Run River

Source: R2 Resource Consultants 1998a.

Results of PHABSIM modeling indicate that habitat conditions for juvenile Chinook salmon increase at a rapid rate between 0 and 100 cfs, with most of the rapid increase occurring between 0 and 20 cfs (R2 Resource Consultants 1998a). Habitat conditions for juvenile Chinook and other salmonids become near constant at flows above 100 cfs.

The results of the PHABSIM modeling are expressed as weighted usable area (WUA), an index of available instream habitat at various increments of flow. R2 Resources Consultants estimated WUA for a number of flows in various reaches of the lower Bull Run River by (1998a) using the PHABSIM model. The WUA estimates for each species are shown in Chapter 8, Effects of the HCP.

Winter Steelhead in the Sandy River Basin

Life History and Diversity

Winter-run steelhead trout (*O. mykiss*) are indigenous to the Sandy River Basin, and historical returns may have once numbered 20,000 adults (ODFW 2002). Recently, Sandy River winter steelhead abundance levels have fallen far below historical levels. In March 1998, they were listed as threatened under the federal ESA (NMFS 2003). Natural origin winter steelhead in the Sandy River Basin are included in the Lower Columbia River steelhead ESU.

Typically, winter-run steelhead native to the Sandy River enter the Basin in significant numbers from February through May, with a few fish still present in June. The majority of suitable spawning habitat is located upstream of the Marmot Dam site in the Salmon River and its tributaries and in Still Creek (PGE 2002). Spawning habitat is also present in Clear Creek, Clear Fork, Lost Creek, Horseshoe Creek, Zigzag River and Camp Creek (Bishop, pers. comm., 2004). Peak passage over Marmot Dam usually occurred in March and April (PGE 2002), with peak spawning occurring mid-March through mid-May (PGE 2002). Estimated periods of occurrence of winter steelhead life stages in the upper portion of the Sandy River Basin are shown in Figure 5-22.

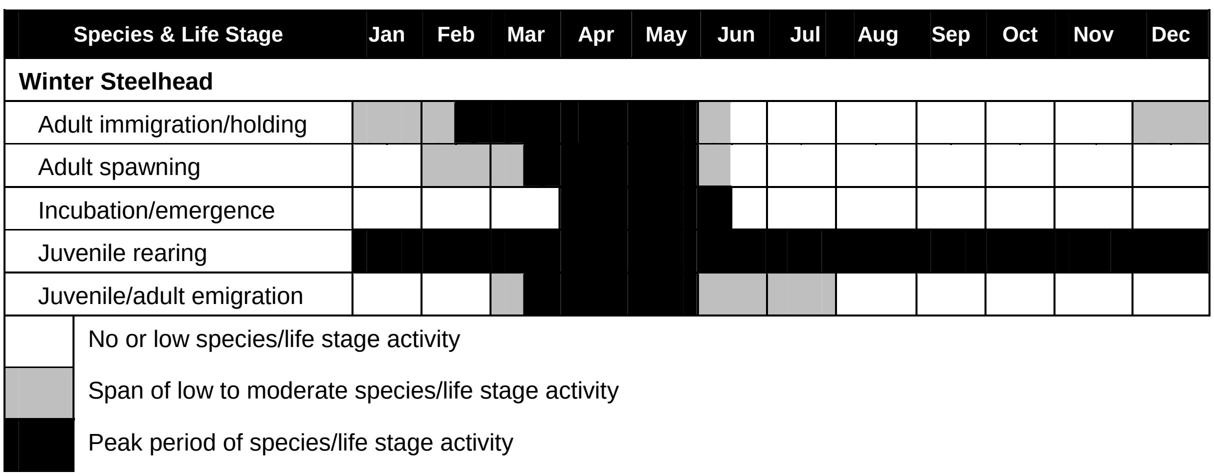


Figure 5-22. Estimated Periods of Occurrence for Steelhead in the Upper Sandy River Basin Above the Marmot Dam Site

Source: Sandy River Basin Agreement Technical Team 2002.

Fertilized winter steelhead eggs may incubate in the gravel for up to 50 days before hatching and an additional two to three weeks before emerging (ODFW 1997). Following emergence, steelhead fry will often seek refuge from fast currents by inhabiting stream margins and pool backwater habitats. As they begin to mature and grow larger, juveniles typically inhabit deeper water habitats of pools, riffles, and runs. PGE (2002) found that the preferred habitats for steelhead in the mainstem Sandy River are where large boulder substrates provide velocity refuge and optimal feeding conditions. Natural origin winter steelhead smolts in the Sandy River Basin emigrate to the ocean typically as age-2+ smolts in spring, but 3+ smolts are common (ODFW 1997).

Sandy River Basin winter steelhead usually spend two years in the ocean, but three-year ocean residence is common (ODFW 1997). Ocean distribution is poorly documented, but Sandy stock winter steelhead juveniles are believed to follow patterns similar to those followed by other Columbia River stocks (ODFW 1997). The NMFS WLC-TRT classified the winter run as a "core" population in its recovery planning efforts. This designation means the population historically was abundant and productive, and currently offers one of the most likely paths to recovery in the Lower Columbia Steelhead ESU (McElhany et al. 2003).

The LCRFRB delineated the priority for contribution of this stock to recovery goals in the ESU as "primary." This classification means the Sandy River winter steelhead stock would be targeted for recovery in the Cascade "stratum" to achieve viable population levels with greater than 95 percent probability of persistence (negligible extinction risk) within 100 years (LCRFRB 2004, McElhany et al. 2003; McElhany et al. 2004).

Distribution

The SRBTT developed a completed list of the reaches in which each natural population of anadromous salmonids was known or assumed to spawn, either currently or historically (City of Portland 2004a). For streams where data were not available to determine species use, the SRBTT assumed that steelhead would not utilize streams with a minimum width less than 8 feet or a gradient higher than 12 percent. After initial EDT model runs were completed in 2001, the SRBTT met again to review the results and re-examine spawning distribution in the Sandy River Basin. Based on this review, several spawning reaches were excluded for some species and added for others. This distribution information was used to develop Figures 5-23 and 5-24.

Current. Current winter steelhead distribution in the Sandy River Basin is shown in Figure 5-23. Native winter steelhead spawning and rearing in the Sandy River primarily occurs upstream of the Marmot Dam site. Lower Basin tributaries (below the Marmot Dam site) that may support additional winter steelhead production include the Bull Run River and Gordon, Trout, and Buck creeks (PGE 2002). Juvenile winter steelhead are likely present year-round throughout most of the Sandy River mainstem in both the upper and lower portions of the Basin. Natural production in the Bull Run and Little Sandy rivers and in Cedar and Alder creeks has been limited by a lack of fish passage into the upper reaches of the streams.

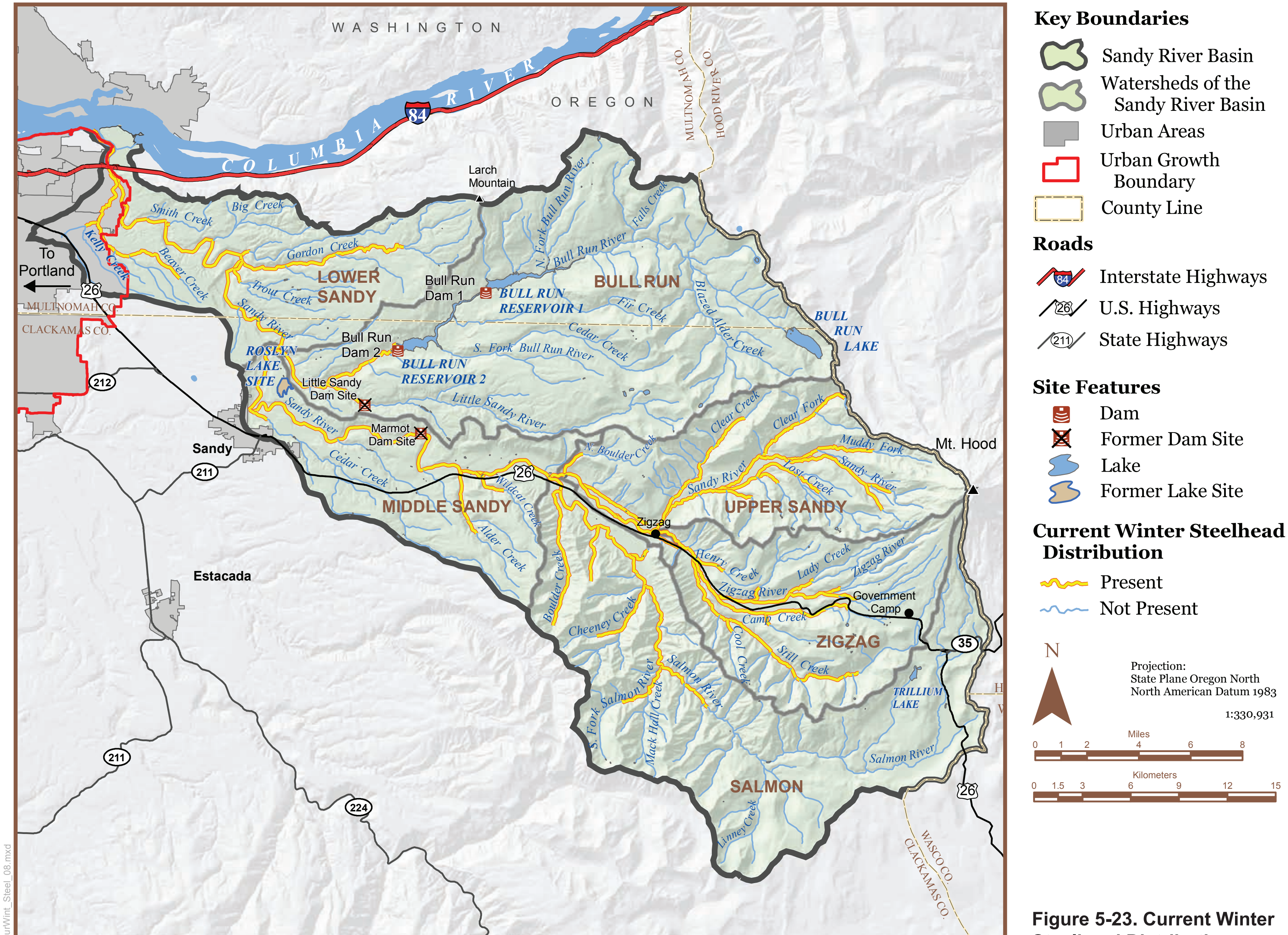


Figure 5-23. Current Winter Steelhead Distribution

Historical. Historical winter steelhead distribution assumed in the Sandy River Basin is shown in Figure 5-24. Historically, Sandy River Basin winter steelhead likely spawned and reared in many reaches of the Basin that are currently not available to anadromy. Winter steelhead runs historically occurred in the Bull Run, Little Sandy, Salmon, and Zigzag rivers (NMFS 2003). The upper Sandy River Basin currently supports the bulk of winter steelhead production in the Basin, and the majority of historical habitat in the upper Basin remains available for winter steelhead use.

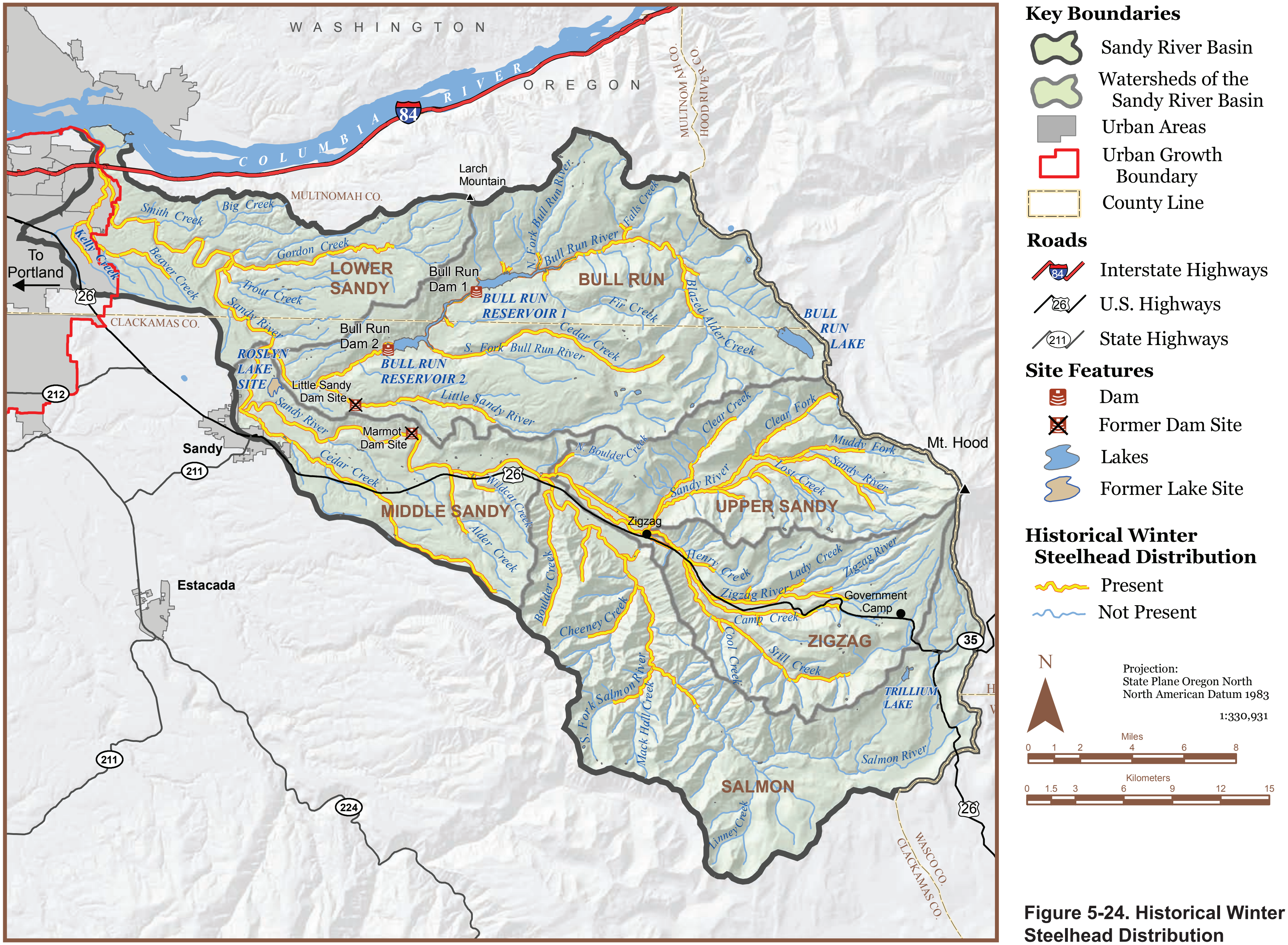


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Figure 5-24. Historical Winter Steelhead Distribution

Anchor Habitat. Of the species analyzed, steelhead anchor habitat reaches are the most numerous and spatially diverse (SRBWG 2006). The anchor habitat analysis, which is based on current conditions, identified 22 widely spread anchor habitat reaches for steelhead in the Sandy River. This is not surprising because, historically, steelhead spawning and rearing was widely distributed throughout the Sandy River Basin, while today most of the productive habitat is upstream of the Marmot Dam site (ODFW 2001). The City considered the anchor habitat reaches for steelhead when choosing offsite areas (non-Bull Run) that should be emphasized for HCP conservation measures (see Chapter 7).

Steelhead anchor habitat reaches were identified in the following watersheds:

- Lower Sandy River: lower end of Trout Creek
- Middle Sandy River: mainstem Sandy River from Bull Run confluence to RM 24 (two miles upstream of the mouth of Cedar Creek), mainstem Sandy River from the Marmot Dam site to the mouth of the Salmon River, and the lower end of Wildcat Creek
- Upper Sandy River: mainstem Sandy River from the Salmon River confluence to the Zigzag River, the lower end of Clear Fork and the lower end of Lost Creek
- Bull Run River: lower Little Sandy River downstream of the Little Sandy Dam
- Salmon River: lower Salmon River downstream of Boulder Creek and the lower ends of Boulder Creek, Sixes Creek, and the South Fork Salmon River
- Zigzag River: the lower 10 miles of Still Creek

Abundance

Even though winter steelhead spawn in many reaches upstream and downstream of the Marmot Dam site, the primary population abundance indicator for Sandy River Basin natural-origin winter steelhead has been determined from Marmot Dam counts. Beginning in run year 1998, all hatchery steelhead collected at the Marmot Dam fish trap were recycled back downstream for increased sport fishing opportunities. Since 1998, only non-adipose-fin-clipped steelhead trout have been passed upstream. Winter steelhead total dam counts (including both the hatchery and wild components) for 1980–1989 averaged approximately 3,007 adults.

Three different estimates of winter steelhead abundance, both wild and hatchery fish, are graphically displayed in Figure 5-25. The high, low, and average counts were 2,916, 537, and 1,316 fish, respectively, for 1990–1999. Average total counts for 1990–1999 were about half of the counts for the previous decade. Average total counts for 2000–2002 showed a continuous decline to approximately 1,065 adults. With the 1998 establishment of wild steelhead sanctuary areas upstream of Marmot Dam, wild spawners passing above Marmot Dam in run years 1998–2002 averaged 818 adults.

ODFW established a long-term escapement goal (based on existing habitat conditions) in the Sandy River Basin of 1,677 natural-origin spawners per year to maximize the number of adults returning to the Basin (NMFS 2003). The objective in the Oregon Administrative Rules (OAR 635-500-3430) is to rebuild the native winter steelhead runs in the Sandy Basin to achieve an average annual spawning escapement of 1,730 wild winter steelhead. The ODFW

Fisheries Management and Evaluation Plan (2003b) established a viable abundance threshold of Sandy River winter-run steelhead of 336 natural-origin spawners per year (20 percent of the maximum seeding). The critical abundance threshold (set to avoid short-term deleterious genetic and demographic effects) was set at 82 natural origin spawners per year (ODFW 2003b).

EDT estimates of adult production were also determined based on the same geographic point of reference (all reaches upstream of Marmot Dam site counts) as was used for the empirical abundance estimates shown in Figure 5-25. EDT estimated current adult steelhead production above the Marmot Dam site at approximately 2,300 adult fish. The EDT estimate assumed the harvest rate on wild steelhead was 10 percent in the 1990s. For the fully restored freshwater habitat condition, winter steelhead abundance was estimated at about 3,800 adult spawners.

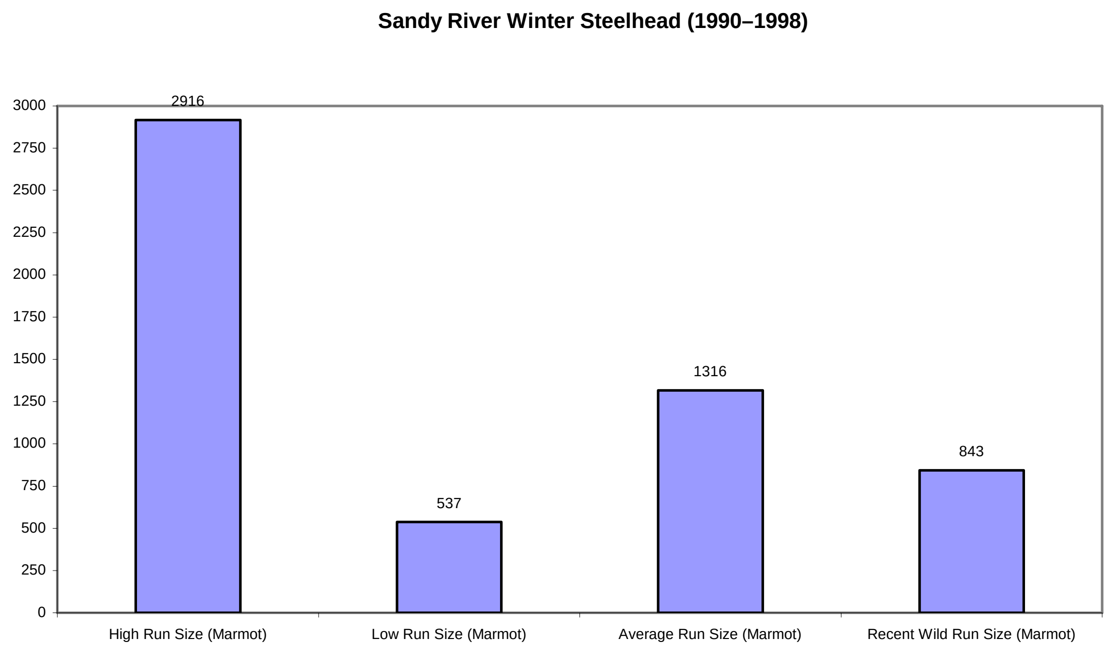


Figure 5-25 Estimates of Winter Steelhead Abundance Upstream of Marmot Dam

Source: ODFW 2003a

The average adult run size observed at Marmot Dam for both hatchery and wild fish combined between 1990 and 1998 (1,316) is less than the EDT prediction of adult returns to this same point. However, the EDT estimate does not exceed the highest number of adults observed (2,916) at Marmot Dam from 1990 to 1998. It should be noted that the dam counts did not separate hatchery and wild fish in some years. From 1990–2000, the number of wild steelhead passing Marmot Dam was estimated at 932 fish (ODFW Fisheries Management and Evaluation Plan 2003b).

Hatchery Production and Plantings

Current. Winter steelhead hatchery programs in the Sandy River Basin have been altered recently to use in-basin brood stock derived from the local wild population. Beginning in brood year 2000, all adult steelhead brood stock collected for hatchery supplementation has been wild fish with an intact adipose fin collected at the Marmot Dam fish trap (NMFS 2003). From brood years 2002–2007, brood stock has been collected from adults returning to Sandy Hatchery and supplemented with wild stock collected at Marmot Dam (no more than 30 percent of annual brood goal) (Bourne pers. comm, 2004; Stahl pers. comm, 2004). The last year for out-of-Basin winter steelhead smolt releases in the Sandy River Basin occurred in 2001; 40,000 Big Creek smolts were released with 118,000 Sandy stock smolts (Bourne pers. comm, 2004). Returning Sandy stock hatchery adults were differentiated from Big Creek adults by the marking of the right maxillary and adipose fins; hatchery Sandy stock has marked adipose fin only (Bourne pers. comm, 2004). In 2002, 162,000 Sandy stock winter steelhead smolts were released; in 2003, 179,000 winter steelhead smolts were released (Bourne pers. comm, 2004).

Historical. Hatchery winter steelhead egg-take and supplementation programs began in the Sandy River Basin in 1896, when winter steelhead eggs were collected at a hatchery on Boulder Creek, a tributary to the lower Salmon River (ODFW 1997). Following the construction of Marmot Dam in 1912, hatchery operations were moved to a site downstream of the dam and continued there from 1913 to 1954 (ODFW 1997). Fish were trapped at this site until 1951, primarily because the Marmot Dam diversion canal was unscreened up to this point. It is likely that a large percentage of fingerlings and smolts released upstream of Marmot Dam prior to 1951 would have been diverted into Roslyn Lake and PGE's Bull Run Hydroelectric Project.

A more focused hatchery smolt release program began in 1955, with the majority of smolts consisting of Big Creek (1955–2000) and Eagle Creek (1986–2000) hatchery stocks. Additional stocks released intermittently throughout the period 1955–2000 included Alsea River, Sandy River, and Cedar Creek stocks. Smolt releases from 1955–1960 remained below 100,000 winter steelhead annually; from 1961 to 1996, smolt releases increased substantially and varied from a low of 119,032 in 1982 to a high of 231,583 in 1994 (ODFW 1997). From 1989 to 2007 when Marmot Dam was decommissioned, all hatchery winter steelhead were released below Marmot Dam to concentrate angler effort and reduce impacts to wild fish spawning upstream (ODFW 1997).

Harvest in the Basin

Current. Current harvest impacts to Sandy River Basin winter steelhead trout have been greatly reduced since the implementation of a marked selective fishery in 1992. Wild steelhead release regulations implemented in 1992 allow only adipose-fin-clipped steelhead

of hatchery origin to be retained. Wild steelhead fishery mortality rates in the Sandy River Basin were estimated to be in the range of 40 percent prior to 1992 (Chilcote 2001; as cited in ODFW 2003b). NMFS (2003) and ODFW (2003b) estimate annual harvest impacts to be 2.0 to 2.5 percent of the natural-origin steelhead returning to the ESU, based on the assumed post-release mortality rate of 5 percent and a maximum fishery encounter rate of 40 percent. This estimate also takes into consideration an assumed 90 percent angler compliance with releasing natural origin sport-caught fish (ODFW 2003b).

Regulations implemented in 1999 created a sanctuary area for steelhead upstream of Marmot Dam and limited sport harvest to downstream of Marmot Dam. Beginning in 1998, all adipose-fin-clipped hatchery fish were to be recycled downstream for increased angler opportunity in the lower Basin, where recreational fishing effort is concentrated (PGE 2002).

Historical. Historical sport harvest of wild and hatchery winter steelhead (from ODFW 2001) varied greatly from 1955 to 1992. Total sport catch ranged from a low of 1,903 in 1960–1961, to a high of 13,000 in 1979–1980. Sport catch estimates are complete through run year 1996–1997. Sport catch in the Sandy River Basin for the 5 years (1987–1991) prior to the wild steelhead release regulation averaged 7,511. Comparatively, the average sport catch for the 5 years (1992–1996) after the wild steelhead release regulation was 2,347.

Reasons for Listing/Threats to Survival

Three sources of information are available to help explain the reasons winter steelhead have decreased in abundance in the Sandy River Basin: NMFS documents, ODFW reports, and EDT model results, as discussed below.

National Marine Fisheries Service. NMFS identified destruction and modification of habitat, overutilization for recreational purposes, and natural and human-made factors as the primary reasons for the decline of west coast steelhead (NMFS 1998b). Specifically for the Lower Columbia River ESU, NMFS identified the following factors contributing to the decline of steelhead: competition and interbreeding with hatchery fish; impeded access to habitat; hydropower development; logging; predation; and harvest (NMFS 1998b). Natural

Photo courtesy of Bonneville Power Administration.

origin steelhead trout were often caught incidentally in spring Chinook fisheries in the mainstem Columbia River due to their coinciding run timing. A 20-year trend in poor ocean conditions further exacerbated the problem of depressed returns in the ESU.

Oregon Department of Fish and Wildlife. The Sandy Basin Management Plan (ODFW 1997) identified the following factors in reducing the production potential of native winter steelhead in the Sandy River Basin (though it is possible some of the listed factors no longer affect current populations):

- Poor ocean conditions
- Reduction in historical habitat in the Bull Run River watershed by construction of dams
- Lack of screening at the water diversion canal at Marmot Dam that likely entrained many outmigrating, naturally produced smolts prior to 1951
- Channelization of many miles of important winter steelhead spawning and rearing habitat in the Basin following the 1964 flood
- Wild steelhead trapping and egg-take operations in the Salmon River Basin and at Marmot Dam prior to 1951
- Recreational overharvest of wild winter steelhead prior to the implementation of catch-and-release in 1990
- Hatchery practices that have led to increased competition and possible genetic introgression between out-of-basin hatchery steelhead stocks and native Sandy steelhead stocks
- Commercial harvest of steelhead in the mainstem Columbia River until 1974

Ecosystem Diagnosis and Treatment. Results from EDT modeling for the Sandy River Basin estimate that the primary limiting factors for winter steelhead are the following:

- Habitat diversity. Loss in habitat diversity was found to be affecting steelhead production in the Salmon and Bull Run rivers. The loss was due to decreased riparian function, increased artificial stream confinement of the channel, and decreased large woody debris.
- Key habitat quantity. Key habitat quantity has decreased due to changes in habitat composition (pools, riffles, and glides).
- Sediment. Sediment has increased throughout most of the Basin due to decreased riparian habitat quality, landslides, and land practices.
- Obstructions. Dams on the Bull Run River, Little Sandy River, Cedar Creek, and mainstem Sandy River (Marmot) have affected steelhead passage and survival.

Other minor limiting factors include changes in both high and low flow, competition with hatchery fish, and channel stability in the lower Sandy River. The factors limiting winter steelhead production are shown in Figure 5-26.

	Limiting Factors															
Geographic Area	Channel Stability	Chemicals	Competition (hatch)	Competition (other species)	Flow	Food	Habitat diversity	Hasassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Bull Run River					•	•	●		⬤				●	•		●
Columbia River			•				•					•				•
Lower Sandy River	•				•	•	●	•			•	•	●	•		•
Middle Sandy River					•	•	•		⬤				•			•
Upper Sandy River					•		•						●			•
Salmon River					•		•					•				●
Zigzag River					•		•						•			•

Figure 5-26. Limiting Factors Affecting Winter Steelhead in the Sandy River Basin[a,b]

Percentage change from historical conditions	Worse
Less than 1%	
Between 1 and 5%	•
Between 5 and 20%	●
More than 20%	⬤

Source: EDT model data run 10/20/05.

[a]Appendix D provides definitions of the limiting factors (level 3 survival factors) and the habitat attributes (level 2 environmental attributes) and a matrix showing the relationship between them.

[b]The habitat attributes are also used in Chapter 8 and Appendix E to define the reference condition for the habitat benefits that arise from the City's HCP measures.

Winter Steelhead in the Bull Run Watershed

Distribution

Steelhead currently use about 7.5 stream miles of stream habitat in the Bull Run River watershed. Fish passage is blocked at RM 5.8 on the lower Bull Run River and at RM 1.7 on the Little Sandy River. Other tributaries to the lower Bull Run River have limited productivity potential for anadromous fish because of steep gradients or natural waterfalls

(City of Portland 2002). Additionally, a culvert barrier in Walker Creek blocks access to about 800 feet of this lower Bull Run River tributary (City of Portland 2002).

Historically, steelhead probably used about 49 stream miles in the Bull Run River watershed, which includes 10 miles of stream for the Little Sandy River. Of the 39 stream miles for the Bull Run portion, approximately 9 miles are now inundated by Bull Run reservoirs.

Table 5-3 summarizes the river segments and historical distribution of winter steelhead in the Bull Run watershed. Figure 5-24 on page 5-47 shows historical steelhead distribution throughout the Sandy River Basin.

Table 5-3. Historical Distribution of Steelhead in the Bull Run River

River Segment	River Miles
Lower Bull Run River	
Bull Run River (mouth to Dam 2 spillway weir)	5.8
Walker Creek	0.15
Little Sandy River (mouth to Little Sandy Dam site)	1.7
Little Sandy River (Little Sandy Dam site to middle waterfalls)	5.6
Little Sandy River Tributaries (upstream of Little Sandy Dam site)	2.0 (est.)
Upper Bull Run River	
Bull Run River (Dam 2 spillway weir up through reservoirs)	9.2
Bull Run River (free-flowing river to waterfall at RM 16.3)	1.3
South Fork Bull Run River	2.7
Bull Run River (RM 16.3 to 80’ waterfall at RM 21.4)	5.4
Cedar Creek (tributary to South Fork Bull Run River)	8.1
Camp Creek	0.6
Fir Creek	0.5
Bear Creek	0.3
Cougar Creek	0.7
North Fork Bull Run River	0.8
Log Creek	0.2
Falls Creek	0.8
West Branch Falls Creek	0.3
Blazed Alder Creek	2.4
Blazed Alder Tributaries	0.4 (est.)
Deer Creek	0.5

Source: USFS, 1999

Figure 5-27 shows the estimated periods of occurrence for steelhead in the lower Bull Run River.

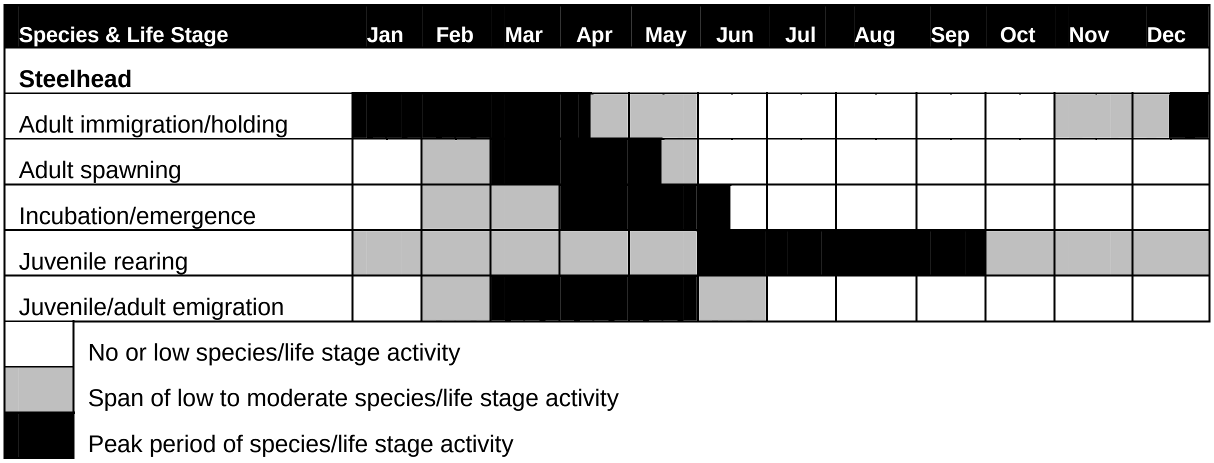


Figure 5-27. Estimated Periods of Occurrence for Steelhead in the Lower Bull Run River

Source: Sandy River Basin Agreement Technical Team 2002.

Abundance

The Sandy River EDT model estimates the habitat conditions that support adult abundance. For current and historical winter steelhead production in the lower Bull Run and Little Sandy rivers, the EDT estimates are 97 and 564 adults, respectively. Juvenile steelhead production for these same time frames was approximately 1,500 and 7,600.

Based on available substrate characteristics, R2 Resource Consultants (1998) estimated a spawning capacity in the lower Bull Run River of 96 redds, or approximately 192 spawners (1:1 female to male ratio). From 1997–2000, the average abundance of age-1+ and age-2+ juvenile steelhead was estimated at 2,393 (Beak 2000b). This abundance estimate is higher than the EDT estimates (2,393 versus 1,500), but as was the case with spring Chinook, the numbers are likely inflated by the presence of hatchery fish spawning in the watershed.

Habitat Conditions

Various studies (Clearwater BioStudies 1997; R2 Resource Consultants 1998 a,b; Beak 1999, 2000a) indicate that the following key environmental factors may have affected abundance and productivity of steelhead in the lower Bull Run River:

- Dam and culverts block access to potential upstream spawning habitat.
- High water temperatures during summer may affect juvenile fish growth and survival.
- Sustained summer low flows may reduce the amount of instream habitat suitable for use by juvenile steelhead.
- Gravel in the lower river suitable for spawning and construction of redds is lacking or absent.
- Rapid, short-term flow fluctuations may strand or displace juvenile steelhead.

Limiting Factors

The City used the EDT model to determine the limiting factors affecting steelhead production in the Bull Run River watershed. Reach-specific results for steelhead in the Bull Run River watershed are summarized in Figure 5-28. This summary indicates that the most affected life stages among the reaches in the watershed are emerging and dispersing fry (fry colonization), overwintering juveniles (0,1-age inactive), and juvenile rearing (0,1-age active rearing), followed by migrating adults (prespawning migrant) and developing eggs (egg incubation).

Thirteen of the 16 limiting factors affect steelhead survival among the reaches in the watershed. Of these, flow, habitat diversity, obstructions, sediment load, temperature, and key habitat quantity have a high effect in depressing productivity in some of the lower Bull Run River reaches (Little Sandy 2 and South Fork Bull Run 2).

	Life Stage Most Affected													Limiting Factors															
	Spawning	Egg incubation	Fry colonization	0-age migrant	0-age active rearing	0,1-age inactive	1-age migrant	1-age active rearing	2+-age active rearing	2+-age migrant	2+-age transient rearing	Prespawning migrant	Prespawning holding	Channel stability	Chemicals	Competition (w/hatch)	Competition (other species)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Blazed Alder 1			1		2	3		3											•										
Bull Run Bear 1		3	1		2									●			•	●	●	⬤									⬤⬤
Bull Run Camp 1		2	1		3									●			•	●	●	●							•		◯
Bull Run Cedar 1					2	1		1										•	•	•									
Bull Run Dam 1							3			2		1										⬤⬤							
Bull Run Dam 2							3			2		1										⬤⬤							
Bull Run Spillway Weir							3			2		1										⬤⬤							
Bull Run 1		3			1			2										•	•	•				●			⬤		●
Bull Run 2		3			1	3		2						●				⬤	•	●				●		•	⬤		●
Bull Run 3		3			1			2										●	•					●		•	⬤		●
Bull Run 4					2	2		1						•		•		⬤	●	⬤				●		•	⬤		•
Bull Run 5							3			2		1										⬤⬤							
Bull Run 6						1		3						•		•		●	●	●						⬤⬤	∘		◯
Bull Run 6a		1	3					2						●		•		●	●	●			•			⬤⬤	●		●
Bull Run 7			2			1		1											•						∘				
Bull Run 8						1		1											•										
Bull Run 9			1		2	2													•										
Bull Run 10			1		2			3											•										
Cougar 1			1		2	3							3	•		•		●	●	●									○
Cougar 2			1			1		2						•				•	●	•									
Deer 1			1		2							3		●		•	•	⬤	⬤	⬤									◯
Deer 2	1	2	3																										⬤⬤
Falls Creek 1			1		2			3											•										
Fir 1			1		2			3											•										
Little Sandy 1					1	2								•				●	•	●									●
Little Sandy 2		1				1		2						•				⬤	•	●						⬤	•		
N.F. Bull Run 1			1		2	3		3						●		•	•	●	●	●					∘				◯
N.F. Bull Run 2						1		3						•				●	•	●									○
SF Bull Run 1		3				1								•			•	⬤	●	⬤					∘	⬤⬤			◯
S.F. Bull Run 2						1		3											•										

Figure 5-28. Limiting Factors for Winter Steelhead in the Bull Run River Watershed[a,b]

Percentage change from historical conditions	Worse	Better
Less than 0.2 %		
Between 1.0 and 0.2%	•	∘
Between 5 and 1%	●	○
Between 25 and 5%	⬤	◯
More than 25%	⬤⬤	◯◯

Source: EDT model run 10/20/05.

[a]Appendix D provides definitions of the limiting factors (level 3 survival factors) and the habitat attributes (level 2 environmental attributes) and a matrix showing the relationship between them.

[a]Bull Run reaches 5 and higher are the reaches at or above the Dam 2 diversion pool and include the reservoirs. The limiting factors in this figure for Bull Run reaches 5 and above are primarily the results of inundation of the Bull Run River by the reservoirs.

Flow and Steelhead Habitat Preferences

Because City operations in the Bull Run divert flow from the watershed, and that effect is a focus of this HCP, additional information on the relationship between streamflow and fish habitat preferences is provided below for steelhead.

Spawning Flow-Habitat Relationships. Figure 5-29 shows the relationship between total usable habitat and flow for spawning winter steelhead in the lower Bull Run River between Dam 2 (approximately RM 5.8) and PGE's powerhouse at RM 1.5. These relationships were developed for Chinook salmon and are applicable to Chinook salmon, steelhead, and coho salmon.

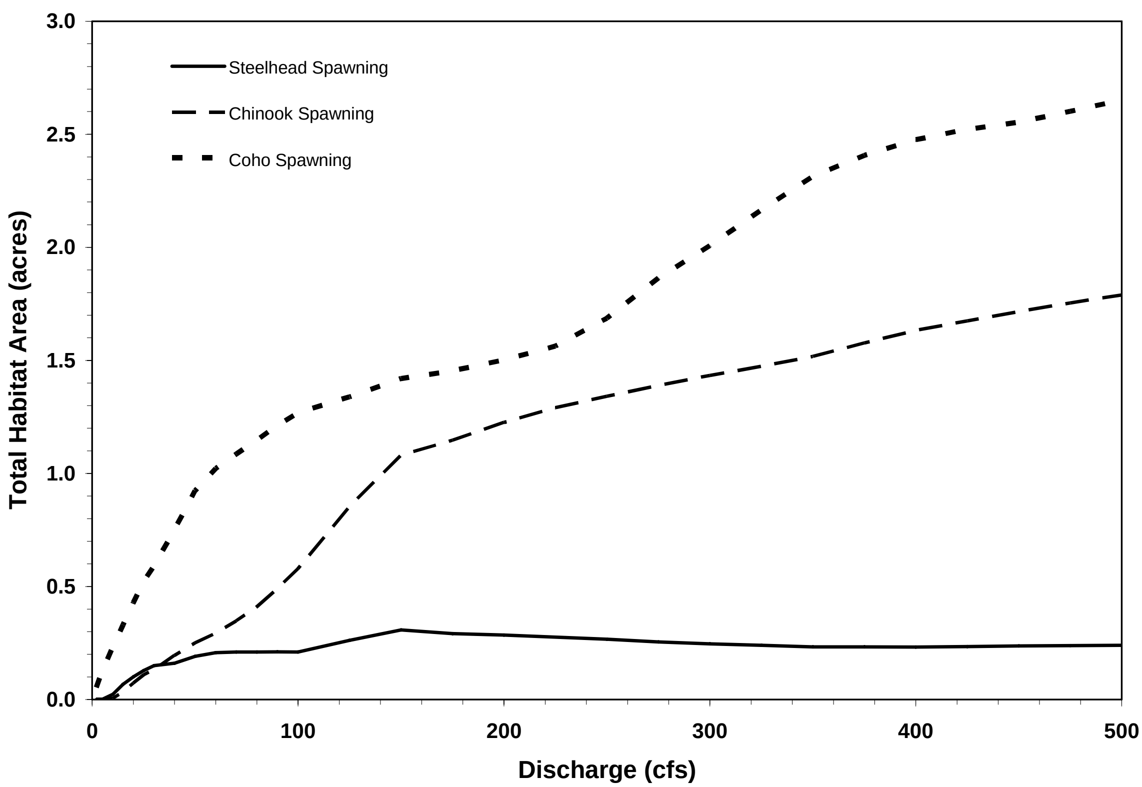


Figure 5-29. Relationship Between Flows in the Lower Bull Run River and Available Spawning Habitat for Chinook, Coho Salmon, and Steelhead

Source: R2 Resource Consultants 1998a.

Within the flow range modeled (0–500 cfs), the relationship for steelhead indicates that spawning habitat increases with increasing discharge.

Juvenile Rearing Flow-Habitat Relationships. Figure 5-30 shows the relationship between total usable habitat and flow for rearing juvenile steelhead in the lower Bull Run River.

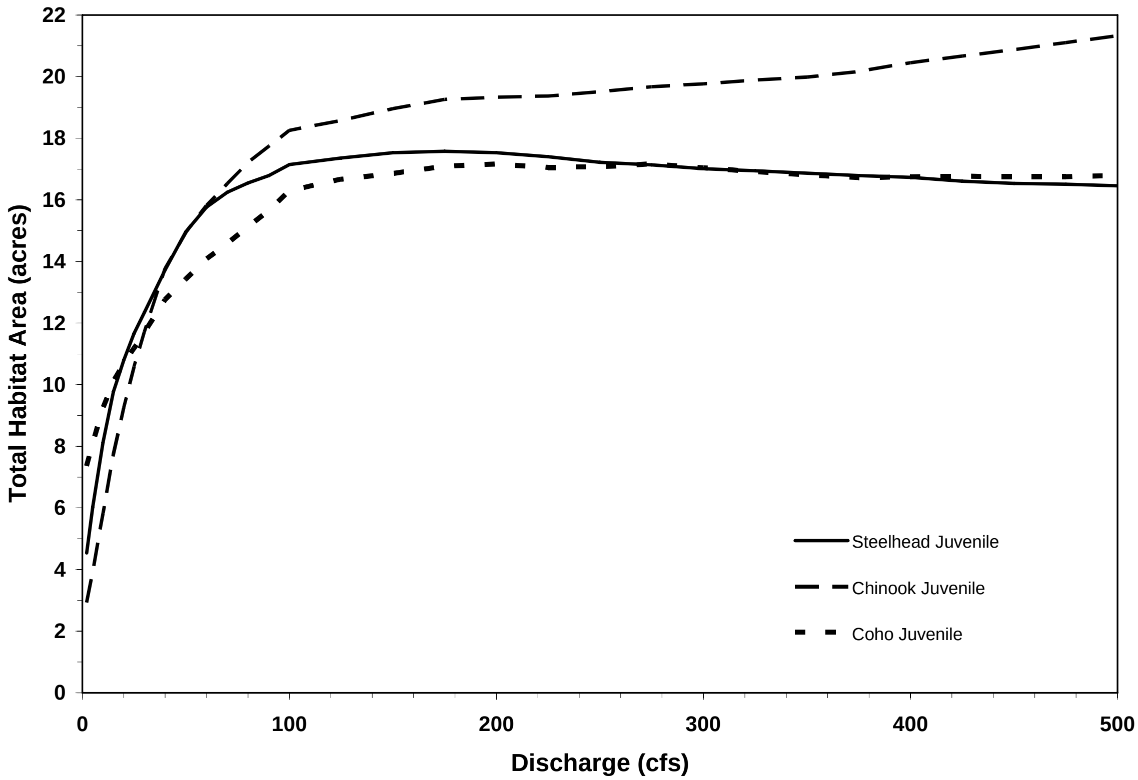


Figure 5-30. Relationship between Total Usable Habitat and Flow for Rearing Juvenile Steelhead in the Lower Bull Run River

Source: R2 Resource Consultants 1998a.

Results of PHABSIM modeling indicate that habitat conditions for juvenile steelhead increase at a rapid rate between 0 and 100 cfs, with most of the rapid increase occurring between 0 and 20 cfs (R2 Resource Consultants 1998a). Habitat conditions for juvenile steelhead and other salmonids become near constant at flows above 100 cfs.

The results of the PHABSIM modeling are expressed as weighted usable area (WUA), an index of available instream habitat at various increments of flow. R2 Resources Consultants estimated WUA for a number of flows in various reaches of the lower Bull Run River by (1998a) using the PHABSIM model. The WUA estimates for each species are shown in Chapter 8, Effects of the HCP.

Coho in the Sandy River Basin

Life History and Diversity

Coho salmon (*O. kisutch*) in the Sandy River Basin belong to the Lower Columbia River ESU, and are listed as threatened under the ESA (June 2005). The Lower Columbia River ESU is sustained primarily by hatchery production. The only two known self-sustaining populations in the ESU include the Sandy and the Clackamas rivers in Oregon (NMFS 2003). Weitkamp et al. (1995) theorized that the only known remaining natural population of coho in the Lower Columbia River ESU is the Clackamas late-run stock. From 1999 to 2007, only natural-origin coho salmon were allowed to pass over Marmot Dam, and a naturally spawning population appears to exist.

Currently, the Sandy River Basin supports both an early hatchery run of coho—with peak presence occurring in September and October—and a late wild run generally peaking from September through November (ODFW 1997). Estimated periods of occurrence of coho life stages in the upper Sandy River Basin are shown in Figure 5-31.

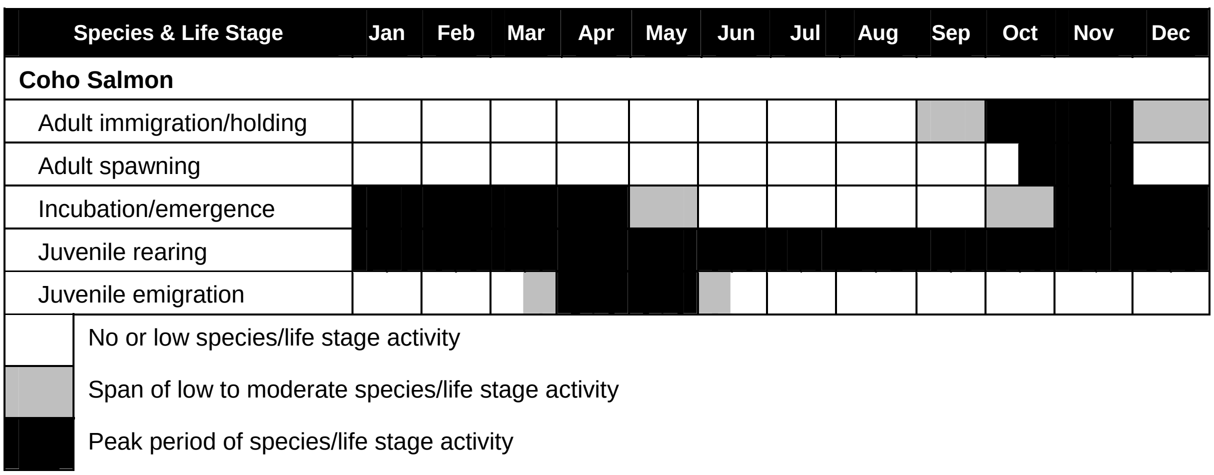


Figure 5-31. Estimated Periods of Occurrence for Coho in the Upper Sandy River Basin Above Marmot Dam

Source: Sandy River Basin Agreement Technical Team 2002.

Historically, the late wild Sandy coho salmon were thought to have been present in the Basin primarily from October through February, with peak spawning occurring in November through February (ODFW 2002). ODFW (1997) lists two possible factors for the possible shift in run timing of wild coho in the Sandy River Basin: inconsistent flow regimes at Marmot Dam throughout the late summer and early fall from the early 1900s through the early 1970s; and possible genetic introgression with early returning hatchery fish escaping to spawning grounds upstream of the Marmot Dam site.

Migration of natural-origin coho salmon into the upper Basin for spawning in run years 1999–2003 showed a peak in passage at Marmot Dam during October. The average passage per year in October was 405 adults. The corresponding figures for September and November were 132 and 153 adults, respectively. Peak spawning activity in the Sandy River Basin occurs in late October through November, with very few fish observed on the spawning grounds after December (ODFW 1997).

Duration of egg incubation and fry emergence of coho salmon is greatly affected by water temperature, but generally takes between two and three months (ODFW 1997). Emergence primarily occurs from February through April and peaks in March (PGE 2002). Following emergence, juvenile coho salmon typically seek stream margin habitats and backwater pools for initial rearing (ODFW 1997). As they continue to grow in size, juveniles seek low-velocity pool and off-channel habitats for summer and winter rearing. Juvenile coho favor slack water habitats with complex large woody debris for protection from winter freshets.

Juvenile coho in the Sandy River typically emigrate to the ocean as age-1+ smolts at about 12 to 14 months of age (ODFW 1997). The timing of juvenile coho outmigration is usually late March through June, peaking in April and May (ODFW 1990). Coho salmon in the Lower Columbia River ESU generally rear in the ocean for two summers and return as three year olds. The primary exception are “jacks,” sexually mature males that return to fresh water after spending one summer in the ocean (NMFS 2003).

Since coho salmon have only recently been listed in the Lower Columbia River ESU under the ESA, there is no WLC-TRT designation of populations as yet. Given the current low numbers of coho populations throughout the ESU, coho salmon viability will rely heavily on the natural populations in the Sandy and Clackamas rivers.

The LCRFRB designated the priority for contribution of this stock to meet recovery objectives in the ESU as “Primary.” This classification means the Sandy River coho stock could be targeted to achieve viable population levels with greater than 95 percent probability of persistence (negligible extinction risk) within 100 years (LCRFRB 2004).

Distribution

The SRBTT developed a completed list of the reaches in which each natural population of anadromous salmonids was known or assumed to spawn, either currently or historically (City of Portland 2004). After initial EDT model runs were completed in 2001, the SRBTT met again to review the results and reexamine spawning distribution in the Sandy River Basin. Based on this review, several spawning reaches were excluded for some species and added for others. This distribution information was used to develop Figures 5-32 and 5-33.

Current. Current coho salmon distribution in the Sandy River Basin is shown in Figure 5-32. The majority of suitable coho spawning and rearing habitat in the Sandy River is located upstream of the Marmot Dam site in the mainstem Sandy River, in the Salmon River and its tributaries below Final Falls, and in Still Creek (ODFW 1997; PGE 2002). Lower Basin tributaries that could support coho salmon include Cedar, Trout, Beaver, Gordon, and Buck creeks (ODFW 2002; Brown, pers. comm., 2004) and the Bull Run River. Natural production in the Bull Run River and in Cedar Creek is limited by blocked fish passage into the upper reaches of the streams. Additional small tributaries may support coho production in some years. Many of the coho entering lower Basin tributaries below the Marmot Dam site are likely strays from Sandy Hatchery (ODFW 1997).

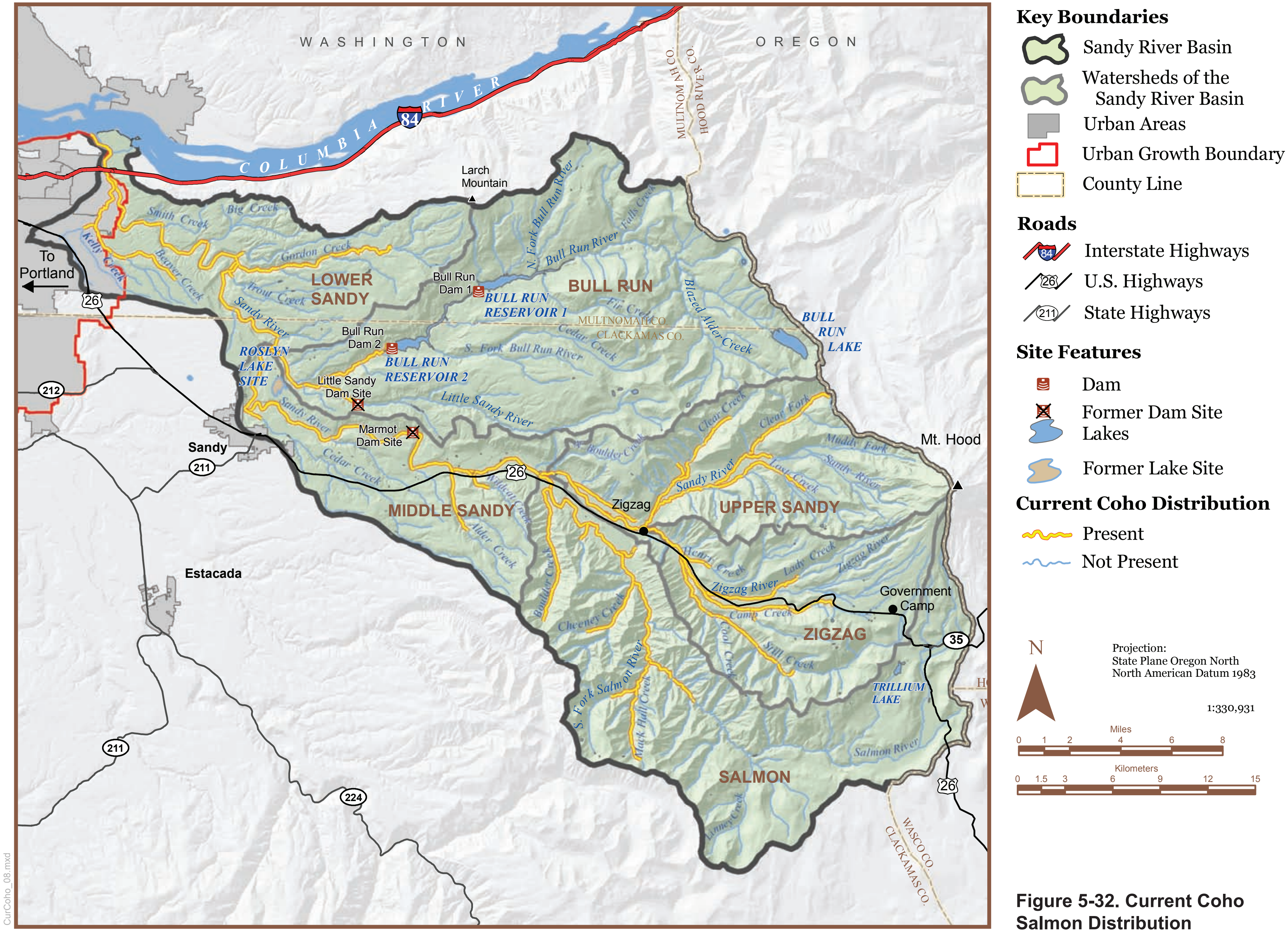


Figure 5-32. Current Coho Salmon Distribution

Historical. Historical coho salmon distribution assumed in the Sandy River Basin is shown in Figure 5-33. Historically, Sandy River Basin coho salmon likely spawned and reared in the majority of the Basin and its tributaries accessible to anadromous fishes. Similar to the current distribution, the major clear water tributaries above the Marmot Dam site (Salmon River, Boulder, Clear, Camp, Lost, and Still creeks, and Clear Fork) were likely important coho producers. Tributaries downstream of the Marmot Dam site were also likely important to coho production.

Anchor Habitat. The anchor habitat analysis—which is based on habitat that is currently accessible to anadromous fish conditions—found that the majority of the coho anchor habitat reaches are located in the upper Sandy River watershed upstream of the confluence of the Sandy and the Salmon rivers. One anchor habitat reach is on lower Gordon Creek, which is in the lower Sandy River watershed. The mainstem Salmon River up to Cheney Creek and the lower portions of Wee Burn, Sixes, and Cheney creeks are all anchor habitat reaches in the Salmon River watershed. A portion of Still Creek in the Zigzag River watershed and portions of Lost Creek and Clear Fork in the upper Sandy River watershed make up the remaining anchor habitat reaches for coho. The City considered the anchor habitat reaches for coho salmon when choosing offsite habitat conservation measures (see Chapter 7).

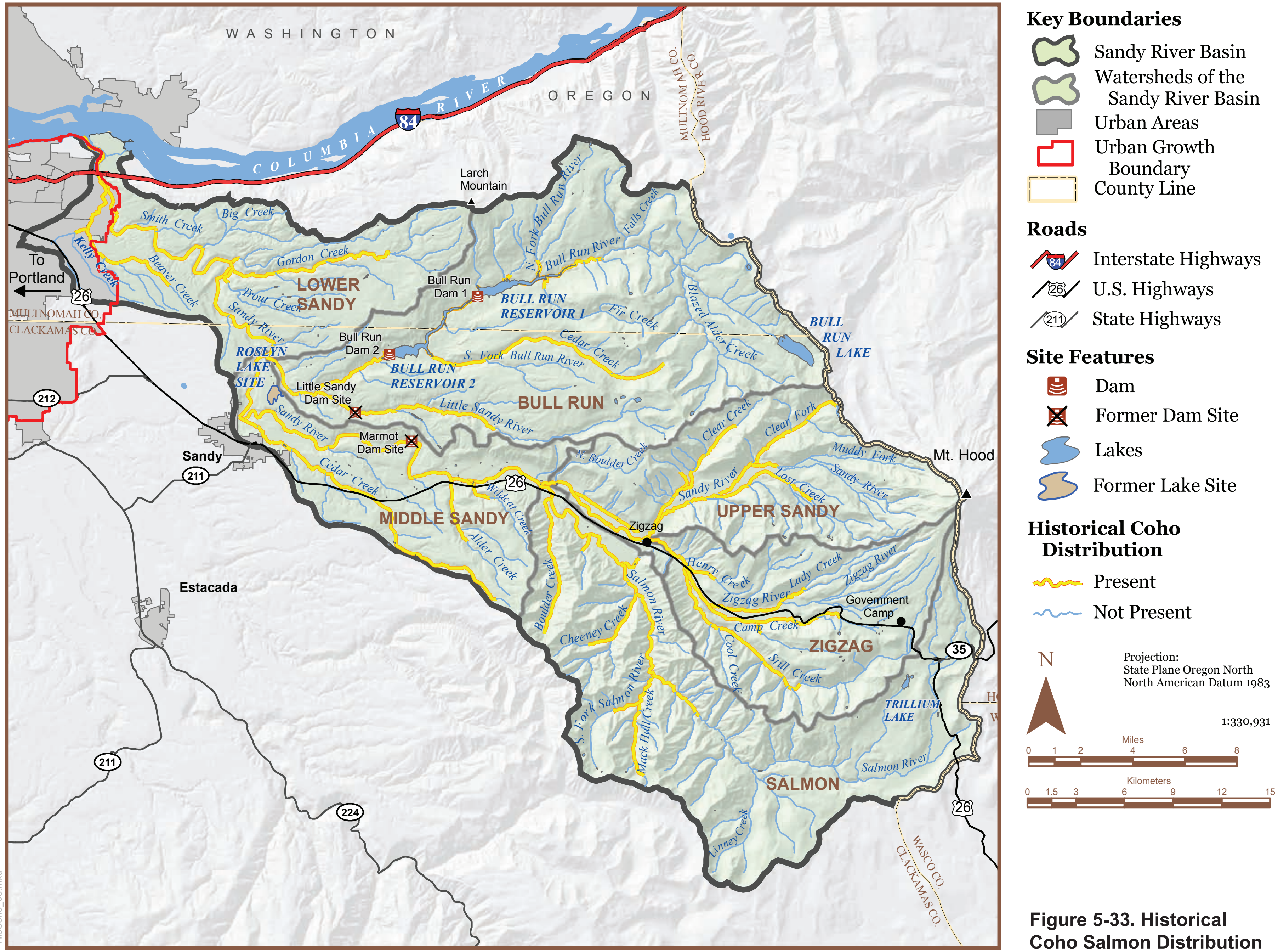


Figure 5-33. Historical Coho Salmon Distribution

Abundance

On an ESU-wide scale, over 90 percent of the Lower Columbia River historical coho populations appear to be either extirpated or nearly extirpated (Iwamoto et al. 2003). The natural origin Sandy and Clackamas river coho populations are believed to be depressed but stable. There are conflicting opinions concerning whether the current naturally produced coho in the Sandy River Basin are the same stock as the historical late run coho indigenous to the Basin. It is possible the historical wild stock of Sandy coho salmon has been extirpated (ODFW 1990; Weitkamp et al. 1995).

Hatchery supplementation of coho salmon above Marmot Dam occurred from the 1960s until the 1990s (ODFW 2001). The extent of historical straying of hatchery-produced coho salmon into the upper Basin spawning tributaries is largely unknown, but is believed to occur at very low levels (ODFW 1997). In November 1998, a trapping facility was created in the Marmot Dam fish ladder which resulted in sorting all fish prior to passage upstream. Record keeping began in 1999, including a complete breakdown of wild and hatchery fish. In run years 1999–2003, a total of 8 hatchery coho and 3,477 unmarked coho were recovered in the trap (0.2 percent hatchery stray rate).

Average recent population abundance of natural-origin spawners is best indicated by adult counts at Marmot Dam. In run years 1980–1989, escapement averaged 1,068 adults. However, sport fishery impacts above Marmot Dam were not recorded until 1988, when stream code segments were derived to differentiate between sport catch in the upper and lower portions of the Basin. In run years 1988 and 1989, only 15 fish were harvested in the upper Basin upstream of Marmot Dam.

Three estimates of coho salmon abundance in the upper Basin are graphically displayed in Figure 5-34. The highest, lowest, and average run sizes between 1990 and 1999 at Marmot Dam were 1,491, 116, and 585 adult fish, respectively. These estimates included hatchery and wild fish. By 1997, most direct harvest of wild coho salmon in the upper Sandy River Basin had been curtailed due to the implementation of marked selective fisheries for adipose-fin-clipped hatchery coho. As a result, sport fishery impacts to natural-origin spawners upstream of Marmot Dam in 1998 and 1999 were probably minimal. In run years 2000–2003, escapement averaged 831 adults and angling upstream of Marmot Dam was not allowed.

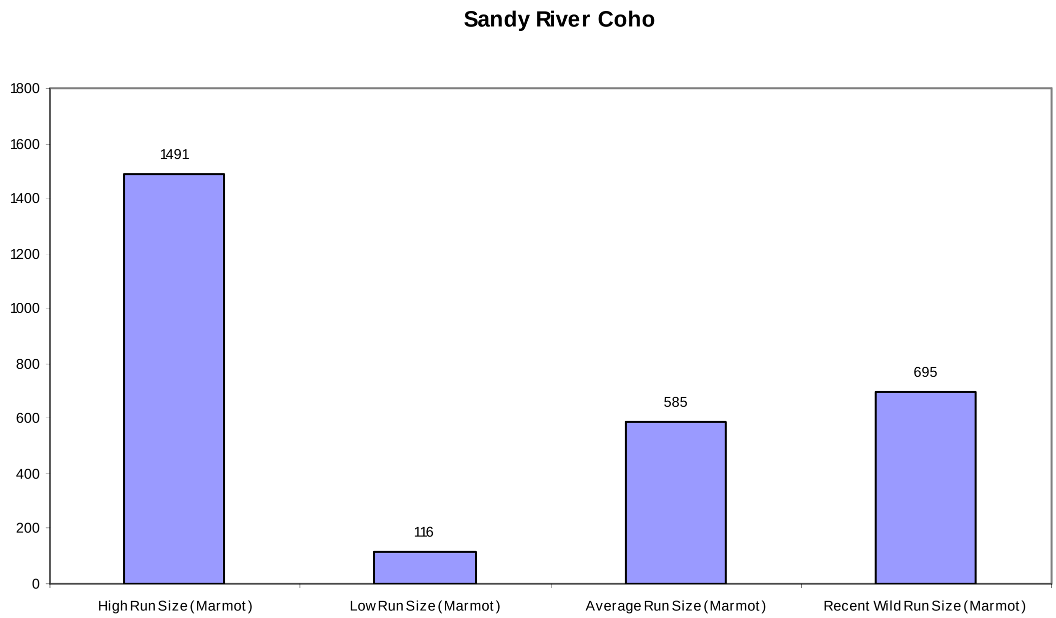


Figure 5-34. Estimates of Coho Salmon Abundance Upstream of Marmot Dam

Source: ODFW 2003a.

There are no Fisheries Management and Evaluation Plan or Critical/Viable abundance threshold criteria developed for coho salmon in the Lower Columbia River ESU. ODFW set an adult coho escapement goal at Marmot Dam of 1,100 adults (ODFW 1997). This goal was only achieved once in the 1990–1999 period. The objective in the Oregon Administrative Rules (OAR 635-500-3450) is to achieve a minimum five-year average spawning escapement of 1,100 wild coho salmon.

EDT estimates of adult coho production were also based on the same geographic point of reference used for the empirical abundance estimates in ODFW (2003a) and on the same harvest rate. EDT estimates of adult abundance included all spawning areas upstream of Marmot Dam. The estimates did not include production occurring from mainstem Sandy River reaches downstream of Marmot Dam or lower river tributaries.

EDT estimated current habitat conditions would support adult coho production above Marmot Dam at approximately 550 adult fish. The EDT estimate assumed a 50 percent harvest rate that reflects the average exploitation rate observed in the 1990s. EDT estimated that under fully restored freshwater conditions, coho adult returns above Marmot would be about 2,400 fish.

Marmot Dam counts of adult coho salmon have been quite variable. Table 5-4 shows the averages in multiple-year increments since 1990. The difference in adult counts during these time frames illustrates that adult run size back to the Basin is highly variable and is primarily the result of out-of-basin factors, such as ocean conditions. Regardless, the EDT estimates of adult coho production appear to fit the Marmot Dam count data quite well.

Table 5-4. Average Adult Escapement, 1990–2003

Time Period	Average Adult Escapement
1990–1995	691
1996–1999	180
2000–2003	831

Source: ODFW 2003a

Hatchery Production and Plantings

Current. Current coho salmon hatchery production in the Sandy River Basin takes place at the Sandy Hatchery located on Cedar Creek, a tributary to the lower Sandy River below the Marmot Dam site. The stock used is native to the Sandy River, and the annual release is 700,000 smolts (Bourne, pers. comm., 2004). To reduce the incidence of straying, all coho smolts released into the Sandy River are reared and acclimated at Cedar Creek.

Historical. Coho salmon hatchery supplementation began in the Sandy River Basin in 1898 at the Oregon Fish Commission Hatchery located on Boulder Creek in the Salmon River watershed (ODFW 1997). In 1912, a new hatchery was constructed in the lower Basin and began operation concurrently with the completion and operation of Marmot Dam. The Marmot Dam diversion canal was unscreened from 1912 to 1951, and managers believed a majority of fish released upstream of the diversion would likely have been diverted into Roslyn Lake and the Bull Run Hydroelectric Project. Coho salmon were intermittently intercepted during the 1912–1951 period when hatchery racks were placed in the river to satisfy various in- and out-of-basin egg-take needs. Records show coho salmon eggs collected at this facility declined from 500,000 in 1939 to less than 15,000 in 1945 (ODFW 1997). Beginning in 1950, smolt releases were directed to Cedar Creek and the Sandy Hatchery that began operations in 1951 (ODFW 1997). Preliminary annual releases of coho from the Sandy Hatchery were 250,000 smolts, but this amount increased steadily to one million smolts by the 1990s (PGE 2002; ODFW 1997).

Harvest in the Basin

Current. Harvest in the Sandy River Basin is now restricted to adipose-fin-clipped coho salmon of hatchery origin. Angling and harvest have been restricted to the lower Basin downstream of Marmot Dam since 1999, when a salmon and steelhead sanctuary was designated in the upper Basin. Recent harvest rates of natural-origin Sandy River coho salmon have declined to less than 20 percent for run years 1998–2001 (Iwamoto et al. 2003).

Sandy Hatchery coho make up a significant portion of recreational and commercial freshwater and ocean harvest in the Northwest. In 2001, the preliminary return of hatchery coho to the Columbia River Basin was 1,076,000 adults and 19,400 jacks (Watts 2003). In the 2001 Buoy 10 recreational fishery, anglers made 125,800 trips and caught 132,000 fin-clipped coho (Watts 2003). The 2001 Lower Columbia River recreational catch of hatchery coho upstream of Buoy 10 was 3,068 adults and 381 jacks, and an additional 425 unmarked coho were released (Watts 2003). The 2001 ocean recreational coho catch for the Columbia River

Catch Area was 39,200; the 2001 ocean coho troll harvest for the same area was 9,300 (Schindler 2003).

Historical. Hatchery production of coho salmon in the Lower Columbia River and tributaries increased in the late 1960s. Annual returns since the mass production of coho smolts in the 1960s have averaged nearly 500,000 coho annually (Watts 2003). From the late 1960s through the early 1990s, harvest rates sometimes reaching 90 to 100 percent of both hatchery and natural origin coho led to precipitous declines in wild coho populations in the Lower Columbia River and its tributaries (Iwamoto et al. 2003; Watts 2003).

Historical harvest of Sandy River natural origin coho was estimated to be in the range of 60 to 100 percent from 1977 through 1993 (Iwamoto et al. 2003). In the 12-year period from 1981 to 1992, sport anglers caught an estimated average of 1,263 coho annually in the Sandy River, for an interception rate of only 2.9 percent of all coho caught in recreational and commercial fisheries or that returned to the Sandy Hatchery (ODFW 1997). Table 5-5 shows the counts of recreational and commercial ocean fish harvests of Sandy Hatchery fish outside of the basin.

Table 5-5. Harvest of Sandy River Coho Outside of the Basin, 1981–1992

	Available Hatchery Fish	
Harvest Type	**Count**	**Percentage**
Recreational sport	10,695	24.3
Commercial ocean	19,170	43.5

Source: ODFW 1997.

Low levels of coho salmon escapement on an ESU-wide scale from 1993–1999 drastically reduced harvest opportunities in both ocean and freshwater fisheries. Coho ocean fisheries from Washington to California were closed in 1994 and were very limited in 1995 through 1999. Additionally, freshwater fisheries in 1993–1999 were limited as well. In 1994 and 1996, emergency closures were enacted on the Sandy River freshwater fishery that prohibited angling for coho salmon. Substantial reductions in commercial gill net fisheries in the Columbia River were also enacted, and current harvest is restricted to adipose-fin-clipped coho salmon.

Reasons for Listing/Threats to Survival

Three sources of information are available to help explain the reasons coho salmon have decreased in abundance in the Sandy River Basin: NMFS documents, ODFW reports, and EDT model results, as discussed below.

National Marine Fisheries Service. Four factors contributed to the decline of West Coast coho salmon populations (NMFS 1995): harvest, habitat degradation, artificial propagation, and adverse environmental conditions (primarily drought and poor ocean productivity). NMFS (1995) identified the following factors contributing to the decline of coho salmon in the Lower Columbia River ESU:

- habitat degradation from logging
- agricultural activities
- urbanization
- stream channelization
- dams
- water withdrawals and unscreened diversions
- competition and interbreeding with hatchery fish
- overharvest
- adverse ocean conditions over the last two decades
- inadequate regulatory mechanisms

Harvest has historically been very high on the Lower Columbia River coho salmon in both ocean and freshwater fisheries. Recent substantial reductions in natural origin coho harvest have not led to significant increases in coho salmon returns to the Lower Columbia River ESU. Habitat degradation has occurred as a result of logging, agricultural activities, urbanization, stream channelization, dam construction and operation, wetland reduction, and water withdrawals. Artificial propagation of coho salmon became very popular in the 1960s and continues today in the ESU. Adverse ocean conditions during the last two decades have led to poor marine survival and further depressed adult coho salmon returns to the ESU.

Oregon Department of Fish and Wildlife. The Sandy River Subbasin Salmon and Steelhead Production Plan (ODFW 1990) and Sandy Basin Management Plan (ODFW 1997) identified the following factors that reduced the production potential of native coho salmon in the Sandy River Basin:

- In the lower Basin tributaries (below the Marmot Dam site), coho production was limited by low summer flow, sedimentation, and high temperatures.
- Upper Basin coho production has been limited by constraints such as blocked passage, low pool-to-riffle ratio, lack of stream cover, channelization and loss of habitat diversity, lack of spawning gravel, and sedimentation in some of the upper tributaries. (Note: several of these passage barriers have since been corrected).
- The Basin has been stocked intensively with early-run coho for many years, probably to the detriment of the late-run native coho. Competition between naturally spawned and planted early-run juveniles may have affected the survival or growth of late-run juveniles.

The Bull Run water supply dams have also blocked passage to approximately 24 miles of historical coho spawning habitat in the upper Bull Run River watershed. Of this total spawning habitat, approximately nine miles have been inundated by the reservoirs, making it no longer suitable for coho spawning.

EDT Modeling. For the Sandy River Basin, EDT model estimated the primary limiting factors for coho to be the following:

- <u>Habitat diversity</u>. The primary losses of habitat diversity affecting coho in the Bull Run River watershed were assumed to be due to dam construction. The lower Sandy and Zigzag rivers have losses due to artificial confinement of the stream channels, loss of riparian function, and reductions in large woody debris.
- <u>Key habitat quantity</u>. Key habitat has decreased due to simplification of the stream channel, loss of large woody debris, increased confinement, and changes in low flow.

- <u>Channel stability</u>. The stream channel has become less stable in most of the Basin. Instability is caused by a loss in large woody debris, riparian function, and high streamflows.
- <u>Obstruction</u>. The dams in the Bull Run River and the weir in Cedar Creek have reduced coho salmon productivity.

Other minor limiting factors include changes in low flow (Bull Run and lower Sandy rivers), food (carcasses), sediment, and competition with hatchery fish released into the lower Sandy River (see Figure 5-35).

	Limiting Factors															
Geographic Area	Channel Stability	Chemicals	Competition (hatch)	Competition (other species)	Flow	Food	Habitat diversity	Hasassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Bull Run River	●				●	•	⬤		⬤				●	•		●
Columbia River			•				•				•	●				●
Lower Sandy River	●		•		●	•	⬤	•					●			●
Middle Sandy River	•				•	•	●		⬤				●			●
Upper Sandy River	•				•	•	●						•			•
Salmon River	•				•	•	●									●
Zigzag River	•				•		⬤						●			●

Figure 5-35. Limiting Factors for Coho Salmon in the Sandy River Basin[a,b]

Percentage change from historical conditions	Worse
Less than 1%	
Between 1 and 5%	•
Between 5 and 20%	●
More than 20%	⬤

Source: EDT model run 10/20/06.

[a]Appendix D provides definitions of the limiting factors (level 3 survival factors) and the habitat attributes (level 2 environmental attributes) and a matrix showing the relationship between them.

[b]The habitat attributes are also used in Chapter 8 and Appendix E to define the reference condition for the habitat benefits that arise from the City's HCP measures.

Coho in the Bull Run Watershed

Distribution

Coho salmon have access to about 7.5 stream miles of stream habitat in the Bull Run River watershed. Of this total, approximately 5.8 miles occur in the lower Bull Run River downstream of the Headworks, with an additional 1.7 miles in the Little Sandy River. Figure 5-36 shows the estimated periods of occurrence for coho salmon in the lower Bull Run River.

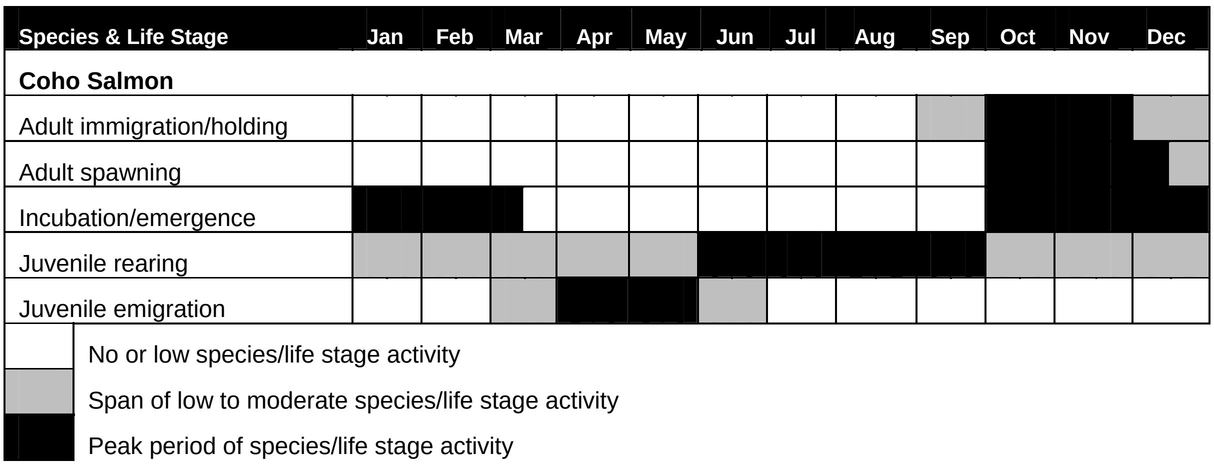


Figure 5-36. Estimated Periods of Occurrence for Coho in the Lower Bull Run River

Source: Sandy River Basin Agreement Technical Team 2002.

Table 5-6 summarizes the river segments and historical distribution of coho in the Bull Run watershed. Figure 5-33 on page 5-64 shows historical coho distribution throughout the Sandy River Basin.

Table 5-6. Historical Distribution of Coho in the Bull Run Watershed

River Segment	River Miles
Lower Bull Run River	
Bull Run River (mouth to Dam 2 spillway weir)	5.8
Walker Creek	0.15
Little Sandy River (mouth to Little Sandy Dam site)	1.7
Little Sandy River (Little Sandy Dam site to middle waterfalls)	5.6
Upper Bull Run River	
Bull Run River (Dam 2 spillway weir up through reservoirs)	9.2
Bull Run River (free-flowing river to waterfall at RM 16.3)	1.3
South Fork Bull Run River	2.7
Cedar Creek (tributary to South Fork Bull Run River)	8.1

Source: USFS, 1999

Photo courtesy of Bonneville Power Administration.

Fish access is blocked by dams and culverts in the Bull Run watershed. Fish passage is blocked at RM 5.8 on the lower Bull Run River and has been blocked at RM 1.7 of the Little Sandy River. Other tributaries to the lower Bull Run River have limited productivity potential for anadromous fish because of steep gradients or natural waterfalls (City of Portland 2002). Additionally, a culvert barrier at the mouth of Walker Creek blocks access to about 800 feet of this Bull Run tributary (City of Portland 2002).

A few adult coho have been sighted during weekly adult fish spawning counts in the mainstem Bull Run up to approximately a mile above the Little Sandy River confluence. However, juvenile coho have seldom been observed in the lower Bull Run River.

Abundance

Under current habitat conditions and access limitations, the EDT model estimates that the habitat in the lower Bull Run and Little Sandy rivers could produce 1 and 382 adult coho salmon, respectively. The low abundance estimates reflect habitat conditions in these two rivers. The rivers are highly confined, relatively steep, and dominated by bedrock and large cobble gravel substrates, conditions not favored by coho salmon. Historical juvenile abundance was estimated through modeling at fewer than 10,000 fish.

These EDT estimates of current coho production are supported by recent observations for the lower Bull Run River. For surveys completed in the late 1990s and recently in 2005, fewer than five adult coho per year have been seen.

Habitat Conditions

The habitat conditions described for Chinook and steelhead also have similar effects on coho salmon for the lower Bull Run River. The City has been studying the aquatic habitat of the lower Bull Run River since the mid-1990s and those studies have focused on current habitat conditions and use by anadromous species. The various studies (Clearwater BioStudies 1997;

R2 Resources Consultants 1998a, b; Beak 1999, 2000a) indicated that the following key environmental factors may have affected the abundance and productivity of coho in the lower Bull Run River:

- Dams and culverts block access to potential upstream spawning habitat.
- High water temperatures during summer may affect coho juvenile growth and survival.
- High water temperatures may affect spawning in early October.
- Sustained summer low flows may reduce the amount of instream habitat suitable for use by juvenile coho.
- Gravel in the lower river suitable for spawning and construction of redds is lacking or absent.
- Rapid, short-term flow fluctuations during spring may cause stranding or displacement of coho fry.

Limiting Factors

The City used the EDT model to determine the limiting factors affecting coho salmon production throughout the historical range for the fish in the Bull Run River watershed. However, coho cannot travel upstream of reach Bull Run 4 and Little Sandy 1 due to the dams. Reach-specific results for coho in the Bull Run River watershed are summarized in Figure 5-37.

	Life Stage Most Affected													Limiting Factor															
	Spawning	Egg incubation	Fry colonization	0-age migrant	0-age active rearing	0,1-age inactive	1-age migrant	1-age active rearing	2+-age active rearing	2+-age migrant	2+-age transient rearing	Prespawning migrant	Prespawning holding	Channel stability	Chemicals	Competition (w/hatch)	Competition (other species)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Bull Run Bear 1		2	1			3								●			•	⬤	⬤	⬤									◯◯
Bull Run Camp 1		3	1		2									●		•	•	●	⬤	⬤							•		◯◯
Bull Run Dam 1				3			2					1										⬤⬤							
Bull Run Dam 2				3			2					1										⬤⬤							
Bull Run Spillway Weir			3				2					1										⬤⬤							
Bull Run 1		1	3		2									⬤⬤				•	●	•						•	⬤		⬤
Bull Run 2		1			2	3								⬤⬤				⬤	•	●							⬤⬤		•
Bull Run 3	3	1			2									⬤⬤				⬤	●	∘							⬤⬤		◯◯
Bull Run 4		3			1	2								●		•		●	●	⬤⬤							⬤		○
Bull Run 5			3			2						1										⬤⬤							
Bull Run 6					2	1	3							•		•		•	●	⬤⬤						⬤	•		◯◯
Bull Run 6a			3		1	2								•		•	•	•	●	⬤⬤							•		◯◯
Bull Run 7			1		2														●										
Cougar 1			2		3	1								•		•		●	●	⬤									◯◯
Cougar 2						1	3	2						•				•	•	•									
Deer 1		3	1										2	●			•	⬤	⬤	⬤									◯
Deer 2	1	2	3																										⬤⬤
Fir 1			1		2	3													•										
Little Sandy 1		3	2		1									•				•	•	⬤									⬤
Little Sandy 2																			•										
N.F. Bull Run 1		3	1		2									●		•	•	●	⬤	⬤⬤									◯◯
N.F. Bull Run 2	3	2	1											•				●	●	⬤									◯
SF Bull Run 1			1	3	2									●		•	•	⬤	⬤	⬤⬤						⬤			◯◯
S.F. Bull Run 2			2		1														●										

Figure 5-37. Limiting Factors for Coho Salmon in the Bull Run River Watershed[a,b]

Percentage change from historical conditions	Worse	Better
Less than 0.2 %		
Between 1.0 and 0.2%	•	∘
Between 5 and 1%	●	○
Between 25 and 5%	⬤	◯
More than 25%	⬤⬤	◯◯

Source: EDT model run 10/20/05

[a]Appendix D provides definitions of the limiting factors (level 3 survival factors) and the habitat attributes (level 2 environmental attributes) and a matrix showing the relationship between them.

[a]Bull Run reaches 5 and higher are the reaches at or above the Dam 2 diversion pool and include the reservoirs. The limiting factors in this figure for Bull Run reaches 5 and above are primarily the results of inundation of the Bull Run River by the reservoirs.

Ten of the 16 limiting factors affect coho survival among the reaches in the watershed. Of these, channel stability, flow, food, habitat diversity, obstructions, sediment load, temperature, and key habitat quantity have a high effect in depressing productivity in all but five (Bull Run 7, Cougar 2, Fir 1, Little Sandy 2, and South Fork Bull Run 2) of the 24 reaches analyzed by EDT for coho salmon.

Flow and Steelhead Habitat Preferences

Because City operations in the Bull Run divert flow from the watershed, and that effect is a focus of this HCP, additional information on the relationship between streamflow and fish habitat preferences is provided below for steelhead.

Spawning Flow-Habitat Relationships. Figure 5-38 shows the relationship between total usable habitat and flow for spawning salmonids in the lower Bull Run River between Dam 2 (approximately RM 5.8) and PGE's powerhouse at RM 1.5. These relationships are applicable to Chinook salmon, steelhead, and coho salmon.

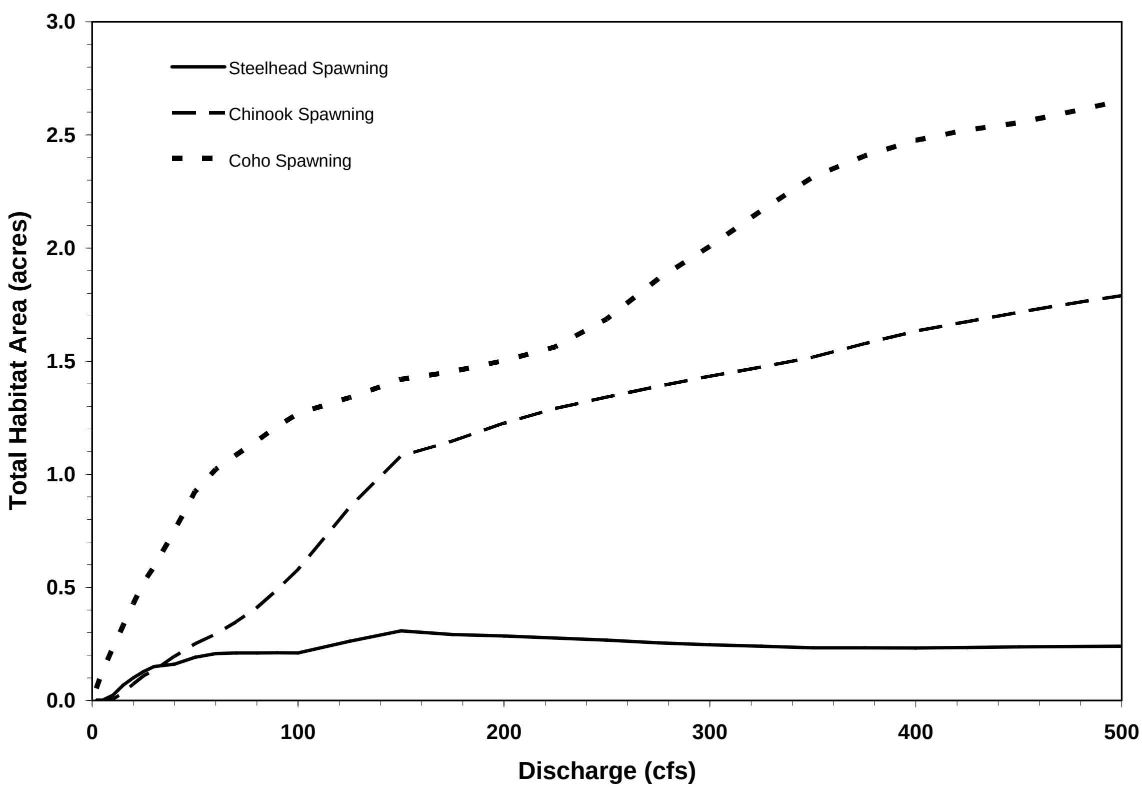


Figure 5-38. Relationship Between Flows in the Lower Bull Run River and Available Spawning Habitat for Chinook, Coho Salmon, and Steelhead

Source: R2 Resource Consultants 1998a.

Within the flow range modeled (0–500 cfs), the relationship for coho indicates that spawning habitat increases with increasing discharge.

Juvenile Rearing Flow-Habitat Relationships. Figure 5-39 shows the relationship between total usable habitat and flow for rearing juvenile coho in the lower Bull Run River.

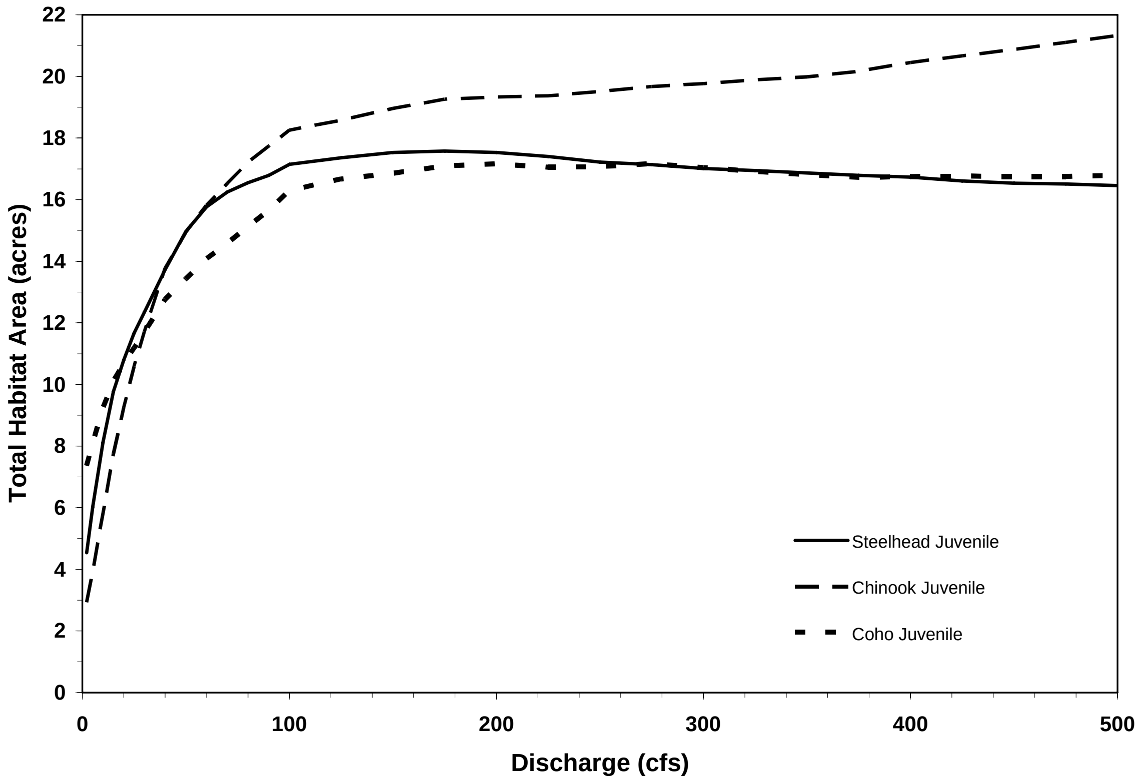


Figure 5-39. Relationship between Total Usable Habitat and Flow for Rearing Juvenile Coho in the Lower Bull Run River

Source: R2 Resource Consultants 1998a.

Results of PHABSIM modeling indicate that habitat conditions for juvenile coho increase at a rapid rate between 0 and 100 cfs, with most of the rapid increase occurring between 0 and 20 cfs (R2 Resource Consultants 1998a). Habitat conditions for juvenile salmonids become near constant at flows above 100 cfs.

The results of the PHABSIM modeling are expressed as weighted usable area (WUA), an index of available instream habitat at various increments of flow. R2 Resources Consultants estimated WUA for a number of flows in various reaches of the lower Bull Run River by (1998a) using the PHABSIM model. The WUA estimates for each species are shown in Chapter 8, Effects of the HCP.

5.4.2 The Other Covered Fish Species

Chum Salmon

Approximately 90 percent of the historical population in the Columbia River chum ESU is extirpated or nearly so (Good et al. 2005). Recently, the abundance of natural spawners has increased substantially at several locations in the ESU. The cause of the increase is unknown. However, long- and short-term productivity trends for the ESU populations are at or below replacement levels.

In Oregon, chum salmon are found in the Columbia River and along the coast as far south as the Coquille River (Kostow 1995). Historically, annual Columbia River harvest of chum reached 500,000 fish (ODFW 2005). Today, chum salmon populations are extinct in the Oregon tributaries to the Columbia, including the Sandy River. It is believed that the few fish observed in Oregon are strays from runs that return to the Washington tributaries of the lower Columbia River. The populations that remain in Multnomah County are low in abundance and have limited distribution.

Life History and Diversity

Salo (1991) reported that chum salmon migrate upstream during October and November, and spawning can continue into December (Cooney and Jacobs 1994). In general, upstream chum migration can occur quickly, with transport rates of 30 miles per day. The length of embryo incubation is influenced primarily by water temperature. For example, eggs at 15 °C hatch approximately 100 days before eggs incubated at 4 °C. Health of the emergent chum fry, as with the other salmonid fish species, also depends on dissolved oxygen, gravel composition, spawner density, stream discharge, and genetic characteristics (Salo 1991).

Juvenile chum salmon rear in fresh water for a period of a few days to several weeks before migrating downstream to saltwater (Grette and Salo 1986). In Washington, downstream chum salmon migration occurs from late January to May (Johnson et al. 1997). Chum outmigration is associated with increasing day length and warming of estuarine waters. Juvenile chum have longer rearing times in estuaries than most salmon, and estuarine survival appears to play a major role in determining subsequent adult return to fresh water (Johnson et al. 1997). Simenstad et al. (1982) found chum salmon generally moved offshore at a size of between 50 and 160 millimeters (mm) (2 to 6 inches) fork length. Chum salmon mature anywhere between two and six years of age (Salo 1991).

Juvenile chum salmon migrate from fresh water shortly after emergence and rear primarily in estuarine waters for a period of up to several months. Fry may remain near the mouth of their natal river after entering the estuary or may disperse rapidly throughout the estuarine system into tidal creeks and sloughs (Johnson et al. 1997).

Chum salmon are reported to spawn in shallow, slow-velocity streams and side channels (Johnson et. al. 1997). Preferred spawning areas include groundwater-fed streams or at the head of riffles (Grette and Salo 1986). Groundwater upwelling is important to redd site selection (Johnson et al. 1997).

Distribution

There is no information on the current or historical distribution of chum salmon in the Sandy River Basin. The few fish that have been observed are believed to be strays from the Washington streams in the Columbia River ESU.

The City assumes that, historically, chum salmon may have been distributed in the lower part of the Sandy River Basin, and perhaps the lower end of Beaver Creek. Chum frequently spawn in tidal areas and show limited ability to surmount migration obstacles.

Abundance and Productivity

No data were available on the Sandy River chum salmon population. The Sandy population is now extinct (ODFW 2005).

Hatchery Production and Plantings

There are three chum salmon artificial production programs considered to be part of the Lower Columbia River ESU (NMFS 2005). They are conservation programs that have been designed to support natural production. The Washougal Hatchery program provides fish for reintroduction into the recently restored habitat in Duncan Creek, Washington. The other two hatchery programs are designed to augment natural production in the Grays River and the Chinook River in Washington. These two programs are relatively new, with the first hatchery chum returning in 2002.

Harvest in the Basin

No data exist on the current or historical harvest of chum salmon in the Sandy River Basin. Almost all of the harvest probably occurred outside of the Sandy River Basin because chum salmon arrive on the spawning grounds in an advanced state of sexual development. Chum salmon are not considered a sport fish, and they are not sought after by anglers.

Reasons for Decline/Threats to Survival

Johnson et al. (1997) listed variations in the freshwater and ocean environment, and artificial propagation as contributing to fluctuations in chum population abundance. Kostow (1995) reported chum salmon spawning habitat in Oregon has been affected by gravel mining operations, channelization, and siltation associated with road construction and logging. Kostow also notes that losses and degradation of estuarine habitats have likely had a large affect on chum salmon populations.

Eulachon

Eulachon (smelt) are endemic to the eastern Pacific Ocean ranging from northern California to southwest Alaska and into the southeastern Bering Sea. Eulachon occur only on the coast of northwestern North America, from northern California to southwestern Alaska. In the portion of the species' range that lies south of the U.S.-Canada border, most eulachon production originates in the Columbia River Basin.

In 1999, NMFS received a petition to list the Columbia River populations of eulachon as an endangered or threatened species and to designate critical habitat under the ESA. NMFS determined that the petition did not present enough substantial evidence to warrant the listing (64 FR 66601). In 2007, NMFS received a petition from the Cowlitz Indian Tribe to list southern eulachon (populations in Washington, Oregon, and California) as a threatened or endangered species under the ESA. After reviewing the information contained in the petition and other information, NMFS determined that the petition presented substantial scientific and commercial information indicating that the petitioned action may be warranted. NMFS commenced a review of the status of the species and will make a determination as to whether the petition action is warranted (73 FR 13185). The current status of eulachon is as a candidate species.

Life History and Diversity

Within the Columbia River Basin, the major and most consistent spawning runs occur in the mainstem of the Columbia River (from just upstream of the estuary, river mile (RM) 25 to immediately downstream of Bonneville Dam at RM 146). Periodic spawning occurs in the Grays, Skamokawa, Elochoman, Kalama, Lewis, Cowlitz, and Sandy rivers (Emmett *et al*. 1991, Musick *et al*. 2000). In the Columbia River and its tributaries, spawning usually begins in January or February (Beacham *et al.* 2005).

Eulachon are anadromous fish that spawn in the lower reaches of rivers in early spring. They typically spend three to five years in saltwater before returning to freshwater to spawn from late winter through mid-spring. Spawning occurs over sand or coarse gravel substrates, eggs are fertilized in the water column, sink, and adhere to the river bottom. Most adults die after spawning, and eggs hatch in 20 to 40 days. The larvae are carried downstream and are dispersed by estuarine and ocean currents shortly after hatching. Runs tend to be erratic, appearing in some years but not others, and appearing only rarely in some river systems (Hinrichsen 1998).

Eulachon are important in the food web as a prey species (Alaska Department of Fish and Game 1994). Newly hatched and juvenile eulachon are food for a variety of larger marine fish such as salmon and for marine mammals including seals, sea lions, and beluga whales. Spawned-out eulachon are eaten by gulls, eagles, bears, and sturgeon.

Although eulachon abundance exhibits considerable year-to-year variability, nearly all spawning runs from California to Alaska have declined in the past 20 years (Hay and McCarter 2000). From 1938 to 1992, the median commercial catch of eulachon in the Columbia River was 1.9 million pounds. From 1993 to 2006, the median catch had declined to approximately 43,000 pounds.

Distribution

There is no information on the current or historical distribution of eulachon in the Sandy River Basin. Spawning runs typically occurred within the first few miles of the Sandy River, perhaps up to the lower end of Beaver Creek.

Abundance and Productivity

No data were available on the Sandy River eulachon population.

Harvest in the Basin

No data exist on the current or historical harvest of eulachon in the Sandy River Basin. A tribal and sport fishery occurs when smelt runs occur, and the Oregon Department of Fish and Wildlife allows a sport (limit of 25 pounds per day) and commercial harvest of eulachon below the I-84 bridge in Troutdale. The commercial harvest is exported to places like Sea World in San Diego to feed the marine mammals.

Reasons for Decline/Threats to Survival

Eulachon spawning runs have declined in the past 20 years, especially since the mid-1990s (Hay and McCarter 2000). The cause of these declines remains uncertain. Eulachon are caught as bycatch during shrimp fishing, but in most areas the total bycatch is small (Beacham et al. 2005). Predation by pinnipeds and sturgeon may be substantial, and other risk factors could include global climate change, blocked passage, and deterioration of marine and freshwater conditions.

5.4.3. Other Fish Species Addressed in the HCP

In addition to the covered species, five other fish species will benefit from this HCP: rainbow trout, cutthroat trout, Pacific lamprey, western brook lamprey, and river lamprey. The following subsections provide information on each species' life history and diversity, distribution, abundance and productivity, hatchery production and plantings, its harvest in the Sandy River Basin, and reasons for its decline or threats to its survival. The information available for each species varies. EDT modeling data and results are not provided for these species.

Rainbow Trout

Rainbow trout is the same species as winter steelhead. The City assumes that habitat preferences for rainbow in the lower Bull Run watershed and the Sandy River Basin are the same as for steelhead. Rainbow trout are also found in Bull Run Reservoir 1, and their habitat preferences should be similar to those described below for cutthroat trout.

Cutthroat Trout

Life History and Diversity

Coastal cutthroat trout (*O. clarki clarki*) are native to the Sandy River Basin and exhibit a wide range of life history characteristics, depending on their location in the watershed. Sandy River Basin coastal cutthroat trout belong to the Southwest Washington/Columbia River distinct population segment, which contains all populations from Grays Harbor (Washington) in the north, south to the Columbia River, and east to the Klickitat River (Washington) and Fifteen Mile Creek (Oregon) (Johnson et al. 1999; PGE 2002).

There are four documented life-history expressions: resident, fluvial, adfluvial, and anadromous. Resident natural cutthroat trout (nonmigratory) exist in small headwater streams, commonly above natural passage barriers to anadromous salmonids, and they rarely venture far from where they hatch. Fluvial cutthroat trout reside in mainstems of large rivers and migrate into small tributaries for spawning and occasional protection from high winter flows. Adfluvial cutthroat trout reside in lakes and migrate to tributaries to spawn. Anadromous (sea-run) cutthroat trout migrate to estuaries and the ocean as juveniles usually for less than one year, before returning to fresh water to spawn.

Reentry of anadromous fish into large freshwater river systems in Washington and Oregon for spawning migrations usually begins as early as June, continuing through October, and peaking in late September and October (Johnson et al. 1999). Estimated periods of occurrence of anadromous cutthroat trout life stages in the lower portion of the Sandy River Basin (below the Marmot Dam site) are shown in Figure 5-40. Anadromous cutthroat trout are assumed not to be present in the upper portion of the Sandy River Basin (above the Marmot Dam site) because no large cutthroat have been counted passing Marmot Dam since 1977, when counting facilities became available (Hooten 1997).

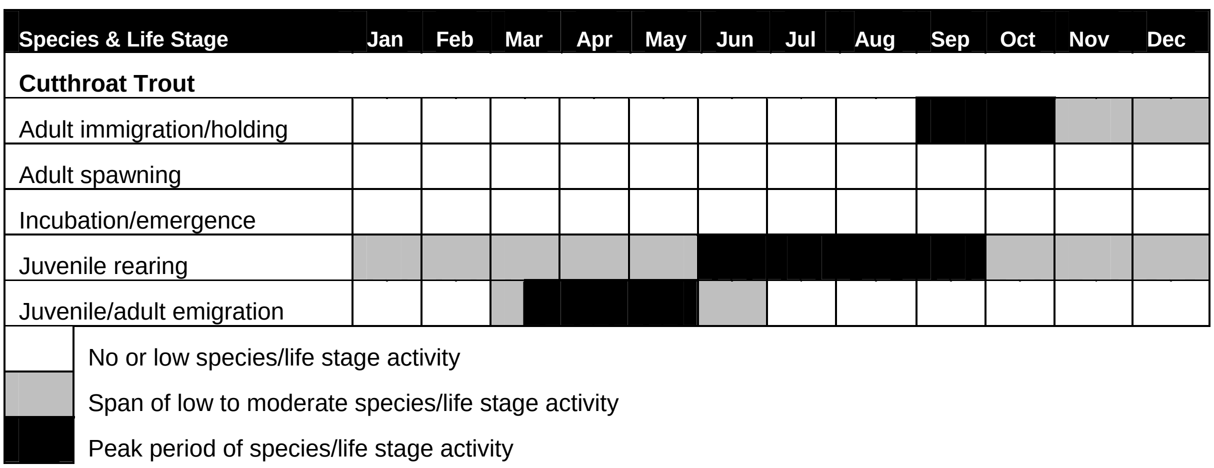


Figure 5-40. Estimated Periods of Occurrence for Cutthroat in the Lower Sandy River Basin Below Marmot Dam

Source: Sandy River Basin Agreement Technical Team 2002.

Generally, coastal cutthroat trout exhibit a wide range of variation in age and size at sexual maturity. Resident, fluvial, and adfluvial coastal cutthroat trout typically mature between two and three years, while anadromous life forms rarely spawn before age four (Johnson et al. 1999).

Coastal cutthroat trout spawning periods vary from late winter to summer, depending on life-history type. Female cutthroat trout commonly lay between 200 to 4,000 eggs in gravel redds (ODFW 1997). Eggs typically hatch within four to eight weeks, depending on water temperature, and fry spend one to two weeks in the gravel before emerging. Resident cutthroat trout remain in their natal streams as juveniles and adults. Fluvial and adfluvial cutthroat trout remain in their natal streams for up to a year before migrating to other streams, rivers, or lakes. Juvenile sea-run cutthroat trout usually migrate to lower reaches of streams in their first year. These smolts then migrate downstream to estuaries as early as one year old, but more commonly when they are between two and four years old (Johnson et al. 1999).

Distribution

Current. Resident cutthroat trout are widely distributed in the Sandy River Basin, but anadromous migratory cutthroat trout behavior and distribution in the Sandy River Basin are poorly documented and understood. Cutthroat trout generally prefer small tributary streams for spawning and rearing (PGE 2002). Resident cutthroat trout populations likely occur in most tributary streams of both the lower and upper portions of the Basin (ODFW 1997). Based on recent counts at Marmot Dam, it is assumed that no anadromous cutthroat trout currently migrate into the upper Basin. Isolated populations of resident cutthroat trout above natural and anthropogenic passage barriers represent an important genetic resource to individual and basin-wide populations. A genetically distinct population of adfluvial cutthroat trout still exists in Bull Run Lake and Bull Run Reservoir 2 (ODFW 1997).

Historical. Historically, resident and migratory cutthroat trout were likely present in most reaches of the Sandy River Basin, where they were not excluded as a result of competition with other salmonid fishes. Cutthroat trout typically have a low position in the competitive hierarchy compared to other salmonid fishes (PGE 2002). They often occupy similar habitat to steelhead trout but are at a competitive disadvantage. Tributary reaches used by sea-run cutthroat trout for spawning are often located upstream of those used by coho salmon and steelhead trout. Historically, sea-run cutthroat trout were documented as migrating into the Sandy River from late summer through fall and using small tributaries for spawning (ODFW 1997). It is unknown how far into the upper Basin sea-run cutthroat trout migrated, but the fish likely utilized lower Basin tributaries. It is not known if sea-run populations were able to ascend the falls at Larson’s Bridge at RM 4.3 on the Bull Run River to access the upper reaches of the Bull Run watershed.

Abundance and Productivity

Data on the abundance of coastal cutthroat trout populations in the Sandy River Basin are very limited. Resident cutthroat trout populations are thought to be healthy in the upper Salmon River above Final Falls (~RM 14) and in Bull Run Reservoir 2. Populations located in remote reaches of the Basin are likely healthier than populations accessible to anglers. As recently as the 1970s, sea-run cutthroat trout were documented in small numbers (a few dozen) at the Sandy Hatchery weir and fish trap on Cedar Creek, but their recent presence has been very rare (ODFW 2002; ODFW 1997). Johnson et al. (1999) believed a dramatic decline in anadromous coastal cutthroat populations occurred across the distinct population segment, and the Sandy River Basin population is one of two on the brink of extinction.

Hatchery Production and Plantings

Current. Hatchery trout (cutthroat or rainbow) have not been released into the Sandy River Basin since 1994.

Historical. There are no reports of cutthroat trout releases into flowing waters of the Sandy River Basin. However, hatchery cutthroat trout were released into Mirror Lake.

Since the 1940s, rainbow trout have been released into upper Basin tributaries, primarily in Still Creek, Lost Creek, Camp Creek, Salmon River, and upper Sandy River (ODFW 1997). Three primary release sites were established in the upper Sandy River Basin from 1979 until stocking was discontinued in 1994: Salmon River, Lost Creek, and Camp Creek (ODFW 1997).

Photo courtesy of Burke Strobel.

Rainbow trout hatchery releases are noteworthy because cutthroat trout typically exhibit a high incidence of hybridization with rainbow trout (PGE 2002; Johnson et al. 1999). Hybridization of rainbow trout and cutthroat trout has also occurred in Bull Run Reservoir 1.

Harvest in the Basin

Current. Trout fishing in all flowing waters on the Oregon side of the distinct population segment is restricted to a late May to October 31 season. Catch-and-release restrictions have been put in place, and only artificial lures are permitted as terminal tackle. These regulations have resulted in reduced angling effort and provided protection for remaining populations of coastal cutthroat trout.

Historical. Because of their opportunistic, aggressive nature, cutthroat trout are susceptible to overexploitation, especially when they are confined to small streams. Historical harvest data concerning coastal cutthroat trout in the Sandy River Basin are extremely limited. Prior to 1995, liberal gear restrictions, trout seasons, and catch limits were in effect throughout much of the Sandy River Basin. Anecdotal information from old angler reports suggests that sea-run cutthroat trout once provided a significant fishery in the Sandy River (ODFW 1997).

Reasons for Decline/Threats to Survival

NMFS and USFWS identified the following factors as contributing to the decline of coastal cutthroat trout in the Southwest Washington/Columbia River DPS (NMFS and USFWS 1999):

- Habitat degradation from logging and other land management activities
- Degradation of estuarine habitats; recreational fishing and incidental catch
- Disease
- Negative effects of hatchery programs
- Inadequate regulatory mechanisms

Specific information about the decline of cutthroat trout in the Sandy River Basin is lacking. ODFW (1997) implied cutthroat trout populations may have been overharvested by angling, especially in the lower elevation reaches. The agency also suggested both instream and riparian habitat quality has been altered in several miles of the Salmon, Zigzag, and Upper Sandy rivers, and channelization activity likely removed significant low-velocity rearing habitat favored by cutthroat. Downstream of the Marmot Dam site, cutthroat trout have been affected by constructed barriers that have blocked significant portions of spawning and rearing habitat. Passage for trout migrants may have been affected in Beaver, Buck, Gordon, and Cedar creeks, and the Bull Run and Little Sandy rivers.

Figure 5-41 shows the estimated periods of occurrence for cutthroat trout in the Bull Run River.

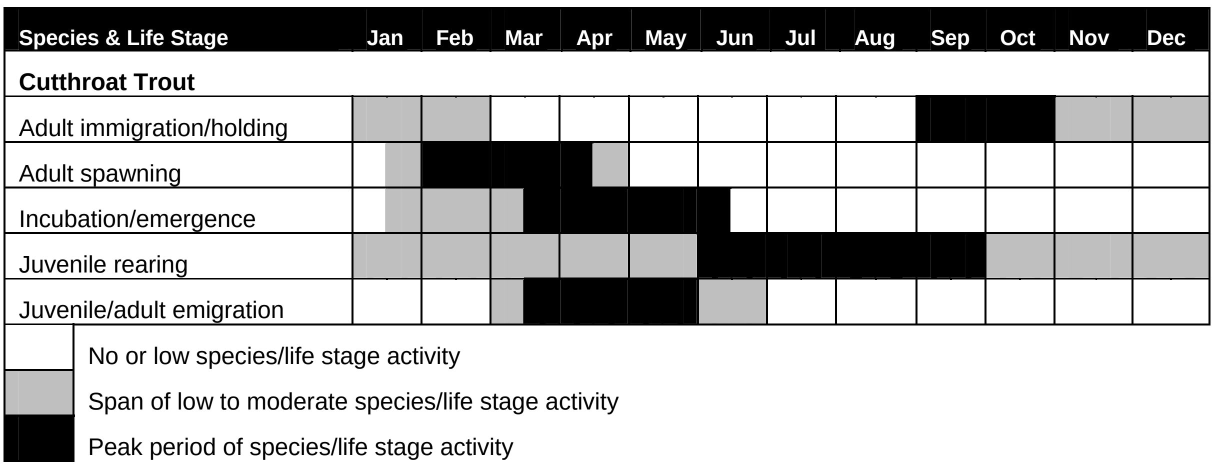


Figure 5-41. Estimated Periods of Occurrence for Cutthroat in the Bull Run River
Source: Sandy River Basin Agreement Technical Team 2002.

Pacific Lamprey

Pacific lamprey (*Lampetra tridentata)* are widely distributed throughout the North Pacific from Hokkaido Island, Japan, north and east to Alaska and south in North America to the Rio Santo Domingo in Baja California (Moyle 2002). They occur throughout coastal rivers and streams in Oregon and throughout the Columbia River Basin (Kostow 2002). Pacific lamprey are present in the Sandy River Basin (Strobel, pers. comm. 2006).

Life History and Diversity

Pacific lamprey are an anadromous and parasitic species. The parasitic phase is restricted to the marine environment, in which lamprey can attach to large fish and marine mammals. Adult lamprey leave the ocean to spawn in freshwater streams (Wydoski and Whitney 1979). Adult Pacific lamprey migrate upstream in July to October. They overwinter in fresh water and spawn from February through May in Oregon (Kostow 2002) when water temperatures are between 10 °C and 15 °C (Close et al. 1995). Both sexes construct a shallow nest in the stream gravel (Morrow 1976). Flowing water (1.6—3.3 feet per second [fps]) in low-gradient sections is preferred for spawning (Close et al. 1995). After preparation of the nest, the female attaches herself to a rock with her oral sucker and the male attaches to the head of the female. The male and female coil together while the eggs and sperm are released. The fertilized eggs adhere to the downstream portion of the nest (Moyle 1976) and then the adults cover the eggs with gravel. The process is repeated several times in the same nest site.

Spawning Pacific lamprey are often observed during steelhead spawning surveys, and they spawn in similar habitat (Jackson et al. 1996; Foley 1998). It is thought Pacific lamprey die after spawning, but a recent ODFW report documents observation of outmigrating lamprey and evidence of repeat spawning (Kostow 2002).

Juvenile Pacific lamprey, termed ammocoetes, swim up from the nest and are washed downstream, where they burrow into mud or sand to feed by filtering organic matter and algae (Moyle 1976). The ammocoetes generally remain buried in the substrate for five or six years, moving from site to site (Wydoski and Whitney 1979). Such an extended freshwater residence makes ammocoetes especially vulnerable to degraded stream and water quality conditions, including bedload disturbances. Larval lamprey transform to juveniles from July through October (Close et al. 1995). During this transition they become ready for a parasitic life stage, developing teeth, tongue, eyes, and the ability to adapt to saltwater. After metamorphosis, juvenile lamprey may remain in fresh water up to 10 months before passively migrating with the current downstream to the ocean in late winter or early spring (Wydoski and Whitney 1979).

After reaching the ocean, Pacific lamprey attach to and parasitically feed upon other fish (Moyle 1976). They may remain in saltwater for up to 3.5 years (Close et al. 1995). At maturity, Pacific lamprey may reach a length of approximately 70 centimeters (cm) (2.3 feet) (Hart 1973).

Pacific lamprey return to fresh water in the fall, overwinter, and spawn the subsequent spring (Close et al. 1995). Adults migrate into rivers and streams to spawn, sometimes traveling several hundred miles to the headwaters of streams. They do not feed during the spawning migration. Once in the streams, adults hide under rocks and other structures while undergoing reproductive maturation. Spawning sites of *L. tridentata* generally occur in low-gradient stream sections where gravel is deposited (Kan 1975). The nest sites are constructed at the tail areas of the pools and in riffles (Pletcher 1963; Kan 1975). Pacific lamprey spawning occurs over gravel with a mix of pebbles and sand (Mattson 1949; Kan 1975). Flow is also an important spawning requirement. Spawning occurs in lotic habitat with velocities ranging from 0.5 to 1.0 meter per second (1.6 to 3.3 fps) (Pletcher 1963; Kan 1975). The water depths where spawning occurs vary, ranging from 0.4 to 1.0 meter (1.3 to 3.3 feet) (Pletcher 1963; Kan 1975).

Ammocoetes move into habitats with slow currents and appropriate substrates. Close et al. (1995) noted high densities of ammocoetes found in floodplain sections of rivers with low gradients. In laboratory experiments, Pletcher (1963) determined that ammocoetes preferred, in relative order, mud (0.004 cm particle size), sand (0.005 cm particle size), and gravel (l.0 to 0.5 cm particle size). Burrowing was inhibited in water velocities greater than 0.305 meter per second (1.0 fps). Ammocoete beds in Oregon streams have been located in habitats with water velocities ranging from 0.1 to 0.5 meters per second (0.3 to 1.6 fps) (Kan 1975). Laboratory experiments have also shown that ammocoetes require appropriate levels of oxygen in the water. Under conditions of low partial pressures of oxygen (7 to 10 millimeters of mercury [mm Hg]) and temperatures of 15.5 °C, ammocoetes emerged from their burrows and died. Ammocoetes remained buried and survived under partial pressure of oxygen between 18 and 20 mm Hg (Potter et al. 1970). Although they reportedly prefer cold water (Close et al. 1995), ammocoetes have been found in waters ranging up to 25 °C in Idaho (Mallatt 1983).

Distribution

The City does not have much distribution information about lamprey in the Sandy River Basin. In the Bull Run watershed, there have been sporadic observations of dead Pacific lamprey in the lower six miles of the river (Kucas, pers. comm. 2005). In the past, arrivals of adult lamprey have been noted in the Bull Run River from late April through the fall (October to November), and these fish may have been Pacific lamprey (PGE 1982). In 1964, the City found juvenile lampreys (probably ammocoetes) in the water diversion pool immediately after construction of Bull Run Dam 2. The lamprey had found their way into the upper watershed because the sluice gates to the diversion pool were open during construction. Prior to that time, lamprey were not observed upstream of the dam. The City tried various remedies to block lamprey passage and eventually constructed a lamprey weir at approximately RM 5.9 on the mainstem Bull Run River.

Abundance and Productivity

Little information is available on the status of Pacific lamprey in the Sandy River Basin. Although previously petitioned for listing, Pacific lamprey have not been listed under the federal ESA. They are considered a federal species of concern and a state sensitive species in Oregon with a vulnerable ranking. No information was available on lamprey abundance in the Sandy River Basin. Data are available from two long-term counts at Columbia River dams and two dams on the Oregon coast (Kostow 2002). These data sets indicate this species may have declined from levels detected in 1970.

Reasons for Decline/Threats to Survival

Freshwater habitat degradation is likely the most significant threat to Pacific lamprey populations. Habitat issues potentially impacting lamprey ammocoetes include streambed siltation, water pollution, hydrologic modifications, and development in or above rearing areas (Kostow 2002). Migrating adult lamprey have difficulty negotiating fish ladders; thus in-channel structures, dams, and perched culverts could inhibit access to spawning habitats. In addition, lamprey are thought to be highly susceptible to injury and mortality at fish screens because of their small size.

Western Brook Lamprey

Almost all of the information on western brook lamprey (*Lampetra richardsoni*) comes from Kostow (2002), and that reference is heavily used for this species description. The nonparasitic western brook lamprey is probably the second most common and widely distributed lamprey in Oregon. ODFW acknowledges that there is very little information on brook lamprey, and most of the life history and behavior observations for the species come from a small tributary of the lower Fraser River in Canada (Pletcher 1963). Those observations are relied on in the descriptions that follow.

Life History and Diversity

Western brook lamprey, like Pacific lamprey and probably river lamprey, spawn in the spring. The eggs hatch according to the temperature of the water; hatching in Canada takes 15 to 20 days. After the larvae grow to about 7 to 10 mm long, they emerge and quickly move to silty areas to burrow. Brook lampreys distribute themselves within a creek system according to size, with smaller ammocoetes farther upstream and in finer silt deposits in shallower waters. They are filter feeders with a diet that is mostly diatoms. They likely undergo metamorphism after four to six years.

After metamorphosis, the western brook lamprey apparently enter deep burrows and become dormant. They stay in these burrows until about March, when they are ready to spawn. Readiness to spawn is temperature-dependent, and they will remain in the burrows until water temperatures reach above 10 °C. When they emerge as sexually mature fish, they range in size from 8 to 17 cm.

Western brook lampreys do not appear to move very much during their lives. Most of their movement is passive downstream movement when they leave their burrows.

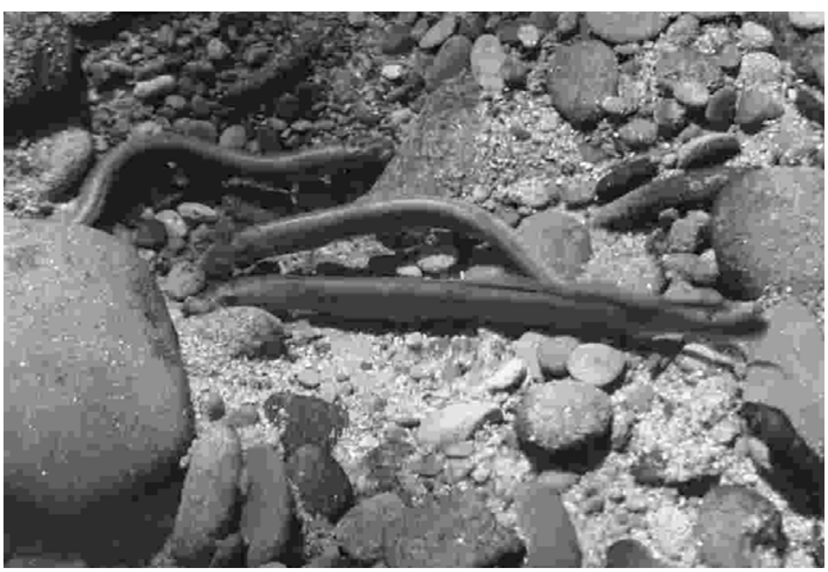


Photo courtesy of ODFW.

Distribution

Distribution information for western brook lamprey in the Sandy River Basin is not available.

Abundance and Productivity

The City does not have any information on abundance or productivity of western brook lamprey in the Sandy River Basin.

Reasons for Decline/Threats to Survival

As is the case for Pacific lamprey, freshwater habitat degradation is likely the most significant threat to western brook lamprey populations. Habitat issues potentially impacting lamprey ammocoetes include streambed siltation, water pollution, hydrologic modifications, and development in or above rearing areas (Kostow 2002). Migrating adult lamprey have difficulty negotiating fish ladders, thus in-channel structures, dams, and perched culverts could inhibit access to spawning habitats. In addition, when migrating downstream to the ocean, lamprey are thought to be highly susceptible to injury and mortality at fish screens because of their small size.

River Lamprey

The small parasitic river lamprey is the sister species of the western brook lamprey (Kostow 2002). The distribution of river lamprey extends from the Sacramento River to southeast Alaska and inland in the Columbia River to the Columbia River Gorge (Kan 1975; Lee et al. 1980). ODFW staff do not believe they have observed river lamprey in many years and have no information about the species. The little information that is available about river lamprey is based on observations in the Fraser River and Georgia Straight in Canada (Beamish 1980; Beamish and Youson 1987). No information is available about their early life history or habitat preferences.

River lampreys spend most of their life in fresh water. In the spring following metamorphosis, development of their oral feeding discs is complete, and they enter the ocean to feed. River lamprey enter saltwater between May and July and promptly begin feeding. They remain close to shore and are found mostly near the mouths of the rivers that produced them. River lamprey remain in the ocean for only about 10 weeks. They leave saltwater in September when they are about 25 cm long (Beamish and Youson 1987). They are assumed to spawn the following spring, although adults are rarely seen in fresh water.

During the brief periods that river lamprey are distinctive in fresh water, they are not seen, probably because they are in deep-water habitats in the mainstems of larger rivers (Beamish and Youson 1987). They may prefer larger rivers, including the Fraser, Columbia, and Sacramento (Kan 1975).

The City has no specific information on life history, distribution, or abundance of river lamprey in the Sandy River Basin. Likewise, the City does not know the specific reasons for their decline or the threats for survival for the species. The City assumes that many of the factors affecting the freshwater habitat of river lamprey would be similar to those of Pacific and western brook lamprey.

5.5 Amphibians and Reptiles

Ten amphibians and reptiles will benefit from the HCP measures: Cope's giant salamander, the cascade torrent salamander, the clouded salamander, the Oregon slender salamander, the coastal tailed frog, the northern red-legged frog, the Cascades frog, the western toad, the western painted turtle, and the northwestern pond turtle. Species with adequate information are described in terms of their species status, life history, habitat needs, and distribution in the Sandy River Basin. Information on other species is reported as it is available.

5.5.1 Amphibians

Western Toad (*Bufo boreas*)

Species Status

The western toad is currently classified as a Sensitive – Vulnerable species in Oregon (ODFW 2005c). Although the species has disappeared from many former breeding sites, it is still common at others (Oregon Natural Heritage Information Center 2003; NatureServe 2005). The species is adapted to such disturbances as flood scour, fire, and even volcanic eruption, but populations may dwindle as plant succession progresses (Corn 1993). Western toads appear to be particularly susceptible to fungal diseases that have emerged recently and are occurring globally (Blaustein and Wake 1990; Blaustein and Olson 1991; Blaustein et al. 1994; Stebbins and Cohen 1995; Kiesecker and Blaustein 1997; Daszak et al. 1999).

Life History

The western toad has aquatic egg and larval stages and a terrestrial adult stage. The timing of breeding is strongly dependent on the phenology of the individual site. For example, at sunny sites at 4,000 feet, breeding may occur immediately after snowmelt in early April. At riverine sites at 500 feet, breeding may not occur until after water temperatures have warmed up in June. Each female can lay up to 16,000 eggs in long strands that are laid communally and often form extensive mats. In warm weather, eggs can hatch within five days, and hatchlings may begin feeding after one or two days.

Tadpoles forage on organic mud, diatoms, and tree pollen; however, they are also scavengers, scraping protein from flesh or fish guts. They frequently form vast swarms that move in one direction, maintaining warmth and safety in numbers rather than fleeing or hiding from garter snakes, predaceous aquatic insects, and other predators. Metamorphosis occurs in mid- to late- summer, with toadlets dispersing en masse as they begin to capture small flying insects and ants.

Adults prey on invertebrates such as insects, spiders, earthworms and slugs. Western toads reach sexual maturity in two to three years. Adults may live for 10 years or more, but females do not produce eggs every year. Adults are vulnerable to predation by ravens and raccoons, particularly when gathered for breeding. (Nussbaum et al. 1983; Olson 1989; Leonard et al. 1993; Koch and Peterson 1995; Stebbins and Cohen 1995; Corkran and Thoms 1996; Hallock and McAllister 2005; and Corkran, unpublished data).

Photo courtesy of Char Corkran.

Habitat Needs

Spanning the Northwest from the Rocky Mountains to the Pacific Coast, and from northern Baja California to southeast Alaska, the western toad's broad geographic range encompasses many physiographic provinces. It occurs from near sea level to about 10,000 feet in elevation (Stebbins 1966; NatureServe 2005).

A habitat generalist, the western toad is found in alpine meadows, coastal river bottoms, and semiarid lands. Breeding sites include shallow ponds, lake or reservoir edges, and river overflow channels. Sites having no shade and a mud or sand substrate with sparse vegetation are generally chosen. Egg strings are usually laid on the bottom in water 4—15 inches deep, but in high water years they are draped over flooded shrubs close to the surface. Larvae seek the warmest available micro-sites: sunny shallows during the day and mud, rotting vegetation, or geothermal springs at night. Metamorphs hide under rocks and logs, then disperse to sunny meadows or open woods. Juveniles and adults hide during the day, as well as hibernate, by burying themselves in duff and loose soil or retreating into large mammal tracks, rodent burrows, and rotting logs. In hot, dry weather they also use springs, stream edges, and moist riparian areas. Western toads have been documented traveling three miles or more from breeding sites during the year. The foregoing discussion of habitat use is based on Nussbaum et al. (1983), Leonard et al. (1993), Koch and Peterson (1995), Corkran and Thoms (1996), Bartelt et al. (2004), Thompson (2004), Hallock and McAllister (2005), NatureServe (2005), and Corkran (unpublished data).

Distribution in the Sandy River Basin

Only one breeding population of western toad is known in the Sandy River Basin: Bull Run Reservoir 1, where an extensive bench on the north side is inundated at full pool (Corkran, unpublished data). Although adult toads are found in the upper Salmon River drainage, they do not breed there.

Cascades Frog (Rana cascadae)

Species Status

The Cascades frog is classified as a federal Species of Concern and a Sensitive – Vulnerable species in Oregon (ODFW 2005c). Declining population trends and lack of breeding at many of the historical localities, apparently caused by infectious diseases and anthropogenic factors, are reasons for the current classifications (Blaustein and Wake 1990; Blaustein and Olson 1991; Fellers and Drost 1993; Blaustein et al. 1994; Kiesecker and Blaustein 1997; Oregon Natural Heritage Information Center 2003; NatureServe 2005).

Life History

Typical of its genus, the Cascades frog has aquatic egg and larval stages and a primarily terrestrial adult stage. Breeding occurs as soon as snow and ice melt at a given site. Each female lays from 100 to 500 eggs in a single mass, and frequently several females deposit their egg masses in one pile. Eggs usually hatch in one to three weeks, depending on water temperature. Hatchlings spend several days on the egg mass before beginning to forage by scraping diatoms, algae, and rotting vegetation, and by filtering micro-organisms. Water temperature, food supply, and crowding of larvae determine the time to metamorphosis, usually two to three months, although some tadpoles survive a winter before transforming. Metamorphs may disperse from the breeding site after they begin foraging on a variety of crawling and flying invertebrates. Males and females reach sexual maturity in about three years, and may not live longer than about five years. (Sype 1975; Nussbaum et al. 1983; Olson 1988; Leonard et al. 1993; Corkran and Thoms 1996; Hallock and McAllister 2005; Corkran, unpublished data.)

Habitat Needs

Although its range extends from northern California to the British Columbia border, the Cascades frog is restricted to a narrow belt in the Cascade Mountains, including both sides of the crest. A separate population occurs in the Olympic Mountains of western Washington. Most of the habitat occupied by this species is between 2,500 and 6,500 feet in elevation. (Nussbaum et al. 1983; Leonard et al. 1993; and Corkran and Thoms 1996).

Predominantly a species of mountain wetlands, the Cascades frog uses separate habitat types for different stages of its life cycle. Breeding sites have shallow water, usually less than seven inches deep, with no shading trees or shrubs. The north edges of ponds or lakes, as well as elk wallows or other pools in wet meadows, provide ideal breeding habitat. Egg masses are deposited at the water surface on moss or other low vegetation at the margin of pools, where rain and snowmelt can carry the hatchlings to deeper water. Older larvae congregate in sunny shallows for foraging and basking, often using submerged rocks or logs as heat reservoirs and shelves near the surface. They utilize deeper water and dense aquatic or emergent vegetation to escape garter snakes, dragonfly larvae, and other predators. At metamorphosis, froglets leave the pooled water and disperse into surrounding wet meadow vegetation, where they may also hide under logs and rocks from predators that include a variety of mammals, birds, and garter snakes. As hot weather dries the meadows in summer and fall, metamorphs move back to well-vegetated pond edges or follow flowing water to join adults along shaded streams, where they hide under logs and rocks. During wet weather, Cascades frogs may forage well away from water in riparian forest, shrub, and meadow habitats, but may not travel more than 0.5 mile from the breeding site during the year. They probably hibernate in the mud of wet meadows or low-gradient stream edges. (Nussbaum et al. 1983, Olson 1988, Leonard et al. 1993; Corkran and Thoms 1996; Richter 1997; Hallock and McAllister 2005; and Corkran, unpublished data.)

Distribution in the Sandy River Basin

Within the Sandy River Basin, Cascades frogs are common only in higher elevations, where wet meadows occur on relatively level terrain (Corkran, unpublished data). They are largely absent from steep forested ridges and low elevations. The largest populations occur near the southern edge of the Basin at several headwaters of the Salmon River, and in the south buffer of the Bull Run watershed at the head of the Little Sandy River. Smaller populations occur near the outlet of Bull Run Lake, near Latourell Prairie, and at the head of Cedar Creek on Wildcat Mountain. One of the lowest known elevation breeding sites occurred north of Bull Run Reservoir 1 at 1,650 feet, but the small site has filled in and is no longer used by Cascades frogs.

Northern Red-legged Frog (*Rana aurora aurora*)

Species Status

The northern red-legged frog is currently classified as a federal Species of Concern and a Sensitive – Undetermined status species in Oregon, except in the Willamette Valley where it is considered Sensitive – Vulnerable (ODFW 2005c). Habitat loss, predation by introduced warm-water fish and American bullfrogs (*Rana catesbeiana*), pesticides, and other pollutants are thought to have impacted Willamette Valley populations, but in other regions of Oregon, numbers of northern red-legged frogs appear to be more stable (Oregon Natural Heritage Information Center 2003; NatureServe 2005).

Life History

Like most of the regional frog species, the northern red-legged frog has aquatic egg and larval stages and a mostly terrestrial adult stage. Its life history, as discussed here, is derived from Nussbaum et al. (1983), Leonard et al. (1993), Stebbins and Cohen (1995), Corkran and Thoms (1996), Hallock and McAllister (2005), and Corkran (unpublished data). The northern red-legged frog is usually one of the two earliest amphibian species to breed, laying eggs in February and occasionally in December. Each female lays a single egg mass containing 500 to 1,300 eggs, and the egg masses are usually scattered around the site. Periods of cold weather often delay embryo development, and eggs do not hatch for four to six weeks. For a few days the hatchlings cling to the egg mass or vegetation, until they begin feeding by filtering micro-organisms and scraping diatoms, algae, and rotting vegetation. Tadpoles metamorphose in early to mid-summer, depending on water temperature. As they disperse from breeding sites, froglets begin foraging on small flying insects; as they grow, they catch a variety of flying and crawling invertebrates. Sexual maturity may be reached at two years of age, and red-legged frogs appear to breed every year. Predators include raccoons, other semiaquatic mammals, herons, and other large birds. Longevity may exceed five years.

Habitat Needs

Extending from the northwestern corner of California to the southwestern coast of British Columbia, including Vancouver Island, populations are widespread from the Pacific coast to the western slopes of the Cascade Mountains. The northern red-legged frog generally occurs from near sea level to about 2,500 feet elevation; however, a few populations in Oregon reach the Cascades crest at 4,500 feet or more (Nussbaum et al. 1983; Leonard et al. 1993; Corkran and Thoms 1996; and NatureServe 2005).

Strongly associated with streams and wetlands in a variety of forest types, the red-legged frog uses several habitats during the year. Typical breeding sites include beaver ponds, lake edges, sag ponds, overflow ponds, and backwaters of slow streams. The eggs are intolerant of warm temperatures, so breeding ponds are either deep, partially shaded, or having slight inflow from a stream or spring. Egg masses are attached to emergent or flooded vegetation, often the tops of sedge clumps or small willows, usually well below the surface in water 20 to 40 inches deep. Tadpoles forage and bask near the water surface and in the shallows of deeper ponds. They actively avoid predators, such as garter snakes, fish, and predaceous insect larvae, by swimming rapidly to deep water or diving into the bottom mud or dense aquatic vegetation. After metamorphosis, froglets usually disperse through wetland vegetation or along brushy streams, hiding under logs and rocks. Red-legged frogs often forage in moist deciduous or coniferous forests well away from streams in wet weather. During hot, dry periods they remain at stream edges and in riparian forests. They sit on rocks or on logs adjacent to or suspended above streams, awaiting flying insect prey and avoiding desiccation and overheating. They hibernate in wetland mud and rodent burrows with entrances under logs or bark. Travel distances during the year may be several miles from the breeding site. (Nussbaum et al. 1983; Leonard et al. 1993; Blaustein et al. 1995; Corkran and Thoms 1996; Richter 1997; Hallock and McAllister 2005; and Corkran, unpublished data.)

Distribution in the Sandy River Basin

Red-legged frogs are widely distributed in the Sandy River Basin up to about 2,000 feet in elevation (Corkran, unpublished data). A large and apparently stable population of approximately 600 frogs breeds in shallows at the head of Bull Run Reservoir 1, although annual productivity is not well monitored. Other large aggregations breed in ponds near the south side of Reservoir 2 and in a beaver pond on a small tributary of the Sandy River near Brightwood. Numerous small breeding sites occur in the lower Basin, where they are vulnerable to invasion by American bullfrogs and particularly by warm-water fish. In recent years, red-legged frogs have not been observed at several former breeding sites at the Sandy River delta.

Coastal Tailed Frog (*Ascaphus truei*)

Species Status

The coastal tailed frog is classified as a federal Species of Concern and a Sensitive – Vulnerable species in Oregon (ODFW 2005c). Irregular distribution and evidence of declining population trends, mostly caused by habitat loss or degradation, are reasons for its current classification (Oregon Natural Heritage Information Center 2003; NatureServe 2005).

Life History

The coastal tailed frog has egg, larval, and adult stages distinctively adapted to streams, although adults are also partially terrestrial. This species mates during low flows in early autumn, and internal fertilization prevents sperm from being carried away by the stream current. Females do not lay their strings of 30 to 50 eggs until the following mid-summer. The eggs hatch late in the summer, and hatchlings continue using their internal yolk for several months. Larger tadpoles forage by scraping diatoms and algae from rocks while clinging with their large mouths, which are modified for suction. Tadpoles often hide on the undersides of rocks during the day; if disturbed, they swim to the stream bottom and push down between cobbles. Metamorphosis does not occur for one to four years, depending on stream temperature. Adults prey on aquatic, terrestrial, and aerial invertebrates. Predators include fish, aquatic salamanders, various mammals, the American dipper (*Cinclus mexicanus*), and probably other birds as well. Sexual maturity is not reached for three to six years, and females probably only breed every other year. Longevity is not known. (Nussbaum et al. 1983; Brown 1989; Adams 1993; Leonard et al. 1993; and Corkran and Thoms 1996.)

Habitat Needs

Extending from northern California to the western fringe of British Columbia, the coastal tailed frog's geographic distribution is restricted to streams in the Coast Range and the Cascade and Olympic Mountains. Its elevation range is from near sea level in the Coast Range to about 5,000 feet (Nussbaum et al. 1983; Leonard et al. 1993; Corkran and Thoms 1996; NatureServe 2005).

Photo courtesy of Char Corkran.

Closely tied to forested mountain streams, the coastal tailed frog uses a limited range of habitats throughout its life. Coastal tailed frogs are entirely dependent on cold streams with moderate to high gradient and little or no silt. Occupied streams are usually in old-growth forests. Breeding sites are not well known, but eggs are apparently deposited under boulders in stream pools with moderate flow. Hatchlings remain in the egg site and under the protected edges of the nest boulder until their mouths develop. Tadpoles require rocks with a fairly smooth-grained surface and no accumulations of silt, moss, or other vegetation that would interrupt their ability to adhere using their suction mouths. Unable to swim against a strong current if dislodged and when moving from one rock to another while foraging, tadpoles may gradually move downstream during their lengthy development. Metamorphs appear to move upstream, using the very shallow stream edges and hiding under cobbles or large gravel. Some dispersal and adult migration does occur overland. Adults are most frequently found in small tributary streams and headwaters, where they may remain year-round except during breeding. During the day, they hide under rocks in shallow stream edges or on land in or under large logs. At night and during rainy weather, coastal tailed frog adults forage in riparian woods 100 feet or more from the water. Distances traveled during the year are unknown but may exceed 0.5 mile. (Nussbaum et al. 1983; Bury and Corn 1988; Brown 1989; Corn and Bury 1989; Welsh 1990; Bury et al. 1991a; Bury et al. 1991b; Gilbert and Allwine 1991; Adams 1993; Leonard et al. 1993; and Corkran and Thoms 1996).

Distribution in the Sandy River Basin

Coastal tailed frogs are widespread within the upper Sandy River Basin, except for the major rivers and streams. They occur in many of the tributaries of the upper Bull Run, Sandy, and Salmon rivers and upper Gordon Creek. In the upper Bull Run watershed, these frogs have been observed at the mouths of the tiny streams that trickle down into the upper reservoir. Populations have not been systematically monitored, but they appear to be stable (Corkran, unpublished data).

Cope's Giant Salamander (*Dicamptodon copei*)

Species Status

The Cope's giant salamander is classified as a Sensitive – Undetermined Status species in Oregon (ODFW 2005c). Reasons for this classification are that several aspects of its life history are still unknown; its population size and trend are unknown; and it is vulnerable to logging, road building, and other activities that increase sedimentation in streams (Bury et al. 1991b; Oregon Natural Heritage Information Center 2003; NatureServe 2005).

Life History

The Cope's giant salamander has aquatic egg and larval stages and is normally neotenic, becoming sexually mature while remaining in a larval stage. Breeding apparently occurs from spring through early fall. Each female lays 25 to 115 eggs and guards them from predation, mostly by other giant salamanders. Hatchlings may remain in the nest until eight months after the eggs were laid, when they emerge and begin to feed on small invertebrates. Larger larvae prey on invertebrates that dwell in or fall into streams, small fish and their eggs, and small amphibians, including young of their own species. These salamanders are often nocturnal, hiding during the day from predators that probably include river otter (*Lutra canadensis*), water shrews (*Sorex* spp.), garter snakes (*Thamnophis* spp.), fish, and larger giant salamanders (*D. copei* as well as *D. tenebrosus*). Age at sexual maturity is unknown but is likely to be more than two years. Females probably do not breed every year. Longevity is unknown. (Nussbaum 1970; Nussbaum et al. 1983; Leonard et al. 1993; Corkran and Thoms 1996; Fiedler 2001; Jones 2001; Hallock and McAllister 2005; and Corkran, unpublished data.)

Habitat Needs

Although the geographic range of the Cope's giant salamander is still not completely known, it mainly occurs in certain streams in western Washington and northwestern Oregon. Populations in Washington are in the Olympic Mountains, Willapa Hills, and southwestern Cascade Mountains. In Oregon, this species occurs in the extreme northern Coast Range and Cascade Mountains, including the Columbia Gorge, but it also occurs around the eastern slopes of the Mt. Hood National Forest. Its elevation range is from near sea level to about 5,200 feet (Leonard et al. 1993; Corkran and Thoms 1996; NatureServe 2005; Corkran, unpublished data).

Dependent on forested mountain streams, Cope's giant salamanders use a restricted range of habitats throughout their lives. Streams with cold water, moderate to high gradient, and a cobble or small boulder substrate with no silt are occupied year-round. Mating sites are unknown. Females choose aquatic nest sites under boulders or streambank ledges, or in spaces inside or under logs in the streambed. Hatchlings move to shallow stream edges with small cobble substrate, where they can avoid predation by larger salamanders that cannot penetrate the small interstitial spaces. Larger adults may use pools more frequently than riffles, and usually the size of the rock or wood cover object chosen is proportional to the size of the individual. Cope's giant salamanders have been observed foraging at night at the head of stream pools, utilizing positions held by cutthroat trout (*Oncorhynchus clarki*) in the daytime. During heavy rains, larvae leave the streams at night to forage along the edge. The few metamorphosed adults that have been found (all in Washington) were on rocky stream banks. Although the species is not known to travel far in a year, it potentially disperses overland during wet weather. (Murphy and Hall 1981; Nussbaum et al. 1983; Bury et al. 1991b; Leonard et al. 1993; Corkran and Thoms 1996; Fiedler 2001; and Jones 2001; and Corkran, unpublished data.)

Photo courtesy of Char Corkran.

Distribution in the Sandy River Basin

The Cope's giant salamander is sporadically distributed in the upper Sandy River Basin. Known populations occur in the headwaters and many smaller tributaries of the Bull Run River, in Still Creek, Mud Creek, Gordon Creek, and Cedar Creek, which is near the southwestern edge of its known range (Corkran, unpublished data). Little is known about its population status in the Basin.

Cascade Torrent Salamander (*Rhyacotriton cascadae*)

Species Status

The Cascade torrent salamander is currently classified as a Sensitive – Vulnerable species in Oregon (ODFW 2005c). Formerly considered a disjunct population of the Olympic salamander (*R. olympicus*), it was recently recognized as a separate species (Good and Wake 1992). Its susceptibility to warmed water and sediment in streams means that it is threatened by logging, road building, or other ground-disturbing activities that affect its habitat (Murphy and Hall 1981; Bury and Corn 1988; Corn and Bury 1989; Bury et al. 1991b; and Oregon Natural Heritage Information Center 2003). Restricted to particular streams on the west slope of the Cascade Mountains in Oregon and southern Washington, the Cascade torrent salamander occurs from near sea level to about 4,000 feet in elevation (Nussbaum et al. 1983; Leonard et al. 1993; Corkran and Thoms 1996; NatureServe 2005).

Life History

The Cascade torrent salamander has aquatic egg and larval stages, and the adults are primarily aquatic also. Breeding behavior and timing for the torrent salamanders are not well known. Probably most eggs are laid in spring, and females may not produce more than about eight eggs each. Eggs are laid communally but apparently none of the females guard them. They probably do not hatch for more than nine months, and hatchlings may not leave the nest and begin feeding until a year after the eggs are laid. Hatchlings, larger larvae, and adults all consume a variety of small, aquatic and stream-edge invertebrates. Predators probably include both Cope's and Pacific giant salamanders, fish, water shrews, and possibly weasels (*Mustela* spp.) and American dipper. Larvae metamorphose at four or five years of age and reach sexual maturity at five to six years. Females may breed annually. Lifespan is unknown. (Murphy and Hall 1981; Nussbaum et al. 1983; Leonard et al. 1993; Corkran and Thoms 1996; Nijhuis and Kaplan 1998; Morrissey and Olenick 2004; and Hallock and McAllister 2005.)

Habitat Needs

Reliant upon forested mountain streams, the Cascade torrent salamander uses a narrow set of habitats during its life. Cold, silt-free water and a substrate derived from basalt or other hard, fine-grained rock are basic requirements. Mating sites are unknown. Females lay eggs unattached in rock crevices through which water seeps permanently. Recently emerged hatchlings have been found in very fine gravel at the base of a mossy, fractured rock outcrop that is presumed to be a nest site. As they grow, larvae move to stream edges where water is shallow, often less than 0.5 inches deep. Larvae and adults use the same sites, usually well-shaded stream edges and side channels, seeps through fractured rock or extensive gravel beds, and the splash zones at the base of waterfalls. Some occupied sites have heavy growths of aquatic mosses, while others are entirely free of moss. Observations that Cascade torrent salamanders occur in streams that flow subsurface during dry weather indicate the possibility that this species uses the hyporrheic zone of some stream systems. Although occasionally seen on the surface in daylight, these small salamanders usually hide during the day under small cobble and in gravel. They actively flee predators by twisting down into the substrate where larger animals cannot pursue. Apparently quite sedentary, there is some evidence that larvae move upstream. During prolonged wet weather, adults are often observed under rocks and woody debris on the streambank. Occasional sightings 100 feet from water may indicate the potential for overland dispersal between small streams. (Nussbaum et al. 1983; Bury and Corn 1988; Corn and Bury 1989; Bury et al. 1991a; Bury et al. 1991b; Leonard et al. 1993; Corkran and Thoms 1996; Nijhuis and Kaplan 1998; and Corkran, unpublished data.)

Distribution in the Sandy River Basin

The Cascade torrent salamander has much the same distribution as the Cope's giant salamander in the Sandy River Basin, known to occur only in the headwaters of the Bull Run River and its tributaries, and several other small streams in the Basin (Corkran, unpublished data). Little is known about its population status in the Basin.

Clouded Salamander (*Aneides ferreus*)

Species Status

The clouded salamander is classified as a Sensitive – Vulnerable species in Oregon (ODFW 2005c). This salamander apparently evolved to take advantage of stand-replacing forest fires that left an abundance of large-diameter logs, a habitat condition that is now rare. Infrequently encountered in most of its range, it can be difficult to take a meaningful census. (Gilbert and Allwine 1991; Corkran and Thoms 1996; Vesely 1999; Oregon Natural Heritage Information Center 2004; and Corkran, unpublished data.)

Life History

Typical of the family Plethodontidae, the clouded salamander is a fully terrestrial species with no larval stage. Breeding occurs in spring and early summer. Each female lays between 8 and 24 eggs, and both females and males have been found to remain with them until they hatch. During early fall rains, hatchlings begin to disperse and forage for small arthropods. Agile and strong, this salamander frequently evades capture by rapid scrambling and is capable of both jumping and climbing to avoid predation, probably by weasels, shrews, and snakes. Adults feed on small arthropods, primarily ants. Males become sexually mature in two or three years and females in three or four years. Females probably breed only every other year. Longevity is unknown. (Nussbaum et al. 1983; Leonard et al. 1993; Blaustein et al. 1995; and Corkran and Thoms 1996.)

Habitat Needs

With the recent split of *Aneides vagrans* and *A. ferreus*, the clouded salamander's geographic range is now mostly in Oregon, extending from northern California to the Columbia River. It is most often found in the Coast Range and central portion of the west slope of the Oregon Cascade Mountains, but does not appear to be common anywhere. Occupied sites are between sea level and about 5,000 feet. (Nussbaum et al. 1983; Leonard et al. 1993; Blaustein et al. 1995; Corkran and Thoms 1996.)

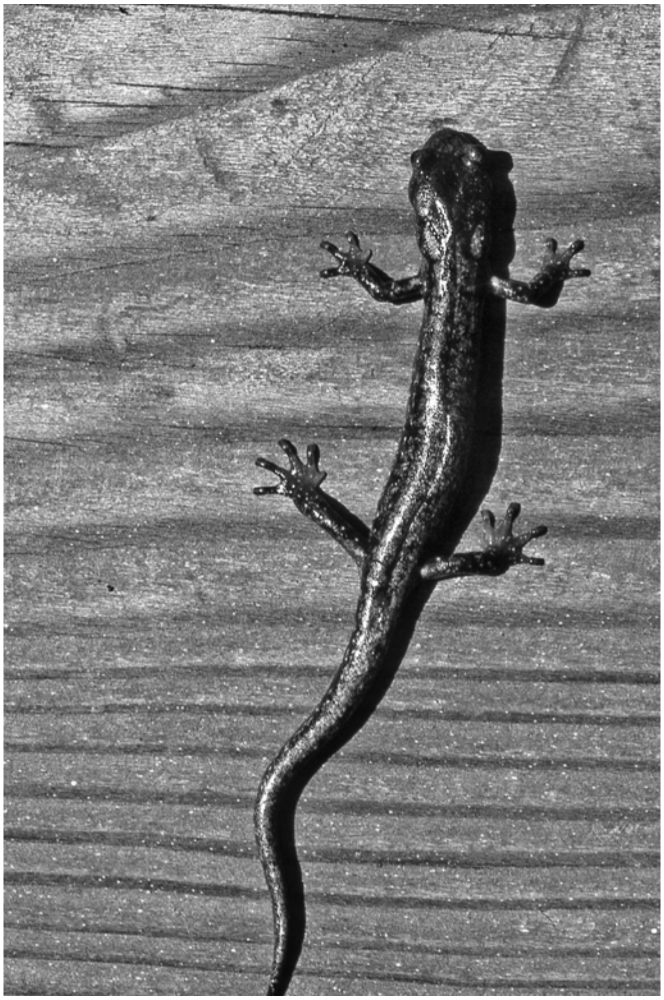


Photo courtesy of Char Corkran.

Strongly associated with conifer forests and forested talus or rock outcrops, clouded salamanders utilize a limited range of habitat types year-round. The nest site is a small cavity in a log or between rocks, and eggs are suspended from the ceiling. Juveniles and adults are found most often in large-diameter Douglas-fir (*Pseudotsuga menziesii*) logs, often in small openings in the forest canopy. Two types of logs are used. Fairly fresh logs, usually Decay Stage 2 (Maser et al. 1979) with slightly loosened bark and hard interior wood, particularly logs with long splits in the wood, are frequently used, perhaps mostly for foraging and hiding. More rotted logs (usually Decay Stage 4) with interior wood that breaks into blocks and layers probably are used most often for nesting and retreating from dry, hot, or freezing weather conditions, but seasonal movements of this species are largely unknown. Clouded salamanders also climb on snags to forage, and use talus and fractured rock outcrops where fairly stable, moist conditions exist. Small populations persist in several urban areas with crumbling rock foundations. This salamander is often present in riparian forests, but appears to show no preference for that habitat over upland sites. Although no studies have been conducted, this species may be capable of traveling considerable distances during wet weather. (Nussbaum et al. 1983; Bury et al. 1991a; Leonard et al. 1993; Blaustein et al. 1995; Corkran and Thoms 1996; and Corkran, unpublished data.)

Distribution in the Sandy River Basin

The clouded salamander is widely distributed but uncommon in the Sandy River Basin, which is near the northern end of its geographic range. Individuals have been found at several locations in the Bull Run watershed and at one site next to the Salmon River. In the Bull Run watershed, clouded salamanders have been observed primarily in large, downed trees at the edges of Reservoir 1 (Corkran, unpublished data).

Oregon Slender Salamander (*Batrachoseps wrightorum* [= *wrighti*])

Species Status

The Oregon slender salamander is classified as a federal Species of Concern and a Sensitive – Undetermined Status species in Oregon (ODFW 2005c). This state classification reflects its restricted distribution, its incompletely known life history, and its close association with large-diameter logs and old-growth conifer forest conditions (Vesely 1999; Oregon Natural Heritage Information Center 2004).

Life History

As a member of the family Plethodontidae, the Oregon slender salamander is a fully terrestrial species with no larval stage. The reproductive biology of this species is incompletely known. Breeding occurs through spring and early summer. Frequently two or more of these salamanders are found under the same cover object, but mating habits are not well known. Each female lays between 3 and 11 eggs and often stays with the eggs until they hatch during the fall. Hatchling behavior is not known. Adults prey on a variety of small invertebrates, especially collembolans and mites. Oregon slender salamanders usually coil up tightly to hide from predators that may include shrews, snakes, and larger salamanders. If caught, the tail may drop off and wriggle while the salamander escapes. The length of time to reach sexual maturity, breeding frequency for females, and longevity are not known. (Nussbaum et al. 1983; Leonard et al. 1993; Blaustein et al. 1995; and Corkran and Thoms 1996).

Habitat Needs

Endemic to the Cascade Mountains in Oregon, this salamander species occurs only from the Columbia River south to southern Lane County. Although its known range has recently been expanded to include sites on the east side of the Mt. Hood National Forest, it primarily occurs on the west slope of the Cascades. Its elevation range is from near sea level in the Columbia River Gorge to about 4,400 feet. (Nussbaum et al. 1983; Leonard et al. 1993; Blaustein et al. 1995; Corkran and Thoms 1996.)

Usually associated with old-growth Douglas-fir forest or forested talus, the Oregon slender salamander uses a restricted set of habitat variables throughout its life. Nests have been found in small crevices inside large logs and under bark on top of logs. Juveniles and adults use small hiding spaces, primarily provided in older debris piles around the base of large Douglas-fir snags or in fairly well rotted Douglas-fir logs (usually Decay Stage 4 [Maser et al. 1979]) with interior wood that breaks into small blocks and layers. Individuals also use the space under bark of Decay Stage 2 or Decay Stage 3 logs. This species also occurs in talus slopes where forest canopy, moss, and abundant quantities of fine debris retain moisture. East of the Cascade Mountains crest, it is found either in lava flow areas or under a greater variety of wood debris than on the west side. During prolonged rainy periods, especially in spring, these salamanders spend more time at the surface, hiding during the day under large sheets of bark, rocks, or sometimes smaller debris. During dry periods in late summer and during subfreezing weather, they apparently retreat underground, probably beneath logs that minimize moisture and temperature changes, or in stable talus slopes. Oregon slender salamanders are sometimes present in coniferous riparian forests, but apparently show no preference for them over upland forests. The short legs of this species would seem to indicate that it cannot travel far, but there are no data on movement distances of individual salamanders. (Nussbaum et al. 1983; Bury et al. 1991a; Gilbert and Allwine 1991; Leonard et al. 1993; Blaustein et al. 1995; Corkran and Thoms 1996; Vesely 1999; Thurman 2005; and Corkran, unpublished data.)

Distribution in the Sandy River Basin

The Oregon slender salamander is widely distributed in the majority of the Sandy River Basin that is covered by coniferous forest, but its occurrence is probably very patchy. Old-growth stands in the Bull Run watershed and along the Salmon River harbor large populations of this species (Gilbert and Allwine 1991; Corkran, unpublished data).

5.5.2 Reptiles

Western Painted Turtle (*Chrysemys picta belli*)

Species Status

The western painted turtle is classified as a Sensitive – Critical species in Oregon (ODFW 2005c). Although it is still found in large numbers, many sites have predominantly older individuals because nest predation by raccoons and predation of hatchlings and juveniles by exotic warm-water fish and American bullfrogs limit recruitment into most populations (Northwest Ecological Research Institute 1998; Oregon Natural Heritage Information Center 2003; NatureServe 2005).

Life History

The western painted turtle is principally an aquatic species, but it lays its eggs in terrestrial nests. Mating occurs in early spring (possibly also in the fall). Females lay 1—20 hard-shelled eggs in mid-summer, after building up yolk reserves by foraging and basking. Each female leaves the water and lays eggs in a hole dug with the back legs, partially plugging the hole with dirt using the back legs and plastron (lower shell). The eggs hatch in late summer or fall, but many hatchlings remain in the nest until early the following spring when they move to water. Hatchlings eat small invertebrates and some vegetation; adults may eat proportionately more aquatic plants, but also catch snails, crayfish, earthworms, small fish, tadpoles, and eat carrion. Turtles forage by swimming slowly at or below the surface. Because basking is important for thermoregulation, prevention of skin diseases and

Photo courtesy of Char Corkran.

parasites, and egg production in females, all ages of turtles spend many hours a day at it. If a potential predator is noticed, the turtles dive suddenly from the surface or off of basking sites and swim rapidly to the bottom. Predators of larger juveniles and adults include terrestrial and semiaquatic mammals and birds. Males reach sexual maturity in three to four years; females not for five to eight years. Most females lay eggs annually. Some individual turtles may live to be 30 years old. (Nussbaum et al. 1983; Storm and Leonard 1995; Blood and Macartney 1998; and St. John 2002.)

Habitat Needs

Primarily occurring in the interior Columbia River Basin, the western painted turtle's range extends from southern British Columbia to the Willamette Valley. A smaller population occurs around Puget Sound in Washington. Occupied sites reach from near sea level to about 3,500 feet in eastern Washington (Nussbaum et al. 1983; Storm and Leonard 1995; Blood and Macartney 1998; St. John 2002).

Associated with large, slow rivers and extensive wetlands and ponds, the western painted turtle uses mostly aquatic habitat types except for nesting. Occupied sites include river backwaters, river islands, and overflow ponds or they may be extensive wetland systems, large ponds, shallow lakes, and marshes. Sites have warm water and little shade. Water depths vary but often exceed 15 feet in some parts of the site. Typically, these sites have limited areas of tall emergent vegetation, such as cattail (*Typha latifolia*) and bulrush (*Scirpus acutus*), that may impede the turtles' underwater movements as well as their view of approaching predators. Aquatic vegetation is usually dense in sections of the water body, providing food directly and as a substrate for prey species. Hatchlings use the shallowest, sunniest parts of a site, often a small bay on a north shoreline that is sheltered from wind and has abundant small aquatic plants. Dense mats of aquatic plants, including patches of pond lily (*Nuphar polysepalum*), are used by turtles for basking, although the preferred basking sites for adults are partially submerged logs. Shoreline dirt and especially rock ledges are also used for basking. Females choose nest sites on land, up to 500 feet from water, where soil is somewhat sandy, there is little or no shade, and vegetation is not thick enough to hinder movement. Western painted turtles do not travel far during the year and hibernate at the bottom of the pond or river. (Nussbaum et al. 1983; Storm and Leonard 1995; Blood and Macartney 1998; and St. John 2002).

Distribution in the Sandy River Basin

The only known population of western painted turtles in the Sandy River Basin is at the Sandy River delta, where good habitat is provided by marshy ponds with logs from adjacent riparian forests and sunny, grassy meadows for nesting sites. Although no formal surveys have been conducted since 1992, turtles are still present in the ponds, the slough, and along the river near its mouth (Salix Associates 1992; Beilke 2005). Reproduction is still occurring, but in 2004, several depredated nests were found near the small ponds south of the slough (Barnes 2005). Individual turtles are occasionally seen further up the Sandy River—for instance in a human-made pond near Marmot—may be released pets (Corkran, unpublished data).

Northwestern Pond Turtle (*Emys* [= *Clemmys*] *marmorata marmorata*)

Species Status

The northwestern pond turtle is classified as a federal Species of Concern and a Sensitive – Critical species in Oregon (ODFW 2005c). Habitat loss, lack of recruitment because of high predation rates from raccoons and from introduced warm-water fish and American bullfrogs, and pneumonia epidemics that are probably related to pollution and other anthropogenic stressors are factors in the declining populations of this species (Holland 1994; Oregon Natural Heritage Information Center 2003; NatureServe 2005).

Life History

The northwestern pond turtle lays its eggs in terrestrial nests and spends its life in both aquatic and terrestrial habitats. Mating probably occurs in early spring. Females lay 1—13 hard-shelled eggs in mid-summer, after building up yolk reserves by foraging and basking. Each female leaves the water and lays eggs in a hole dug with the back legs, and partially plugs the hole with dirt and vegetation using the back legs and plastron (lower shell). The eggs hatch in late summer or fall, but at the northern end of their range most or all hatchlings remain in the nest until early the following spring, when they move to water. Hatchlings eat a variety of small invertebrates; adults also eat some aquatic plants, particularly pond lily seedpods, and carrion. Turtles forage by swimming slowly along the bottom or near the bank. Because basking is important for thermoregulation, prevention of skin diseases and parasites, and egg production in females, all ages of turtles spend many hours a day at it. If a potential predator is noticed, they dive suddenly from the surface or off of basking sites and swim rapidly to the bottom. Predators of larger juveniles and adults include terrestrial and semiaquatic mammals and birds. Females reach sexual maturity in 8 to 12 years; males are probably similar. In northern Oregon, females usually lay eggs only every other year. Pond turtles may live to be 40 years old, and some individuals apparently reach 50 years. (Nussbaum et al. 1983; Holland 1994; Storm and Leonard 1995; and St. John 2002.)

Habitat Needs

Predominantly occurring in California and southwestern Oregon, the northwestern pond turtle's range includes the Willamette Valley and adjacent Columbia River lowlands, with relict populations on both sides of the eastern Columbia Gorge. It occurs at elevations from near sea level to about 4,000 feet, but only to about 1,000 feet at the northern edge of its range (Holland 1994; Storm and Leonard 1995; St. John 2002).

Utilizing a variety of river and pond habitats, the northwestern pond turtle also makes extensive use of nearby terrestrial areas. Primary use areas include slow rivers and side channels, oxbow ponds, large wetlands, large ponds, and groups of smaller ponds. Low-gradient streams are often used in the southern part of their range. Deep, permanent water bodies, as well as shallow and ephemeral ones, are used, but all have full sun and warm water. Typical occupied areas have abundant basking sites, including logs, rocks, and mats of emergent vegetation, although tall emergent vegetation usually occurs in limited sections of the site. Aquatic vegetation is usually dense in some sections, providing food directly and as a substrate for prey species. Hatchlings use the shallowest, sunniest parts of a site, often a small bay on a north shoreline that is sheltered from wind and has abundant small aquatic plants. Females choose nest sites on land up to 1,300 feet from water, but more often 250 feet or less. Nest sites usually have clay soil, little or no shade, and vegetation is not thick enough to hinder movement. Northwestern pond turtles frequently hibernate in duff or soil in partially sunny locations as far as 1,600 feet from water, although in the northern part of the range some individuals hibernate at the bottom of the pond or river. Throughout the year, adults may move overland from one pond to another or change terrestrial hibernation sites during warm weather in mid-winter, so annual travel distances may exceed 0.5 mile. (Nussbaum et al. 1983; Holland 1994; Storm and Leonard 1995; St. John 2002.)

Distribution in the Sandy River Basin

There is no known population of northwestern pond turtles in the Sandy River Basin. Individuals of this species are occasionally seen in the Columbia Slough, although none have been reported from the Sandy River delta (Salix Associates 1992; Barnes 2005; Beilke 2005). Because this species travels fairly long distances, is often transported by people, and is wary and secretive in its behavior, it is possible that individuals do occur at the Sandy River delta.

5.6 Birds and Mammal

This HCP addresses two bird species and one mammal: the bald eagle, the northern spotted owl, and the fisher. When available, the following information is provided for each species: species status, life history, habitat needs, threats to survival, and distribution in the Sandy River Basin.

5.6.1 Birds

Bald Eagle *(Haliaeetus leucocephalus)*

Species Status

The bald eagle was removed as a threatened species from the federal list of endangered species on July 9, 2007 (USFWS 2007a), but is still listed as a threatened species in Oregon (ODFW 2005). Under the former federal and current state ESA regulations, habitat protection and management actions to protect nest sites and communal foraging and roosting areas have improved bald eagle reproduction and have enabled the population to expand. The City has used the National Bald Eagle Management Guidelines (USFWS 2007b) to guide its preparation of the bald eagle measures in the HCP.

Life History

Bald eagles reach maturity at 4-plus years of age, but may not enter the breeding population in denser populations until they are 6 or 7 years old (Gerrard et al. 1992, in Buehler 2000; Buehler 2000). The breeding season extends from January through August in Oregon (Isaacs et al. 1983). Nest initiation begins in February, with incubation starting in early March (Isaacs et al.983). Young hatch from early April to late May and fledge from mid-June to mid-August (Isaacs et al. 1983). Bald eagles generally lay one to three eggs, two being most common. Occasional four-egg clutches have been reported (Stalmaster 1987; Buehler 2000).

Habitat Needs

The breeding range of the bald eagle extends from Alaska and Canada, south to California, Texas and Florida (Csuti et al. 1997; Buehler 2000). In western Oregon, the bald eagle is found in the Willamette Valley, along the Columbia River, on the coast, and along most major rivers in the southwestern portion of the state (Csuti et al. 1997).

Bald eagles typically nest in large, super-dominant trees in forested areas adjacent to large bodies of water and in areas not subject to intense human activity (Anthony et al. 1982; Anthony and Isaacs 1989; Watson and Pierce 1998; Stinson et al. 2001). Douglas-fir (*Psuedostuga menziesii*), Sitka spruce (*Picea sitchensis*), and western hemlock (*Tsuga heterophylla)* are used as nest trees in western Oregon (Anthony et al. 1982). Douglas-fir with a mean diameter at breast height (DBH) of 69 inches constitutes 74 percent of the nest trees. Nesting territories need to contain a number of alternate nest trees similar in size to the active nest tree to persist, because nests are known to last from 5 to 20 years and eventually need to be replaced (Stalmaster 1987; Stinson et al. 2001). In Oregon, 84 percent of nest trees were within one mile of permanent bodies of water, and all were within 4.5 miles (Anthony and Isaacs 1989). In western Oregon, bald eagles are known to nest up to 5,500 feet in elevation (Isaacs and Anthony, unpublished data cited in Isaacs and Anthony 2003).

Foraging habitat consists of large areas of open water with fish and waterfowl populations that are available to eagles (Buehler 2000). Areas used most often are in the vicinity of foraging perch trees (Stalmaster 1987; Stinson et al. 2001). Stalmaster (1987) reviewed bald eagle food habits from across North America and found that fish make up 56 percent of the diet, while birds and mammals make up 28 and 14 percent, respectively.

Many bald eagles congregate at communal winter roosts in areas of abundant prey. Winter roost use is primarily influenced by the abundance and distribution of prey and only secondarily influenced by roost characteristics (Watson and Pierce 1998). Bald eagle winter roosts have been shown to provide more favorable microclimates than are generally available in the vicinity (Stalmaster 1981, cited in Stinson et al. 2001; Knight and Knight 1983; Keister et al. 1985; Stellini 1987, cited in Stinson et al. 2001). Microclimate conditions are a result of tree structure and topographic location. Stands with the largest and most decadent trees are most often used for roosting (Stinson et al. 2001).

Threats to Survival

Bald eagles are known to be sensitive to human disturbance, though they are believed to become habituated to, or learn to tolerate, regular human activity (Stalmaster and Newman 1978; Knight and Knight 1984; Anthony and Isaacs 1989; Stalmaster and Kaiser 1997). Experimental pedestrian disturbance indicates that restricting human activity within 394 feet of nests and providing high levels of visual screening around nests would be most effective at minimizing the effects of disturbance (Watson and Pierce 1998). In general, a bald eagle's response to human disturbance increases inversely with distance to the disturbance and increases with the duration of a disturbance, the number of vehicles or persons at the disturbance, visibility, and sound (Grubb and King 1991).

Nest success has been found to be related to disturbance levels. Unsuccessful nests received twice the rate of disturbance from pedestrians, aircraft, and total human activities than did successful nests (Watson and Pierce 1998). The presence of homes within 197 feet of nests was correlated to passive pedestrian activity (e.g., nonaudible) and found to be the only human factor to reduce time spent in incubation (Watson and Pierce 1998). However, a number of studies from across the country have documented bald eagles in developed areas showing signs of adapting to human activity (Grubb et al. 1992; Watson et al. 1999; Stinson et al. 2001).

Wintering bald eagles can be displaced by human activity for up to 30 minutes following the activity (Stalmaster and Newman 1978; Skagen 1980; Knight and Knight 1984). Disturbance response decreases with increasing distance from the disturbance. Stalmaster and Kaiser (1997) found 61 percent of bald eagles flushed in response to boat disturbance along a river, but they generally tolerated the discharge of firearms within 0.3 to 3.7 miles.

Temporary disturbances and habitat modification do not necessarily result in winter roost abandonment. Timber harvest adjacent to communal roosts and partial harvest within roosts did not alter the number of eagles using the roost in subsequent years, but logging activities did cause the eagles to leave the roost each day at an earlier time than normal (Hanson et al. 1980).

Although raptors are not generally considered at high risk of collision with power lines (Hunting 2002a), bald eagles are known to have been harmed or killed by electrical power lines from collisions with overhead wires and electrocution. Factors that may increase their risk of collision with power lines include adverse weather conditions that may reduce visibility and placement of power lines near communal roost areas (Steenhof and Brown 1978, cited in Hunting 2002a). A review of 4,300 bald and golden eagle carcasses from the early 1960s through the mid-1990s found electrocution was the fourth leading cause of death for bald eagles (12 percent of deaths due to electrocution); accidental trauma (collision with vehicles, power lines, or other structures) was the most common cause in both species (Franson et al. 1995). Harmata et al. (1999) banded bald eagles in the Greater Yellowstone Ecosystem and found that 20 percent of the 49 birds recovered had died of electrocution or collisions with power lines. Olendorff et al. (1989, cited in Herbert et al. 1995) did not consider collision mortality among raptors to be a primary cause for population decline, except in a critically endangered species like the California condor.

Bald eagles are more susceptible to electrocution than to collisions when compared with other birds, due to their large size and ability to avoid collisions in flight (Bevenger 1994, 1998). The risk of avian electrocution is greater for power lines of low to medium voltage (less than 69 kilovolts) because the distances between energized conductors decrease with voltage, thereby increasing the potential for the birds to span the distances with their wings increases (Avian Powerline Interaction Committee 1996, cited in Hunting 2002b; Dorin et al. 2005). Juvenile birds make up a high percentage of raptor electrocution mortality (Miller et al. 1975, cited in Herbert et al. 1995; Nelson and Nelson 1976, cited in Herbert et al. 1995; Ledger et al. 1987, cited in Herbert et al. 1995; Harness and Wilson 2001). Harness and Wilson (2001) examined 1,428 electrocuted birds and found 66 percent of eagles were juveniles.

Power pole design can influence raptor mortality from electrocution. Dwyer and Mannan (2004, cited in Dorin et al. 2005) found electrocution of Harris' hawks declined from 1.3 to 0.3 electrocutions per nest after poles were retrofitted with raptor safe hardware. However, design modifications may need to be site-specific to be effective. Ferrer and Hiraldo (1991) found that installing raised perches did not alter mortality rates for the Spanish imperial eagle in Spain, while converting danger lines to isolated cables or buried lines increased juvenile survival from 18 to 81 percent.

Distribution in the Sandy River Basin

There are no known bald eagle nest sites in the Bull Run Management Unit, though bald eagles are periodically reported around the reservoirs (Oregon Natural Heritage Information Center 2004; Isaacs 2006; Robbins 2006). One active bald eagle nest is located along the Bull Run River downstream of the management area (Oregon Natural Heritage Information Center 2004; Isaacs and Anthony 2004). The bald eagles at this site unsuccessfully nested from 2002 through 2004. The bald eagle pair successfully nested for the first time in 2005 (Isaacs 2006). There are no known winter communal roost areas in the Sandy River drainage.

PGE does not have any records of bald eagle collisions or electrocution along the power lines in the Bull Run drainage (Marheine 2006).

Northern Spotted Owl *(Strix occidentalis caurina)*

Species Status

The northern spotted owl is a state and federally listed threatened species (ODFW 2005). The primary threats to the spotted owl identified in the federal listing were the loss, modification, and fragmentation of habitat (USFWS 1990).

A recent demographic analysis of spotted owl populations in the Warm Springs and H. J. Andrews demographic study areas (the two closest demographic study areas to the Sandy River Basin) found stable fecundity rates and no significant trend in apparent survival (Anthony et al. 2004). However, there was strong evidence of a population decline through time. When the 13 demographic study areas from across the range of the species were combined, there was a 3.7 percent annual rate of decline. The analysis indicated the rate of change may not be as high on federal lands. The eight demographic study areas that are part of the monitoring program for the Northwest Forest Plan showed an annual decline of 2.4 percent, compared to 5.8 percent for the other areas (Anthony et al. 2004).

Life History

Spotted owls may occasionally breed their first year, but reproductive success is very low for birds less than two years old (Miller et al. 1985, cited in Gutiérrez et al. 1995; Anthony et al. 2004). Eggs are laid in March and April (mean initiation date for Oregon is April 2; range is March 9 to April 19) (Forsman et al. 1984; Gutiérrez et al. 1995). The limited information available on clutch size indicates two-egg clutches are most common, but clutch size can range from one to four eggs (Bendire 1892 and Dunn 1901, both cited in Gutiérrez et al. 1995; Gutiérrez et al. 1995). Incubation averages 30 days, and young fledge from the nest when they are about 34 to 36 days old, usually from mid-May through the end of June (Forsman et al. 1984; Gutiérrez et al. 1995). By September or October, the young reach an adult weight and disperse from the natal area (Gutiérrez et al. 1985; Miller 1989).

Habitat Needs

The spotted owl is a permanent resident of the temperate conifer forests of the Pacific Northwest, ranging from southern British Columbia through Washington and Oregon to northern California, along the Cascades and coastal mountain ranges (USFWS 1990).

Spotted owls are forest dwellers. They use a variety of conifer dominated forest types for nesting in the Pacific Northwest (Gutiérrez et al. 1995). Nests are generally in mature, old forest stands having more forest structure and complexity than random sites (Forsman et al. 1984; Solis and Gutiérrez 1990; Carey et al. 1990 1992).

Spotted owls nest frequently in Douglas-fir trees in western Oregon Cascades (87 percent) and the Oregon Coast Range (93 percent), while on the Olympic Peninsula nesting is more evenly distributed among western hemlock, Douglas-fir, and western red cedar (Hershey et al. 1998). In western Oregon, the mean DBH for trees with cavity nests was 53 inches and for those with platform nests was 42 inches (Forsman et al. 1984). All nest trees (live and dead) on the Olympic Peninsula had a mean DBH of 54 inches (Forsman and Giese 1997).

Nests can be in cavities or on platforms. Cavities used for nesting can form where a limb or the top of a tree has broken off (Forsman et al. 1984; Buchanan et al. 1993; Forsman and Geise 1997). Platform nests can be placed on mistletoe brooms, on platforms created by multiple leaders, on healthy limbs, or on structures constructed by other birds or mammals (Forsman et al. 1984; Buchanan et al. 1993; Forsman and Geise 1997). The majority of nests (80 to 94 percent) in northern California, the western Oregon Cascades, the Oregon Coast Range, and the Olympic Peninsula were placed in top or side cavities, compared to only 16 percent cavity nests in the eastern Washington Cascades (Forsman et al. 1984; Buchanan et al. 1993; Forsman and Giese 1997; Hershey et al. 1998).

Spotted owls appear to use a wider variety of forest conditions for foraging than for nesting or roosting (Thomas et al. 1990). Foraging habitat consists of forest stands with a high canopy closure and complex forest structure (Gutiérrez et al. 1995). Mature and old-growth stands were selected for perching outside the breeding season in western Washington (Herter et al. 2002). Roost stands were dominated by trees with a DBH greater than 20 inches and a canopy closure of 60 percent. Studies in western Oregon, the Klamath Province, and northern California also found older forests were used for perching more frequently than was expected (Carey et al. 1992; Tanner 1999, cited in Courtney 2004; Irwin et al. 2000). Modeling of demographic performance in Oregon found a mix of mid- and late-seral forest with younger forest and nonforest to be best for spotted owl survival and reproduction, although the authors suggest further study is required due to the low variability in survival and productivity attributed to habitat (Olson et al. 2004).

Threats to Survival

Habitat loss and fragmentation were the primary threats to the northern spotted owl when it was listed (U.S. Department of Interior 1990). The rate of harvest from 1994 to 2003 on federal land was lower than projected at the time of listing, due to the Northwest Forest Plan (U.S. Department of Interior 2004, cited in Courtney et al. 2004). However, suitable spotted owl habitat is estimated to have declined range wide by 5.14 percent on federal lands from 1994 to 2003 (U.S. Department of Interior 2004, cited in Courtney et al. 2004). The majority of the decline (3.03 percent) was a result of natural events (e.g., wildfire), while 2.1 percent was from management activities. There is insufficient information available to estimate a trend in suitable habitat on nonfederal land (Courtney et al. 2004).

While spotted owls have been known to be injured or killed by shooting and collisions with vehicles (Gutiérrez et al. 1995), they do not appear to be particularly sensitive to human disturbance. Human contact during research was not found to negatively impact spotted owls (Gutiérrez et al. 1995).

Photo courtesy of Char Corkran.

A significant amount of attention has been paid recently to the potential threat that the barred owl (*Strix varia*) presents to the spotted owl. The barred owl has been expanding its range in the Pacific Northwest over the last 50 years, and it is now sympatric with the northern spotted owl throughout most, if not all, of its range (Kelly 2002; Kelly et al. 2003; Courtney 2004). The full effect of barred owl presence on the spotted owl population is not known, but there is a concern about competition, particularly competition that leads to displacement, and, to a lesser extent, hybridization. A third, minor concern is fighting or threatening behaviors that may lead to barred owls killing spotted owls. There is some circumstantial evidence that barred owls may periodically kill spotted owls (Leskiw and Gutiérrez 1998), but the extent to which this may occur is unknown.

Competition between barred owls and spotted owls may occur at the level of resource use and may extend to territorial displacement. Compared with the spotted owl, the barred owl is more of a habitat and dietary generalist. The ability of the barred owl to occupy younger conifer and mixed forests may allow it to become established in regenerating forest landscapes prior to the spotted owl. While the barred owl utilizes a wider array of prey species, Hamer et al. (2001) found that the diets of barred owl and spotted owl have a 76 percent overlap. When availability of prey used in common by spotted owls and barred owls is limited, the ability of the barred owl to use a wider variety of prey may provide it a competitive advantage.

Competition could lead to barred owls displacing spotted owls from otherwise suitable habitat. Pearson and Livezey (2003) found significantly greater numbers of barred owls in proximity to unoccupied spotted owl site centers than to occupied site centers. A number of authors report barred owls replacing spotted owls in established territories (Sharp 1989; Dark et al. 1998; Kelly et al. 2003). However, most of the studies relied on the results of survey information and do not indicate whether the sites were abandoned by spotted owls prior to barred owl occupancy, were actively displaced by agonistic behavior, or were still in the area and simply went undetected because of reduced vocalization. On the Olympic Peninsula, spotted owls were confirmed to have moved 2,461 feet when barred owls were found in the vicinity of a site center previously occupied by spotted owls (Gremel 2000).

Anthony et al. (2004) considered the effects of barred owl presence on spotted owl fecundity and apparent survival. In general, barred owls were not found to have an effect on spotted owl fecundity, though there was a negative effect recorded for the Wenatchee and Olympic Peninsula study areas. Barred owl presence impacted apparent spotted owl survival in three Washington demographic study areas, but it did not influence apparent survival in the Oregon study areas. More than 50 cases of hybridization between spotted and barred owls were recorded from 1974 to 1999, and while the extent of hybridization is not known, the rate appears to be low (Courtney 2004). Herter and Hicks (2000) did not document any hybridization in their Central Washington Cascade study area from 1991 to 1993, even though barred owls were well established in the area by that time. Hybridization was not generally considered to be a significant threat by the panel convened for the five-year review of the status of the northern spotted owl (Courtney 2004). In situations where a population is very low, the panel thought hybridization could exacerbate the problem, but demographic processes would have more influence on the population.

Spotted owls do not seem to be as sensitive to human activity as some other avian species. Direct human contact during research activities has not been found to negatively impact spotted owls, and hiker disturbance trials did not alter the energy budget of Mexican spotted owls inhabiting canyons (Gutiérrez et al. 1995; Swarthout and Streidl 2003). Spotted owls have been recorded as being harmed or killed by shooting and collisions with vehicles. While the extent of this type of mortality is unknown, it is thought to be low (Gutiérrez et al. 1995).

Two studies have looked at the Mexican spotted owl's response to aircraft and chainsaws. During five-minute trials with helicopters and chainsaws, no spotted owls flushed when the disturbance stimuli were at least 345 feet from the owl (Delaney et al. 1999) and only two of the 22 recorded flushing events (9 percent) were at distances over 197 feet. There was some indication during this study that spotted owls may have been habituating to the treatments, but the sample size was not large enough for statistical testing. Johnson and Reynolds (2002) observed spotted owl behavior during overflights of military fixed-wing aircraft. Trials consisted of three consecutive overflights at progressively faster and louder passes. Spotted owl behavioral response during the trials did not exceed the 10 minute pre- and post-treatment periods.

Distribution in the Sandy River Basin

As of 1997, there were 49 resident spotted owl sites within the Sandy River Basin, including one on City lands and 21 on USFS lands within the Bull Run watershed (Robbins 2006). Of the 21 sites on USFS lands in the Bull Run, seven are within 1.2 miles of City lands. Most of these sites were located during a two-year survey conducted in 1993 and 1994; current status of the sites is unknown. A search of the Oregon Natural Heritage Information Center database identified three additional spotted owl sites in the upper Sandy River Basin outside the Bull Run watershed (Oregon Natural Heritage Information Center 2004).

5.6.2 Mammal

Fisher *(Martes pennanti)*

Species Status

The West Coast DPS of the fisher is listed as a candidate for federal listing (USFWS 2005). The USFWS 12-month findings found listing of the fisher to be warranted but precluded (1994).[11] The principal threats to the DPS are related to isolation of populations and continued fragmentation of suitable habitat. The fisher also is listed as Sensitive - Critical in Oregon (ODFW 2005).

Life History

Female fishers can breed by one year of age (Douglas and Strickland 1977; Eadie and Hamilton 1958; Hall 1942, all cited in Powell 1993; Wright and Coulter 1967). Breeding occurs from February to April (Csuti 1997). Fishers give birth in late March and early April (Mead 1994; Aubry and Raley 2002), and females will mate approximately one week after parturition (Powell and Zielinski 1994). Young are born almost a year after fertilization, following about 10 to 11 months of delayed implantation (Csuti 1997). Litters range from one to six kits; average is about 2.7 (Powell 1993). Juvenile fishers dispersed and established their own territories by one year of age (Arthur 1987 and Paragi 1990, both cited in Powell 1993). The female fisher and young leave the natal den when the young are about eight weeks old (Leonard 1980, cited in Powell 1993). The upper limit for life expectancy in the wild is estimated to be about 10 years of age (Powell 1993).

Habitat Needs

The fisher is found across Canada and the United States, from New England, the upper Midwest, northern Rockies, and the western mountains, south to the Sierra Nevada in California (Csuti 1997). The range of the fisher includes southwest Oregon, the south half of the Cascades, and northeastern Oregon (Csuti 1997). Fishers have been most commonly associated with low to mid-elevation forests in the Pacific states, up to 8,200 feet (Grinnell et

[11] "Warranted but precluded" status indicates that the data submitted with the petition to list the species under the ESA support the need to list the species, but other species are of higher priority. Section 4(b)(3)(B) of the ESA directs the federal agency that makes a "warranted-but-precluded" finding to review the petition annually to reassess the petition.

al. 1937, and Schempf and White 1977, both cited in Powell and Zielinski 1994; Aubrey and Houston 1992).

Fishers are associated with older, closed-canopy forests with abundant large coarse woody features (snags and logs) and understory vegetation (Buck et al. 1983, cited in Lewis and Stinson 1998; Arthur et al. 1989b; Jones 1991; Powell 1993; Seglund 1995). In the Pacific Northwest, fishers are more frequently found in late-successional forests than in early- to mid-successional forests resulting from timber harvest (Aubry and Houston 1992; Buck et al. 1983, cited in Powell and Zielinski 1994; Buck et al. 1994; Raphael 1984, cited in Powell and Zielinski 1994; Rosenberg and Raphael 1986).

Natal dens are most often elevated cavities in snags or trees (Buck et al. 1983, cited in Lewis and Stinson 1998; Weir 1995, cited in Lewis and Stinson 1998; Zielinski et al. 1995, cited in Lewis and Stinson 1998; Aubry et al. 1996, cited in Lewis and Stinson 1998; Paragi et al. 1996; Aubry and Raley 2002), but occasionally logs and rock formations are used. The mean height of 12 natal den openings in the southern Oregon Cascade Range was 53 feet; range was 13 to 153 feet (Aubry and Raley 2002).

Maternal dens have been located in a variety of tree species in the West, including quaking aspen (*Populus tremuloides*), black oak (*Quercus kelloggii*), black cottonwood (*Populus balsamifera*), incense cedar (*Calocedrus decurrens*), Douglas-fir, (*Pseudostuga menziesii*), white and grand fir (*Abies concolor and grandis*), pine (probably *Pinus ponderosa and P. monticola)*, and golden chinquapin (*Castanopsis chrysophylla*) (Buck 1982; Weir 1995; Zielinski et al. 1995; Aubry et al. 1997, all cited in Lewis and Stinson 1998; Aubry and Raley 2002). Trees and snags with natal and maternal dens have been found to range in DBH from 21 to 56 inches (Buck 1982; Weir 1995; Zielinski et al. 1995; Aubry et al. 1997, all cited in Lewis and Stinson 1998; Aubry and Raley 2002). Fisher kits may be moved to as many as five maternal den sites (Paragi et al. 1996). Maternal den sites may be near the ground or high in a tree and snag (Aubry, pers. comm., cited in Lewis and Stinson 1998).

Fishers tend to forage in habitats or microhabitats with high densities of prey (Powell 1977, cited in Powell and Zielinski 1994). Since food habit studies have not been conducted in the West for fisher, it is assumed that snowshoe hare habitat (a common prey species of fisher in other areas of the country) constitutes suitable foraging habitat (Lewis and Stinson 1998). In the Pacific Northwest, the range of the snowshoe hare is consistent with the original range of the Douglas-fir forest.

Fishers generally use structures in large standing live trees and snags for rest sites rather than sites on the ground (Buck 1982; Jones 1991; Seglund 1995; Weir 1995; Zielinski et al. 1995; Aubry et al. 1997; Zielinski et al. 2004). Live tree and snag structures used for resting include cavities, witches' brooms, mistletoe clumps, large lateral limbs, squirrel and woodrat nests, stick nests, and forks. Ground rest sites include logs and root-wads, log or slash piles, stumps, rock outcrops, subnivean and ground burrows, and vegetation thickets.

The largest available trees (most often over 39 inches DBH) are selected for rest sites (Zielinski et al. 2004). In the north Coast Range of California, 66 percent of rest sites were in Douglas-fir trees. Live conifer and conifer snags were the largest trees used for rest sites, having mean DBH of 46 inches and 47 inches, respectively (Zielinski et al. 2004).

Life History

Fisher have been found to avoid areas with low canopy cover and large forest openings, including those created by clearcuts (Buck et al. 1983, cited in Lewis and Stinson 1998; Arthur et al. 1989b; Powell 1993; Buskirk and Powell 1994; Jones and Garton 1994, cited in Lewis and Stinson 1998; Weir 1995, cited in Lewis and Stinson 1998). The fisher's avoidance of open habitats has affected local distribution and population expansion (Coulter 1966 and Earle 1978, cited in Powell and Zielinski 1994). Low- and mid-elevation forests are now younger, have reduced amounts of course wood, are fragmented, and may not be capable of supporting fishers (Rosenberg and Raphael 1986; Lyon et al. 1994; Powell and Zielinski 1994).

Fishers tend to avoid humans and are seldom seen, even where abundant (Douglas and Strickland 1987; Powell 1993); however, fisher may not be as sensitive to human disturbance as once thought (Johnson and Todd 1985). Maternal dens were found on a few occasions in the Northeast within a few yards of utilized roads, and harvest activity within 16 feet did not result in the den being moved (Powell et al. 1997). In Oregon, fisher movements are not hindered by unpaved logging roads, but home ranges are not maintained on both sides of paved roads (K. Aubry, pers. comm., cited in Lewis and Stinson 1998).

Fishers are known to occasionally use habitat near low-density housing, farms, and roads, and they even den under occupied structures (Pittaway 1978, cited in Lewis and Stinson 1998; Johnson and Todd 1985; Arthur et al. 1989a; Jones 1991, cited in Lewis and Stinson 1998). Fisher in New England may be adapting to live near humans, since they now inhabit suburban areas (W. Krohn, pers. comm., cited in Lewis and Stinson 1998). However, human disturbance at or near the den may result in the litter being moved to a new den (Paragi 1990, cited in Lewis and Stinson 1998).

Distribution in the Sandy River Basin

There are no recent records of fisher in the Sandy River Basin (Oregon Natural Heritage Information Center 2004). The closest known fisher population is in the south and central Oregon Cascades, north into southern Linn County (Csuti et al. 1997). Fishers are not expected to be present in the Sandy River drainage.

Chapter 6. Goals and Objectives

6. Goals and Objectives

The Endangered Species Act Section 10 (ESA Section 10) defines criteria for issuing an Incidental Take Permit. The primary biological criterion is that the resulting incidental take "will not appreciably reduce the likelihood of survival and recovery of the species in the wild." The City of Portland (City) has developed specific Habitat Conservation Plan (HCP) Goals, HCP Objectives, and Measurable Habitat Objectives with this desired result in mind.

6.1 HCP Goals

Consistent with the conservation planning approach described in Chapter 2, the City has developed a set of goals for the HCP. These goals provide "broad, guiding principles" as recommended in federal guidance for HCPs. The goals help explain the City's rationale for the conservation measures described in Chapter 7.

The City's overall biological goal of the HCP is to improve habitat conditions and thereby increase sustainability of populations of the four primary covered species (fall Chinook, spring Chinook, winter steelhead, and coho) in the greater Sandy River Basin to offset losses caused by the continued operation of the Bull Run water supply.

The four primary covered species are anadromous fish that travel thousands of miles during their life cycles. These fish are subject to a variety of factors and threats that determine population outcomes. The majority of these factors are out of the City's jurisdiction and control, making it impossible for the City to commit to numerical population targets. For this reason, the City is focusing on improving habitat in the Bull Run River as well as in the larger Sandy River Basin. The measures in Chapter 7 are designed to conserve and improve habitat conditions in a manner supported by current scientific literature and with reasonable certainty that the measures will result in increased sustainability for the covered species.

The City's more specific HCP goals are the following:

- Minimize and mitigate, to the maximum extent practicable, the impacts of incidental take on all covered species, but particularly the four primary covered fish species (fall Chinook, spring Chinook, winter steelhead, and coho)
- Provide habitat improvements in the Bull Run River where the City's historical impacts have occurred
- Implement habitat improvements as early as possible during the term of the HCP to help turn the trajectory of the currently decreasing fish population trends in the Sandy River Basin
- Provide benefits for additional non-covered species (e.g., amphibians) potentially affected by covered activities
- Improve conditions in the Bull Run River to the degree practicable given the City's primary mission to provide water supply to the Portland metropolitan area

- Provide habitat improvements for the covered species that are proportional and commensurate with water system impacts
- Clarify the quality and quantity of water needed to meet ESA requirements so that the City can plan more effectively for water supply to meet customer needs
- Define the City's financial obligation for ESA and Clean Water Act (CWA) compliance so that the City can plan for and manage the resulting impacts to ratepayers
- Achieve reasonable certainty about the City's ESA and CWA regulatory obligations for the term of the HCP and meet all related legal requirements
- Implement the HCP in a manner consistent with City of Portland policy (e,g., City Council Resolutions 37715 [1998] and 35894 [2000])
- Select habitat conservation measures that are feasible, can be implemented, and are compatible with ongoing operation of the water system to meet customer needs
- Provide reasonable flexibility to adapt to changing conditions, new information, and improved scientific understanding
- Work in cooperation with all the public and private entities involved in recovering Sandy River fish populations, particularly the organizations involved in the Sandy River Basin Partners
- Leverage the opportunities to use City investments to foster larger-scale improvements in habitat conditions across the Sandy River Basin
- Implement scientifically sound strategies that provide a meaningful contribution to recovery of the four primary covered fish species

The City's HCP Goals for fall Chinook, spring Chinook, winter steelhead, and coho are based on a common framework: improve the habitat for the species in the Bull Run River to the maximum extent practicable, and improve additional "offsite" habitat in the larger Sandy River Basin to further mitigate the species-specific impacts of the City's water system. This approach reflects the economic and operational constraints associated with continuing to operate a water system for a major metropolitan area while sharing the river with these fish species.

HCP Goals for chum salmon and eulachon—covered species—and for the other species addressed in the HCP are based primarily on impacts that may occur incidental to covered activities, including as part of implementing the conservation measures. These goals are defined using currently available information about the foreseeable impacts.

6.2 HCP Objectives

The City's conservation approach, as described in Chapter 2, led to the development of two layers of habitat-based objectives for this HCP. The first layer is comprised of HCP Objectives described in this chapter. These HCP Objectives apply the HCP Goals to the Bull Run Watershed and to the geographic areas envisioned for the offsite Sandy River Basin measures in Chapter 7. The HCP Objectives were used to develop the habitat conservation measures presented in Chapter 7. The HCP Objectives are the following:

Bull Run Watershed

- Provide instream flows in the lower Bull Run River to improve existing conditions for the four primary covered fish species
- Provide water temperature conditions in the lower Bull Run River that are equivalent to natural pre-water-system conditions and in compliance with the Sandy River Basin Total Maximum Daily Load (TMDL) and water quality management plan
- Improve instream habitat conditions in the lower Bull Run River
- Protect riparian forest conditions on City land along the lower Bull Run River
- Ensure access for fish into lower Bull Run River tributaries
- Avoid or minimize periodic temporary disturbance of habitat (for species covered or addressed in the HCP) that might otherwise result from routine operation, maintenance, repair of water supply facilities, or incidental land management
- Avoid or minimize periodic temporary disturbance of habitat (for species covered or addressed in the HCP) that might otherwise result from implementation of the HCP habitat conservation measures
- Protect instream flows in the Little Sandy River

Sandy River Basin

- Protect and improve instream and riparian habitat conditions for the primary covered fish species at targeted locations in the larger Sandy River Basin, particularly locations affected by covered activities or locations where benefits would offset impacts that are expected to continue to occur in the Bull Run River
- Provide habitat improvements offsite to specifically benefit spring Chinook spawning because of the constraints limiting spawning in the lower Bull Run River
- Provide habitat benefits offsite to specifically benefit fall Chinook, a species for which the Sandy River Basin population is particularly important to the Lower Columbia Evolutionarily Significant Unit (ESU)
- Avoid or minimize periodic temporary disturbance of habitat (for species both covered or addressed in the HCP) that might otherwise result from implementation of the HCP habitat conservation measures

- Choose locations and project types for offsite conservation measures based on the best available current information about habitat conditions, role in productivity of the four primary covered species, and the habitat factors limiting productivity
- Focus on private lands where incentives and requirements for habitat protection by the landowner are otherwise limited
- Prioritize projects that provide the most benefit per dollar paid by the City's ratepayers
- Assist the Sandy River Basin Partners with implementation of the Sandy River Basin Restoration Strategy

6.3 Measurable Habitat Objectives

The City has also identified Measurable Habitat Objectives. These Measurable Habitat Objectives—at least one for each HCP habitat conservation measure—are included in the HCP's second layer of objectives and are presented in Chapter 9. These objectives were used to define the amount and types of habitat targeted for improvement. They also help focus the monitoring and adaptive management programs.

Chapter 7. Habitat Conservation Measures

7. Habitat Conservation Measures

7.1 Introduction

To address the habitat impacts of the City's water supply system, the City developed the conservation strategy described in Chapter 2. Chapter 6 translated the conservation strategy into species-specific goals and objectives. Measures to accomplish the goals and objectives are described in this chapter.

To provide context for the measures, the impacts the City has had, or could have, in the Bull Run River are briefly summarized in Table 7-1 as they might affect groupings of species addressed or covered by this HCP. Table 7-1 also briefly introduces the habitat conservation measures and associates them with the impacts the measures are intended to address. The biological effects expected to result from implementing the measures are described in Chapter 8.

Table 7-1. Summary of Potential Water Supply System Impacts and Associated Habitat Conservation Measures in the Bull Run River, by Species Grouping

Species[a]	Potential Impacts of Water Supply System[b]	Habitat Conservation Measures[c]
Anadromous Fish		
Fall Chinook **Spring Chinook** **Coho** **Winter Steelhead** **Chum** **Eulachon** Lamprey (Pacific, River and Western Brook)	• Reduced flow • Flow fluctuations • Reduced water quality • Depleted spawning gravel • Loss of riparian habitat • Reduced instream habitat complexity • Blocked access to spawning and rearing habitat at dams and culverts	• Provide flow in lower Bull Run River • Avoid effects on flow in Little Sandy River (lower Bull Run tributary) • Add summer season flow in Cedar Creek • Manage flow fluctuations in lower Bull Run River • Manage water temperatures in lower Bull Run River • Augment spawning gravel in lower Bull Run River • Protect riparian habitat on City land along lower Bull Run River • Manage water supply operations and maintenance activities to avoid or minimize effects • Protect and enhance riparian habitat in other Sandy River Basin reaches • Increase instream habitat complexity in other Sandy River Basin reaches • Provide passage at current culvert on Walker Creek (lower Bull Run tributary) • Provide passage at current blockages on Alder Creek and Cedar Creek

Table continued on next page.

Table 7-1. Summary of Potential Water Supply System Impacts and Associated Habitat Conservation Measures in the Bull Run River Watershed, by Species Grouping, continued

Species[a]	Potential Impacts of Water Supply System[b]	Habitat Conservation Measures[c]
Resident Fish		
Cutthroat Trout Rainbow Trout	• Loss of habitat due to reservoir operations • Seasonal stranding in Dam 2 spillway approach canal	• Protect habitat by maintaining current limitations on reservoir operations (e.g. surface elevations during spring season tributary spawning) • Rescue stranded fish and return them to reservoir • Manage water supply operations and maintenance activities to avoid or minimize effects
Amphibians and Reptiles		
Salamanders (Cope's Giant, Cascade Torrent, Clouded, Oregon Slender) Frogs (Coastal Tailed, Northern Red-legged, Cascade) Western Toad Turtles (Western Painted, Northwestern Pond)	• Temporary habitat disturbance • Potential loss of habitat in riparian zones	• Control reed canarygrass on bench at upper end of Reservoir 1 • Survey for presence of turtles and avoid impacts during implementation of habitat conservation measures proposed near the mouth of the Sandy River • Protect riparian forests on City land along lower Bull Run River • Manage water supply operations and maintenance activities to avoid or minimize effects • Protect and enhance riparian forests along other Sandy River Basin reaches
Birds		
Bald Eagle[d] Northern Spotted Owl	• Temporary noise disturbance • Loss of nesting habitat • Loss of roosting habitat	• Avoid noise-generating activities (e.g., road brushing) during nesting season • Avoid cutting nest trees • Avoid cutting roost trees • Manage water supply operations and maintenance activities to avoid or minimize effects

Table continued on next page.

Table 7-1. Summary of Potential Water Supply System Impacts and Associated Habitat Conservation Measures in the Bull Run River Watershed, by Species Grouping, continued

Species[a]	**Potential Impacts of Water Supply System**[b]	**Habitat Conservation Measures**[c]
Mammals		
Fisher	• Temporary habitat disturbance • Loss of habitat	Consult with USFWS about necessary additional measures if fishers recolonize Bull Run watershed, or recolonize locations in the Sandy River Basin where City is implementing habitat conservation measures

[a]The six covered fish species are listed in bold type; all other species are addressed by, but not covered by, this HCP. Fall and spring Chinook are separate races of the same species *(O. tshawytscha)*. In this HCP, the City refers to them as two species. Fall and spring Chinook, steelhead, and coho are therefore referred to as the four primary covered species.

[b]This list is not comprehensive; see additional information in Chapters 2 and 8 and the discussion of limiting factors in Chapters 5 and 8.

[c]This list is not comprehensive; see additional details below in this chapter and in Chapter 8.

[d]Although the bald eagle has been delisted as a threatened species on the Endangered Species List, the City has prepared its bald eagle measure according to the National Bald Eagle Management Guidelines (U.S. Fish and Wildlife Service 2007b).

For each measure, the intended enforceable terms are described in the boxed text, and include the referenced tables. Unless otherwise indicated, the habitat conservation measures will be implemented (annually or continuously, as applicable) for the 50-year term of the HCP.

Habitat conservation measures for the lower Bull Run River are described in Sections 7.2 and 7.3, and include measures for the Bull Run reservoirs. Measures related to operating and maintaining the water supply infrastructure are described in Section 7.4. Habitat conservation measures in the larger Sandy River Basin (referred to as “offsite” measures) are presented in Section 7.5. The Habitat Fund discussed in Section 7.6 is designed to implement additional projects in the Sandy River Basin to meet the City’s conservation responsibilities. Section 7.7 describes measures provided to protect terrestrial wildlife, in the Bull Run watershed and for other covered activities where applicable. Summary tables are provided for each section.

7.2 Lower Bull Run River Habitat Conservation Measures

The City’s direct impacts on fish and fish habitat occur in the lower Bull Run River. The impacts are in three general categories: river flow, water temperature, and habitat (e.g., spawning gravel). To address these impacts, the City will implement measures to avoid or minimize flow and temperature impacts, and measures to protect and improve both instream and riparian habitat. The effects of implementing these measures are described in Chapter 8 and Appendix E for each species.

The HCP Objectives described in Chapter 6 were used to identify habitat conservation measures for the lower Bull Run River. These objectives are as follows:

- Provide instream flows in the lower Bull Run River to improve existing conditions for the four primary covered fish species
- Provide water temperature conditions in the lower Bull Run River that are equivalent to natural pre- water-system conditions and in compliance with the Sandy River Basin Total Maximum Daily Load (TMDL) and temperature management plan
- Improve instream habitat conditions in the lower Bull Run River
- Protect riparian forest conditions on City land along the lower Bull Run River
- Ensure access for fish into lower Bull Run River tributaries
- Avoid or minimize periodic temporary disturbance of habitat (for species covered or addressed in the HCP) that might otherwise result from routine operation, maintenance, repair of water supply facilities, or incidental land management
- Avoid or minimize periodic temporary disturbance of habitat (for species covered or addressed in the HCP) that might otherwise result from implementation of the HCP habitat conservation measures
- Protect instream flows in the Little Sandy River

Figure 7-1 is a map of the lower Bull Run River area marked with the major landscape and structural features that are pertinent to implementing the Bull Run measures.

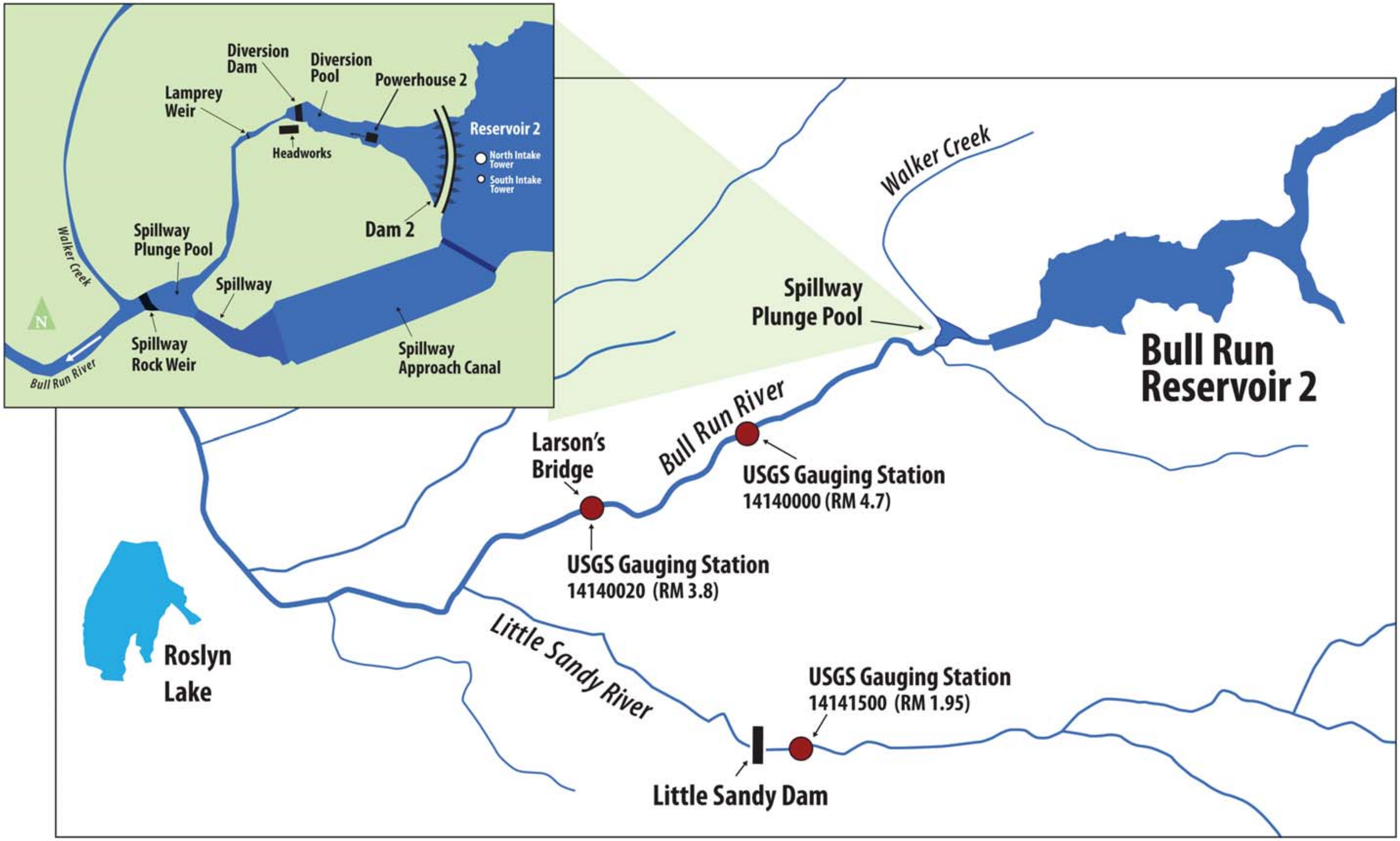


Figure 7-1. The Lower Bull Run River and Surrounding Area

Note: Map not to scale

7.2.1 Instream Flow Measures in the Lower Bull Run River

Estimates of natural, pre-water-system flows in the lower Bull Run River are shown in Table 4-5 in Chapter 4. These flows provided passage upstream for adult steelhead, salmon, and other aquatic species and created pools, riffles, and runs that rearing and migrating fish used. The natural flow conditions also tended to result in gradual rises and drops in river levels.

The City has gathered data and conducted modeling to estimate the relationship between flow and total usable habitat for salmon and steelhead, and has contrasted those results with natural streamflow conditions. A flow regime was developed to regulate the amount and timing of flow releases from Bull Run Dam 2. The goal was to protect and improve aquatic habitat in the lower six miles of the Bull Run River.

Two flow regimes are included in this HCP: normal water years and water years that have either a critical spring season or a critical fall season.[1] Instream minimum flows had not been previously established for the lower Bull Run River. To design the flow regimes, the City evaluated ongoing operations and identified opportunities for instream habitat enhancement below the water supply dams. The flow regime is structured according to four key components: guaranteed minimum flow, variable flow to manage temperature, a fall season flow increment based on percent of reservoir inflow, and a maximum required flow (cap) to manage reservoir refill. The fall season increment is determined by the minimum flow commitment or the percentage of reservoir inflows—whichever is higher. The maximum fall flow is defined by the cap until reservoir refill is complete. Critical spring seasons are predicted to occur 20 percent of the time; critical fall seasons are predicted to occur 10 percent of the time.

The guaranteed minimum flows for the HCP will be expressed as the mean daily flows in cubic feet per second (cfs). The flows will be recorded by the U. S. Geological Service (USGS) every 15 to 30 minutes and the City will determine the mean of the daily flows. The City will also determine the mean daily maximum water temperatures for the water temperature conservation measures.

Drawdown is defined as the point in time annually when water supply diversions consistently exceed reservoir inflows and precipitation is not anticipated. Refill is defined as the point in time annually when both reservoirs have filled to the normal winter operating ranges (1034-1036 feet above mean sea level (MSL) in Reservoir 1 and 858-860 feet above MSL in Reservoir 2).

In addition to the flow releases, the City created a measure to protect against large decreases in the river level due to reservoir operations that might otherwise trap small salmonids (i.e. downramping). The City will also sign a flow agreement that is expected to result in natural instream flows in the Little Sandy River for the term of the HCP. Chapter 8 discusses the habitat effects of the City's flow measures for each species.

Release of water into the lower Bull Run River for fish will have an effect on the water supply otherwise available from Bull Run for water system customers. The City anticipates

[1] The water year is the 12 months beginning on October 1 of one year and ending September 30 of the following year. For example, water year 2000 began on October 1, 1999 and ended September 30, 2000.

using groundwater from the Columbia South Shore Well Field to ensure an adequate supply, particularly in dry years. Water conservation programs also help ensure an adequate future supply by decreasing water demand. Chapter 2 provides additional background on the wellfield and on the City's water conservation programs.

Flow Releases During Normal Water Years

Minimum instream flows to improve fish habitat conditions in the lower Bull Run River during normal water years are described in Measure F-1. The measure includes guaranteed minimum flow amounts and other criteria that will maintain flow levels for spawning, rearing, and migrating salmonids and other aquatic species.

Measure F-1—Minimum Instream Flows, Normal Water Years: For HCP Years 1-50, the Bull Run water supply will be operated during normal water years to achieve the guaranteed flows in the lower Bull Run River specified in Table 7-2 (expressed in mean daily flows in cubic feet per second, cfs).

Table 7-2. Flow Commitments for the Lower Bull Run River During Normal Water Years, Measured at USGS Gauge 14140000, RM 4.7

Time Period	Guaranteed Minimum Flow (cfs)	Required Percent of Inflow	Maximum Required Flow (cfs)
January 1–June 15	120	n/a[a]	n/a
June 16–June 30	Gradually decrease flows over 15 days from minimum of 120 cfs to a minimum of 35 cfs. If reservoir drawdown begins before June 30, decrease flows at no more than 2”/hour to reach the 20–40 cfs operating range, see below.		
July 1–September 30	Vary flow from 20 cfs to 40 cfs to manage downstream water temperature[b]		
October 1–October 31	70	50%	400
November 1–November 30	150	40%	400
December 1–December 31	120	n/a	n/a

[a]n/a = not applicable [b]See Measure T-1.

For the period from June 16 to June 30, the guaranteed minimum flow of 120 cfs will be decreased by 5 cfs per day until the minimum of 35 cfs is achieved at Gauge No. 14140000.

Variable flows will be implemented in summer (July through September) of normal water years. Water temperature is a key management concern during this season, and the reservoirs will be operated to take advantage of the limited amount of cold water that can be stored. Releases from the reservoirs will vary with weather conditions to better manage use of the available cold water. During mild weather, when temperatures in the river are naturally lower, less cold water will be released from the reservoirs. During warm weather, when cold water from the reservoirs is needed to moderate river temperatures, more cold water will be released. The resulting average summer flow in normal water years is expected to be 35 cfs.

Flow releases in October and November are defined as a percentage of reservoir inflow, with both upper and lower bounds as shown in Table 7-2. The City will provide a “floor” or minimum flow levels for the lower Bull Run River. The City will also cap the maximum flow level in October and November to allow the reservoir to refill to reduce the potential for unacceptable turbidity. The percentage of inflow released is higher in October than

Measure description continued on next page.

Measure F-1, continued

in November, but the total amount of water released will be higher in November because (1) the floor for the November minimum flow is higher than the floor for October and (2) inflow is generally higher in November than October.

Basing water release on a percentage of inflow will ensure that fall flow in the lower river is determined by flow into the reservoirs, not by the amount of water stored in the reservoirs or the amount diverted for municipal supply. Reservoir storage and diversions are both affected by water demand. Inflow is not affected by water demand.

The City will control streamflow releases below Dam 2 at Headworks (RM 6.0 on the Bull Run River) and the lower Bull Run River flow will be measured at USGS Gauge No. 14140000 (RM 4.7). For purposes of determining streamflow releases in October and November, reservoir inflow will be measured and totaled for four USGS Gauges (No. 14138850, Bull Run River at RM 14.8; No. 14138870, Fir Creek at RM 0.6; No. 14138900, North Fork Bull Run River at approximately RM 0.2; and No. 14139800, South Fork Bull Run River at RM 0.6). The daily mean flows of the four gauges will be added and then multiplied by 1.2 to account for the ungauged area of reservoir inflows in the Bull Run Watershed.

City staff will determine the week's reservoir inflows once a week and determine the following week's flow target based upon the inflow data. The first determination of reservoir inflow levels will occur prior to October 1. The flow releases to meet the targets will be implemented starting on October 1. Flow release targets will be set each week through the end of November.

Through the term of the HCP, the flow releases in the lower Bull Run River may exceed the guaranteed minimum flows in Table 7-2 if the reservoir inflows exceed demands for drinking water and the guaranteed minimum flows for fish.

The minimum flow requirements may not be met during the days that the Chinook surveys occur. Flows will be held to less than 150 cfs, as measured at USGS Gauge No. 14140000, to allow safe surveying. The surveys are expected to occur approximately once per week from August through November. See Appendix F for more details on the Chinook survey procedures.

Under Measures F-1 (normal water year) and F-2 (critical seasons), the flow in October and November is capped to allow for reservoir refill prior to fall storm events. Because the Bull Run water system is unfiltered, the water supply is vulnerable to high turbidity during fall storms. Turbidity interferes with effective disinfection of the water supply and increases the potential for waterborne disease. Intense late fall and winter storms can cut through sediment deltas and wash sediment from reservoir banks. These storms also flush accumulated sediment from tributaries into the reservoirs. Without filtration, turbidity generated by these storms can only be removed by dilution, settling, and flushing—none of which can be relied on to occur quickly. If heavy rain events occur when the reservoirs are low, the turbidity generated can move rapidly (within hours) from the tributaries to the intake towers. Full reservoirs help dilute the inflow and can slow the movement of turbid water long enough (about a day) to enable the City to shut down the reservoir supply and turn on the Columbia South Shore Well Field supply.

During recent events, in-reservoir turbidities higher than 20 NTUs (nephelometric turbidity units) have been recorded (late November, 1999). While this turbidity level does not adversely affect fish, it does exceed drinking water quality regulations. The filtration avoidance criterion for turbidity, as specified in the federal Surface Water Treatment Rule, is 5 NTU. If the City were to supply water exceeding 5 NTU, customers might have to boil their water and EPA could require construction of a filtration facility. Current practice is to not use the Bull Run supply when turbidity exceeds 3.5 NTU; groundwater from the Columbia South Shore Well Field is used instead.

The need to fill Bull Run reservoirs in the fall constrains the City's ability to provide fall season flows. The flow measures in the HCP do not guarantee the City's ability to refill the reservoirs, but they do reduce the risk that the reservoirs will not be refilled by November 15th to an acceptable level (less than 20 percent probability). If the reservoirs are already full and municipal demands are being met, flows in excess of the maximum (cap) can and will be released, primarily because there is no storage capacity in the watershed or in the distribution system to hold them.

Flow Releases During Years with Critical Water Seasons

Inflows will be lower and water demand will be higher in water years that have either a critical spring or fall season. The challenges involved in meeting water demand during dry years were used to design the critical season flow triggers. Three different water supply and demand situations are involved:

> **Years with a dry spring that causes early reservoir drawdown:** In normal water years, drawdown typically begins in early July. Initiation of drawdown before June 15 is often an indication of a challenging summer season for water supply. If followed by a normal summer and fall, years of early drawdown are manageable and have a limited effect on the City's ability to provide flows for fish and for water temperature management. Unfortunately, there is no way to tell early in the season whether dry conditions will persist. If critical season flows are not implemented at the first sign of a potentially dry summer season (early drawdown), the effects of a continued dry season could be severe—both for water supply and for the City's ability to provide sustained flows and suitable water temperatures for fish.
>
> **Years with a normal spring and summer but a dry fall:** Years that change from normal to dry late in the summer can be difficult to manage because the signal of trouble (insufficient inflow) comes late and the options to supplement water supply are, by then, more limited. Fall is a challenging season in all years because these months are when spawning and incubation for Chinook occurs, the reservoirs reach their lowest levels, and the threat of water shortage is greatest. Without early fall rain to increase inflow, releases can quickly outstrip remaining reservoir capacity. Lack of rain in the late fall can also delay refill of the reservoirs and exacerbate efforts to control turbidity during early winter storms. Sporadic fall rains can partially alleviate low reservoir levels, but they make it difficult to judge if and when reservoir refill will actually occur.

Years that are dry from spring through fall: This scenario has the most serious implications for water supply. For purposes of the HCP, these circumstances mean that the watershed faces both spring and fall critical conditions. The problem in such years is the very long duration of drawdown and the resulting large volume of water needed to satisfy the needs of both people and fish.

As described in Measure F-2, the HCP establishes “triggers” to determine the onset of either spring or fall critical flow conditions. The spring and fall season triggers are independent, but it is possible that both would be triggered in a single year. It is more likely that only one would be triggered. The combination of normal and critical flows in any single water year will be determined by the weather.

If critical spring conditions arise, the City will ramp down to summer flows earlier. Summer flows through September 30, however, remain as during normal flow years, varying from 20 to 40 cfs for purposes of meeting water temperature targets.

If critical fall conditions arise, the flow changes compared to normal years will be as follows:

- Summer minimum flows of 20–40 cfs will extend until October 15, rather than ending in late September.
- From October 16 to November 15, minimum guaranteed flows will be reduced to 30 cfs (from 70 cfs) and maximum flow released will be 250 cfs (from 400 cfs under normal years).
- From November 16 to November 30, the minimum guaranteed flows are reduced to 70 cfs (from 150 cfs) and maximum required flows are reduced to 350 cfs (from 400 cfs).

Measure F-2 describes the flows to be implemented in water years with critical seasons when reservoir inflows are very low.

Measure F-2—Minimum Instream Flows, Water Years With Critical Seasons: During HCP Years 1-50, for any years that have a critical spring or fall season, the Bull Run water supply will be operated to achieve the guaranteed flows in the lower Bull Run River specified in Tables 7-4 and 7-5 (in mean daily flow in cfs). Fall flows in Table 7-5 will not be implemented more frequently than two years in a row and will not be implemented 4 years after a previous season of critical fall flows has been implemented (to avoid affecting the same age cohort twice). If a year does not have a critical spring or fall season, all flows will be the normal water year flows described in Measure F-1.

The triggers for a critical spring or fall season are defined in Table 7-3.

Table 7-3. Critical Spring and Fall Season Triggers

Critical Season	Trigger
Spring	Drawdown occurs prior to June 15
Fall	August and September inflows within lowest 10% of historic record (1940 to current HCP Year)

The response to a critical spring season is outlined in Table 7-4.

Table 7-4. Flow Commitments for the Lower Bull Run River During Water Years with Critical Spring Seasons

Time Period	Guaranteed Minimum Flow[a] (cfs)	
June 1-June 30	30	If critical spring season trigger is met, decrease flow after drawdown begins but no earlier than June 1. Maintain downramping rate described in Measure F-3, from 120 cfs to 30 cfs.

[a] Measured at USGS Gauge No. 14140000 (RM 4.7)

In any year of the HCP when a critical spring season has been triggered, there may be additional rain that temporarily raises reservoir inflow levels above outflow levels. The City may elect, in such circumstances, to raise the flow of the Bull Run River higher than the critical-period guaranteed minimums indicated in Table 7-2. Also, the City may elect to release more flow than the guaranteed minimum to the lower Bull Run River during critical spring seasons to meet water temperature objectives as described in Measure T-1 and T-2.

The trigger for the critical fall season is based on whether the mean daily flow for the August and September inflows to the Bull Run reservoirs are within the lowest 10 percent of historical flows for that time period. Throughout HCP Years 1-50, the 10th-percentile flow level will be updated annually to include new years of record.

Measure description continued on next page.

Measure F-2, continued

Table 7-5. Flow Commitments for the Lower Bull Run River During Water Years with Critical Fall Seasons[a]

Time Period	Guaranteed Minimum Flow[a] (cfs)	Required Percent of Inflow (cfs)	Maximum Required Flow (cfs)
October 1–October 15	20	If critical fall season trigger is met, continue to vary flow from 20–40 cfs to manage downstream water temperature	
October 16–October 31	30	50%	250
November 1–November 15	30	40%	250
November 16–November 30	70	40%	350
December 1–May 31	120	n/a	n/a

[a]Measured at USGS Gauge No. 14140000 (RM 4.7)

The percentage of inflow and maximum flow requirements might not be met during the days that the Chinook surveys occur. Flows will be held to less than 150 cfs, as measured at USGS Gauge No. 14140000, to allow safe surveying. The surveys are expected to occur approximately once per week from August through November. See Appendix F for more details on the Chinook survey procedures.

The City will control streamflow releases at Headworks (RM 5.9 on the Bull Run River) and the lower Bull Run River flow will be measured at USGS Gauge No. 14140000 (RM 4.7). For purposes of determining streamflow releases in October and November, reservoir inflow will be measured and totaled for four USGS Gauges (No. 14138850, Bull Run River at RM 14.8; No. 14138870, Fir Creek at RM 0.6; No. 14138900, North Fork Bull Run River at approximately RM 0.2; and No. 14139800, South Fork Bull Run River at RM 0.6). The daily mean flows of the four gauges will be added and then multiplied by 1.2 to account for the ungauged area of reservoir inflows in the Bull Run Watershed. City staff will determine the previous week's reservoir inflows once each week and establish the next week's flow release target based on that inflow data. The first determination of streamflow level will occur prior to October 1. The flow releases to meet the targets will be implemented starting on October 1. Additional flow release targets will be set each week through the end of November.

Flow Downramping

Hydropower operation occurs as a byproduct of water supply operation. The existing Federal Energy Regulatory Commission (FERC) license for the City's Bull Run Hydroelectric Project specifies a maximum ramping rate (up or down) of two feet per hour as measured at USGS Gauge No. 14140000 (RM 4.7). Ramping up flows at this rate is not particularly problematic for covered fish species, but lowering the river at this rate can strand juvenile salmonids in side channels and isolated pools. The City is committing to a lower downramping rate to reduce effects on covered fish in the lower Bull Run and Sandy rivers.

Measure F-3—Flow Downramping: For HCP Years 1-50, the City will release flow into the lower Bull Run River, below Dam 2 as a result of hydropower operation, at a maximum downramping rate of no more than 2"/hour (0.17 feet/hour), as measured at USGS Gauge 14140000 (RM 4.7). City staff will monitor recordings at USGS Gauge No. 14140000 to ensure that the decreases adhere to this downramping rate.

This maximum downramping rate will not apply to events beyond the control of system operators, such as unexpected power grid interruptions, downed power lines, equipment failures, emergency responses at the Headworks as required to assure compliance with federal Safe Drinking Water standards, the mandatory annual testing of the powerhouse, and other circumstances that preclude the use of the North Tunnel or Diversion Pool at the City's water supply Headworks. The maximum downramping rate will also not apply when naturally occurring high flows, as measured at USGS Gauge 14138850 (Bull Run RM 14.8), decrease by more than two inches per hour.

7.2.2 Little Sandy River Flows

The City and Portland General Electric (PGE) are the only two entities with water rights claims on the Little Sandy River. The City has a statutory water right on the Little Sandy River, a tributary of the Bull Run River, with a priority date of 1909. Both the City of Portland and PGE have claims to water rights on the Little Sandy River with earlier priority dates. PGE's water claim (1907 priority date) will be converted to an instream right as part of the decommissioning of its Bull Run hydroelectric project (which includes Marmot Dam, Little Sandy Dam, Roslyn Lake, and the Bull Run powerhouse). The City's water claim (1892 priority date) and water right (1909) on the Little Sandy will continue to exist.

The City will forgo consumptive use of Little Sandy water under the 1892 claim and the 1909 right for the term of the HCP. When coupled with the conversion of PGE's claim to instream use, the City's action assures natural flows in the Little Sandy for 50 years. In addition, flows in the lower Bull Run River, below the confluence with the Little Sandy and above PGE's

Bull Run powerhouse (about 1.5 miles), will be significantly higher than flows that occurred during PGE's Marmot/Little Sandy hydropower operation (when most Little Sandy River flows were diverted to Roslyn Lake).

> **Measure F-4—Little Sandy Flow Agreement**: In HCP Years 1-5, the City will create a flow agreement documenting the City's commitment to forgo exercise of the City's water right and claims to the Little Sandy River for the term of the HCP. Flows associated with the City's unexercised water rights will remain instream.

7.2.3 Water Temperature Measures for the Lower Bull Run River

Warm water temperature significantly affects salmon and steelhead production in the lower Bull Run River. The lower Bull Run has been identified as a water-quality-limited stream by the Oregon Department of Environmental Quality (ODEQ 2005). Chinook, steelhead, and coho are all affected by the water temperature conditions.

The City will alter its water supply infrastructure and its water supply operations to reduce water temperatures in the lower Bull Run River. The City's strategy relies on sharing the available cold water in the Bull Run reservoirs.

The City cannot dedicate all the cold water to the fish, diverting only warm water to the water supply system, without threatening drinking water quality. Excessively warm water in the distribution system could cause bacteriological growth and nitrification. These processes deteriorate the chlorine residual levels in drinking water; the chlorine levels are set by public health regulations to protect customers from pathogenic organisms. Attempts to manage or ameliorate nitrification problems once they occur can require extensive flushing of the reservoirs and the water mains, which wastes water and can result in combined sewer overflows. Excessively warm water in the open reservoirs at Mt. Tabor and Washington Park also promotes algae growth, which reduces chlorine residual and causes an unpleasant taste and smell. The City plans to maintain conduit water temperatures that will prevent such conditions from developing to avoid non-compliance with drinking water regulations.

The City's temperature management measures involve both infrastructure and operational changes. The infrastructure changes include modifying the Dam 2 water intake structures and the Dam 2 stilling pool and its rock weir. Both of these changes allow more effective use of cold water stored in the reservoirs. The operating changes involve the variable flow releases described in Section 7.2. Flow releases for July through September will vary within a prescribed range of 20 to 40 cfs in response to changing weather conditions. Once water temperatures naturally begin to decline in late October for physical reasons (e.g., shorter day length, lower sun angle), the minimum flows established in Measures F-1 and F-2 will be sufficient to limit high water temperatures. The City will store cold water in the reservoirs in early summer when overall temperatures are lower, and release it in the late summer when river temperatures are warmer. The multilevel intakes already existing at Dam 1 are used for this purpose.

Design, permitting, and construction of the infrastructure changes at Dam 2 will take several years. Until the changes are in place and operational (2013), the City will maintain the 7-day moving average of the maximum daily water temperature of the lower Bull Run River below 21°C for salmon/trout rearing (described in Measure T-1). The City chose a 21 °C maximum target because it allows for continued salmonid growth (Sullivan et al., 2000) and because the City cannot meet a lower maximum temperature with the current water supply infrastructure. In 2005 and 2006 the City maintained a maximum water temperature target of 21 °C for the lower Bull Run River. For those years, the mean water temperature was approximately 16.5 °C.

Analysis leading to the development of the City's temperature measures is described in ODEQ's TMDL for the Sandy River (ODEQ, 2005). Appendix G of this HCP is the Temperature Management Plan (TMP), approved by ODEQ in May 2008 to comply with the TMDL. The TMP describes the steps the City will take to comply with Clean Water Act requirements for water temperature, and refers directly to the flow, temperature, and riparian measures included in this chapter of the HCP.

Measure T-1—Pre-infrastructure Temperature Management: Prior to the completion of the infrastructure changes described in Measure T-2, the City will manage flow releases from Headworks to maintain the 7-day moving average water temperature of the daily maximums at equal to or less than 21.0 °C. Stream temperatures will be recorded at Larson's Bridge on the mainstem Bull Run River (USGS Gauge No. 14140020).

Measure T-2—Post-infrastructure Temperature Management: Within HCP Years 1-5, the City will design, permit, and complete two significant changes to Bull Run water supply infrastructure to implement this conservation measure:

The Dam 2 intake towers will be modified to allow taking water from the reservoir at different levels.

The spillway rock weir in the Bull Run River immediately downstream of the Dam 2 spillway will be modified to allow rapid movement of flow through the spillway stilling basin.

After the infrastructure changes are made to the Dam 2 intake towers and the spillway rock weir, the City will manage flow to meet Oregon state water quality standards in the lower Bull Run River, as established in ODEQ's Sandy River Basin TMDL (ODEQ, 2005) and the ODEQ-approved Temperature Management Plan. The City will use the Little Sandy River water temperature (measured at USGS gauge 14141500) as a surrogate for the natural thermal potential of the lower Bull Run River. Water temperature compliance will be measured at Larson's Bridge on the mainstem Bull Run River (USGS site 14140020). All water temperatures will be expressed as the 7-day moving average of the daily maximum temperature.

Measure description continued on next page.

Measure T-2, continued

Per the Sandy River Basin TMDL, Bull Run River water temperature target will be maintained

• at or below the appropriate biologically based numeric temperature criteria shown in Table 7-6 when the Little Sandy River temperature is below the criteria

Table 7-6. Appropriate Numeric Temperature Criteria

River Reach	Time Period	Habitat Use	Numeric Criterion (7-Day Average Maximum)
River Mile 0 to 5.3	June 16 to August 14	Salmonid rearing	16°C
	August 15 to June 15	Salmonid spawning	13°C
River Mile 5.3 to 5.8	June 16 to October 14	Salmonid rearing	16°C
	October 15 to June 15	Salmonid spawning	13°C

Source: ODEQ 2005

or

• at or below the Little Sandy River temperature (as adjusted, see below) when the Little Sandy River temperature is above the numeric criteria

Also per the TMDL, the Bull Run water temperature target will be adjusted above the actual measured Little Sandy temperatures as follows:

• Between August 16 and October 15, allowances will be made for a 1.0 °C departure above the Little Sandy temperature.

• If the 7-day moving average of daily maximum air temperature is above 27 °C, the lower Bull Run water temperature target will be the lower Little Sandy River water temperature plus 1 °C.

• If the 7-day moving average of daily maximum air temperature is above 28 °C, the lower Bull Run water temperature target will be the lower Little Sandy River water temperature plus 1.5 °C.

The ODEQ temperature standards [OAR 340-041-0028(12)(c)] provide an additional exception if the maximum daily air temperature exceeds the 90th percentile of the 7-day average of the daily maximum air temperature calculated in a yearly series over the historical record. If this situation occurs in the lower Bull Run River, the numeric criteria and natural condition criteria (Little Sandy water temperatures as adjusted above) would not apply.

Daily maximum air temperatures will be recorded at the Water Bureau's Headworks facility below Dam 2 (approx. RM 6).

Measure description continued on next page.

Measure T-2, continued

The Bull Run water temperature criteria will also not apply to events beyond the control of the water system operators, such as unexpected power grid interruptions, downed power lines, equipment failures, loss of computer contact with the Dam 2 intake towers, emergency responses at Headworks as required to assure compliance with federal Safe Drinking Water standards, the mandatory annual testing of the protection devices at the powerhouse, and other circumstances that preclude the use of the intake towers or diversion pool at the City's water supply Headworks.

7.2.4 Habitat Measures in the Lower Bull Run River

Gravel Augmentation

The Bull Run reservoirs trap gravel and reduce gravel input to the lower river. Recent studies by R2 Resource Consultants (1998b) and Beak Consultants (2000a) have shown that Chinook salmon and steelhead populations in the lower Bull Run River are limited by the lack of gravel for spawning. The City will replenish spawning gravel and mimic natural supply and accumulation as described in Measure H-1. The three selected sites provide the best combinations of access for delivery of gravel to the river and proximity to known spawning areas (CH2M HILL, 2000). There are more specifics on gravel augmentation in Appendix F.

Measure H-1—Spawning Gravel Placement: The City will augment spawning gravel in the lower Bull Run River and monitor the effects of the gravel placements. A total of 1,200 cubic yards of gravel will be placed in the river annually during HCP Years 1–5; 600 cubic yards will be placed annually for the remainder of the HCP term (HCP Years 6–50). The gravel will consist of a spawning matrix composed of medium to very coarse material (0.5 to 4 inches) that has been washed or sorted to remove fine sediment. The City will purchase gravel from companies with current valid permits for the mining or removal of gravel. The City will only purchase gravel that comes from areas outside of river floodplains.

Measure description continued on next page.

Measure H-1, continued

Gravel will be placed in the river downstream of the City's water supply intakes. Equal amounts will be placed at three locations:

- 1,200 feet downstream of the Plunge Pool at RM 5.7
- 450 feet downstream of USGS Gauge No. 1414000 at RM 4.7
- 600 feet downstream of Larson's Bridge at RM 4.0

Spawning gravel placement will occur in December after the primary fall Chinook salmon spawning period, and before steelhead spawning starts in the spring.

Gravel placements will continue as described above unless

- the lower Bull Run River does not experience high enough flows to distribute the gravel at the three placement locations

or

- the gravel placement is determined to be ineffective for creating spawning habitat for the covered species.

If either of these two conditions arise, the City will work with the NMFS to modify implementation of the measure as needed.

Appendix F describes how the City will assess the effectiveness of the placed spawning gravel.

This habitat conservation measure includes provisions for adaptive management. If the five-year trial proves effective at improving spawning habitat for salmon and steelhead, the City will continue gravel placement for the 50-year term of the HCP. If gravel augmentation is found to be ineffective, the City will reallocate the associated budget (approximately $15,000 per year) to other habitat conservation measures benefiting the covered species (see the Adaptive Management section of Chapter 9).

Fish Passage

Walker Creek is the only tributary to the lower Bull Run River in which a City culvert has blocked fish access. The short stream probably supported steelhead, coho, and cutthroat trout historically.

Measure P-1—Walker Creek Fish Passage: Within HCP Years 1-5, the City will provide volitional fish passage into Walker Creek. Passage design will be reviewed and approved in advance by NMFS.

Riparian Forest Protection

Riparian forest plays a key role in the health and productivity of freshwater habitats for fish. Examples of some of the habitat functions provided by a riparian forest are the following:

- Input of large wood through tree fall
- Moderation of water temperature through shading
- Input of nutrients from dropped leaves and debris
- Maintenance of bank stability
- Maintenance of water quality by trapping sediment

Past management practices have left many riparian forests impaired in their ability to provide these functions, with resulting degradation of instream habitats. City-owned lands along the lower Bull Run River, on the other hand, have experienced minimal timber harvest cutting the past 90 years and remain capable of providing riparian habitat at a level comparable to unmanaged late-seral forest. The City will continue managing these lands for the duration of the HCP so that their value to instream habitat will be maintained, and in some cases improved.

Note: None of the City-owned lands included in Measure H-2 are involved in the City-USFS land exchange described in Chapter 2. City-owned lands included here are expected to remain City-owned for the term of the HCP.

Measure H-2—Riparian Land Protection: For HCP Years 1-50, City-owned lands adjacent to the lower Bull Run River will be managed for the conservation of riparian habitat. The City will not cut trees within 200 feet of the river's average high water level on City-owned lands for the term of the HCP. A tree, as defined here, is any coniferous species with a minimum average diameter at breast height of 12 inches. Exceptions will include selective tree cutting to construct, maintain, and operate water supply and treatment facilities, water monitoring facilities, power lines, roads, and bridges. The City will also remove trees if they threaten City facilities, pose a significant risk to human safety, or when the City and NMFS determine selective cutting is desirable for the purpose of maintaining or improving riparian habitat. If trees are removed, the City will assess the site to determine whether an appropriate riparian species could be planted where the tree (or trees) was removed and will replant trees where feasible. The planted trees will be species that do not grow as tall as the removed trees. See also Measures W-1 and W-2.

7.3 Bull Run Reservoir Habitat Conservation Measures

The City will implement three measures to address potential impacts of covered activities in the Bull Run reservoirs. The HCP Objective (from Chapter 6) that guides these measures is the following:

- Avoid or minimize periodic temporary disturbance of habitat (for species both covered or addressed) that might otherwise result from routine operation, maintenance, and repair of water supply facilities

The City will avoid or minimize mortality of cutthroat and rainbow trout in the two Bull Run reservoirs by operating the reservoirs in a manner consistent with past operating criteria (see Measure R-1) for the term of the HCP. Removal of cutthroat trout and other fish species from the spillway canal will avoid mortality due to high water temperatures when pools in the canal become isolated from the reservoirs during the summer. Removal of reed canarygrass *(Phalaris arundinacea)*, an invasive non-native species, will minimize impacts of reservoir operation on salamanders, toads, and frogs.

Reservoir Operations

The City has managed the Bull Run reservoirs to achieve water supply goals for many years. The City will continue to manage the reservoirs to assure compliance with federal Safe Drinking Water standards and according to the current operating criteria described in Measure R-1.

Measure R-1—Reservoir Operations: For HCP Year 1-50, the City will operate the two Bull Run reservoirs to avoid or minimize mortality of cutthroat and rainbow trout. The operating criteria for the reservoirs will be the following:

1. When the City is operating its hydroelectric powerhouses at the two Bull Run dams during the winter, the reservoir surface elevations will not normally vary outside of the upper two feet of the reservoirs' normal full pool range (except as noted in items 2 and 3 below). For Bull Run Reservoir No. 1, the elevation range is 1,034 to 1,036 feet above MSL. For Reservoir 2, the range is 858 to 860 feet above MSL.

2. The City will lower the surface elevation of the two reservoirs beyond the upper two feet of the normal full pool level only for water supply and/or quality reasons, for downstream fish habitat reasons, for dam safety reasons, or for repairs or maintenance to the dam or hydropower project facilities.

3. The City will operate the two reservoirs as needed to maintain required streamflows and water temperatures in the lower Bull Run River for covered species.

4. During the summer drawdown season, Reservoir 1 may be lowered to approximately elevation 970 feet above MSL and Reservoir 2 may be lowered to approximately 832 feet above MSL as needed for water supply purposes

5. At the end of each drawdown season, the two Bull Run reservoirs will be filled as rainfall, streamflow and required downstream releases permit.

6. The spillway gates on Bull Run Dam No. 1 will be lowered onto the spillway crest in the spring to store additional water for use in the summer months. After the risk of major flooding has passed, and any habitat maintenance work has been completed in the upper reaches of Bull Run Reservoir No. 1 (see Measure R-3, Reed Canarygrass Removal), the water surface level in that reservoir will be raised to a summer supply full pool level of 1045 feet.

7. The City will use 4-cycle engines on its boats to minimize reservoir water pollution.

The two Bull Run Reservoirs are currently operated under a FERC license agreement that is valid until 2029, and a Special Use Permit from the USFS. If, during the term of the HCP, these license agreements are changed or if the operating criteria for the reservoirs need to be modified, the City will work with NMFS to assess effects on the covered species.

Spillway Approach Canal

When the Reservoir 2 water surface elevation is 855—860 feet above MSL, the spillway approach canal is connected to the reservoir and is full of water. Cutthroat trout swim into the approach canal and can get trapped once the reservoir drops below elevation 855 after drawdown and the canal becomes isolated. Water in the canal during the summer varies in depth with a maximum depth of approximately 15 feet. The water temperature in the canal ranges from 21 °C to 27 °C in July, and can be lethal for cutthroat trout (Bell 1990).

In 2000, the City drained the spillway approach canal and attempted to rescue the cutthroat trout. The City trapped 108 cutthroat trout during that effort and successfully placed 47 fish, 3–14" long, back in Reservoir 2. Because of the high water temperatures, 61 fish died during the operation.

Measure R-2—Cutthroat Trout Rescue: For HCP Years 1-50, the City will remove cutthroat trout from the Dam 2 spillway approach canal annually to prevent mortality due to elevated summer water temperatures.

The City will use several approaches to implement this measure and will determine which one is most effective.

In HCP Year 1, the City will install a fyke net and place salmon eggs in a basket in the trap box to attract cutthroat trout. The fyke net will be placed in the spillway approach canal in early June when water temperatures are cool and will be checked two to three times per week through the end of the month. After June, and when drawdown first starts to isolate the water in the spillway approach canal, the City will drain the canal to determine whether the fyke net was effective for capturing fish.

If at least two-thirds of the cutthroat found in the approach canal are trapped by the fyke net and successfully returned to Reservoir 2, the City will continue that approach for HCP Years 2-50. If less than two-thirds of the cutthroat trout are successfully returned to Reservoir 2, the City will consider a new orientation and location for the fyke net.

After HCP Year 2, if the City determines that fyke netting does not effectively capture the cutthroat in the canal, the City will drain the canal in Reservoir 2 as soon as reservoir elevations allow.

If the City determines that draining the canal sends warm water down the Bull Run River, and interferes with the objectives for Measures T-1 and T-2, the City will not continue this conservation measure. Funding would be allocated to other habitat conservation measures according to the adaptive management process described in Chapter 9.

If the City's methods for the spillway approach canal fish rescue are ineffective—defined as having more than one-third mortality associated with the trapping of fish or leaving fish in the spillway to experience high water temperatures—the City will not continue the measure. In that case, the funding will be allocated to other habitat conservation measures according to the adaptive management process described in Chapter 9.

Reed Canarygrass

Western toads and red-legged frogs lay their eggs around the edges of the reservoirs in the Bull Run watershed. All pond-breeding amphibians need warm sunny shallows while their eggs and young are developing. The western toad and red-legged frog tadpoles use the north shoreline in upper Reservoir 1. The egg incubation for these species can be affected when reed canarygrass invades and shades their breeding areas. The City has identified three areas along the upper end of Bull Run Reservoir 1 that would have less than three feet of water when the reservoir is full, and these areas are important for reproduction and egg incubation for the toads and frogs.

Measure R-3—Reed Canarygrass Removal: For HCP Years 1-50, the City will cut and rake reed canarygrass away from three areas along the north bank of the upper end of Bull Run Reservoir 1. The City will access the site by boat from the reservoir and by trail. Power tools will be used for cutting the grass. Neither heavy equipment nor additional road access will be needed. The cutting will occur just prior to the summer season lowering of the spillway gates on Dam 1, which will flood the shallow area of the reservoir. The areas to be cut are approximately 10' x 15', 100' x 100', and 100' x 40'; this total area to be cut is approximately one-third acre.

7.4 Water System Operation and Maintenance Conservation Measures

The City maintains and operates the water supply facilities in the Bull Run watershed. Associated activities are introduced in Chapter 3 and described in more detail in Chapter 8, Section 8.7. The City will implement two measures to address potential impacts of these covered activities: Bull Run Infrastructure Operations and Maintenance, and Bull Run Spill Prevention.

Measure O&M-1— Bull Run Infrastructure Operations and Maintenance: For HCP Years 1-50, the City will take the following actions to avoid or minimize effects on species covered or addressed in the HCP in the Bull Run watershed:

Covered Lands

- The City will prevent paint and debris from falling in the river during bridge and conduit maintenance at all active stream crossings.
- The City will avoid or minimize erosion during repair and maintenance of all water supply infrastructure.
- Water drained from the conduits will be dechlorinated and routed through energy dissipaters prior to releases in the nearest waterway.
- The City will not use insecticides on covered lands. The City will allow BPA to use the herbicide Garlon 3A in a limited manner on the BPA transmission line easement on City land (see Section 8.7 for more information). The City will avoid or minimize use of other herbicides on covered lands except as necessary to control invasive plants. Plans for herbicide use that might affect habitat for covered species will be provided to NMFS for preapproval.
- The City will use fertilizers on lands if necessary to encourage plant establishment and growth after projects that cause ground disturbance (e.g., as part of hydroseeding).
- The City will remove trees in riparian areas if they threaten City facilities or pose a significant risk to human safety. The City will plant replacement trees, in the same approximate locations, if trees of greater than 12 inches diameter at breast height are cut.

Sandy River Station

- Within HCP Years 1-10, the City will evaluate stormwater drainage at Sandy River Station and improve facilities if needed.

See also Measures W-1 and W-2.

Measure O&M-2 — Bull Run Spill Prevention: For HCP Years 1–50, the City will implement the following actions to avoid or minimize spill effects on the species covered or addressed in the HCP in the Bull Run and Sandy rivers:

Headworks

- Fuel and chlorine deliveries will be escorted by a pilot car via paved roads.
- Secondary containment will be provided for the fuel tanks.
- Containment basins will be inspected and pumped out as needed.

Sandy River Station

- Secondary containment systems will be provided for the fuel tanks and pumps to contain any leaks. Containment basins will be inspected and pumped out as needed.
- Within Years 1–5 of the HCP, the City will evaluate the feasibility of moving existing fuel tanks and pumps out of the Sandy River floodplain. This feasibility analysis will be done in conjunction with a City capital improvement project.

See also Measures W-1 and W-2.

Table 7-6 summarizes the 14 measures the City will implement in the Bull Run as part of this HCP.

Table 7-7. Summary of Bull Run HCP Measures

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[a]	Reaches Affected	Time Frame for Implementation
Flow Measures				
F-1 F-2 F-3 F-4	Minimum Instream Flows, Normal Water Years Minimum Instream Flows, Water Years with Critical Seasons Flow Downramping Little Sandy Flow Agreement	a) Instream flow b) Reduced flow due to water diversions and both reservoir and hydropower operations c) Fall Chinook, spring Chinook, winter steelhead, coho, cutthroat trout, lamprey	Lower Bull Run River Lower Sandy River	Years 1–50[a]
Temperature Measures				
T-1	Pre-infrastructure Temperature Management	a) Water quality b) Warm water temperatures exacerbated due to reservoir operations c) Fall Chinook, spring Chinook, winter steelhead, coho, cutthroat trout, lamprey	Lower Bull Run River	Until tower modifications are complete (2012)
T-2	Post-infrastructure Temperature Management			After tower modifications are complete
Fish Passage Measure				
P-1	Walker Creek Fish Passage	a) Fish access b) Access currently blocked by a City culvert c) Winter steelhead	Lower Bull Run River	Years 1–5

Table continued on next page.

Table 7-7. Summary of Bull Run HCP Measures, continued

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[a]	Reaches Affected	Time Frame for Implementation
Reservoir Measures				
R-1	Reservoir Operations	a) Spawning area access and rearing habitat conditions b) Access to spawning areas, rearing conditions in the reservoirs, and fish entrainment c) Cutthroat trout, rainbow trout	Bull Run Reservoirs 1 and 2	Years 1–50
R-2	Cutthroat Trout Removal	a) Fish stranding b) Seasonal stranding in warm water pools located in Dam 2 spillway approach canal c) Cutthroat trout	Bull Run Reservoir 2	Years 1–50
R-3	Reed Canarygrass Control	a) Habitat diversity b) Seasonal disturbance of breeding habitat on a bench at the upper end of Reservoir 1 c) Western toad and red-legged frog	Bull Run Reservoir 1	Years 1–50
Water System Operation and Maintenance Conservation Measures				
O&M-1	Bull Run Infrastructure Operations and Maintenance	a) Habitat diversity, reservoir and river water quality, riparian function b) Minimal historical impact c) Fall Chinook, spring Chinook, steelhead, coho, cutthroat trout, rainbow trout, lamprey	Bull Run Reservoirs 1 and 2, Lower Bull Run River	Years 1–50
O&M-2	Bull Run Spill Prevention	a) Habitat diversity, reservoir and river water quality b) Minimal historical impact c) Fall Chinook, spring Chinook, steelhead, coho, cutthroat trout, rainbow trout, lamprey	Bull Run Reservoirs 1 and 2, Lower Bull Run River	Years 1–50

Table continued on next page.

Table 7-7. Summary of Bull Run HCP Measures, continued

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[a]	Reaches Affected	Time Frame for Implementation
Habitat Measures				
H-1	Spawning Gravel Placement	a) Spawning gravel b) Trapping of gravel behind Bull Run dams c) Fall Chinook, spring Chinook, steelhead, coho, cutthroat trout	Lower Bull Run River	Years 1–50
H-2	Riparian Land Protection	a) Habitat diversity b) Minimal historical impact. Riparian habitat along lower Bull Run River is in good condition. c) Fall Chinook, spring Chinook, steelhead, coho, cutthroat trout, lamprey	Lower Bull Run River	Years 1–50

[a]See Chapter 8 for additional information on affected reaches and species benefits.

7.5 Offsite Aquatic and Riparian Habitat Conservation Measures

Chapter 2 describes the City's rationale for implementing additional aquatic and riparian habitat conservation measures in the larger Sandy River Basin. Chapter 6 describes the City's HCP Goals and HCP Objectives. The HCP Objectives that guide the offsite Sandy River Basin measures are the following:

- Protect and improve instream and riparian habitat conditions for the primary covered fish species at targeted locations in the larger Sandy River Basin , particularly locations affected by covered activities or locations where benefits would offset impacts that are expected to continue to occur in the Bull Run River
- Provide habitat improvements offsite to specifically benefit spring Chinook spawning because of the constraints limiting spawning in the lower Bull Run River
- Provide habitat benefits offsite to specifically benefit fall Chinook, a species for which the Sandy River Basin population is particularly important to the Lower Columbia Evolutionarily Significant Unit (ESU)
- Avoid or minimize periodic temporary disturbance of habitat (for species both covered or addressed in the HCP) that might otherwise result from implementation of habitat conservation measures
- Choose locations and project types for offsite conservation measures based on the best available current information about habitat conditions, role in productivity of the four primary covered fish species, and the habitat factors limiting productivity
- Focus on private lands where incentives and requirements for habitat protection by the landowner are otherwise limited
- Prioritize projects that provide the most benefit per dollar paid by the City's ratepayers
- Assist the Sandy River Basin Partners with implementation of the Sandy River Basin Restoration Strategy

The City relied on the work of the Partners to identify appropriate aquatic and riparian habitat conservation opportunities in the Sandy River Basin. The Partners agreed in June 2000 to use the Ecosystem Diagnosis and Treatment (EDT) approach as a tool for documenting habitat conditions and quantifying potential fish production benefits from sets of conservation actions.

Fish biologists and other technical staff serving on a technical team were assigned specific streams/reaches within the Sandy River Basin. The technical team members used the EDT model to assess the habitat factors that limit the productivity of fish populations. The results are described as limiting factors in Chapter 5 (see Tables 5-8, 5-10, 5-17, 5-19, 5-26, 5-28, 5-36 and 5-38). The limiting factors analysis results were used to identify habitat factors that could be strategically implemented to improve habitat conditions and fish population productivity.

The result of the technical team effort was a database of more than 100 potential actions throughout the Sandy River Basin, not including options for the lower Bull Run River. These actions included riparian easements, placement of large wood and boulders, culvert removal, channel restoration, and land acquisitions. The City relied on this database to identify conservation actions for the HCP.

The Partners discussed the habitat conservation measures in a series of meetings in 2003 and 2004. In October 2004, the Partners signed an Agreement in Principle (AIP). The AIP acknowledged the collaborative work of the Partners from 1999 to 2004 and recommended that the City proceed to prepare an HCP based on the discussions up to that point (SRBP 2004).

The offsite measures described in this section are organized by watershed. For an overview of the Sandy River Basin, refer to Figure 4-1. For spatial relationships among tributaries in each watershed, refer to the maps in Chapter 4, organized by watershed.

Tables 7-7 through 7-13 in each watershed subsection provide summary information about the measures for that watershed, including the

- name and number of the measure
- habitat attributes affected
- historical impacts in the Bull Run watershed that are addressed through that measure
- species targeted for primary benefit from the measure
- reaches affected in each watershed
- time frame for implementing the measure

7.5.1 Habitat Conservation Measures in the Little Sandy River

The lowest reach of the Little Sandy River does not currently provide significant habitat for salmonids due to PGE's hydroelectric power project on the river. The hydroelectric project is scheduled to be decommissioned in 2008. Once the hydroelectric project is decommissioned, PGE's water right on the Little Sandy River will be converted to an instream right, which will increase flows in the Little Sandy River (see Measure F-4). The City will forgo its water right for consumptive use of the water for the term of the HCP. With the increased flows and upstream fish passage, the Little Sandy River could support anadromous fish production.

Large Wood Placements

Current large wood (LW) levels are low in the lower 1.8 miles of the Little Sandy River. LW additions will increase habitat complexity mainly for steelhead which would favor the Little Sandy because of its stream geomorphology and gradient.

Measure H-3—Little Sandy 1 and 2 LW Placement: During HCP Years 6-10, the City will work with willing landowners to place a minimum of 50 key pieces of large wood (LW) in the lower 1.8 miles of the Little Sandy River. The key pieces will be placed to collect other additional woody debris. Individual LW pieces will be sound conifer logs with a small-end diameter of at least 12 inches and a length of at least 30 feet. LW with large root wads, if available, will be given preference for placement. Artificial anchoring of the wood will only be used when wood movement cannot be tolerated. Anchoring will only be used if the large wood might move downstream and damage road culverts, bridges, private property or other streamside improvements. It is desirable for the stream to redistribute the placed large wood to some extent, as long as damage is avoided. Methods and timing for LW placement and maintenance will be determined in consultation with NMFS and the Oregon Department of Fish and Wildlife (ODFW).

The LW placement in the Little Sandy River will be maintained for 15 years. Year 1 of the maintenance will be the calendar year following the wood placement.

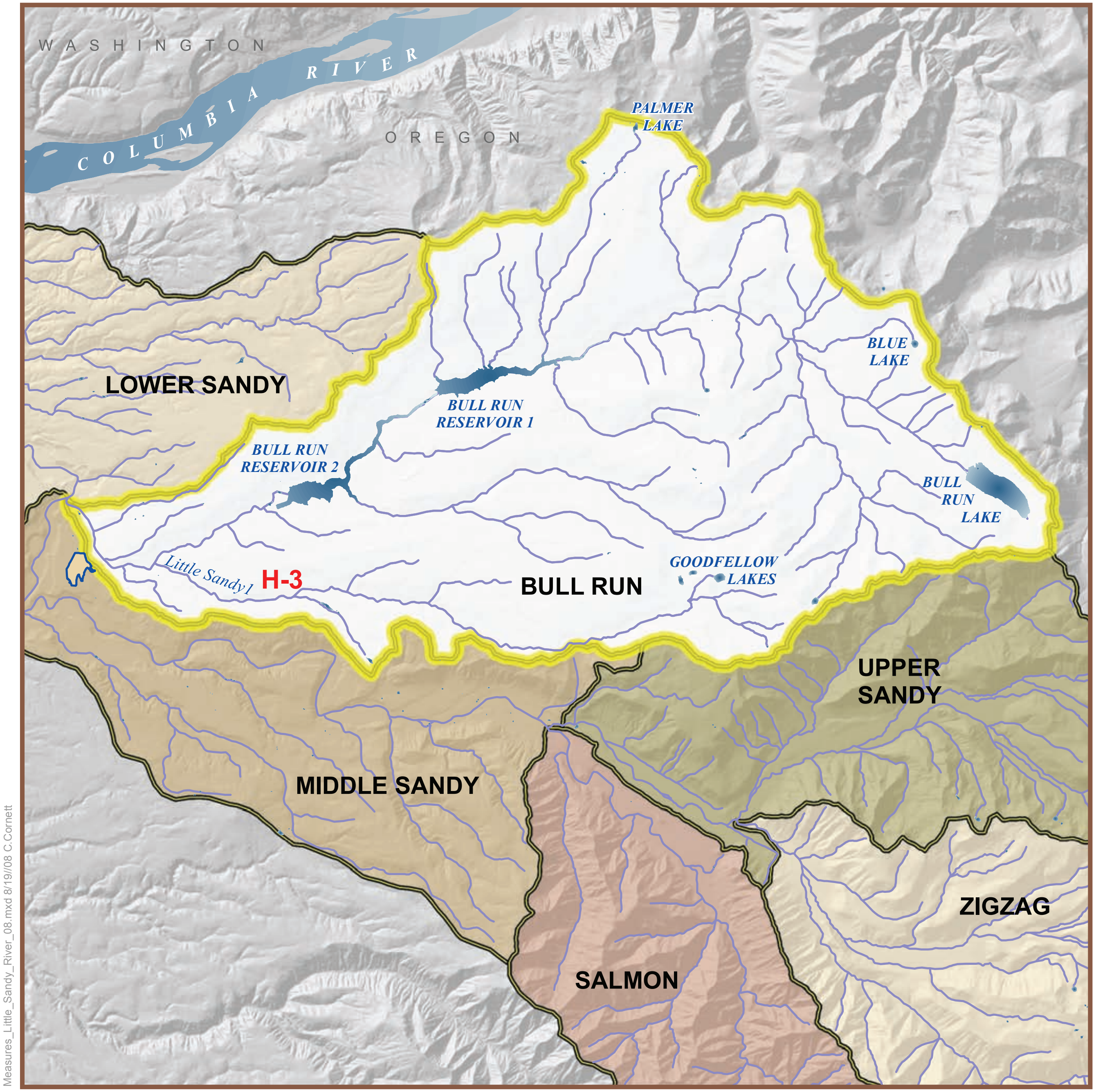
Table 7-7 is a summary of the Little Sandy offsite measure. Figure 7-2 is a map showing the location of Measure H-3.

Table 7-8. Offsite Habitat Conservation Measure in the Little Sandy River

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[b]	Reaches Affected	Time Frame for Implementation
H-3	Little Sandy 1 and 2 LW Placement	a) Large wood b) Reduced habitat complexity c) Winter steelhead, coho	Little Sandy 1	Years 6–10

[a]Although the HCP measures can affect multiple habitat attributes and have effects in multiple reaches, not every habitat attribute will be affected in each reach. For a reach-by-reach summary of the habitat attribute effects, see the tables in Chapter 8 or Appendix E.

[b]See Chapter 8 for additional species benefits



Site Features

- Watersheds of the Sandy River Basin
- Bull Run Watershed
- Rivers and Streams
- Lakes
- Former Lake Site

HCP Offsite Measures

H-3 Large Wood Placement *

* Large Wood Placement in the Little Sandy River is an offsite habitat conservation measure.

Measure numbers are placed in general river reach areas, not in exact locations. (Exact locations depend on willing landowner participation.) Only reaches in which measures are implemented are named. Measures may be implemented in multiple reaches.

N

Projection:
State Plane Oregon North
North American Datum 1983

1:216,824

Miles: 0 0.5 1 2 3 4 5 6 7

Kilometers: 0 1.5 3 6 9 12

Figure 7-2. Offsite Habitat Conservation Measure in the Little Sandy River

7.5.2 Habitat Conservation Measures in the Lower Sandy River Watershed

The lower Sandy River watershed is an important migration corridor for all anadromous species in the Sandy River Basin and a core production area in the lower Columbia ESU for fall Chinook salmon (SRBWG 2005a). The majority of fall Chinook spawning occurs in the mainstem Sandy River and tributaries below Oxbow Park. Fall Chinook also use Gordon and Trout creeks for spawning when rains increase the flows in these tributaries (ODFW 1997).

Many of the lower Sandy reaches, however, lack naturally occurring habitat factors such as LW and natural stream meanders due to human activity either within the lower Sandy watershed or further upstream. The City's HCP measures in the lower Sandy watershed were selected to target improvements primarily for fall Chinook habitat. However, the habitat conservation measures will also improve important habitat for juveniles and adults of all species.

Large Wood

Lower Sandy River reaches 1 and 2 contain densities of large wood at roughly a quarter of estimated historic levels (City of Portland EDT database, 2005). Both reaches lack the large log jams characteristic of similar-sized alluvial channels in a pristine state. The log jam and LW measures for reaches in the lower Sandy will quickly provide benefits such as pools, cover, and nutrients for migrating fish.

Measure H-4—Sandy 1 and 2 Log Jams: Within HCP Years 6-10, the City will work with willing landowners to place engineered log jams at strategic locations along the shoreline within reaches Sandy 1 and Sandy 2. For this HCP, engineered log jams are defined as permanent collections of large wood that create or redirect flow and capture additional wood. The probable locations will be north of the Interstate 84 bridge (Sandy 1) and near Oxbow Park (Sandy 2). A minimum of 300 logs will be placed in the Sandy River reaches. The log jams will be designed to remain at the placed locations. The engineered log jams will be maintained for 15 years. Year 1 of the maintenance will be the calendar year following the wood placement.

The engineered log jams will increase the amount of large wood in reaches Sandy 1 and 2 both through the placement of logs and the subsequent accumulation and retention of wood naturally floating down the channel. They will also improve the functioning of the riparian zone by restoring flow to at least 2,100 lineal feet of side channel in reaches Sandy 1 and Sandy 2. The engineered jams will be designed to deflect flow into the side channels during at least average bankfull flows, which by definition will be at least every two years.

The City will monitor the engineered logs jams for 15 years after placement. If the river changes course during the 15 years after log jam construction, and any log jam is stranded out of the wetted channel, the City will cease monitoring activities on that log jam. Monitoring will restart if the wetted channel changes again to include the area where the log jam was originally placed.

Measure H-5—Gordon 1A and 1B LW Placement: Within HCP Years 1-5, the City will work with willing landowners to place a minimum of 300 key logs along the entire length of reaches Gordon 1A and 1B, at approximately 75 pieces per mile. Individual LW pieces will be sound conifer logs with a small-end diameter of at least 12 inches and a length of at least 30 feet. The key pieces will be placed to collect other additional woody debris. If available, large root wads will also be selected for placement. Artificial anchoring of the wood will only be used when wood movement cannot be tolerated. Anchoring will only be used if the large wood might move downstream and damage road culverts, bridges, private property or other streamside improvements. It is desirable for the stream to redistribute the placed large wood to some extent, as long as damage is avoided. Methods and timing for LW placement will be determined in consultation with NMFS and the ODFW.

The LW placement in Gordon Creek will be maintained for 15 years. Year 1 of the maintenance will be the calendar year following the wood placement. The City will monitor the wood as described in Chapter 9, Monitoring and Adaptive Management.

Measure H-6—Trout 1A LW Placement: Within HCP Years 1-5, the City will work with willing landowners to place logs in the upper one-third of reach Trout 1A, which is approximately 1,000 feet long. Individual LW pieces will be sound conifer logs with a small-end diameter of at least 12 inches and a length of at least 30 feet. The key pieces will be placed to collect other additional woody debris. If available, large root wads will also be selected for placement. Artificial anchoring of the wood will only be used when wood movement cannot be tolerated. Anchoring will only be used if the large wood might move downstream and damage road culverts, bridges, private property or other streamside improvements. It is desirable for the stream to redistribute the placed large wood to some extent, as long as damage is avoided. Methods and timing for LW placement will be determined in consultation with NMFS and the ODFW. A minimum of 25 key logs will be placed.

The LW placement in Trout 1A will be maintained for 15 years. Year 1 of the maintenance will be the calendar year following the wood placement.

Measure H-7—Trout 2A LW Placement: Within HCP Years 1-5, the City will work with willing landowners to place logs in the entire length of reach Trout 2A, which is approximately 1,500 feet long. Individual LW pieces will be sound conifer logs with a small-end diameter of at least 12 inches and a length of at least 30 feet. The key pieces will be placed to collect other additional woody debris. If available, large root wads will also be selected for placement. Artificial anchoring of the wood will only be used when wood movement cannot be tolerated. Anchoring will only be used if the large wood might move downstream and damage road culverts, bridges, private property or other streamside improvements. It is desirable for the stream to redistribute the placed large wood to some extent, as long as damage is avoided. Methods and timing for LW placement will be determined in consultation with NMFS and ODFW. A minimum of 20 key logs will be placed.

The LW placement in Trout 1A will be maintained for 15 years. Year 1 of the maintenance will be the calendar year following the wood placement.

Reconnection of Isolated Habitat

The re-establishment of the mouth of the Sandy River and the channel reconstruction will open the original mouth of the Sandy River to migrating fish and improve side-channel habitat. Approximately one mile of channel habitat will be opened and one-third of a mile of side-channel habitat will be maintained. Log placement in the Sandy 1 side channel will improve habitat diversity, providing cover and refuge for migrating fish. Measures H-8 and H-9 will be designed to minimize short-term effects to chum salmon and eulachon that may use the lower Sandy River stream reaches.

Measure H-8—Sandy 1 Reestablishment of River Mouth: Within HCP Years 6-10, the City will contribute up to a maximum of $1.1 million for the removal of a 1930s-era dike in the Sandy River delta area in coordination with the Columbia River Gorge National Scenic Area. All project designs will be submitted to USFS and NMFS for review.

Measure H-9—Sandy 1 Channel Reconstruction: Within HCP Years 6-10, the City will construct a gradient control weir to maintain flow in a side-channel of the lower Sandy River. The work will occur downstream of the I-84 bridge in the lower reach. A minimum of 25 logs will also be placed in the side channel. All project designs will be submitted to USFS and NMFS for review.

The turtle species have very limited distributions within the Sandy River Basin. These species may be present in the lower delta, downstream of the I-84 bridge, where low-elevation pools and backwater areas are present. Disturbance of these turtles could occur as part of implementing measures H-8 and H-9, or other Habitat Fund projects in the Sandy River delta. Measure H-10 will minimize this disturbance.

Measure H-10—Turtle Survey and Relocation: The City will survey areas downstream of the I-84 bridge in the Sandy River delta for the presence of western painted and northwestern pond turtles if there will be any ground disturbance associated with implementation of the City's habitat conservation measures in the Sandy River delta (e.g., H-8 and H-9). Any of the two species of turtles that would be directly affected will be relocated. Relocations with be coordinated with ODFW.

Riparian Easements and Improvements

The City has identified three habitat conservation measures for the lower Sandy River watershed that will improve riparian zone conditions. The City will obtain easements from willing landowners for a total of approximately 150 acres of riparian lands in the lower Sandy River watershed. The land easements will improve and protect 100 feet of riparian forest on either side of the active channel width of the river or creeks. None of the areas has riparian zones that are in historical condition and the conservation measures include silvicultural practices (i.e., selective thinning and tree planting) to improve the riparian zones. The acreage totals for the land protection easements will be calculated by multiplying the lineal distance of the stream by the amount of riparian forest protected by the easement. These riparian easement and improvement measures have been identified for specific stream reaches in the lower Sandy.

Measure H-11—Sandy 1 Riparian Easement and Improvement: Within HCP Years 1-5, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 11 acres which will comprise the total number of lineal feet x 100 feet of riparian width on either side of the Sandy River in reach Sandy 1. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and the easement will be replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Measure H-12—Sandy 2 Riparian Easement and Improvement: Within HCP Years 1-5, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 62 acres which will comprise the total number of lineal feet x 100 feet of riparian area on either side of the Sandy River in reach Sandy 2. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Measure H-13—Gordon 1A and 1B Riparian Easement and Improvement: Within HCP Years 1-5, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 78 acres which will comprise the total number of lineal feet x 100 feet of riparian area on either side of the Sandy River in reach Sandy 2. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Table 7-8 is a summary of the 10 habitat conservation measures in the lower Sandy River watershed. Figure 7-3 is a map showing the location of Measures H-4 through H-13.

Table 7-9. Offsite Habitat Conservation Measures in the Lower Sandy River Watershed

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts inLower Sandy Addressed c) Species Targeted for Primary Benefit[b]	Reaches Affected[a]	Time Frame for Implementation
H-4	Sandy 1 and 2 Log Jam Placements	a) Riparian function, large wood b) Reduced instream habitat complexity c) Fall Chinook	Sandy 1 Sandy 2	Years 6-10
H-5	Gordon LW Placement	a) Large wood b) Reduced instream channel complexity c) Fall Chinook, winter steelhead	Gordon 1A Gordon 1B Sandy 2	Years 1-5
H-6	Trout 1A LW Placement	a) Large wood b) Reduced instream channel complexity c) Fall Chinook, Winter Steelhead	Sandy 1 Sandy 2 Trout 1A	Years 1-5
H-7	Trout 2A LW Placement	a) Large wood b) Reduced instream channel complexity c) Fall Chinook, Winter Steelhead	Sandy 2 Trout 2A	Years 1-5
H-8	Sandy 1 Reestablishment of River Mouth	a) Riparian function, artificial confinement b) Multiple c) Fall Chinook	Sandy 1	Years 6-10
H-9	Sandy 1 Channel Reconstruction	a) Artificial confinement, large wood, riparian function b) Multiple c) Fall Chinook	Sandy 1	Years 6-10
H-10	Sandy 1 Turtle Survey and Relocation	a) Not applicable b) Not applicable c) Western painted turtle, northwestern pond turtle	Sandy 1	As needed

Table continued on next page.

Table 7-9. Offsite Habitat Conservation Measures in the Lower Sandy River Watershed, continued

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[b]	Reaches Affected[a]	Time Frame for Implementation
H-11	Sandy 1 Riparian Easement and Improvement	a) Riparian function, large wood b) Multiple c) Fall Chinook	Beaver 1A Sandy 1	Years 1-5
H-12	Sandy 2 Riparian Easement and Improvement	a) Riparian function, maximum water temperature, large wood b) Multiple c) Fall Chinook	Sandy 1 Sandy 2	Years 1-5
H-13	Gordon 1A and 1B Riparian Easement and Improvement	a) Fine sediment, backwater pools, large cobble/boulder riffles, primary pools, pool tailouts, small cobble/gravel riffles, riparian function, large wood b) Multiple c) Fall Chinook, winter steelhead	Gordon 1A Gordon 1B Sandy 2	Years 1-5

[a] Because of the cumulative nature of the HCP measures, not all of the reaches in this table will have all of the habitat attribute effects listed here. For a reach-by-reach summary of the habitat attribute effects, see the tables in Chapter 8 or Appendix E.

[b] See Chapter 8 for additional species benefits.

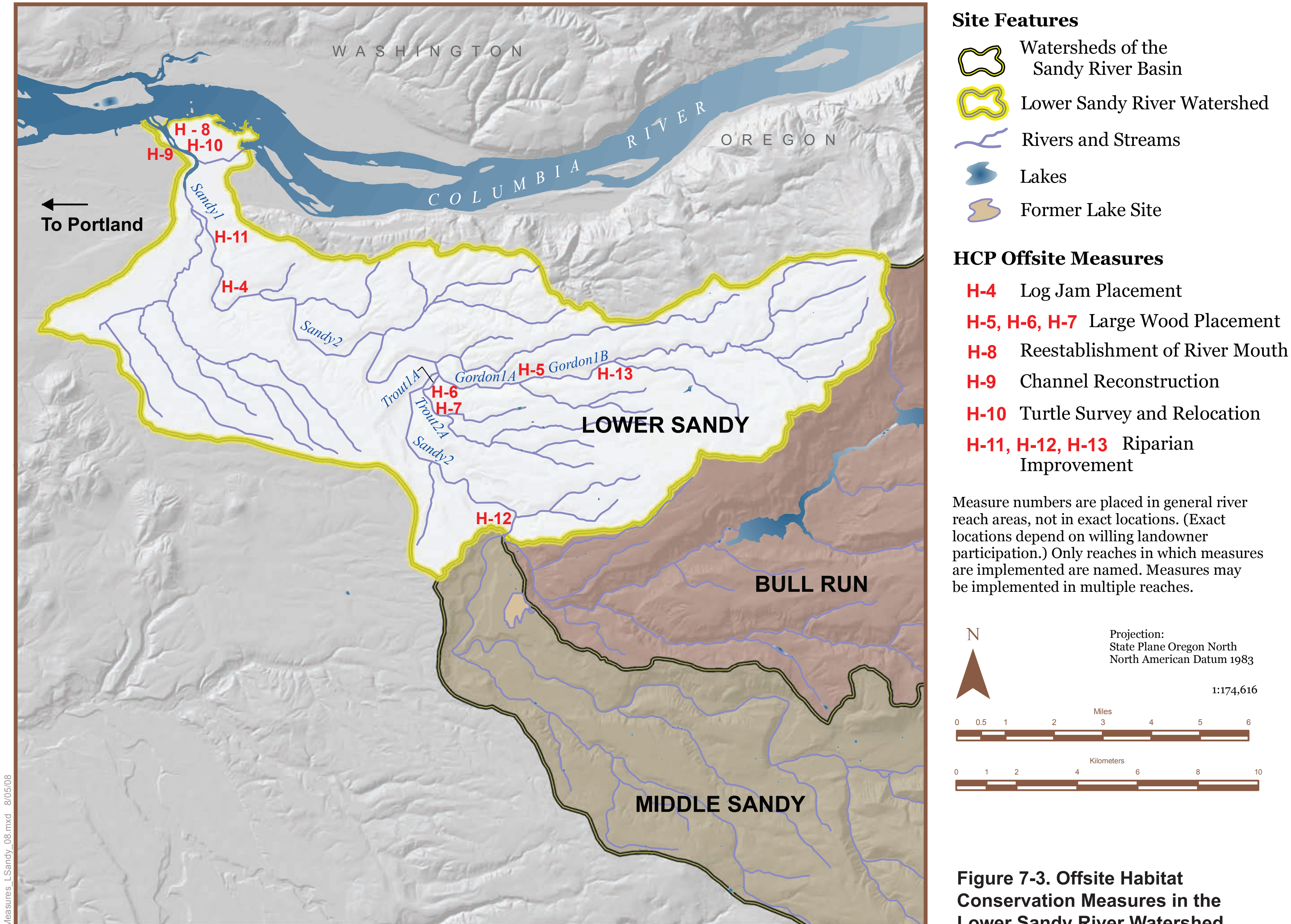


Figure 7-3. Offsite Habitat Conservation Measures in the Lower Sandy River Watershed

7.5.3 Habitat Conservation Measures in the Middle Sandy River Watershed

The middle Sandy River watershed functions primarily as a migration corridor for juvenile and adult salmonids, but also provides some spawning habitat for Chinook salmon and rearing habitat for a variety of resident and anadromous salmonids (Cramer and Associates 1998). Several dams and diversions in the middle Sandy have affected fish and fish habitat for many years. The former Marmot Dam, between reaches Sandy 5 and 6, influenced fish from the time of its construction in 1912 until it was decommissioned in 2007. ODFW constructed the Sandy River Fish Hatchery on Cedar Creek, along with the weir that blocks fish passage at RM 0.5, in the 1950s. Alder Creek, a tributary to the middle Sandy, has a municipal water diversion that supplies the city of Sandy, Oregon. This diversion creates a partial fish passage barrier and affects access for steelhead and coho.

The City's habitat conservation measures in the middle Sandy River watershed were developed considering the pending changes to the existing infrastructure described above. Marmot Dam was decommissioned in July 2007; the distribution of fish, as well as the habitat upstream and downstream of the dam site, may change with the dam removal. The riparian easements were planned to complement the improved fish passage expected from removal of Marmot Dam and the City's fish passage measures in Cedar and Alder creeks.

Riparian Easements and Improvements

The City has identified three habitat conservation measures for the middle Sandy River watershed that will improve riparian zone conditions. For these measures, the City will obtain land protection easements from willing landowners for a total of approximately 130 acres of riparian lands in the middle Sandy River watershed. The land easements will improve and protect 100 feet of riparian forest on either side of the average bankfull width of the river or creek. The riparian easements will extend 100 feet from the average bankfull width of the river. None of the areas has riparian zones that are in historical condition; the conservation measures include silvicultural practices to improve the riparian zones. The acreage totals for the land protection easements will be calculated by multiplying the lineal distance of the stream by the amount of riparian forest protected by the easement. The three riparian easement and improvement measures have been identified for specific stream reaches in the middle Sandy River.

Measure H-14—Sandy 3 Riparian Easement and Improvement: Within HCP Years 11-15, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 7 acres which will comprise the total number of lineal feet x 100 feet of riparian area on either side of the Sandy River in reach Sandy 3. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Measure H-15—Cedar 2 and 3 Riparian Easement and Improvement: Within HCP Years 6-10, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 49 acres which will comprise the total number of lineal feet x 100 feet of riparian area on either side of Cedar Creek in reaches Cedar 2 and Cedar 3. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Measure H-16—Alder 1A and 2 Riparian Easement and Improvement: Within HCP Years 1-5, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 43 acres which will comprise the total number of lineal feet x 100 feet of riparian area on either side of Alder Creek in reaches Alder 1A and Alder 2. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Acquisition of Surface Water Rights

Cedar Creek is a populated watershed with numerous privately-owned parcels and associated water rights for rural residential and agricultural purposes. The creek has elevated water temperatures in late summer partially due to the water withdrawals. The City will acquire water rights to improve water quality and baseflows in Cedar Creek for steelhead, coho, and cutthroat trout.

Measure F-5—Cedar Creek Purchase Water Rights: Within the first 10 years of the HCP term, the City will acquire approximately 50 percent of the current certificated surface water rights that affect summer flows on Cedar Creek. These water rights will be acquired from willing sellers and will be converted to instream use for at least the term of the HCP.

Fish Passage

Alder Creek, one of the larger tributaries to the middle Sandy River, currently supports steelhead and coho. The two fish passage conservation measures will provide access to 5.5 miles of good quality steelhead and coho habitat.

Measure P-2—Alder 1 Fish Passage: Within HCP Years 1-5, the City will modify the fish ladder under the Highway 26 bridge in reach Alder 1 to provide upstream and downstream volitional passage for steelhead and coho salmon. Passage design will be reviewed and approved in advance by NMFS.

Measure P-3—Alder 1A Fish Passage: Within HCP Years 1-5, the City will modify the City of Sandy water diversion weir at RM 1.7 of reach Alder 1A to provide upstream and downstream volitional passage for steelhead and coho. Passage design will be reviewed and approved in advance by NMFS.

Cedar Creek is one of the largest, low-gradient tributaries to the Sandy River. Historically, fish runs were significant in Cedar Creek and the stream supported fish camps (Russ Plaeger, personal communication, January 2007). Fish access to Cedar Creek has been blocked since the Sandy River Hatchery was constructed in the 1950s. The City's conservation measure, in conjunction with ODFW's commitments to fish passage on Cedar Creek, will provide passage to approximately 12—14 miles of stream habitat for coho, steelhead, and anadromous cutthroat trout.

Measure P-4—Cedar Creek 1 Fish Passage: Within HCP Years 1-5, the City will provide up to a maximum of $3.7 million dollars to fund three components of fish passage improvements on Cedar Creek. The City will provide the money to ODFW to fund the following:

1. Upgrades to the Sandy Fish Hatchery water intake screens and associated features to conform to NMFS criteria

2. Passage improvements at the adult diversion ladder, downstream passage pipeline, and downstream plunge pool

3. Upgrades at the discharge channel to the plunge pool, the sluice gates, the diversion dam, and safety improvements for daily maintenance

The City will not provide money to fund the necessary water treatment improvements and any operations and maintenance costs that may be necessary for fish passage on Cedar Creek.

If ODFW cannot secure money for the other components necessary to implement this passage project, the City will redirect the $3.7 million to the Habitat Fund to finance other capital projects in the Sandy River Basin. This reallocation will occur in consultation with NMFS and the Sandy River Basin Partners. The $3.7 million will be

Measure description continued on next page.

Measure P-4, continued

reallocated in a manner (e.g., time frame) that will not adversely affect the City's water rate payers, as determined by the City.

The City will not be responsible for monitoring fish passage on Cedar Creek after the improvements have been made. The City assumes that ODFW will be responsible for monitoring, treatment, and operation and maintenance.

Large Wood

Measure H-17—Cedar 2 and 3 LW Placement: Within HCP Years 6-10, the City will work with willing landowners to place a minimum of 600 key logs along the entire length of reaches Cedar 2 and 3, at approximately 75 pieces per mile. Individual LW pieces will be sound conifer logs with a small-end diameter of at least 12 inches and a length of at least 30 feet. The key pieces will be placed to collect other additional woody debris. If available, large root wads will also be selected for placement. Artificial anchoring of the wood will only be used when wood movement cannot be tolerated. Anchoring will only be used if the large wood might move downstream and damage road culverts, bridges, private property, or other streamside improvements. It is desirable for the stream to redistribute the placed large wood to some extent, as long as damage is avoided. Methods and timing for LW placement will be determined in consultation with the NMFS and ODFW.

The LW placement in Cedar Creek will be maintained for 15 years. Year 1 of the maintenance will be the calendar year following the wood placement.

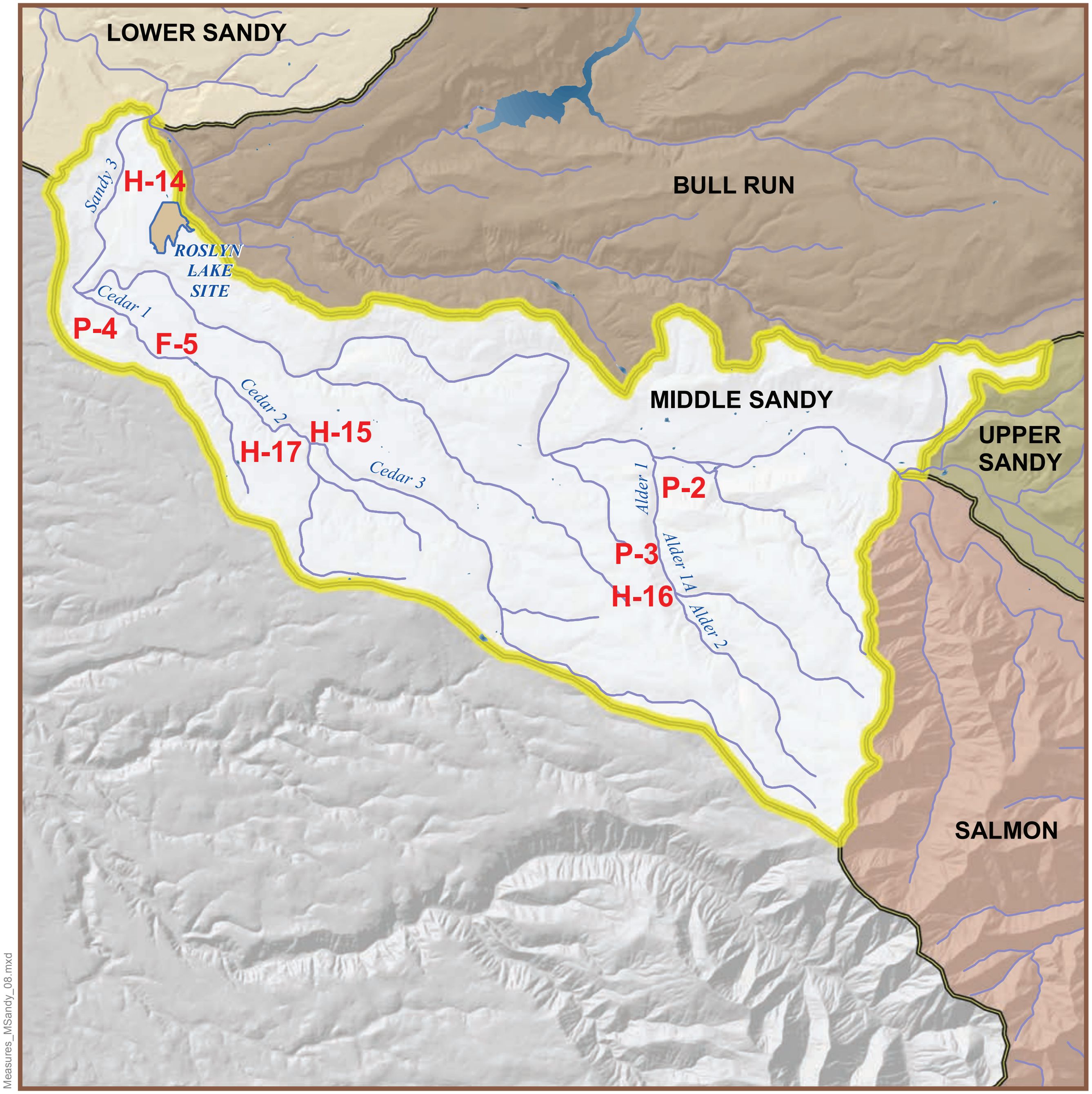
Table 7-9 is a summary of the seven habitat conservation measures in the middle Sandy River watershed. Figure 7-4 is a map showing the location of Measures H-14 through H-17, F-5, and P-2 through P-4.

Table 7-10. Offsite Habitat Conservation Measures in the Middle Sandy River Watershed

#	Measure Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[b]	Reaches Affected[a]	Time Frame for Implementation
F-5	Cedar Creek Purchase Water Rights	a) Dissolved oxygen, fish pathogens, minimum and maximum water temperature, temperature moderation by groundwater b) Multiple c) Winter steelhead, coho, cutthroat trout	Cedar 1 Cedar 2 Cedar 3	Years 6-10
H-14	Sandy 3 Riparian Easement and Improvement	a) Riparian function, maximum water temperature, large wood b) Multiple c) Spring Chinook, winter steelhead, coho	Sandy 3	Years 11-15
H-15	Cedar 2 and 3 Riparian Easement and Improvement	a) Off-channel habitat, riparian function, large wood b) Multiple c) Winter steelhead, coho, cutthroat trout	Cedar 2 Cedar 3	Years 6-10
H-16	Alder 1A and 2 Riparian Easement and Improvement	a) Large wood, riparian function b) Multiple c) Winter steelhead, coho, cutthroat trout	Alder 1 Alder 1A Alder 2	Years 1-5
H-17	Cedar 2 and 3 LW Placement	a) Large wood, beaver ponds, primary pools b) Multiple c) Winter steelhead, coho, cutthroat trout	Cedar 2 Cedar 3	Years 6-10
P-2 P-3	Alder 1 Fish Passage Alder 1A Fish Passage	a) Fish Access b) Blocked access to spawning and rearing habitat c) Winter steelhead, coho, cutthroat trout	Alder 1 Alder 1A	Years 1-5
P-4	Cedar Creek Fish Passage	a) Fish Access b) Blocked access to spawning and rearing habitat c) Winter steelhead, coho, cutthroat trout	Cedar 1 Cedar 2 Cedar 3 Cedar 4	Years 1-5

[a] Although the HCP measures can affect multiple habitat attributes and have effects in multiple reaches, not every habitat attribute will be affected in each reach. For a reach-by-reach summary of the habitat attribute effects, see the tables in Chapter 8 or Appendix E.

[b] See Chapter 8 for additional species benefits



Site Features

Watersheds of the Sandy River Basin

Middle Sandy River Watershed

Rivers and Streams

Lakes

Former Lake Site

HCP Offsite Measures

F-5 Purchase Water Rights

H-14, H-15, H-16 Riparian Improvement

H-17 Large Wood Placement

P-2, P-3, P-4 Fish Passage

Measure numbers are placed in general river reach areas, not in exact locations. (Exact locations depend on willing landowner participation.) Only reaches in which measures are implemented are named. Measures may be implemented in multiple reaches.

N

Projection:
State Plane Oregon North
North American Datum 1983

1:138,910

Miles: 0, 0.5, 1, 2, 3, 4, 5

Kilometers: 0, 1, 2, 4, 6, 8

Figure 7-4. Offsite Habitat Conservation Measures in the Middle Sandy River Watershed

7.5.4 Habitat Conservation Measures in the Upper Sandy River Watershed

Compared with the other watersheds in the Sandy River Basin, the upper Sandy River watershed contains the most stream miles of habitat currently used by anadromous fish in the Sandy River Basin Characterization Report (SRBP 2005). Spring Chinook, coho salmon, and steelhead use the upper watershed for spawning and rearing. Fall Chinook and sea-run cutthroat trout historically used the upper Sandy, but did not pass Marmot Dam in the middle Sandy. The upper Sandy River watershed originates high on the flanks of Mount Hood and the upper Sandy River receives high turbidity from the mountain glaciers during the summer months. Streamflow from the glaciers also provide cool water temperatures for migratory fish seeking clear water spawning tributaries. The City identified one habitat conservation measure to improve habitat for spring Chinook, steelhead, and coho salmon on the mainstem of the upper Sandy River.

Riparian Easement and Improvement

The City's land easement measure in the upper Sandy will improve and protect 100 feet of riparian forest on either side of the active channel width of the river. This measure includes silvicultural practices to improve the riparian zones, which will eventually result in improved habitat diversity through LW recruitment.

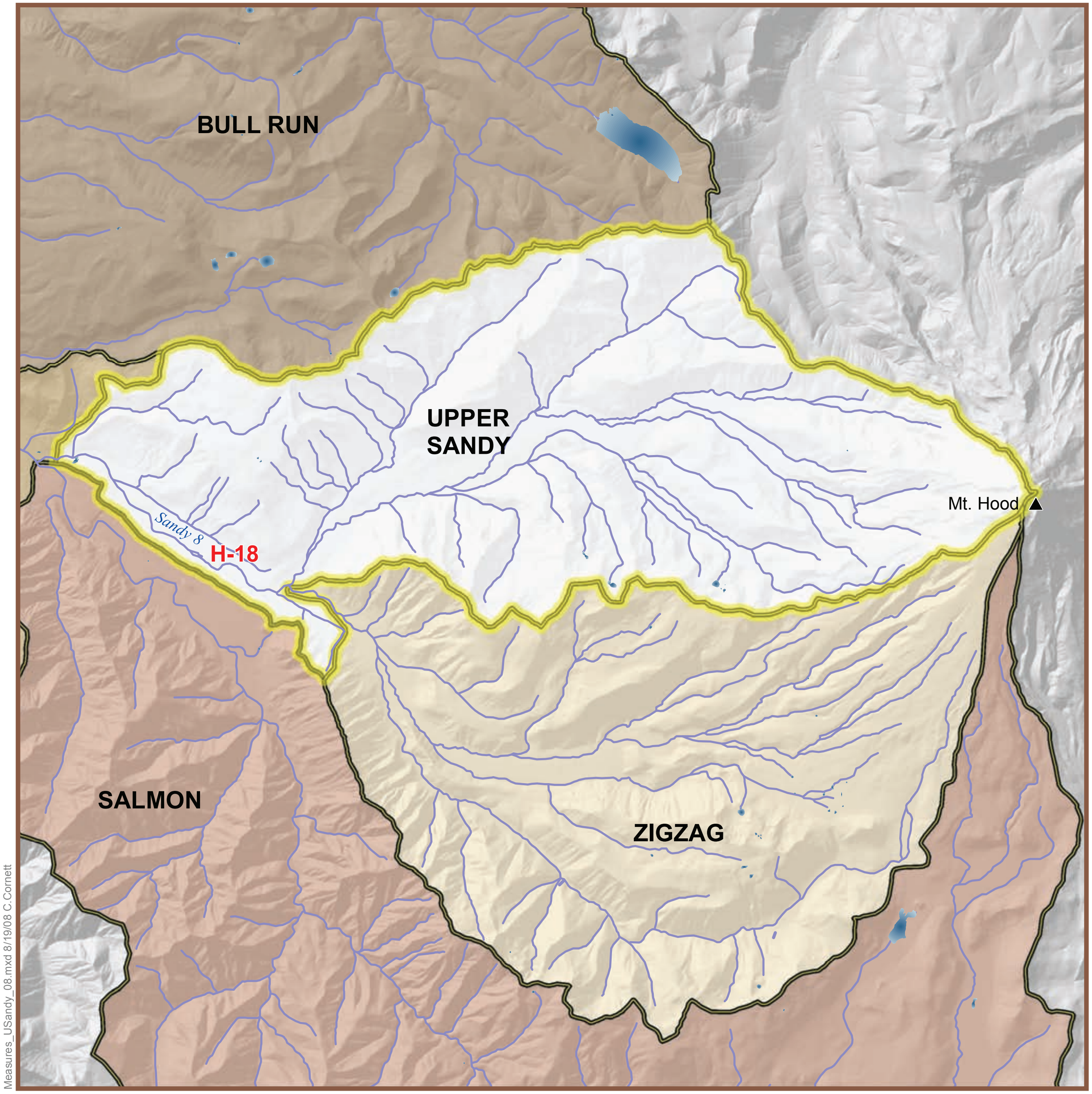
Measure H-18—Sandy 8 Riparian Easement and Improvement: Within HCP Years 11-15, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 25 acres, which will comprise the total number of lineal feet x 100 feet of riparian area on either side of the upper Sandy River in reach Sandy 8. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Table 7-10 summarizes the habitat conservation measure in the upper Sandy River watershed. Figure 7-5 is a map showing the location of Measure H-18.

Table 7-11. Offsite Habitat Conservation Measure in the Upper Sandy River Watershed

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[b]	Reaches Affected[a]	Time Frame for Implementation
H-18	Sandy 8 Riparian Easement and Improvement	a) Maximum water temperature, riparian function, large wood b) Multiple c) Spring Chinook, winter steelhead	Sandy 7 Sandy 8	Years 11-15

[a] Because of the cumulative nature of the HCP measures, not all of the reaches in this table will have all of the habitat attribute effects listed here. For a reach-by-reach summary of the habitat attribute effects, see the tables in Chapter 8 or Appendix E.
[b] See Chapter 8 for additional species benefits.



Site Features

- Watersheds of the Sandy River Basin
- Upper Sandy River Watershed
- Rivers and Streams
- Lakes

HCP Offsite Measures

H-18 Riparian Improvement

Measure numbers are placed in general river reach areas, not in exact locations. (Exact locations depend on willing landowner participation.) Only reaches in which measures are implemented are named. Measures may be implemented in multiple reaches.

N

Projection:
State Plane Oregon North
North American Datum 1983

1:162,227

Miles: 0 0.5 1 2 3 4 5

Kilometers: 0 1 2 4 6 8

Figure 7-5. Offsite Habitat Conservation Measure in the Upper Sandy River Watershed

7.5.5 Habitat Conservation Measures in the Salmon River Watershed

The Salmon River provides some of the most diverse and productive salmon and steelhead habitat in the Sandy River Basin. The Salmon River usually runs clear all year and provides miles of spawning and rearing habitat for spring Chinook, steelhead, and coho, as well as a migration corridor for fish to its smaller tributaries. Final Falls, at RM 14, is the upstream limit of anadromous fish distribution. Historically, the Salmon River also provided spawning habitat for fall Chinook, coastal cutthroat trout, and other species. The City's habitat conservation measures in the Salmon River watershed focus on actions that produce both short- and long-term habitat benefits for fish.

Riparian Easements and Improvements

The City has identified habitat conservation measures for the Salmon River watershed to improve riparian zone conditions. The City will obtain land protection easements from willing landowners for a total of approximately 85 acres of riparian lands in the Salmon River watershed. The land easements will improve and protect 100 feet of riparian forest on either side of the active channel width of the river or creeks. None of the areas has riparian zones that are in historical condition. The conservation measures include silvicultural practices to improve the riparian zones. The acreage totals for the land protection easements will be calculated by multiplying the lineal distance of the stream by the amount of riparian forest protected by the easement.

Measure H-19—Salmon 1 Riparian Easement and Improvement: Within HCP Years 6-10, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 23 acres, which will comprise the total number of lineal feet x 100 feet of riparian area on either side of the Salmon River in reach Salmon 1. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Measure H-20—Salmon 2 Riparian Easement and Improvement: Within HCP Years 11-15, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 36 acres which will comprise the total number of lineal feet x 100 feet of riparian area on either side of the Salmon River in reach Salmon 2. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Measure H-21—Salmon 3 Riparian Easement and Improvement: Within HCP Years 11-15, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 12 acres which will comprise the total number of lineal feet x 100 feet of riparian area on either side of the Salmon River in reach Salmon 3. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Measure H-22—Boulder 1 Riparian Easement and Improvement: Within HCP Years 1-5, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 15 acres which will comprise the total number of lineal feet x 100 feet of riparian area on either side of Boulder Creek in reach Boulder 1. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Land Acquisition and Channel Redesign

Artificially confined banks, degraded riparian function, and reduced large wood are all major factors limiting Chinook, coho, and steelhead in reach Salmon 2. Restoration of the Miller Quarry site will add side channel habitat, improve riparian function, and increase large wood to the channel, which will improve habitat diversity for spawning and rearing fish.

Measure H-23—Salmon 2 Miller Quarry Acquisition: Within HCP Years 6-10, the 40-acre Miller Quarry parcel in reach Salmon 2 will be purchased. The restoration commitments are described in Measure H-24 below.

Measure H-24—Salmon 2 Miller Quarry Restoration: Within HCP Years 11-15, the City will remove riprap along 0.25 mile of river front of the Miller Quarry parcel to reconnect floodplain and side-channel habitat. Approximately 1,000 feet of new side channel will be opened. 160 pieces of LW will be placed in the side channel to create approximately eight log jams. Approximately four acres of riparian zone will be amended with soil and then replanted with suitable riparian species.

Salmon Carcass Placement

Salmon carcasses have been added to streams in the Sandy River Basin since 2001 in an annual effort to enhance in-stream productivity and benefit fish. The City will contribute to this ongoing project with carcass placements in reach Salmon 2 that are designed to return benefits in the stream quickly.

Measure H-25—Salmon 2 Carcass Placement: Within HCP Years 6-10, the City will provide funding, for one season, to place at least 1,800 salmon carcasses (approximately 300 carcasses per mile) in reach 2 of the Salmon River. The carcass placement will be implemented as part of a basin-wide partnership project by ODFW, USFS, and the Sandy River Basin Watershed Council. This measure will only occur during one year and the City will work with the Partners to determine the best timing and method for implementation of the measure, which will depend on available carcasses at ODFW's hatchery facilities and other considerations.

Large Wood

Large wood placed in Boulder Creek will form pools, provide cover, and retain gravel. These habitat attributes will accrue relatively quickly, providing benefits primarily for steelhead and coho.

Measure H-26 Boulder 0 and 1 LW Placement: Within HCP Years 1-5, the City will work with willing landowners to place a minimum of 65 key logs along the entire length of reaches Boulder 0 and 1. Individual LW pieces will be sound conifer logs with a small-end diameter of at least 12 inches and a length of at least 30 feet. The key pieces will be placed to collect other additional woody debris. If available, large root wads will also be selected for placement. Artificial anchoring of the wood will only be used when wood movement cannot be tolerated. Anchoring will only be used if the large wood may move downstream and damage road culverts, bridges, private property, or other streamside improvements. It is desirable for the stream to redistribute the placed large wood to some extent, as long as damage is avoided. Methods and timing for LW placement will be determined in consultation with NMFS and ODFW.

The LW placement in Boulder Creek will be maintained for 15 years. Year 1 of the maintenance will be the calendar year following the wood placement.

Table 7-11 is a summary of the eight habitat conservation measures in the Salmon River watershed. Figure 7-6 is a map showing the locations of Measures H-24 through H-26.

Table 7-12. Offsite Habitat Conservation Measures in the Salmon River Watershed

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[b]	Reaches Affected[a]	Time Frame for Implementation
H-19	Salmon 1 Riparian Easement and Improvement	a) Off-channel habitat, small cobble/gravel riffles, riparian function, large wood b) Multiple c) Spring Chinook, winter steelhead, coho	Salmon 1	Years 6-10
H-20	Salmon 2 Riparian Easement and Improvement	a) Riparian function, maximum water temperature, large wood b) Multiple c) Spring Chinook, winter steelhead, coho	Salmon 1 Salmon 2	Years 11-15
H-21	Salmon 3 Riparian Easement and Improvement	a) Large wood, riparian function b) Multiple c) Spring Chinook, winter steelhead, coho	Salmon 2 Salmon 3	Years 11-15
H-22	Boulder 1 Riparian Easement and Improvement	a) Fine sediment , maximum water temperature, large wood, riparian function b) Multiple c) Spring Chinook, winter steelhead, coho	Boulder 0 Boulder 1 Salmon 1	Years 1-5
H-23	Salmon 2 Miller Quarry Acquisition	a) Bed scour, artificial confinement, off-channel habitat, riparian function, large wood b) Multiple c) Spring Chinook, winter steelhead, coho	Salmon 2	Years 6-10

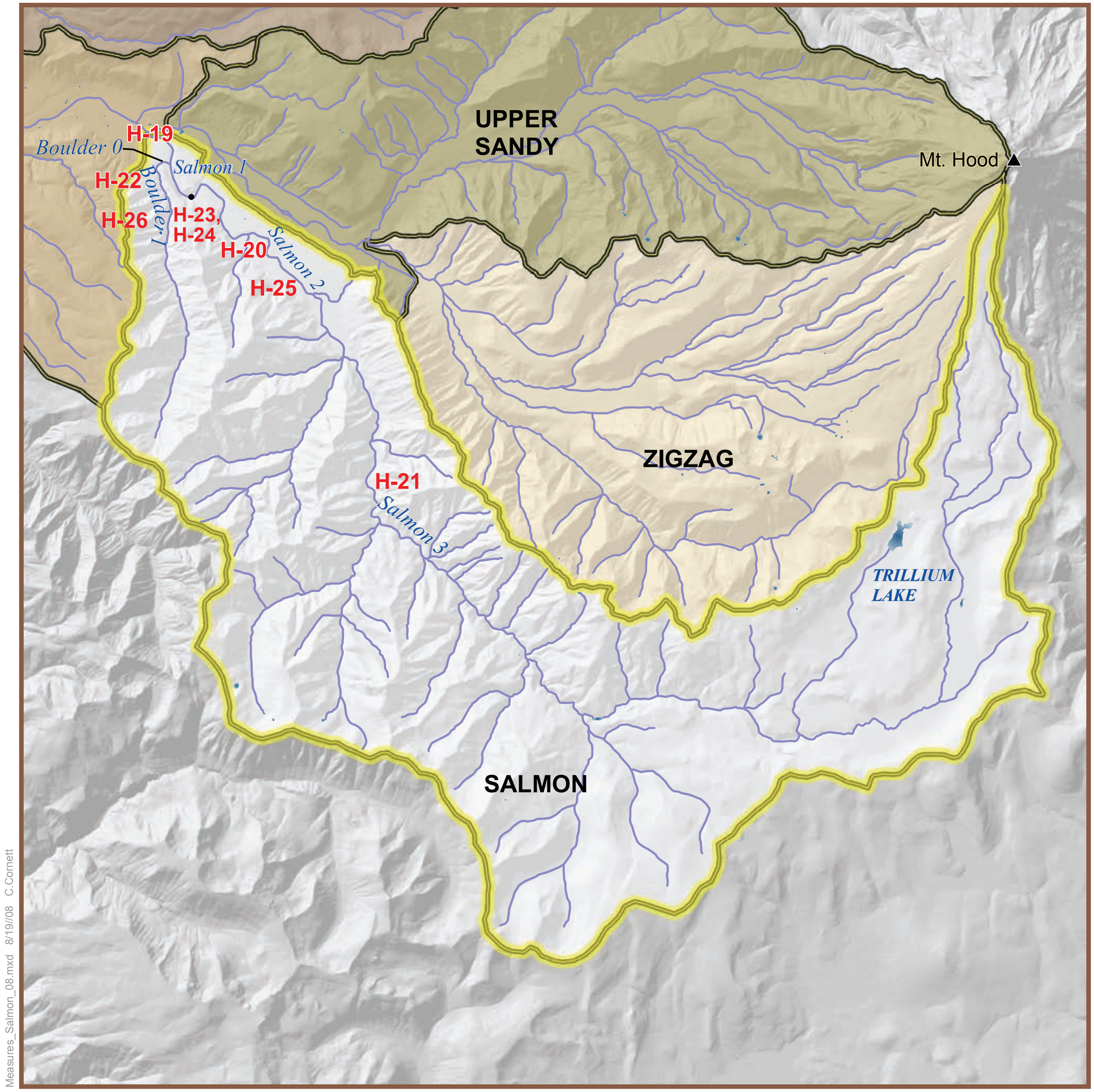
Table continued on next page.

Table 7-12. Offsite Habitat Conservation Measures in the Salmon River Watershed, continued

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[b]	Reaches Affected[a]	Time Frame for Implementation
H-24	Salmon 2 Miller Quarry Restoration	a) Bed scour, artificial confinement , off-channel habitat , riparian function, large wood b) Multiple c) Spring Chinook, winter steelhead, coho	Salmon 2	Years 11-15
H-25	Salmon 2 Carcass Placement	a) Salmon carcasses b) Blocked access to habitat for spawning c) Spring Chinook, winter steelhead, coho	Salmon 1 Sandy 7	Years 6-10
H-26	Boulder 0 and 1 LW Placement	a) Large wood b) Reduced instream habitat complexity c) Spring Chinook, winter steelhead, coho	Boulder 0 Boulder 1 Salmon 1 Sandy 7	Years 1-5

[a] Because of the cumulative nature of the HCP measures, not all of the reaches in this table will have all of the habitat attribute effects listed here. For a reach-by-reach summary of the habitat attribute effects, see the tables in Chapter 8 or Appendix E.

[b] See Chapter 8 for additional species benefits



Site Features

Watersheds of the Sandy River Basin

Salmon River Watershed

Rivers and Streams

Lakes

HCP Offsite Measures

H-19, H-20, H-21, H-22 Riparian Improvement

H-23 Miller Quarry Acquisition

H-24 Miller Quarry Restoration

H-25 Carcass Placement

H-26 Large Wood Placement

Measure numbers are placed in general river reach areas, not in exact locations. (Exact locations depend on willing landowner participation.) Only reaches in which measures are implemented are named. Measures may be implemented in multiple reaches.

N

Projection:
State Plane Oregon North
North American Datum 1983

1:186,491

Miles: 0 0.5 1 2 3 4 5 6

Kilometers: 0 1.25 2.5 5 7.5 10

Figure 7-6. Offsite Habitat Conservation Measures in the Salmon River Watershed

7.5.6 Habitat Conservation Measures in the Zigzag River Watershed

Spring Chinook, steelhead, and coho use most of the stream miles available to anadromous fish in the Zigzag River watershed. Although turbidity from glacial melt may limit production potential in some reaches, the Zigzag also provides passage to its clear water tributaries, such as Still Creek. The mainstem channel in the lower Zigzag was deepened and straightened after floods in 1964 and 1972. These flood control measures eliminated natural meanders, oxbows, and side channels. The City's channel modification and riparian measures in the lower Zigzag River will reestablish natural stream conditions for spawning and rearing anadromous fish.

Channel Modification

The channel modification planned for Zigzag reach 1A will create more natural channel conditions, including riparian areas that mimic natural gradients, connecting the river with natural flood plains. Installation of LW will allow for gravel recruitment and pool formation.

Measure H-27—Zigzag 1A Channel Design: Within HCP Years 11-15, the City will work with willing landowners to modify Zigzag 1A to create more natural channel conditions. Approximately one-half mile of new side channel will be created and an additional one-half mile of existing side channel will be improved. A minimum of 270 pieces of large wood will be placed in the side channel and mainstem of Zigzag 1A.

Riparian Easements and Improvements

The City has identified one habitat conservation measure for the Zigzag River watershed that will improve riparian zone conditions. The City will obtain land protection easements from willing landowners for a total of approximately 12 acres of riparian lands in the Zigzag River watershed. The land easements will improve and protect 100 feet of riparian forest on either side of the active channel width of the river or creeks. Riparian conditions in this area are degraded from historical conditions. The acreage totals for the land protection easements will be calculated by multiplying the lineal distance of the stream by the amount of riparian forest protected by the easement.

Measure H-28—Zigzag 1A and 1B Riparian Easement and Improvement: Within HCP Years 11-15, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least 12 acres which will comprise the total number of lineal feet x 100 feet of riparian area on either side of Zigzag River in reaches Zigzag 1A and 1B. At a minimum, the easements will be maintained for the term of the HCP. The City will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of $\geq$70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned and replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species. See also Measures W-1 and W-2.

Salmon Carcass Placements

The salmon carcasses will be added to the Zigzag reaches as part of an annual basin-wide effort to enhance in-stream productivity and benefit fish. The City's efforts are designed to quickly return benefits in the Zigzag River and downstream.

Measure H-29—Zigzag 1A, 1B, and 1C Carcass Placement: Within HCP Years 11-15, the City will provide funding, for one season, to place at least 1,800 salmon carcasses (approximately 300 carcasses per mile) in reaches Zigzag 1A, 1B, and 1C. The carcass placement will be implemented as part of a basin-wide partnership project by ODFW, USFS and the Sandy River Basin Watershed Council. This measure will occur during one year only and the City will work with the Partners to determine the best timing and method for implementation of the measure, which will depend on available carcasses at ODFW's hatchery facilities and other considerations.

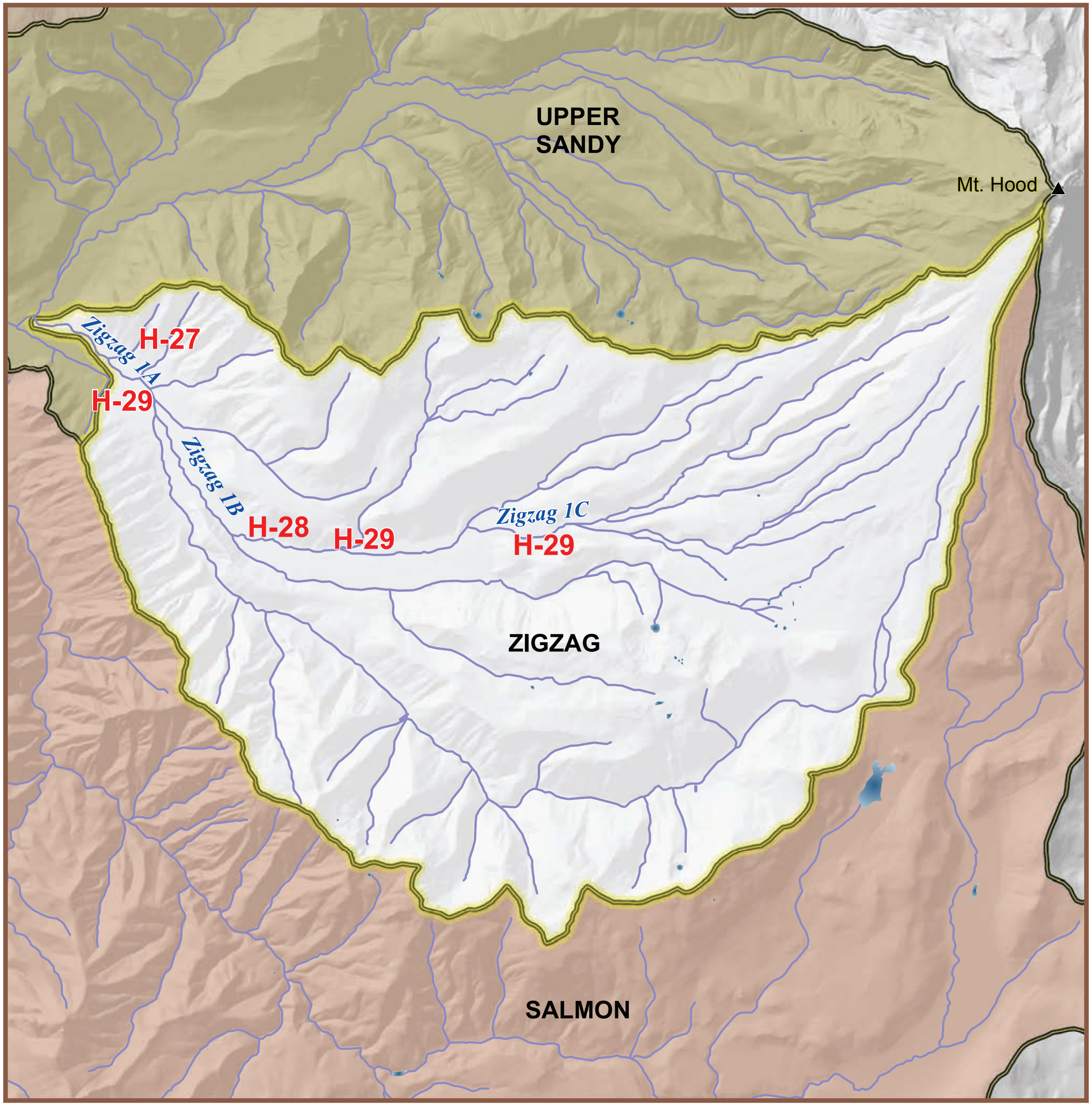
Table 7-13 is a summary of the three habitat conservation measures in the Zigzag River watershed. Figure 7-7 is a map showing the locations of Measures H-27 through H-29.

Table 7-13. Offsite Habitat Conservation Measures in the Zigzag River Watershed

#	Name	a) Habitat Attributes Affected[a] b) Historical Impacts in Bull Run Addressed c) Species Targeted for Primary Benefit[b]	Reaches Affected[a]	Time Frame for Implementation
H-27	Zigzag 1A Channel Design	a) Large wood, artificial confinement, large cobble/boulder riffles, off-channel habitat b) Multiple c) Spring Chinook, winter steelhead, coho	Sandy 8 Zigzag 1A	Years 11-15
H-28	Zigzag 1A and 1B Riparian Easement and Improvement	a) Large wood, harassment, riparian function b) Multiple c) Spring Chinook, winter steelhead, coho	Sandy 8 Zigzag 1A Zigzag 1B	Years 11-15
H-29	Zigzag 1A,1B, and 1C Carcass Placement	a) Salmon carcasses b) Blocked access to habitat for spawning c) Spring Chinook, winter steelhead, coho	Sandy 8 Zigzag 1A Zigzag 1B Zigzag 1C	Years 11-15

[a]Because of the cumulative nature of the HCP measures, not all of the reaches in this table will have all of the habitat attribute effects listed here. For a reach-by-reach summary of the habitat attribute effects, see the tables in Chapter 8 or Appendix E.

[b]See Chapter 8 for additional species benefits.



Site Features

Watersheds of the Sandy River Basin

Zigzag River Watershed

Rivers and Streams

Lakes

HCP Offsite Measures

H-27 Channel Design

H-28 Riparian Improvement

H-29 Carcass Placement

Measure numbers are placed in general river reach areas, not in exact locations. (Exact locations depend on willing landowner participation.) Only reaches in which measures are implemented are named. Measures may be implemented in multiple reaches.

N

Projection:
State Plane Oregon North
North American Datum 1983

1:119,334

Miles: 0, 0.5, 1, 2, 3, 4

Kilometers: 0, 0.5, 1, 2, 3, 4, 5, 6, 7

Measures_Zigzag_08.mxd 8/19//08 C.Cornett

Figure 7-7. Offsite Habitat Conservation Measures in the Zigzag River Watershed

7.6 Habitat Fund

The Habitat Fund was designed to enable adaptive management, to address water system impacts not otherwise fully addressed, to contribute to partnership projects, and to respond to future opportunities not yet known. The Habitat Fund is divided into two portions: adaptive management and partnership projects. The adaptive management portion of the Habitat Fund will be used to implement additional habitat projects if one or more of the offsite measures (described in Section 7.5) does not meet its objectives. Section 9.4 provides more information on the adaptive management approach. The "partnership" portion of the Habitat Fund will be used to implement additional habitat projects that help compensate for water system impacts not fully addressed by the other projects in this chapter of the HCP (e.g., benchmark comparison for steelhead shown in Table 8-38). Project selection will be guided by the Sandy Basin Habitat Restoration Strategy (see Section 9.4.1). The priority for this portion of the fund is to implement partnership projects that also rely on matching funds obtained by other partners. The partnership approach helps build support for larger, more challenging projects and can increase the probability that these projects can be implemented. Frequently, partners are not able to successfully obtain grant funds or federal budget allocations if local matching money is not available. When appropriate, the Habitat Fund will be used to match funds obtained by partners. Projects funded with these resources can also take advantage of specific opportunities to meet City habitat improvement objectives that might not have been known at the time the HCP was developed. Overall, the intent of the Habitat Fund is to help improve the basin's fish populations, compensate for water system impacts, and to help meet the City's commitment to contribute to fish recovery (e.g., City Council Resolution 37715).

Measure H-30—Habitat Fund: The City will provide money to create a Habitat Fund of $9 million. A $5-million portion of the Habitat Fund is available in four increments prior to HCP Year 20 and is dedicated to partnership projects. The increments are described in Chapters 9 and 11 (see also Figure 11-1). The remaining $4 million is dedicated to adaptive management needs but will be used for additional partnership projects if not needed for adaptive management (see Chapters 9 and 11). Projects will be selected in consultation with the HCP Implementation Committee (see Chapter 9) and will be guided by the Sandy River Basin Restoration Strategy. The City and NMFS will make the final project selection decisions.

Of the $5 million, the City will specifically dedicate $1.7 million toward habitat enhancement projects on the Salmon River to be implemented jointly by the Sandy River Basin Partners, and with additional funds from the Partners and/or from grants. If partnership funds cannot be obtained to implement these projects, the City funds will be used for other projects in the Sandy River Basin.

Based on an informal agreement in October 2004, the City will also work with the Partners to provide resources from the $5-million portion of the Habitat Fund to (1) participate in basin-wide efforts to control invasive plants that threaten riparian habitat, and (2) build the organizational capacity of the Partners to implement the basin-wide Restoration Strategy, including outreach.

7.7 Terrestrial Wildlife Habitat Conservation Measures

Impacts to northern spotted owls, bald eagles, and fishers are expected to be rare because of the well-established nature of water supply facilities and activities in the Bull Run watershed, and the low numbers of spotted owls, bald eagles, and fishers in the Sandy River Basin. The potential for disturbance does exist, however, and these measures will minimize the related impacts.[2] The HCP Objectives that guide these measures are the following:

- Avoid or minimize periodic temporary disturbance of habitat (for species both covered or addressed in the HCP) that might otherwise result from routine operation, maintenance, and repair of water supply facilities
- Avoid or minimize periodic temporary disturbance of habitat (for species both covered or addressed in the HCP) that might otherwise result from implementation of the HCP habitat conservation measures

7.7.1 Spotted Owl Measure

Measure W-1—Minimize Impacts to Nesting Spotted Owls: For the term of the HCP, the City will take the following steps to avoid or minimize impacts to nesting spotted owls on all covered lands as described in Chapter 3:

A. Activities with Little or No Potential to Adversely Affect Nesting Spotted Owls: Spotted owls rarely nest near roads or other openings in the forest, so the use, maintenance and minor repair of existing project facilities and roads has little or no potential to disrupt nesting spotted owls. The following covered activities will be allowed to occur on the covered lands without restrictions for spotted owls:

- Operation, maintenance and repair of the water system as described in HCP Section 3.4.1, other than activities described in Items B through F below
- Implementation of the habitat conservation, research and monitoring measures described in this HCP, other than activities described in Items B through F below
- Performance of incidental land management activities as described in Section 3.4.4 of this HCP, other than activities described in Items B through E below
- Use of roads by vehicles and humans on foot
- Mowing and cutting of roadside brush
- Cleaning and maintenance of roadside ditches
- Grading of road surfaces
- Patching of asphalt road surfaces

Measure description continued on next page.

[2] In 2007, the bald eagle was delisted as a threatened species under the Endangered Species Act. The City has used the guidelines developed by the U.S. Fish and Wildlife Service (2007b) as the basis for Measure W-2.

Measure W-1 continued

- Spot patching of other road surfaces
- Sealing of road surface cracks
- Application of chip seal to asphalt roads
- Maintenance of water bars and other road drainage features
- Cleaning and repair of road culverts, replacement of road culverts lasting seven days or less
- Replacement of bridges lasting seven days or less, and not involving pile driving or blasting
- Maintenance and repair of project powerlines
- Mowing of shrubs and small trees on power line rights-of-way

B. Activities with the Potential to Disrupt Nesting Spotted Owls Within 200 Feet: The following activities have the potential to disrupt nesting spotted owls up to 200 feet away.

- Replacement of road culverts lasting more than seven days
- Replacement of bridges lasting more than seven days
- Road reconstruction
- Use of pile drivers
- Removal of trees from along the powerlines in the rights-of-way

These activities may occur without restrictions for spotted owls between July 1 and February 28. If they occur between March 1 and June 30 (the period when nesting spotted owls and their young may be restricted to the immediate vicinity of the nest), the City will evaluate all forest within 200 feet of the proposed activity to determine whether it is suitable spotted owl nesting habitat. If no suitable nesting habitat is found, the activity may occur. If suitable nesting habitat is found within 200 feet of the proposed activity, it will be surveyed for the presence of nesting spotted owls. If no nesting owls are found, the activity may occur. If nesting spotted owls are found within 200 feet of the proposed activity, the activity will not occur until after June 30, unless it is part of an emergency action as described below. When surveys for nesting spotted owls are conducted and no evidence of nesting is found, the results of those surveys will be considered adequate for the breeding season (year) in which they are conducted and the following breeding season (year) as well.

C. Activities with the Potential to Disrupt Nesting Spotted Owls Within 0.25 Mile: The following activities have the potential to disrupt nesting spotted owls up to 0.25 mile away.

- Use of helicopters at altitudes of 500 feet above the tree line
- Operation of rock crushers

These activities may occur without restrictions for spotted owls between July 1 and February 28. If they occur between March 1 and June 30, the City will evaluate all forest

Measure description continued on next page.

Measure W-1 continued

within 0.25 mile of the proposed activity to determine whether it is suitable spotted owl nesting habitat. If no suitable nesting habitat is found, the activity may occur. If suitable nesting habitat is found within 0.25 mile of the proposed activity, it will be surveyed for the presence of nesting spotted owls. If no nesting owls are found, the activity may occur. If nesting spotted owls are found within 0.25 mile of the proposed activity, the activity will not occur until after June 30, unless it is part of an emergency action as described below. When surveys for nesting spotted owls are conducted and no evidence of nesting is found, the results of those surveys will be considered adequate for the breeding season (year) in which they are conducted and the following breeding season (year) as well.

D. Activities with the Potential to Disrupt Nesting Spotted Owls Within 1.0 Mile: The following activity has the potential to disrupt nesting spotted owls up to 1.0 mile away:

- Blasting

This activity may occur without restrictions for spotted owls between October 1 and February 28. If it occurs between March 1 and September 30 (the spotted owl nesting season), the City will evaluate all forest within 1.0 mile of the proposed activity to determine whether it is suitable spotted owl nesting habitat. If no suitable nesting habitat is found, the activity may occur. If suitable nesting habitat is found within 1.0 mile of the proposed activity, it will be surveyed for the presence of nesting spotted owls. If no nesting owls are found, the activity may occur. If nesting spotted owls are found within 1.0 mile of the proposed activity, the activity will not occur until after September 30, unless it is part of an emergency action as described below. When surveys for nesting spotted owls are conducted and no evidence of nesting is found, the results of those surveys will be considered adequate for the breeding season (year) in which they are conducted and the following breeding season (year) as well.

E. Emergency Activities: The following activities may need to be conducted on an emergency basis, and could occur, in rare instances, within the spotted owls nesting season:

- Removal of trees that threaten City facilities or pose a significant risk to human safety
- Removal of landslide debris
- Emergency replacement of culverts
- Emergency repair or replacement of power lines
- Emergency repair of roads needed for access to Dam 1, Dam 2, Headworks, or water conduits
- Emergency helicopter flights to assess damage to the Bull Run water supply facilities

These activities may occur without restrictions for spotted owls. However, in the unlikely event it is necessary to cut a tree containing an occupied spotted owl nest, the City will notify the U.S. Fish and Wildlife Service (USFWS) 24 hours in advance of cutting the tree.

Measure description continued on next page.

Measure W-1 continued

F. Protection of Known Nest Trees: The City will avoid cutting live or dead trees that support nests of the spotted owl. Cutting nest trees will occur only if the tree presents an imminent risk to human safety or reliable operation of the water supply and hydroelectric facilities. If cutting a tree must occur, the City will make every effort to cut the tree when the nest is not occupied.

7.7.2 Bald Eagle Measure

In 2007, the USFWS determined that the bald eagle population had recovered to the point that the species no longer warranted listing under the Endangered Species Act (USFWS 2007a). In preparation for the delisting, the USFWS developed the National Bald Eagle Management Guidelines (USFWS 2007b). These guidelines give landowners information on how to avoid disturbing bald eagles. The USFWS encourages adherence to these guidelines to ensure the bald eagle population is sustained (USFWS 2007b). Consequently, these guidelines serve as the basis for the bald eagle management measures in this HCP.

Measure W-2—Minimize Impacts to Bald Eagles: For the term of the HCP, the City will take the following steps to avoid or minimize impacts to bald eagles on all covered lands as described in Chapter 3:

A. Activities with Little or No Potential to Disrupt Nesting or Roosting Bald Eagles: The use and maintenance of facilities, roads and rights-of way on covered lands will have little or no adverse effect on bald eagles. All are well-established features to which nesting and roosting eagles will have become habituated. Routine maintenance represents a minimal increase in noise and human activity compared with regular use. The following activities will be allowed to occur on covered lands without restrictions for bald eagles:

- Operation, maintenance and repair of the water system as described in HCP Section 3.4.1, other than activities described in Items B through H below.
- Implementation of the habitat conservation, research and monitoring measures described in chapters 7 and 9 of this HCP, other than activities described in Items B through J below.
- Performance of incidental land management activities as described in Section 3.4.4 of this HCP, other than activities described in Items B through J below.
- Use of roads by vehicles and humans on foot
- Mowing and cutting of roadside brush
- Cleaning and maintenance of roadside ditches
- Grading of road surfaces
- Patching of asphalt road surfaces

Measure description continued on next page.

Measure W-2 continued

- Spot patching of other road surfaces
- Sealing of road surface cracks
- Application of chip seal to asphalt roads
- Maintenance of water bars and other road drainage features
- Cleaning and repair of road culverts
- Replacement (lasting seven days or less) of road culverts
- Replacement (lasting seven days or less) of bridges, and not involving pile driving or blasting
- Maintenance and repair of power lines
- Mowing of shrubs and small trees on power-line rights-of-way

B. Activities with the Potential to Disrupt Nesting Bald Eagles Within 660 feet: The following activities have the potential to disrupt nesting bald eagles 660 feet or more away:

- Replacement (lasting more than seven days) of road culverts
- Replacement (lasting more than seven days) of bridges
- Road reconstruction
- Use of pile drivers
- Operation of rock crushers
- Removal of trees from along the power lines in the rights-of-way

These activities may occur between September 1 and December 30 without restrictions for nesting bald eagles. If they occur between January 1 and August 31, the City will evaluate forest habitat within 660 feet of the proposed activity to determine whether it is suitable bald eagle nesting habitat. If no suitable nesting habitat is found, the activity may occur. If suitable nesting habitat is found within 660 feet of the proposed activity, it will be surveyed for the presence of nesting bald eagles. If no nesting bald eagles are found, the activity may occur. If nesting bald eagles are found within 660 feet of the proposed activity and the activity is visible from the nest, the activity will not occur until after August 31, unless it is part of an emergency action as described below. If the activity is not visible from the nest, it may occur up to 330 feet from the nest during the nesting season. When surveys for nesting bald eagles are conducted and no nests are found, the results of those surveys will be considered adequate for the breeding season (year) in which they are conducted and the following breeding season (year) as well.

Measure description continued on next page.

Measure W-2 continued

C. Activities with the Potential to Disrupt Roosting Bald Eagles Within 330 feet: The following activities have the potential to disrupt bald eagles in communal winter night roosts within 330 feet:

- Replacement (lasting more than seven days) of road culverts
- Replacement (lasting more than seven days) of bridges
- Road reconstruction
- Use of pile drivers
- Operation of rock crushers
- Removal of trees along power-line rights of way
- Power-line and right-of-way maintenance
- Maintenance and repair of power lines (other than emergency repair)
- Mowing of shrubs and small trees from power-line rights-of-way
- Removal of trees along power-line rights of way

These activities may occur between March 16 and November 14 without restrictions for roosting bald eagles. They may also occur from one hour after sunrise until one hour before sunset from November 15 through March 15 without restrictions for roosting bald eagles. If they occur from one hour before sunset until one hour after sunrise from November 15 through March 15, the City will evaluate forest habitat within 330 feet of the proposed activity to determine whether it is suitable habitat for bald eagle communal night roosting. If no suitable roosting habitat is found, the activity may occur. If suitable communal roosting habitat is found within 330 feet of the proposed activity, it will be surveyed for the presence of roosting bald eagles. If no roosting bald eagles are found, the activity may occur. If roosting bald eagles are found within 330 feet of the proposed activity, the activity will not occur from one hour before sunset until one hour after sunrise until after March 15, unless the activity is part of an emergency action, as described below. When surveys for roosting bald eagles are conducted and no roosts are found, the results of those surveys will be considered adequate for the roosting season (winter) in which they are conducted and the following roosting season (winter) as well.

D. Activities with the Potential to Disrupt Nesting Bald Eagles Within 1,000 feet: The following activity has the potential to disrupt nesting bald eagles within 1,000 feet:

- Use of aircraft at altitudes of 1,000 feet above the tree line

This activity may occur between September 1 and December 30 without restrictions for nesting bald eagles. If it occurs between January 1 and August 31, the City will evaluate forest habitat within 1,000 feet of the proposed activity to determine whether it is suitable bald eagle nesting habitat. If no suitable nesting habitat is found, the activity may occur. If suitable nesting habitat is found within 1,000 feet of the proposed

Measure description continued on next page.

Measure W-2 continued

activity, it will be surveyed for the presence of nesting bald eagles. If no nesting bald eagles are found, the activity may occur. If nesting bald eagles are found within 1,000 feet of the proposed activity, the activity will not occur until after August 31 unless the activity is part of an emergency action as described in subsection H below. When surveys for nesting bald eagles are conducted and no nests are found, the results of those surveys will be considered adequate for the breeding season (year) in which they are conducted and the following breeding season (year) as well.

E. Activities with the Potential to Disrupt Roosting Bald Eagles Within 1,000 feet: The following activity has the potential to disrupt bald eagles in communal winter night roosts within 1,000 feet:

- Use of aircraft at altitudes of 1,000 feet above the tree line

This activity may occur between March 16 and November 14 without restrictions for roosting bald eagles. It may also occur from one hour after sunrise until one hour before sunset from November 15 through March 15 without restrictions for roosting bald eagles. If it occurs from one hour before sunset until one hour after sunrise from November 15 through March 15, the City will evaluate all forest within 1,000 feet of the proposed activity to determine whether it is suitable habitat for bald eagle communal night roosting. If no suitable roosting habitat is found, the activity may occur. If suitable communal roosting habitat is found within 1,000 feet of the proposed activity, it will be surveyed for the presence of roosting bald eagles. If no roosting bald eagles are found, the activity may occur. If roosting bald eagles are found within 1,000 feet of the proposed activity, the activity will not occur from one hour before sunset until one hour after sunrise until after March 15, unless the activity is part of an emergency action as described in subsection H below. When surveys for roosting bald eagles are conducted and no roosts are found, the results of those surveys will be considered adequate for the roosting season (winter) in which they are conducted and the following roosting season (winter) as well.

F. Activities with the Potential to Disrupt Nesting Bald Eagles Within 0.5 Mile: The following activity has the potential to disrupt nesting spotted owls within 0.5 mile:

- Blasting

This activity may occur between September 1 and December 30 without restrictions for nesting bald eagles. If it occurs between January 1 and August 31, the City will evaluate all forest within 0.5 mile of the proposed activity to determine whether it is suitable bald eagle nesting habitat. If no suitable nesting habitat is found, the activity may occur. If suitable nesting habitat is found within 0.5 mile of the proposed activity, it will be surveyed for the presence of nesting bald eagles. If no nesting bald eagles are found, the activity may occur. If nesting bald eagles are found within 0.5 mile of the proposed activity, the activity will not occur until after August 31 unless the activity is part of an emergency action as described in subsection H below. When surveys for nesting bald eagles are conducted and no nests are found, the results of those surveys will be

Measure description continued on next page.

Measure W-2 continued

considered adequate for the breeding season (year) in which they are conducted and the following breeding season (year) as well.

G. Activities with the Potential to Disrupt Roosting Bald Eagles Within 1.0 Mile: The following activity has the potential to disrupt bald eagles in communal winter night roosts within 1.0 mile:

- Blasting

This activity may occur between March 16 and November 14 without restrictions for roosting bald eagles. It may also occur from one hour after sunrise until one hour before sunset from November 15 through March 15 without restrictions for roosting bald eagles. If it occurs from one hour before sunset until one hour after sunrise from November 15 through March 15, the City will evaluate all forest within 1.0 mile of the proposed activity to determine whether it is suitable habitat for bald eagle communal night roosting. If no suitable roosting habitat is found, the activity may occur. If suitable communal roosting habitat is found within 1.0 mile of the proposed activity, it will be surveyed for the presence of roosting bald eagles. If no roosting bald eagles are found, the activity may occur. If roosting bald eagles are found within 1.0 mile of the proposed activity, the activity will not occur from one hour before sunset until one hour after sunrise until after March 15, unless the activity is part of an emergency action as described below. When surveys for roosting bald eagles are conducted and no roosts are found, the results of those surveys will be considered adequate for the roosting season (winter) in which they are conducted and the following roosting season (winter) as well.

H. Emergency Activities: The following activities may need to be conducted on an emergency basis:

- Removal of trees that threaten City facilities or pose a significant risk to human safety
- Removal of landslide debris
- Emergency replacement of culverts
- Emergency repair or replacement of power lines
- Emergency repair of roads needed for access to Dam 1, Dam 2, Headworks, or water conduits
- Emergency helicopter flights to assess damage to the Bull Run water supply facilities

These activities may occur without restrictions for bald eagles. However, in the unlikely event that it is necessary to cut a tree containing a bald eagle nest, the City will notify USFWS 24 hours prior to cutting the tree.

I. Protection of Known Nest Trees: The City will avoid cutting live or dead trees that support nests of the bald eagle. Cutting nest trees will occur only if the tree presents an imminent risk to human safety or reliable operation of the water supply and hydroelectric facilities. If cutting a tree must occur, the City will make every effort to cut the tree when the nest is not occupied.

Measure description continued on next page.

Measure W-2 continued

J. Protection of Known Roost Trees: The City will avoid cutting live or dead trees that are used as communal winter night roosts by the bald eagle. Cutting roost trees will occur only if the tree presents an imminent risk to human safety or reliable operation of the water supply and hydroelectric facilities. If cutting a tree must occur, the City will make every effort to cut the tree when the communal winter roost is not occupied.

7.7.3 Fisher Measure

The City does not anticipate any impacts to the fisher during the term of the HCP because fishers have not been found in the Sandy River Basin. However, the City developed a contingency habitat conservation measure in case the fisher is found in the Basin during the term of the HCP.

Measure W-3—Minimize Impacts to Fishers: If the fisher is found to occur within 30 miles of the Bull Run watershed, or the locations of any unfinished HCP measures, the City will meet with USFWS to discuss whether any steps need to be taken to avoid or minimize impacts to fishers during the performance of the covered activities.

Chapter 8. Effects of the HCP on the Species

8. Effects of the HCP on the Species

8.1 Introduction to the Analysis of Effects

This chapter describes how the habitat conservation measures in the City of Portland's (City's) Habitat Conservation Plan (HCP) will affect the covered species and the other species addressed in the HCP. The discussion is primarily organized by species. For each species (or group of species), the effects of the City's HCP conservation measures are discussed using a variety of metrics and more than one scientific analysis tool. The analysis of effects is first discussed for the four primary covered fish species for which there is considerable biological information and then for other species for which less data are available. The last part of this chapter provides a summary of effects of the City's covered activities on habitat, including detail on incidental land management activities.

8.1.1 Analysis of Effects on the Four Primary Covered Species

This HCP is primarily focused on four species of anadromous fish: fall Chinook salmon, spring Chinook salmon, winter steelhead, and coho salmon. Considerable biological and modeling data are available for these species. Each of these species is described in a separate section.

The analysis of effects on these fish species is presented from the following perspectives:

1. Effects of lower Bull Run River Conservation Measures
    - Habitat effects in the lower Bull Run River
    - Habitat effects in the lower Sandy River, below the Bull Run confluence, related to direct impacts in the Bull Run River
    - Habitat effects in the Columbia River related to the City's use of groundwater from the Columbia South Shore Well Field
2. Effects of Offsite Sandy River Basin Conservation Measures
3. Effects on Sandy River Basin Populations
    - Estimated effects expressed in terms of Viable Salmonid Population (VSP) parameters (McElhany et al. 2000)
    - Benchmark comparison of fish abundance in the Bull Run watershed

At the end of the effects discussion for each of these species, the City provides conclusions about the overall effects and the adequacy of the conservation measures for protecting the species.

8.1.2 Key Data Sources

To assess the effects on these four species, the City has used the Ecosystem Diagnosis and Treatment (EDT) habitat database and model developed by the professional biologists involved in the Sandy River Basin Partners. Habitat benefits of the City's HCP measures are expressed in terms of EDT environmental attributes. Definitions for these attributes are provided in Appendix D. Some of the environmental attributes are expressed as units per measure of habitat (e.g., large wood pieces per channel width). Other attributes are expressed as EDT ratings from zero to four, in which zero represents optimal conditions (zero negative impact) and four represents extremely poor or lethal conditions. The post-implementation conditions were derived according to the EDT methodology (see Appendix D) and in consultation with local fish biologists involved in the Sandy River Basin Partners.

The habitat benefit analysis takes into consideration the periodicity charts presented in Chapter 5 (Figures 5-4, 5-9, 5-13, 5-18, 5-22, 5-27, 5-31, 5-36, 5-40, and 5-41). These charts are specific to the Sandy River Basin and were developed by local biologists after consulting the available literature and comparable seasonal utilization depictions for these species.

Reference Conditions

To help analyze and explain the effects of implementing the HCP, the City established reference conditions. The effects analyses contrast the expected change in habitat or population resulting from the City's conservation measures with the reference condition. The reference conditions differ according to the type of analysis and the location in the Sandy River Basin.

Effects of Lower Bull Run River Conservation Measures

The City chose not to use "current condition" as the reference condition for evaluating the effects of the Bull Run measures for two primary reasons. First, it was difficult to determine whether the current condition should be defined as when the fish were first listed as threatened species; just prior to release of the HCP for public review; or as another point in time. Second, the City has been gradually implementing some of the measures (e.g., flow and temperature management) so no one recent point in time would be representative of pre-HCP current conditions. Given these complications, the City instead compared the effects of the HCP measures to historical or "natural" conditions that would have existed prior to the existence of the water system (i.e., for analysis of base flows and water temperature).

In some cases, historical conditions did not apply or were not the only relevant metric. The City therefore also used criteria known to be protective of fish (e.g., the downramping rate of 2"/hour) or standard analyses used in fisheries science (e.g., weighted usable area). Weighted usable area (WUA) is an index of available instream habitat at various increments of flow. WUA estimates were generated for a number of flows in various reaches of the lower Bull Run River by R2 Resources Consultants (1998) using the Physical Habitat Simulation System (PHABSIM) model. The City used a "percentage-of-maximum" format for the WUA results. The incremental WUA values at various discharges that would be realized with the City's HCP flow measures were contrasted with the WUA values that would be obtained with natural streamflows (i.e., no Bull Run dams or diversions). The percentage of natural-flow WUA facilitates comparisons across species/life stages. For the effects analysis, the City also assumed that flows that provide WUA values that exceed 85-95 percent of the maximum natural-flow WUA are considered to be "optimal or near optimal flows" (R2 Resource Consultants 1998, NMFS 2002, IWSRCC 2003, R2 Resource Consultants 2004, Sutton and Morris 2004).

Effects of Offsite Sandy River Conservation Measures

Current conditions were used as the reference condition for the offsite measures. The EDT database that compiled available habitat attribute data by river reach was the source of the current conditions data. The EDT model was used to estimate the fish habitat benefits that would derive from implementing the conservations measures. Estimated effects were then compared to the current conditions. Appendix E provides the percentage improvements. In addition, the effects analysis discusses the benefits that the conservation measures will have in addressing limiting factors for the four primary covered species in the affected reaches. Limiting factors were also derived using the EDT model.

Sandy Basin Population Effects

The City analyzed the effect of implementing the HCP conservation measures on the populations in two ways:

- Estimated effects expressed in terms of VSP parameters
- Benchmark comparison of fish abundance in the Bull Run watershed

VSP Parameters. The National Marine Fisheries Service (NMFS) defines the health of an anadromous salmonid population in terms of the VSP parameters of abundance, productivity, life history diversity, and spatial structure (population distribution) (McElhany et al. 2000). Table 8-1 lists the VSP parameters and provides a short definition for each.

Table 8-1. Definition of Viable Salmonid Population Attributes

Attribute	Definition
Abundance	The average number of fish of any life stage in a given stream, watershed, or basin; the more fish in the population the lower the extinction risk. Abundance is determined by the amount (capacity) and quality (productivity) of the habitat present in the basin.
Productivity	The maximum number of recruits (adults) produced by a single spawner. Productivity determines population resilience to mortality pressures, such as from fishing, dams, and further habitat degradation. Habitat quality (including water quality) is a major determinant of a population's productivity. This parameter is especially important when efforts are being made to reverse long-term downward trends in population abundance.
Diversity	The number of possible self-sustaining life histories exhibited by a population and the robustness of the genetic and environmental conditions that determine life history diversity. Populations that can sustain a wide variety of life-history patterns are likely to be more resilient to the influences of environmental change.
Spatial Structure	The number and location (distribution) and timing of salmon populations in the ESU or the basin. Wider distribution of fish abundance reduces fish susceptibility to catastrophic events such as flooding, chemical spills, or geologic disturbance.

Source: McElhany et al. 2000.

The EDT model was run for two sets of scenarios: current habitat conditions with the reservoirs in place and the projected future habitat conditions after the City's HCP measures have been implemented. The projections for the VSP parameters were then compared and expressed as an increase (by percentage) in productivity, diversity, and abundance.

In general, there is less information available on how spatial structure relates to salmonid viability than there is for the other VSP parameters but historic spatial processes should be preserved (McElhany et al. 2000). For purposes of the spatial structure analysis, the City determined whether the four primary species would be enhanced in the known primary spawning reaches or whether the current distribution of the species would be increased from the HCP offsite measures.

Benchmark Comparison of Fish Abundance in the Bull Run Watershed. For each of the four primary species, an estimate of the increase in population abundance that would result from implementing the HCP was compared to an estimate of what the Bull Run habitat might be capable of producing if restored to the "modified historical condition." The modified historical condition is defined as the following:

- Pre-water-supply-system (1800s-era) flow conditions for the Bull Run, downstream from Dam 2 to the mouth of the Bull Run and upstream, including tributary streams draining into the reservoirs
- Including 8.3 miles of stream habitat assumed to be usable by steelhead above the waterfall at river mile (RM) 16.3 on the upper Bull Run River.
- Not including riverine habitat now inundated by the reservoirs
- Including fish passage and 100 percent fish passage efficiency (upstream and downstream) at the Bull Run dams (a standard impossible to meet in practice)
- Including current-day out-of-basin impacts (e.g., ocean and estuary mortality)

The City believes the Modified Historical Bull Run Condition is a generous benchmark because it likely exceeds the highest possible current fish production potential of the Bull Run (assuming the reservoirs are left in place) and simulates a condition in which the City's water supply operations would have no ongoing impacts to salmonid habitat.

The City believes that the estimated production that would result from the HCP conservation measures is an underestimate of what is likely to result from full implementation of the HCP because it does <u>not</u> include the following measures:

- Implementation of the $9 million Habitat Fund (Measure H-30)
- Measures in the Little Sandy River (Measures F-4 and H-3)
- Carcass placement in Salmon and Zigzag rivers (Measures H-25 and H-29)
- Fish passage measures in Walker and Alder creeks (Measures P-1, P-2, and P-3)

8.1.3 Analysis of Effects on Chum and Eulachon

This HCP also covers chum salmon and eulachon. The current distribution of chum in the Sandy River Basin is nearly nonexistent and the eulachon run in the Sandy River has been absent in recent years (see Section 5.4.2 in Chapter 5 for more information on the distribution of the species). This HCP however discusses effects for these species should they become established in, or return to, the Basin.

8.1.4 Analysis of Effects on the Other Species Addressed in the HCP

The HCP addresses 18 species in addition to the six covered fish species. Five of the 18 species addressed are fish: rainbow trout, cutthroat trout, Pacific lamprey, river lamprey, and western brook lamprey. The other species addressed include amphibians (salamanders and frogs) and reptiles (turtles), birds, and one mammal.

The amount of biological information available for these other species varies, as do the applicable metrics and analysis tools. Each of these species is described in a separate section. The sections are grouped as follows: other fish species, amphibians and reptiles, and birds and mammal. A summary of effects is provided at the end of the species discussion. The level of detail for the effects analysis varies depending on the amount of available information.

8.2 The Four Primary Covered Fish Species: Fall Chinook, Spring Chinook, Winter Steelhead, Coho

8.2.1 Fall Chinook Habitat Effects

The HCP measures in the Bull Run watershed minimize the effects on juvenile and adult fall Chinook salmon in the lower Bull Run River to the maximum extent practicable. Offsite measures were selected to provide additional benefits for fall Chinook to help mitigate for the effects not avoided in the Bull Run. In addition, offsite measures that mitigate for impacts on other covered species also provide benefits for fall Chinook. Chapter 11 describes the City's commitment to fund the implementation of the necessary measures.

The potential effects of the City's Bull Run water supply operations and the HCP measures on fall Chinook salmon are described in this section. These effects are described in six subsections:

1. Effects in the lower Bull Run River—Describes the habitat effects of both the City's water supply operations and the HCP measures on lower Bull Run habitat for fall Chinook
2. Effects in the lower Sandy River—Describes the habitat effects of both the City's water supply operations and the HCP measures on habitat in the lower Sandy River for fall Chinook
3. Effects in the Columbia River— Describes the effects of using the City's groundwater supply at the Columbia South Shore Well Field on fish habitat in the Columbia River
4. Effects in Sandy River Basin watersheds—Describes the habitat effects of the offsite HCP measures on fall Chinook habitat in watersheds of the Sandy River Basin
5. Effects on the Sandy River populations by VSP parameter—Describes the population effects of all of the HCP measures (those in the Bull Run and those in the Sandy River Basin offsite locations) on abundance, productivity, diversity, and spatial structure for fall Chinook
6. Comparison to a population benchmark—Compares estimates of fall Chinook abundance under historical conditions to estimated abundance after HCP implementation

Summaries for all subsections appear in shaded boxes. A detailed description of the effects for the species in the geographic location follows each summary. Conclusions about the habitat effects on fall Chinook from implementation of all HCP measures, including a discussion of the predicted accumulation of habitat benefits over time, are provided on page 8-38.

Summary of Effects on Fall Chinook in the Bull Run Watershed from Bull Run Water Supply Operations and HCP Measures

The City identified 11 types of effects that the water supply operation could have on fall Chinook habitat in the Bull Run watershed. The City also analyzed the potential impacts on the base flow of the Columbia River from the HCP flow commitments.

- Impacts in the lower Bull Run that will be avoided or minimized include: flow downramping, water temperatures, Little Sandy base flows, riparian function and large wood, and spawning gravel.
- Impacts associated with blocked access to the upper watershed, low base flows, and reduced WUA values for fall Chinook cannot be fully avoided in the lower Bull Run River but will be mitigated by the Sandy offsite conservation measures.
- The City does not yet know whether redd scour flows and total dissolved gas (TDG) levels will impact fall Chinook salmon but these conditions will be studied and addressed, as necessary, through adaptive management provisions described in Chapter 9.
- The City's flow measures will have an extremely small effect on the Columbia River base flows, and fall Chinook habitat will not be affected.

Table 8-2 summarizes the effects of the water supply operations, the reference condition for each effect, and the predicted effects of the City's HCP conservation measures in the Bull Run watershed for fall Chinook.

Table 8-2. Effects of the Bull Run Measures on Lower Bull Run River Habitat for Fall Chinook[a]

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Base Flows	Natural Bull Run base flows	
Winter/Spring Period (Juvenile Rearing)		HCP flows will be approximately 80% of natural base flows during the juvenile rearing period.
Fall Period (Spawning)		HCP flows will be approximately 60% of natural base flows during the spawning period.
Weighted Usable Area (WUA)		
Juvenile Rearing	Natural flow	HCP WUAs for juvenile rearing will be close to 100% of the maximum WUA value.
Spawning	Weighted Usable Area	HCP WUAs for spawning will be 50 to 100% of the natural flow WUA levels.
Redd Scour Flows	Natural Bull Run base flows	City's flow regime will reduce the risk of redd scour compared to natural base flow conditions. The City will further study redd scour in the lower Bull Run River to verify this expectation.
Flow Downramping	Protective downramping rate: 2"/hour	The City will meet the protective downramping rate (2"/hour), and fish stranding effects will be minimal.
Little Sandy Base Flows	Natural flow; free-flowing	The City's commitment to forgo development of Little Sandy Water rights will avoid any effect on free-flowing conditions in the Little Sandy River.
Water Temperature	ODEQ standard: natural thermal potential	There will be minor, short-term water temperature impacts prior to installation of infrastructure improvements at Dam 1. Once the infrastructure improvements are in place, the City will meet the natural thermal potential of the lower Bull Run River and minimize water temperature effects on fall Chinook.

Table 8-2. Effects of the Bull Run Measures on Lower Bull Run River Habitat for Fall Chinook[a], continued

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Large wood	Natural wood routing and accumulation	Removal of large wood from the reservoirs to protect the water supply infrastructure does not substantially affect large wood in the lower Bull Run River because this channel is a transport reach.
Spawning Gravel	Natural levels of gravel recruitment	The City will replace the natural level of gravel recruitment in the lower Bull Run River. All impacts will be avoided.
Fish Access	Historical fish anadromy Total blocked stream miles in Bull Run River watershed: 16.1 Blocked free-flowing miles in Bull Run River watershed (excluding the Little Sandy River): 1.3 (remaining miles are inundated by the reservoirs)	City will not provide access into the upper Bull Run River. Approximately 10 miles of river will be provided in the Little Sandy River, of which 8 miles could be used by fall Chinook
Riparian Function	Mature riparian zones	City's riparian lands along the lower Bull Run River are currently in good condition. Protective measures in the HCP will maintain and somewhat improve these conditions as younger trees mature.
Total Dissolved Gases (TDG)	ODEQ standard: maximum of 110% saturation at flows below the 7Q10 flow.[b]	The City does not believe there are elevated TDG levels in the current range of anadromy at flows below the 7Q10 flow, but the City will continue monitoring to determine whether the ODEQ standard is being met.

[a]For the list of conclusions about the habitat effects of all HCP measures on fall Chinook, see page 8-38.

[b]The 7Q10 flow is the ten-year, seven day average flood. The 7Q10 flow for the lower Bull Run River is 5,743 cfs.

Habitat Effects in the Lower Bull Run River

The effects on fall Chinook in the lower Bull Run River are described in the following categories: streamflow (both base flows and WUA), water temperature, large wood, spawning gravel, access, riparian function, and total dissolved gases (TDG).

Streamflow

The City analyzed streamflow effects on fall Chinook by two means: comparing the effects of the HCP Bull Run base flows with the natural (pre-water-system) conditions, and determining the Chinook spawning and rearing weighted usable area (WUA) likely to result from the Bull Run flow measures. In addition, this section deals with critical fall flows, scour flows, downramping, and Little Sandy flows.

Bull Run Base Flows. The City compared an estimate of median monthly flows (50 percent exceedance flows) under natural conditions (i.e., no dams or diversions in the Bull Run watershed) with anticipated future flows during implementation of the HCP, assuming normal and critical years occur at the same frequency in the Bull Run as they have in the past. A 64-year hydrological record (1940–2004) was used for the analysis. The estimated median natural and HCP flows for the Bull Run River upstream of the Little Sandy River are shown in Figure 8-1 with peak periods of life-stage occurrence, as documented in the periodicity chart in Chapter 5 (Figure 5-9). All flow amounts are relative to the U.S. Geological Survey (USGS) Gauge No. 14140000 located at river mile (RM) 4.7 on the Bull Run River.

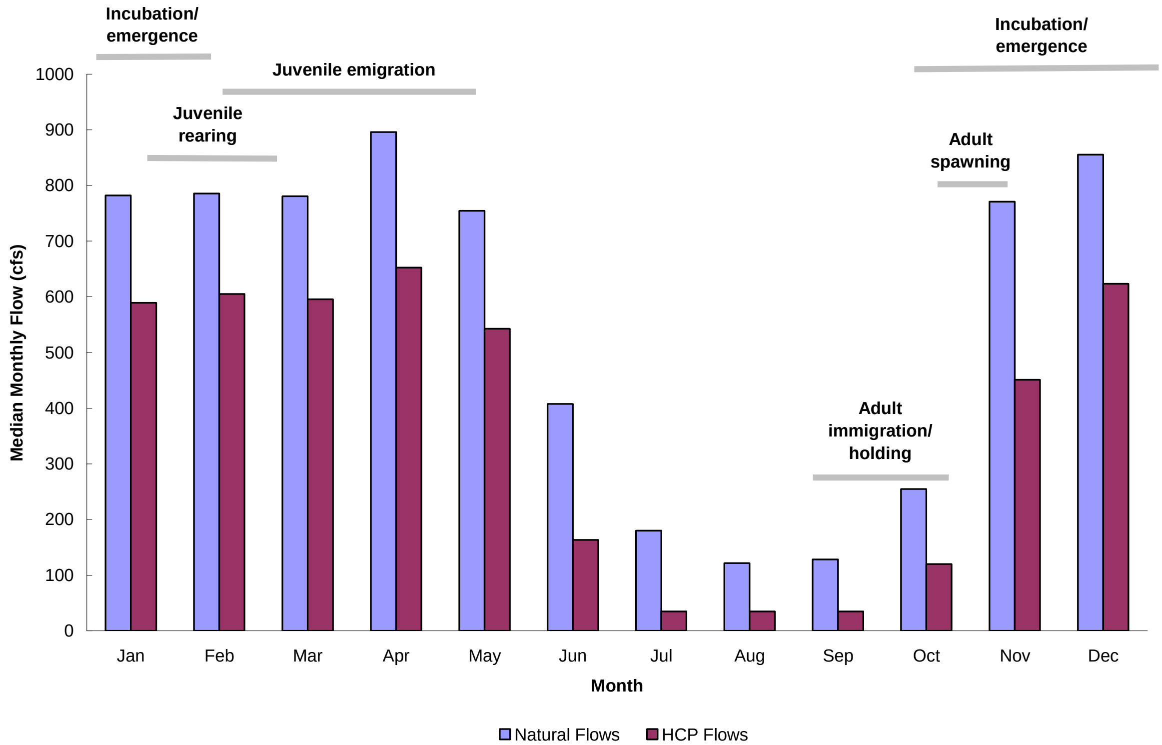


Figure 8-1. Median Monthly Flows and Peak Periods of Occurrence for Fall Chinook Salmon in the Lower Bull Run River above the Little Sandy River Confluence[a]

Source: Median monthly flows for the upper reach of the lower Bull Run River 1940–2004, taken at USGS Gauge No. 14140000 (RM 4.7).

[a]Although peak or important periods of occurrence are shown in this figure, some life-stage activities occur during non-peak periods as well. See Figure 5-18 for periods of occurrence for fall Chinook.

Table 8-3 lists the median natural flows and the median flows anticipated from implementing the HCP. The comparison is for flows in two segments: upstream of the confluence with the Little Sandy River (RM 3.0—RM 5.8), and downstream of the confluence with the Little Sandy River (RM 0—RM 3.0). For the portion of the Bull Run River downstream of the Little Sandy River, median flows were determined using the estimated Little Sandy median natural flows that would occur after the Little Sandy Dam is removed.[1]

[1] PGE has scheduled the decommissioning and removal of the Little Sandy Dam for 2008 which will restore natural flow conditions to the full length of the Little Sandy River. See Chapter 4, Section 4.1.5, Water Quantity and Water Rights.

Table 8-3. Natural and HCP Median Flows by Month for the Lower Bull Run River

	Flows above Little Sandy (cfs)[a]		Flows below Little Sandy (cfs)[b]	
Month	**Natural**	**HCP**	**Natural**	**HCP**
January	782	611	938	765
February	785	608	957	776
March	780	606	932	760
April	896	672	1,072	846
May	755	563	898	709
June	408	196	487	274
July	180	35	213	67
August	122	35	141	54
September	128	35	152	55
October	255	120	304	166
November	771	427	924	608
December	857	654	1,031	829

[a]Median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000, Bull Run River (RM 4.7).

[b]The sum of median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000, Bull Run River (RM 4.7) and median monthly flows taken at USGS Gauge No. 14141500, Little Sandy River (RM 1.95).

Upstream of the Little Sandy confluence, median HCP flows will be approximately 75 percent of the estimated median natural flows for the months of January through June. Downstream of the Little Sandy, the median HCP flows will be approximately 80 percent of the estimated median natural flows during this period.

Effects of Base Flows on Fall Chinook Spawning. Late-maturing Lower River Wild (LRW) stock of fall Chinook indigenous to the Sandy River Basin primarily spawn from about October 15 to December 31 (Lower Columbia River Fish Recovery Board [LCRFRB] 2004; Myers et al. 2003; ODFW 2001; ODFW 2005) and tule fall Chinook in the Sandy Basin primarily spawn from late September to mid-October (ODFW 2001). During the period, flows in the Bull Run River upstream of the Little Sandy will be approximately 65 percent of natural flow conditions. Flows below the Little Sandy River confluence will be about 60 percent of natural flows. Average median flows in the lower Bull Run River for this period will be approximately 400 to 500 cubic feet per second (cfs). R2 Resource Consultants (1998) concluded that these flows fall within the range of flows predicted to provide near-optimal spawning habitat conditions for fall Chinook salmon (see discussion below titled Bull Run Weighted Usable Area).

Effects of Base Flows on Fall Chinook Rearing. Flows are consistently highest during the winter and spring period, which will have a minimal effect on fall Chinook survival. The projected median flows under the HCP will be approximately 80 percent of the natural median flows. Averaged over five months, January through May, median flows will be about 610 and 770 cfs for the Bull Run River upstream and downstream, respectively, of the Little Sandy. These median flows provide ample water depths to protect egg incubation, fry emergence, rearing, and emigration for fall Chinook. Juvenile emigration (March–May) will occur before these flows decrease.

Flows during the early summer and the summer/early fall will have little or no effect on fall Chinook. Juvenile Chinook salmon have not been observed in the lower Bull Run River in the summer, and they are believed to emigrate from the watershed by late spring.

Bull Run Weighted Usable Area. R2 Resource Consultants (1998) estimated habitat-flow relationships for Chinook salmon to assess the effect of the HCP flow measures on spawning and juvenile rearing habitat in the lower Bull Run River. Using the PHABSIM model, they generated estimates of WUA for median flows up to 500 cfs for four segments of the Bull Run River. The four segments were combined into the two segments of the lower Bull Run River: upstream and downstream of the Little Sandy River. Table 8-4 compares WUA estimates for natural flow conditions (no dams and no diversions) with estimates of HCP flows, both upstream and downstream of the Little Sandy River. For flows greater than 500 cfs, goodness-of-fit curves were used to extrapolate WUA values.

The WUA estimates for natural and HCP flows are compared using a "percentage of natural" metric. For example, if the HCP percentage of natural flow is 90 percent, the HCP median flow will yield a WUA value of 0.9 acre in a month, and the WUA value would be 1.0 acre in a month.

Table 8-4. Comparison of Chinook Spawning Weighted Usable Area (WUA) Values in the Bull Run River

	Flows (cfs)		WUA Calculated From Flow (acres)		HCP WUA as a Percentage of Natural WUA
	Natural	HCP	Natural	HCP	
Above the Little Sandy River (Upper Section)					
September	128	35	0.60	0.01	2
October	255	120	1.05	0.52	50
November	771	427	2.07	1.39	67
December	855	654	2.24	1.83	82
Below the Little Sandy River (Lower Section)					
September	152	55	0.79	0.39	49
October	304	166	1.19	0.82	67
November	927	608	1.41	1.40	99
December	1,030	829	1.41	1.41	100

Source: R2 Resource Consultants 1998a

Extrapolation above 500 cfs. Extrapolation is considered to provide conservative WUA estimates (Carlson, pers. comm., 2005), although some uncertainty exists regarding extrapolation of Chinook spawning WUA values above 500 cfs. That is, the goodness-of-fit curves used to extrapolate WUA values for Chinook spawning continue to trend upward as flows increase above 500 cfs. However, WUA values for Chinook spawning may start to decline at higher flow levels, such as those observed by R2 Resource Consultants (1998) in the segment of the Bull Run River below the Bull Run powerhouse (i.e., segment 1). In this segment, PHABSIM modeling to 2,400 cfs was possible, and the modeled WUA values for Chinook spawning start to decline at flow levels above about 700 cfs (R2 Resource Consultants 1998).

Estimated WUA for Spawning. The direct effects of the HCP flows on WUA for fall Chinook was difficult to determine because the City does not know whether fall Chinook currently use the lower Bull Run River for spawning. The City has collected tissue samples for genetic analysis to determine whether fall Chinook use the river, but those results are not yet known. For this analysis, the City assumed that LRW and tule fall Chinook do use the lower Bull Run River.

During the LRW fall Chinook spawning period (October–December), HCP flows will create a total WUA that is 50–100 percent of the corresponding natural flow WUA, depending on the month. During October, the HCP flows will have a negative effect on spawning, compared with natural conditions. During November and December, HCP flows will create approximately the same WUA as would be expected for natural flows in the lower Bull Run River. This analysis may, however, overestimate the negative effects on fall Chinook for two primary reasons. First, LRW fall Chinook spawning does not start until mid-October, when HCP median flows will be somewhat higher than flows for the whole of October. Second, almost all of the fall Chinook spawning occurs downstream of Larson’s Bridge (RM 3.8) where the flows are higher, as indicated by the WUA estimates for below the Little Sandy River (RM 3.0) in Table 8-4.

During the tule fall Chinook spawning period (late September to mid-October), HCP flows will create a total WUA this is approximately 50 percent of the corresponding natural flow WUA.

The HCP includes a provision to reduce flows in the fall during years with critical seasons (see Measure F-2 in Chapter 7). The frequency of these reductions will be limited by the City’s commitment. Critical fall flows will only occur in 10 percent of the HCP years. The City’s commitment will also limit the occurrence of critical fall flows to no more than two consecutive years. If critical fall flows are triggered, the City will not release critical fall flows in the specific year when most of the resulting adult fish would return to their place of origin. When a critical fall flow year occurs, the City will not implement critical fall flows four years later regardless of whether the critical fall trigger occurs. This will reduce impacts on spawning fall Chinook because normal fall flows will be provided when the majority of adults return from a specific cohort. The age composition of the late-maturing Sandy River LRW fall Chinook run has been calculated as 7, 22, 52, and 19 percent for 2-, 3-, 4-, and 5-year-old adults, respectively (ODFW 2001). Because adults of any single cohort will primarily return in year 4, limiting reduced fall flows to a single year will minimize the impact to fall Chinook spawning.

Estimated WUA for Rearing. Fall Chinook juveniles rear in the lower Bull Run and emigrate in the late spring/early summer. Guaranteed minimum HCP flow from December to June is 120 cfs. The projected median flow varies from approximately 200 to 850 cfs for those months.

R2 Resource Consultants (1998) estimated that total habitat area (WUA) for juvenile Chinook reaches its maximum at approximately 350 cfs in the Bull Run River, downstream from the Dam 2 spillway (RM 5.8) to the Portland General Electric (PGE) Powerhouse (RM 1.5). Downstream of the PGE Powerhouse, total habitat area (WUA) for juvenile Chinook reaches its maximum at approximately 110 cfs. Above those maximums, the amount of habitat area remains constant as streamflow increases.

The HCP flows will create a total WUA for fall Chinook rearing that ranges from approximately 90 percent to more than 100 percent of the corresponding natural flow WUA, depending on the month (Table 8-5). Therefore, the HCP flows will minimize impacts to rearing juvenile fall Chinook.

Table 8-5. Comparison of Weighted Usable Area (WUA) Values for Fall Chinook Juvenile Rearing in the Lower Bull Run River

	Flow (cfs)		WUA Calculated from Flow (acres)		HCP WUA as a Percentage of Natural WUA
	Natural	HCP	Natural	HCP	
Above the Little Sandy River (Upper Section)					
December	857	654	21.16	19.21	91
January	782	611	20.45	18.79	92
February	785	608	20.48	18.77	92
March	780	606	20.43	18.75	92
April	896	672	21.56	19.39	90
May	755	563	20.19	18.33	91
June	408	196	16.83	14.77	88
Below the Little Sandy River (Lower Section)					
December	1,031	829	8.38	9.81	>100
January	938	765	9.04	10.26	>100
February	957	776	8.90	10.19	>100
March	932	760	9.08	10.30	>100
April	1,072	846	8.08	9.69	>100
May	898	709	9.32	10.66	>100
June	487	274	12.23	13.58	>100

Source: R2 Resource Consultants

WUA values for juvenile rearing during other months were not analyzed; fall Chinook have not been observed rearing in the lower Bull Run River during the summer and fall months.

Bull Run Peak Flows. The City assessed effects on peak flows in the lower Bull Run River by evaluating the annual peak winter flows since Water Year 1960. This data set was used for the peak flow analysis because the USGS gauge was in another location prior to 1960. The City estimated peak winter flows in the absence of the City's water supply diversions, peak winter flows with current (2006) water diversions, and peak winter flows with estimated 2025 water diversions based on Metro's population projections. The estimated change in annual total water yield diverted for supply is expected to increase from 20 percent currently to 22 percent in 2025.

The estimated magnitude of the annual peaks with no water diversions ranged from 4,010 to 25,420 cfs, depending on weather conditions. The estimated magnitude of the annual peaks for current water demands ranged from 3,880 to 25,100 cfs. The estimated magnitude of the annual peaks for 2025 water demands ranged from 3,863 to 25,094 cfs. Differences were determined by comparing flows on individual peak flow dates. The differences between no diversions and current diversions ranged from 0.3 percent to 3.3 percent. The differences between no diversions and estimated 2025 diversions ranged from 0.6 percent to 3.7 percent.

The City also characterized each peak flow event into a return frequency category (i.e., less than 2-year event, 2–5-year event, 5–10-year event, 10–25-year event, 25–50-year event, and 50–100-year event). The flow conditions experienced in those events were applied to current water diversions and 2025 estimated water diversions. In only one case did the increase in winter season water diversions in 2025 cause a change in the return frequency category for peak events. The January 5, 1969 weather year changed from a slightly greater than 2-year event to a slightly less than 2-year event.

The City concluded from this analysis that implementation of the HCP will not significantly change the magnitude of peak-flow events in the lower Bull Run River. Peak-flow events will continue to occur with a frequency and magnitude similar to current conditions and similar to conditions that would occur without water supply diversions.

Bull Run Scour Flows. The HCP flow regime will reduce the risk of scour in fall Chinook redds in the lower Bull Run River, compared with historical flows. Based on a recent analysis (CH2M HILL 2003b), flows sufficient to mobilize gravels will occur less frequently and over fewer days during the HCP flows than during natural flows. The analysis focused on two time periods: primary spawning from mid-October–December and dominant egg incubation and fry emergence from January—mid-May.

A 25-year record (1980-2004) of mean daily flows in the lower Bull Run River was examined to determine the number of separate flow events large enough to mobilize spawning gravel. Those flows were contrasted with the flow regime estimated to occur under natural conditions (without City infrastructure and operations). Flows sufficient to mobilize gravels are expected to occur less frequently under the HCP flows than under natural flows. In addition, the rates of change during these peak events are likely to be lower under the HCP flows. This finding suggests that the HCP flow regime will reduce the risk of redd scour caused by peak flows compared with what would occur under natural conditions.

Even though the HCP flow measures are not anticipated to increase fall Chinook redd scour in the lower Bull Run River, the City will complete a redd scour study (see Chapter 9, Monitoring and Adaptive Management).

Bull Run Flow Downramping. The City's hydroelectric plant at the base of Dam 2 varies the streamflow in the lower Bull Run River during the winter and spring months when there is enough streamflow to run the facility. The current Federal Energy Regulatory Commission (FERC) license allows for a downramping rate of 2 feet per hour (2'/hour) for the lower Bull Run River, but the City is committing to a lower rate of 2 inches per hour (2"/hour) to protect juvenile salmonids.

The City has studied juvenile salmonid stranding during different downramping events in the lower Bull Run River (Beak Consultants 1999; CH2M HILL 2002). The sites selected for monitoring were the widest areas of the channel, considered most sensitive to ramping effects and stranding. Steelhead fry (about 40 millimeters [mm] average length) and yearlings (Age-1) juveniles were observed. No other salmonids were present during the stranding studies, and the City has assumed that observations of juvenile steelhead behavior are adequate for determining potential ramping rate effects. Based on the studies, a ramping rate of no more than 2"/hour was recommended for the lower Bull Run River. This rate is what the state of Oregon and others have generally recommended to protect against juvenile fish stranding (CH2M HILL 2002; Hunter 1992).

The City will minimize the risk of stranding fall Chinook juveniles by maintaining a maximum downramping rate of 2"/hour year-round for the hydroelectric powerhouse downstream of Bull Run Dam 2. All impacts from flow downramping, however, cannot be avoided due to certain circumstances beyond the control of the City.

The City conducted a year-long evaluation of downramping (Galida 2005) and determined that circumstances when the City would not meet the ramping rate occurred 0.4 percent of the time. These circumstances included natural storm flows beyond the City's control, mechanical/control system failures that are impossible to predict, and FERC mandatory testing of safety equipment. Out of a test period of approximately 8,800 hours of hydropower operation, the 2"/hour downramping rate was exceeded only for 35 hours. The exceedances occurred from mid-November through late-March, and streamflow in the lower Bull Run River was 200—12,600 cfs. Natural streamflows were quite variable and since the reservoirs were full, the downramping rate could not be controlled by the City for approximately one-third of the 35 hours. Other exceedances can be attributed to equipment testing and operator error. Overall, the City was very successful in controlling the downward fluctuation of the lower Bull Run River.

The City's commitment to a downramping rate of 2"/hour will result in minimal effects on fall Chinook. The occurrences of downramping greater than 2"/hour will rarely occur in the future, and if they do, they will happen during the winter months. This is after the fall Chinook have spawned. The redds will not be negatively affected because the streamflows are high enough to protect them. Also, there will be a very low potential for stranding juvenile fall Chinook because the higher downramps would occur only infrequently and sporadically during the late winter and early spring.

The City will continue to monitor downramping in the lower Bull Run as part of the compliance monitoring efforts (see Chapter 9).

Little Sandy River Base Flows. Forgoing development of the City's water rights on the Little Sandy River during the term of the HCP will help assure unimpeded natural flows on the

Little Sandy River for fall Chinook. Fall Chinook will have access to approximately 10 river miles of the Little Sandy for spawning and rearing. Flows from the Little Sandy River will also increase base flows in the Bull Run River below its confluence with the Little Sandy by 19–181 cfs, depending on the month (see Table 8-3).

Water Temperature

Fall Chinook salmon utilize the Bull Run River in October and November when water temperatures are generally cool and acceptable for the species (see Figure 5-9 for the periodicity chart and Figure 8-2 for daily maximum temperatures). The species spawns in the lower Bull Run in fall, emerges from the gravel and rears in the winter and late spring, and emigrates from the Bull Run watershed by early summer. The only time of the year when the water temperatures are too warm for the species is during the first half of October when the species is spawning.

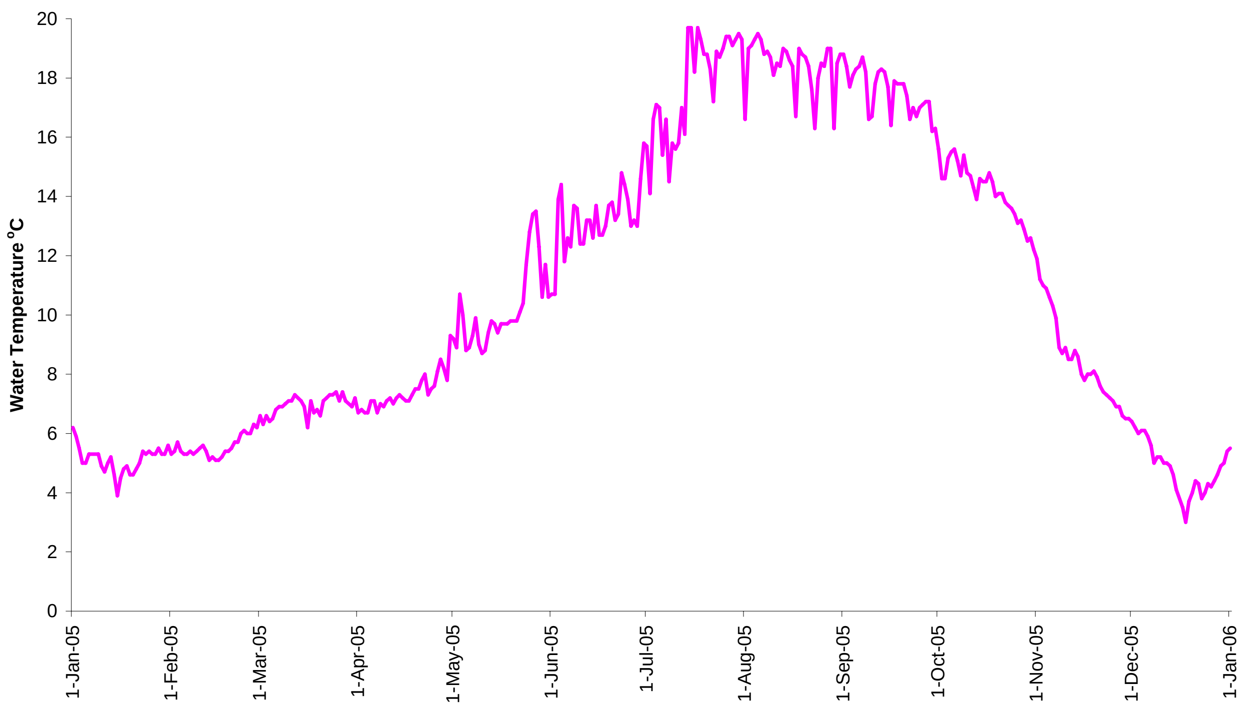


Figure 8-2. 2005 Daily Maximum Water Temperatures for the Lower Bull Run River as Measured at USGS Gauge No. 14140000 (RM 4.7)

Source: USGS Gauge No. 14140000 on the Bull Run River (RM 4.7)

The reference condition for water temperature is the natural thermal potential of the lower Bull Run River. Natural thermal potential is defined by the Oregon Department of Environmental Quality (ODEQ) in the Sandy River Total Maximum Daily Load (TMDL) (2005) as the water temperatures that would occur in the Bull Run River if there were no dams or diversion. The City, in conjunction with ODEQ, developed a method to determine the natural thermal potential of the lower Bull Run River and found that the current temperature regime of the Little Sandy River is a good surrogate for the Bull Run. (See temperature measures T-1 and T-2 in Chapter 7 for more details.)

Pre-infrastructure Water Temperature Effects. The City plans to make significant infrastructure improvements at Dam 2 to meet the natural thermal potential of the lower Bull Run River. However, prior to completion of the infrastructure improvements, water temperatures in the lower Bull Run River during the first half of October will exceed those preferred for spawning fall Chinook (see Figure 8-3).

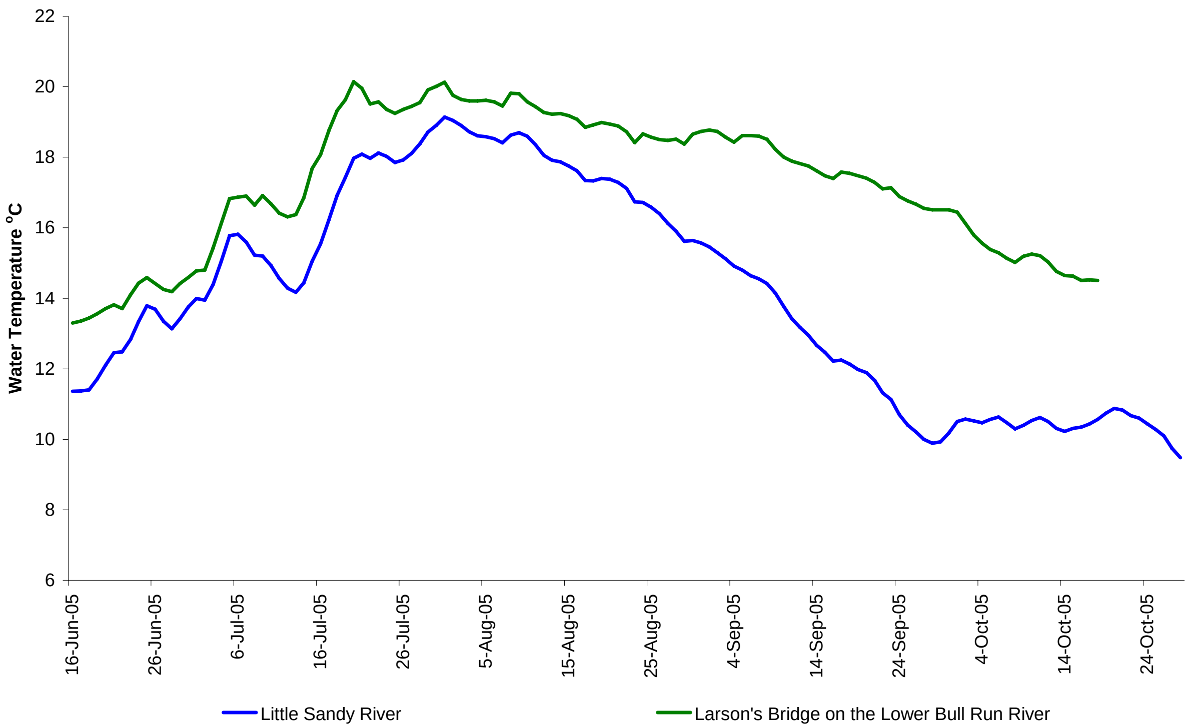


Figure 8-3. 7-Day Maximum Average Water Temperatures for the Little Sandy and Lower Bull Run Rivers, June 16–October 24, 2005

Source: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8) and USGS Gauge No. 14140000 on the Bull Run River (RM 4.7).

Before the infrastructure changes, the City will continue to carefully manage the amount of cool water in the reservoirs for downstream flow releases. Figure 8-3 indicates the water temperature performance that the City will be able to achieve in the first years of the HCP. The water temperature of the lower Bull Run River, expressed at Larson's Bridge in Figure 8-3, would be approximately 14—16 °C for the first two weeks of October. That is slightly higher than ODEQ's water temperature criterion of 13 °C for spawning salmonids. Within five years of the start of the HCP, the infrastructure changes at Dam 2 will be completed and the natural thermal potential of the Bull Run River will be met. The pre-infrastructure water temperature effects should be minimal because the water temperature will not be significantly higher than ODEQ's criterion and these conditions should only last approximately five years.

Post-infrastructure Water Temperature Effects. The City used the CE-QUAL-W2 water quality model to predict natural condition stream temperatures in the lower Bull Run River (City of Portland 2004). The model predicted that maximum stream temperatures would occur at Larson's Bridge (RM 3.8) in the lower Bull Run River. City staff and ODEQ staff evaluated modeling results and empirical data and concluded that natural stream temperatures in the lower Bull Run River could be estimated using the stream temperature of the Little Sandy River (see Figure 8-4)

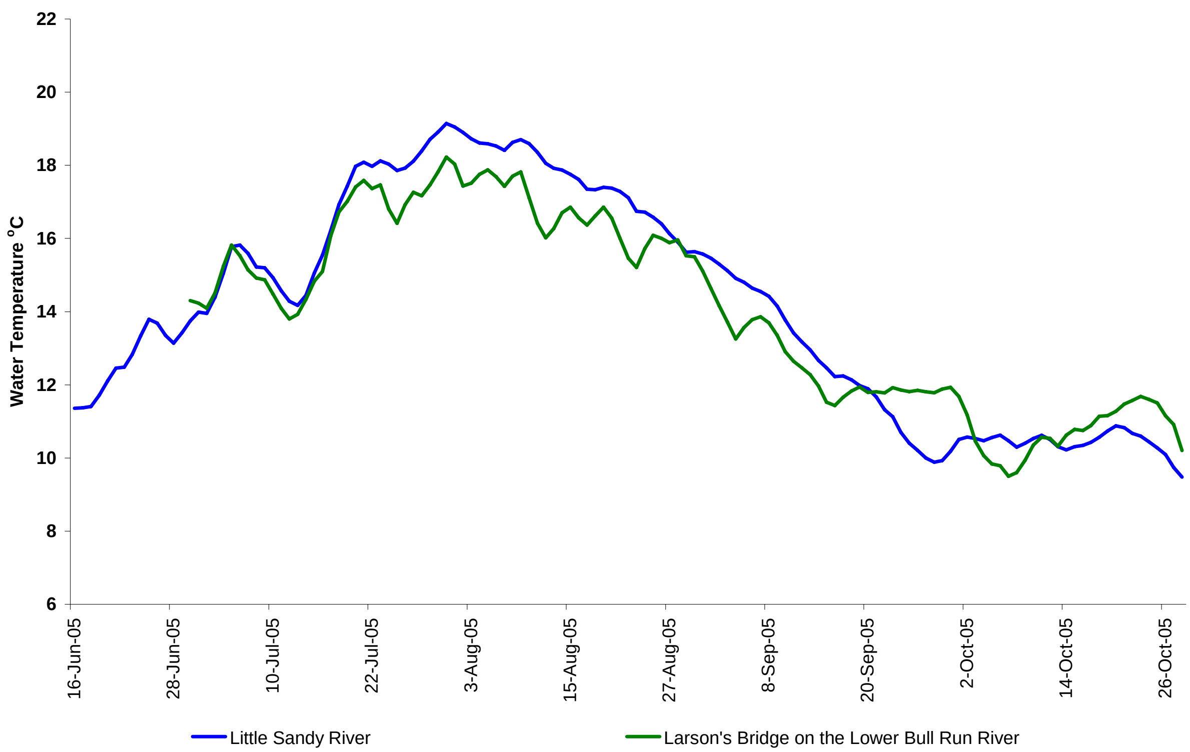


Figure 8-4. Comparison of Actual 7-Day Maximum Water Temperatures for the Little Sandy Rivers with Predicted 7-Day Maximum Average Temperatures for the Lower Bull Run River, June 16–October 24, 2005

Source: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8) and CE-QUAL-W2 Modeled Temperatures (February 2006)

The summer and early fall water temperatures in 2005 shows that water temperatures at Larson's Bridge are generally lower than temperatures in the Little Sandy but are within approximately 1 °C (see Figure 8-3). ODEQ has established water temperature criteria for the Larson's Bridge location under the authority of the Clean Water Act (CWA) and the Sandy Basin TMDL (see Measure T-2 in Chapter 7).

After completion of the infrastructure improvements, the flow and temperature management measures in the HCP will closely approximate the natural thermal potential and will reduce impacts to fall Chinook spawning. Additional details are provided in Chapter 7 and in Appendix G, Temperature Management Plan.

Large Wood

Large wood is removed from the upper end of Reservoir 1 to protect the downstream water supply dams from damage. The U.S. Forest Service (USFS) owns this wood because it is transported by tributaries from national forest land. Since this wood is not allowed to travel down the lower Bull Run River, a small amount of beneficial habitat is potentially lost for fall Chinook. The lower Bull Run River is, however, a high-order steep stream and is not likely to trap and store large wood. Photographs taken of the lower Bull Run in the late 1890s, before the dams and water diversions were constructed, show little large wood in the channel. The lower river is probably a transport reach for large wood.

The channel of the lower river is dominated by bedrock and boulders. This channel roughness supports diverse habitats, including about 27 percent pool habitat. The presence of this pool habitat suggests that large wood is not important for pool formation, and the addition of large wood would provide only a minor increase in pool habitat.

The City does not plan to artificially place large wood in the lower Bull Run River above Larson's Bridge because of concerns about the vulnerability of water supply infrastructure (i.e., conduit bridge crossings). The City will let natural recruitment of large wood occur downstream of Larson's Bridge. Trees that fall naturally will be left in place to modify the stream channel as long as the water conduits and bridges are not threatened. This large wood could slightly improve habitat conditions for fall Chinook by reducing the overall grain sizes and creating pools in localized areas in the lower 3.8 miles of the lower Bull Run River.

Spawning Gravel

The two Bull Run dams interrupt bedload and gravel movement to the lower Bull Run River, resulting in reduced spawning habitat for fall Chinook salmon and other species. The estimated historic gravel supply rate varied from 30 to 1,000 cubic yards (CH2M HILL 2003b). The City will place approximately 1,200 cubic yards each year for the first five years and 600 cubic yards per year thereafter (see Measure H-1 in Chapter 7). The gravel replacement rate will be higher than the estimated natural accumulation for the first five years of the HCP. Placement of gravel in the lower Bull Run River under the HCP will significantly improve the spawning conditions for fall Chinook and minimize City impacts.

Photo courtesy of Bonneville Power Administration.

Access

Fall Chinook were first blocked from the upper Bull Run River in 1921 by construction of the Diversion Dam (approximately RM 5.9). The dam diverted Bull Run water into conduits to supply the greater Portland metropolitan area. In 1964, as part of Dam 2 construction, a rock weir at RM 5.8 was built to create the Dam 2 plunge pool. This pool provides energy dissipation below the Dam 2 spillway. The rock weir is now the upstream limit for fall Chinook in the Bull Run watershed. Fall Chinook distribution is also limited in the Little Sandy River due to PGE's diversion of water to Roslyn Lake and the Little Sandy Dam at RM 1.7.[2]

Fall Chinook access will remain blocked by the rock weir at RM 5.8 during the term of the HCP. Continued operation of the City's water supply will block access for fall Chinook to approximately 10.5 miles of the upper Bull Run River. Of these mainstem Bull Run River stream miles, only 1.3 miles are free-flowing river, and 9.2 river miles are inundated by City reservoirs.

When PGE removes the Little Sandy Dam, fall Chinook will have access to an additional 5.6 miles of the mainstem Little Sandy River, and possibly 2.0 additional miles of tributary streams. The City's agreement to maintain flows for fish in the Little Sandy (see Measure F-4, Chapter 7) will help retain habitat benefits from this renewed access to the historical habitat for fall Chinook.

[2] The Little Sandy Dam is scheduled for decommissioning and removal in 2008. See Chapter 4, section 4.1.5, Water Quantity and Water Rights, for more information.

Riparian Function

The City owns land along 5.3 miles of the lower Bull Run River (1,650 acres). The City's lands represent 82 percent of the riparian corridor below Dam 2. Managing these lands to protect riparian habitat will improve habitat for fall Chinook (see Measure H-2 in Chapter 7). Approximately 30 percent of the riparian corridor along the lower river is in late-successional (late-seral) timber that can provide immediate large wood recruitment to the channel. Further, 80 percent of the riparian corridor is of mid- to late-seral age that will provide wood to the channel at an increasing rate over the next 10 to 70 years (Cramer et al. 1997).

Analysis of shading in the lower Bull Run River indicates that riparian vegetation currently intercepts 40 to 60 percent of the total solar radiation that potentially could reach the water surface (Leighton 2002). This shading provides a substantial benefit by maintaining lower water temperatures. This shading benefit become greater over time as the vegetation continues to mature. The mature vegetation in the lower Bull Run combined with the temperature measures (infrastructure changes to the intake towers and temperature management) will closely approximate natural water temperatures and reduce the effects of water system operations on fall Chinook.

Total Dissolved Gases

Oregon's Water Quality Standards state that TDG levels should not exceed 110 percent of saturation, unless flows exceed the ten-year, seven day average flood (7Q10) flow for the site [OAR 340-041-0031]. The 7Q10 flow for the lower Bull Run River is 5,743 cfs. The City has monitored all water system structures, valves, or turbines that could elevate TDG levels since 2005, and has determined that fall Chinook are unlikely to be adversely affected by TDG levels in the Bull Run River. A 55-foot deep stilling pool at the base of the Dam 2 spillway is the site most likely to produce TDG levels that could affect fall Chinook. This location, however, is upstream of the range of anadromous fish. Monitoring by the City indicates that elevated levels of TDG quickly decrease as water passes over the rock weir below the stilling pool (RM 5.8). The City has never measured TDG levels that met or exceeded 110% in the anadromous portion of the Bull Run River, unless the 7Q10 flow was also exceeded. TDG levels further dissipate between the rock weir and Larson's Bridge, about 1 mile downstream (RM 4.7). Almost all of the fall Chinook observed in the lower Bull Run River were downstream of Larson's Bridge (Strobel 2007a, Clearwater BioStudies 1997, 2006; ODFW 1998; Beak Consultants 2000a,b). Fall Chinook are probably not impacted by TDG levels in the Bull Run River. The City, however, will continue to monitor TDG levels in the Bull Run as described in Chapter 9 and Appendix F, Monitoring Plans and Protocols.

Summary of Effects on Fall Chinook in the Lower Sandy River from Bull Run Water Supply Operations and HCP Measures

The City identified four types of effects that water supply operations could have on fall Chinook habitat in the lower Sandy River.

- Base flows in the lower Sandy will be reduced by continued water supply operations in the Bull Run, but the weighted usable area for fall Chinook spawning habitat will be increased.
- Flow downramping effects in the lower Sandy will be avoided.
- The HCP will have small but beneficial effects on water temperatures in the lower Sandy.
- The HCP will also minimize the impact of removing large wood from the lower Bull Run by adding large wood directly into the lower Sandy.

Overall, the City's HCP measures for the Bull Run River will have positive effects on fall Chinook habitat in the lower Sandy River. Table 8-6 summarizes the habitat effects of the Bull Run measures in the lower Sandy.

Table 8-6. Effects of the Bull Run Measures on Lower Sandy River Habitat for Fall Chinook[a]

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Base Flows	Natural Sandy River base flows	Flows after implementation of the HCP will be more than 80% of natural base flows.[b]
Weighted Usable Area	Natural Sandy River base flows	Flows will increase habitat for spawning by up to 20 percent.[c]
Flow Downramping	Protective downramping rate: 2"/hour	The City's water supply operations will have minimal effects on fish stranding due to downramping.
Water Temperature	ODEQ standard: natural thermal potential	The City's HCP measures will probably have small water temperature benefits.
Large wood	Natural wood accumulation	Removal of large wood from the reservoirs reduces the amount of large wood loading to downstream Sandy River reaches and reduces channel complexity. City measures will increase large wood levels and habitat diversity, minimizing adverse effects of Bull Run operations in the Sandy River below the Bull Run confluence.

[a]For the list of conclusions about the habitat effects of all HCP measures on fall Chinook, see page 8-38.

[b]Based on flow data from 1985–2001, natural base flows were reduced by 4–19 percent (CH2M HILL 2002).

[c]Based on flow data from 1985–2001, habitat for spawning was increased by 2–18 percent.

Habitat Effects in the Lower Sandy River from the Bull Run Measures

The EDT database and model were used to identify limiting factors having the greatest impact on fall Chinook in the lower Sandy River below the confluence with the Bull Run River. The factors identified were food, habitat diversity, harvest, flow, channel stability, competition from the same species, predation, water temperature, pathogens, and sediment. Of these 10 factors, three are potentially affected by water supply operations in Bull Run: flow, water temperature, and large wood recruitment (as a subfactor in habitat diversity). The other seven factors are not directly related to water supply operations.

Streamflow

A flow effects analysis was completed for Chinook salmon in the lower Sandy River below the Bull Run (CH2M HILL 2002). This analysis focused on the potential effects of the City's Bull Run operation on base flows and on flow fluctuations (ramping). The analysis used Bull Run flows from 1985 to 2001, which are lower than the HCP flows as described in Chapter 7.

Base Flows. The City compared the WUA and monthly flow amounts without City operations to the WUA and monthly flows during the 1985 to 2001 period. City operations from 1985 to 2001 reduced base flows in the lower Sandy River by 4 percent to 19 percent (depending on month), but increased habitat for Chinook spawners in the lower Sandy River by about 2 percent to18 percent October through December. October to December is the prime spawning period for LRW fall Chinook. Available habitat for Chinook fry (expressed as WUA) was 2 percent lower in April but about 0.7 percent to 3 percent higher during February, March, and May.

The CH2M HILL analysis (2002) concluded that fall Chinook spawning and rearing in the lower Sandy River would not be adversely affected by the City's operations, even at lower flows than described in Measure F-1 in Chapter 7. R2 Resources Consultants (1998) similarly concluded that flow enhancement in the lower Bull Run River would have little or no beneficial effect on spawning and rearing Chinook salmon in the lower Sandy River.

Downramping. The CH2M HILL analysis (2002) indicates that a downramping rate of 2"/hour would eliminate juvenile salmonid stranding in the lower Bull Run River. Given the analysis above about base flow effects, the HCP downramping measure is also expected to minimize any potential juvenile stranding effect in the lower Sandy River.

Water Temperature

Both ODEQ's and the City's water temperature modeling results indicate that water temperatures in the lower Sandy River reaches are in a state of relative equilibrium. City water supply operations have little influence on heating or cooling of the lower Sandy River. This conclusion is supported in the Sandy River Basin TMDL report (ODEQ 2005).

Even though the City's operations in the Bull Run will not affect water temperatures lower in the Sandy River, some of the City's offsite conservation measures will probably have small water temperature benefits.

Large Wood

Removal of large wood from the Bull Run reservoirs reduces the amount of large wood loading to downstream Sandy River reaches and reduces channel complexity for fall Chinook. To mitigate for this impact, the HCP includes several large wood measures in the lower Sandy River (see Measures H-4, H-11, H-12, and H-13 in Chapter 7). Installing large log jams (Sandy, RM 0 – RM 8) will increase habitat diversity for fall Chinook. Easements located in prime fall Chinook spawning and rearing areas will also improve riparian conditions in the Sandy River. None of the easement areas have riparian zones that are in natural condition and as these riparian areas mature, large wood recruitment will increase. Collectively, these measures will minimize any adverse effects of Bull Run operations on habitat complexity for fall Chinook in the lower Sandy River.

Habitat Effects in the Columbia River from Use of Groundwater

The City will use groundwater from the Columbia South Shore Well Field, in conjunction with the Bull Run River flows, to provide the total amount of water needed to meet water supply demands and the HCP flow commitments. The Columbia River is located adjacent to the well field, so the City analyzed the effect groundwater use might have on flows in the Columbia River.

As context, only one instream flow commitment has been established for the lower Columbia River to maintain the persistence of Endangered Species Act (ESA)-listed species. This requirement is the Federal Columbia River Power System's (FCRPS's) minimum flows of roughly 125,000 cfs below Bonneville Dam, unless competing priorities preclude it (U.S. Army Corps of Engineers [USCOE] et. al. 2006). These minimum flows are increased by contributions from the Sandy and Washougal rivers before arriving at the Glenn Jackson Bridge (I-205 bridge), approximately 14 miles west of the mouth of the Sandy River.

The well field has an estimated sustainable capacity of approximately 85 million gallons per day (mgd), which is equivalent to approximately 130 cfs. The actual amount and duration of pumping will vary according to the weather and supply conditions, but typically the amount pumped per day would be significantly less than the full capacity. The well field draws on four regional alluvial aquifers. Recharge for these aquifers occurs as far south as the Boring Hills (Hartford and McFarland 1989). These aquifers generally discharge into the Columbia River.

As a simplifying worst-case assumption for this analysis, the City assumed that 85 mgd would be pumped from the well field and that this amount would be drawn into the aquifers from the Columbia River. (This is a significant overestimate because the water pumped would actually be drawn primarily or completely from the aquifers themselves and not from the river into the aquifers.) The assumed flow into the aquifers would reduce the assumed flow available in the Columbia River for fish.

If the City's groundwater pumping were to result in a 130 cfs reduction in Columbia River flows, that reduction would be at most 0. 1 percent of the total river flow (based on the 125,000 cfs minimum flows mentioned above). To put this reduction in perspective, the typical margin of error on measured flows for the Columbia River is +/- 10 percent (see for example the gauge at the Columbia River at The Dalles, USGS 2003). This measurement error is significantly larger than the estimated flow reduction due to groundwater use. In addition, the mainstem Columbia River has tidal fluctuations that average approximately 1.7 feet (data from USGS Gauge No. 14144700). This natural daily change in river stage is many orders of magnitude greater than any potential reduction of Columbia River flows due to the City's use of groundwater. The City's conclusion is therefore that use of the Columbia South Shore Well Field as a means to enable the HCP flow commitments in the lower Bull Run River, will have a negligible influence on the Columbia River base flows and associated habitat for fall Chinook salmon migrating in the river.

Summary of Effects in the Sandy River Basin from the HCP Offsite Measures

This HCP includes offsite measures in fall Chinook production areas in the Sandy River Basin to mitigate effects that cannot be avoided in the lower Bull Run River.[3] HCP measures in the lower Sandy River mainstem to benefit fall Chinook include reconnecting a side channel, reestablishing the river mouth, improving riparian conditions, and adding engineered log jams. The HCP also includes measures to place large wood and enhance riparian conditions in Gordon and Trout creeks. Measures to benefit fall Chinook salmon in the middle Sandy River watershed include riparian easements and improvements, and large wood placement.

The effects of the offsite measures for fall Chinook are as follows:

- Reduced risk of peak flow displacement, increased cover from predators, increased rearing habitat, and improved habitat diversity will benefit juveniles in the lower and middle Sandy River watersheds.
- Holding adults will benefit from the improved habitat diversity in the middle Sandy River and Gordon Creek.
- Increased pools in Gordon Creek will provide key habitat for rearing juveniles.
- Trout Creek improvements will improve spawning and egg incubation.

Details of the specific improvements in fall Chinook habitat that will result from the offsite measures are described in this chapter and in Appendix E. Overall, the City's offsite conservation measures will improve habitat for fall Chinook in the lower and middle portions of the Sandy River Basin.

[3] Effects in the lower Bull Run River for fall Chinook include reduced base flows and weighted usable area and blocked access to the upper Bull Run River. Chapter 5 includes a detailed description of the impacts for this species.

Habitat Effects in the Sandy River Basin from the HCP Offsite Measures

The City's HCP includes 30 offsite habitat conservation measures. Most of these actions address environmental problems affecting the production of more than one species. This analysis describes the effects of the HCP measures on fall Chinook. Effects are described by watershed and address fall Chinook life stages and limiting factors. (See Chapter 5 for additional information on the fall Chinook population in the Sandy River Basin and the habitat factors that limit production.)

Little Sandy River

The City's water supply operations do not affect the Little Sandy River because it is a tributary to the lower Bull Run River downstream of the City's dams and diversion. The City's large wood habitat conservation measure for the Little Sandy River was selected to improve habitat diversity for spawning and rearing salmonids, but the primary focal species was not fall Chinook.

The City will place large wood in the Little Sandy River (see Measure H-3 in Chapter 7), which will slightly increase channel complexity and gravel sorting for fall Chinook and other fish species. The City believes that the large wood measure will slightly benefit fall Chinook spawning because the large wood will trap suitable spawning gravel.

Lower Sandy River Watershed

Fall Chinook primarily spawn in the mainstem Sandy River up to the Marmot Dam site.[4] If early season rainfall occurs, fall Chinook use the lower portions of Gordon, Trout, and Cedar creeks. Gordon and Trout creeks are utilized by the Late Bright portion of the wild fall Chinook run (Sandy River Basin Partners [SRBP] 2005).

The HCP offsite measures were selected in fall Chinook production areas with the intent to mitigate effects that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The analysis also considers beneficial effects for fall Chinook that are likely to result from measures designed primarily for other species.

The City will implement measures in the lower Sandy River watershed to benefit fall Chinook, including reconnecting a side channel, reestablishing the river mouth, restoring the riparian area, and adding engineered log jams on the lower Sandy mainstem, as well as placing large wood and making riparian enhancements in Gordon and Trout creeks. A detailed description of each measure and the affected reaches is available, by watershed, in Chapter 7.

Table 8-7 lists the reaches affected by HCP measures planned in the lower Sandy River watershed and provides a summary of the expected habitat benefits in each reach (see also tables in Appendix E for percentages for reference condition and post-implementation values).

[4] Marmot Dam was decommissioned by PGE and removed in July of 2007.

Table 8-7. Habitat Benefits for Fall Chinook in the Lower Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Beaver 1A	Riparian function	Improvement
	Large wood	Increase
Gordon 1A	Fine sediment in gravel patches	Decrease
	Backwater pools	Increase
	Large-cobble riffles	Decrease
	Pool habitat	Increase
	Pool-tail habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Large wood	Increase
Sandy 1	Artificial confinement	Reduction
	Off-channel habitat	Increase
	Riparian function	Improvement
	Large wood	Increase
	Off-channel habitat	Increase
	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Trout 1A	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

The riparian protection/enhancement projects in the lower Sandy mainstem reaches will increase large wood, improve riparian function, decrease confinement in Sandy 1, and slightly improve water temperature, benefiting juveniles and holding adults. Additional large wood will help stabilize the stream channel, lessen peak flow displacement risks, and provide escape cover from predators for fry. Increased riparian function should also lessen impacts attributed to limited food availability. Reopening the historic mouth of the Sandy River is also likely to aid adult passage and create additional rearing habitat for fall Chinook.

Key habitat for juveniles will increase in Gordon Creek as large wood increases the amount of pools, backwater pools, and pool tail-outs for juveniles and holding adults. Gravel retention created by the newly installed log structures will also improve channel stability. A riparian enhancement project on the lowermost reach will stabilize crumbling banks and filter out surface inputs of sediment to spawning substrate. The additional spawning habitat and the improvement in riparian function should improve habitat for holding adults.

Large wood measures in Trout Creek will directly increase the stability of gravel bars, thus aiding incubation. Spawning habitat will also likely improve because the large wood will increase sorting and storage of suitably sized gravels for fall Chinook.

Middle Sandy River Watershed

Most of the middle Sandy mainstem is carved through bedrock in a deep, steep-walled gorge. The main impact to habitat quality in the mainstem middle Sandy has been the Marmot Dam, which is outside the authority of the City and was decommissioned in July 2007.

The Marmot Dam inflow reach (Sandy 6) provides exceptional spawning and rearing habitat with a low gradient, pools, riffles, side channels, and relatively abundant cobble/gravel substrate and large wood. Fall Chinook, however, had not been observed going over the Marmot Dam (SRBP 2005), but the distribution of the species may increase dramatically once the dam has been removed and the natural flow pattern is returned to the Sandy River.

The portion of Cedar Creek that is accessible supports natural fall Chinook productivity. A weir constructed in the early 1950s partially blocks fish passage approximately 0.5 mile upstream from the mouth of Cedar Creek (SRBP 2005).

The HCP measures for the middle Sandy River were selected with the intent to mitigate effects that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The analysis also considers beneficial effects for fall Chinook that are likely to result from measures designed primarily for other species.

The City will implement measures to benefit fall Chinook salmon in the middle Sandy River watershed, including riparian easements and improvements and large wood placement. The City will also purchase available water rights in Cedar Creek from willing landowners (see Measure F-5, Chapter 7) to improve habitat conditions for fall Chinook and other species. A detailed description of each measure and the affected reaches is available, by watershed, in Chapter 7.

Table 8-8 lists the reaches affected by HCP measures planned in the middle Sandy River and provides a summary of the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-8. Habitat Benefits for Fall Chinook in the Middle Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Cedar 1	Dissolved oxygen	Increase
	Fish pathogens	Improvement
	Minimum water temperature	Decrease
	Maximum water temperature	Decrease
	Temperature moderation by groundwater	Improvement
Sandy 3	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

The riparian easements and improvements in the middle Sandy River and Cedar Creek will protect intact portions of the riparian corridor, improve the arboreal species composition (by culling hardwoods and planting conifers), and allow for related habitat improvements (such as large wood recruitment and decrease in temperature) to occur over time. Large wood placement will increase channel stability to some degree for all life stages, decrease the risk of displacement by peak flows, and improve habitat diversity for juveniles and holding adults. In Cedar Creek, after fish passage is provided at the Oregon Department of Fish and Wildlife's (ODFW's) weir, large wood placement above the weir will increase key habitat for fry.

Currently, fall Chinook use only the lowest reach of Cedar Creek. The City does not yet know how much flow might be returned to Cedar Creek from purchasing existing surface water rights, and therefore the benefits of the action can only be generally described as an increase in base flows over existing conditions as a result of the City's commitments.

The City did not assume that any habitat benefits for fall Chinook salmon from the HCP conservation measures would occur upstream of the Marmot Dam site. The Sandy River Basin Agreement Technical Team (SRBTT) determined that the current fall Chinook distribution in the Sandy River Basin was up to the dam site. However, fall Chinook can access the upper Sandy Basin now that the dam has been removed. Since the accrual of benefits after dam removal was speculative at the time benefits were calculated, the City did not include them as part of this effects analysis.

Summary of Population Effects and VSP Parameters

Implementation of the HCP will significantly improve habitat for the Sandy River population of fall Chinook salmon. The VSP parameters for productivity, diversity, and abundance are projected to increase by 11–18 percent with the City's HCP commitments. These projected increases in the VSP parameters are conservative because they do not include benefits to fall Chinook that will also be derived from projects supported by the City's $9 million Habitat Fund (see Measure H-30, Chapter 7).

Population Effects and VSP Parameters

The HCP habitat conservation measures were designed to minimize and mitigate the effects of the Bull Run water supply operations on fall Chinook, as well as the other covered species. This section describes estimated effects of the City's HCP on the overall Sandy River fall Chinook population using parameters established in the NMFS recovery planning process, specifically the work of the Lower Columbia River Technical Recovery Team (LCR-TRT).

Sandy River fall Chinook are part of the Lower Columbia Evolutionarily Significant Unit (ESU) (Cascade Zone). Sandy River fall Chinook are considered by the LCR-TRT and the LCRFRB (LCRFRB 2004) to be a primary population for recovery in the Lower Columbia ESU. Primary populations are those that need to be restored to "High" or "Very High" viability levels in order to recover the species. Sandy River fall Chinook have been identified (LCRFRB 2004) as needing to be restored to a “High” viability level, or 95–99 percent likelihood of persistence.

The EDT model was used to estimate the benefits for fall Chinook that are likely to result from implementing the HCP. Current habitat conditions were established as the reference condition for this analysis. Population results that would result from implementation of the HCP were compared to population results that are representative of current habitat conditions.

Although the model results are not absolute predictions of fish abundance, they do provide a relative comparison of the expected salmon population performance based on the best available science. The inputs to the model represent a combination of site-specific empirical habitat data and, where that data was not available, the professional opinion of biologists intimately familiar with the Sandy River ecosystem. (See Appendix D for an explanation of the theory and information structure as well as the habitat rating rules for the EDT model.)

The HCP measures are expected to result in substantial increases in all of the fall Chinook VSP parameters.[5] Increases in productivity, diversity, and abundance are presented in Table 8- 9. These estimates represent increases over what could be expected to result from current habitat conditions in the Sandy River Basin. Improvements in the species spatial structure are discussed in the following text. NMFS (in coordination with ODFW) has not yet developed a recovery plan for the Lower Columbia ESU or set clear objectives for each VSP parameter, so the significance of these improvements is not yet known.

Table 8-9. Increases for Fall Chinook Expected Due to HCP Implementation[a]

	Productivity	Diversity	Abundance
Without Cedar Creek Weir Removal	11%	18%	12%
With Cedar Creek Weir Removal	11%	18%	12%

Source: EDT model run April 17, 2007

[a]Estimates do not include benefits from removing the Marmot Dam on the Sandy River.

Productivity

The estimated 11 percent increase in productivity results from increased quality of stream habitat in river reaches located below the Marmot Dam site and in the lower Bull Run River. Increased productivity allows the population to rebound quickly from periods of either low seawater or freshwater survival that depress population size.

[5] Modeling results for fall Chinook represent both the fall and late fall races.

Diversity

The 18 percent increase in life history diversity represents improvements in habitat conditions over both time and space. The flow regime measures for the lower Bull Run River create habitat conditions that will allow both spawn timing and juvenile rearing to occur over a longer time frame. Improved habitat conditions in the mainstem Sandy River and Gordon Creek also increase life history diversity.

Abundance

The estimated 12 percent improvement in adult fall Chinook abundance in the Sandy River Basin results from the increases in productivity and diversity. Increased abundance reduces extinction risk for the population. In addition, with the removal of Marmot Dam , fall Chinook are expected to colonize mainstem Sandy River habitat upstream. Juvenile fish produced upstream of Marmot Dam will also be able to utilize the lower Sandy River for rearing. The habitat improvements from the HCP measures will help leverage the increased juvenile fall Chinook survival expected to occur after the Marmot Dam removal.

The higher abundance will result in increased ecological benefits. Salmonids improve both their physical and biological environments through various mechanisms. For example, adult spawners reduce fine sediment concentrations in gravels, and their carcasses provide a food source for other aquatic and terrestrial species.

Although the LCR-TRT has not yet established recovery goals for Sandy River fall Chinook, others have indicated that the Sandy River Basin has the potential to produce up to 10,200 adults (LCRFRB 2004). The City’s HCP makes a significant contribution toward achieving this objective.

Spatial Structure

The viability of a salmon population depends not only on the population’s productivity, abundance, and diversity, but also on its spatial structure (McElhany et al. 2000). The more watersheds in a basin that contain large numbers of spawners, the less likely that catastrophic events such as landslides, volcanic eruptions, and human-caused disasters will result in the extinction of the population.

Historically, the vast majority of Sandy River fall Chinook spawned in the mainstem Sandy River and in larger tributaries from its mouth to near its confluence with the Salmon River. Currently, fall Chinook are limited to the mainstem Sandy River below Marmot Dam, the lower Bull Run River, and near the mouths of small tributaries such as Gordon, Trout, and Cedar creeks. The City’s action will not increase the distribution of fall Chinook in the Sandy River Basin but will improve habitat conditions for the species in primary spawning areas.

The City’s actions are designed to improve riparian conditions, increase the amount of large wood, and increase streamflow for four of the watersheds where fall Chinook historically ranged. In addition, measures implemented in streams such as the Salmon River and Zigzag River may provide additional benefits to fall Chinook if this species recolonizes those areas after the removal of Marmot Dam. Because the combination of HCP measures targets all of the spatial structure objectives, the City's plan addresses all three of the spatial diversity objectives and will thereby help reduce the extinction risk for fall Chinook.

Table 8-10 summarizes the population effects of the HCP measures on fall Chinook by the VSP parameters of abundance, productivity, diversity, and spatial structure.

Table 8-10. Effects of the HCP Measures on Sandy River Basin Fall Chinook Populations by Viable Salmonid Population (VSP) Parameters

VSP Parameter	Reference Condition	Effect of Conservation Measures
Abundance	Current habitat conditions	Abundance for the Sandy River population is projected to increase by 12%.
Productivity	Current habitat conditions	Productivity for the Sandy River population is projected to increase by 11%.
Diversity	Current habitat conditions	Diversity for the Sandy River population is projected to increase by 18%.
Spatial Structure	Current habitat conditions	HCP will increase spawner abundance in the Bull Run, lower Sandy, and middle Sandy river watersheds, the core of current fall Chinook production. Increased adult abundance in multiple watersheds will increase spatial diversity and reduce extinction risk.

Sources: EDT model run April 17, 2007 for abundance, productivity, and diversity percentages; for spatial structure assessment, Kevin Malone, personal comm. 2006

Summary of Population Effects

The projection of adult fall Chinook abundance under the City's HCP is greater than the modified historical Bull Run condition scenario established for the Bull Run watershed.[6] This comparison indicates that the HCP will produce enough beneficial habitat changes for fall Chinook salmon to offset impacts caused by the City's water supply operations in the Bull Run.

Population Effects and Benchmark Comparison of Fish Abundance

The introduction to this chapter describes a benchmark scenario the City developed to compare results of the HCP with a reference condition (see Section 8.1.1). The EDT model was used to generate the estimated abundance of fall Chinook and to compare the benchmark against the benefits of the City's HCP measures. The City believes that the Modified Historical Bull Run Condition benchmark estimate represents generous assumptions and that the HCP estimate is an underestimate of probable HCP results (as described in Section 8.1.1).

[6] See the subsection Sandy Basin Population Effects under Section 8.1.1 for an explanation of the benchmark comparison of fish abundance in the Bull Run watershed.

Model results indicate that the HCP measures would improve habitat for fall Chinook to match or exceed the production potential of the Modified Historical Bull Run Condition scenario (Table 8-11).

Table 8-11. Model Results for Fall Chinook Abundance: Modified Historical Bull Run Condition Compared with HCP Measure Implementation[a]

Scenario	Adult Abundance
Modified Historical Bull Run Condition	6,669
HCP Measures Without Cedar Creek	6,913
HCP Measures With Cedar Creek	6,913

Source: EDT model run April 17, 2007
[a]Estimates do not include benefits from removing the Marmot Dam on the Sandy River.

The City believes these results help demonstrate that the HCP will provide the benefits for fall Chinook necessary to meet the ESA Section 10 requirements. However, the City does not propose to use EDT population estimates as an enforceable performance measure for fall Chinook. The City's HCP is purposefully habitat-based. It is designed using measurable objectives, monitoring, and an adaptive management trigger that all relate to habitat condition, as described in other chapters of this document.

Note: The analysis in this HCP does not include any benefits for fall Chinook above the Marmot Dam site.

Conclusions about the Habitat Effects of HCP Measure Implementation

- **Effects in the Lower Bull Run River.** All of the HCP measures in the lower Bull Run River will benefit fall Chinook salmon. These measures avoid or minimize ongoing City impacts in the Bull Run River (as described in Table 7-1) to the maximum extent practicable. Impacts associated with blocked fish access to the upper watershed and reduced base flows will not be completely addressed in the Bull Run but will be mitigated by the offsite measures in the Sandy Basin. Benefits provided by the Bull Run HCP measures are summarized in Table 8-2.
- **Effects in Sandy River Watersheds.** Substantial additional benefits for fall Chinook are provided by HCP measures in the lower Sandy River and its tributaries (e.g., Gordon Creek) and in the Middle Sandy River watershed. The lower Sandy has the primary spawning areas for fall Chinook in the Sandy River Basin; all anchor habitat reaches for fall Chinook are located in these areas. The primary limiting factors for fall Chinook for those areas include a lack of key habitat quantity and diversity, and reduced channel stability due to loss of large wood, increased channel confinement, and simplification of the stream channel. HCP measures H-4–H-9, H-11, H-12, and H-13 will improve these conditions and thereby contribute to improving fall Chinook productivity. Fall Chinook also can utilize the mainstem Sandy River upstream of the Bull Run. The mainstem Sandy River habitat upstream of the Bull Run is likely to improve with the removal of Marmot Dam in July 2007. Measures in the middle Sandy Basin also benefit fall Chinook by improving riparian zone conditions and increasing large wood levels. Benefits provided by the offsite measures are summarized in Tables 8-7 and 8-8 and in Appendix E, and Tables E-5 and E-6.
- **Timing for Implementing Measures.** The timing for implementing measures relevant to fall Chinook and other species is provided in Tables 7-6 through 7-12. Measures in the lower and middle Sandy River are primarily scheduled for HCP Years 6-10 based on specific input from NMFS staff to wait for the removal of Marmot Dam so that the post-removal conditions would be known and benefits of the HCP measures would not be compromised. The City will be conducting effectiveness monitoring for the instream measures; the objective in those cases is to accrue 80 percent of the predicted habitat change within 15 years of implementing each measure (see Chapter 9).
- **Population Response.** Although the HCP is not intended to guarantee specific population responses, implementation of the HCP is expected to result in improved population conditions for fall Chinook. Table 8-10 describes the anticipated increases of the four VSP parameters: abundance, productivity, diversity, and spatial structure. The estimated population response compared to the Modified Historical Bull Run Condition also indicates that implementation of the HCP will likely result in population responses greater than the production potential in the Bull Run watershed. Neither of these estimates includes the habitat or population benefits that will result from the $9 million Habitat Fund.
- **Accumulation of Habitat Benefits.** The HCP conservation measures will accumulate benefits for fall Chinook at varying rates. Figure 8-5, which is based on EDT model results, depicts the accumulation of benefits over the 50-year HCP term. The figure shows the

predicted increase in adult fall Chinook abundance that could result from the habitat changes. Benefits are organized according to three general categories of HCP measures: flow, instream actions, and riparian easements. Fish passage improvements for Cedar Creek are not anticipated to benefit fall Chinook. The City assumes that the benefits from large wood additions would only contribute to adult fall Chinook abundance for the first 15 years of their project life. This is a very conservative assumption because it is likely that the wood will be in the various stream reaches beyond 15 years and adding some habitat value for fish. Other instream actions, such as the opening of side channels and riprap removal, are considered permanent for the purpose of the HCP. Riparian easements are assumed to take 15 years before beginning to provide benefits, and they would not provide full benefits until 30 years after implementation. Flow measures will provide habitat for fall Chinook starting in Year 1 of the HCP.

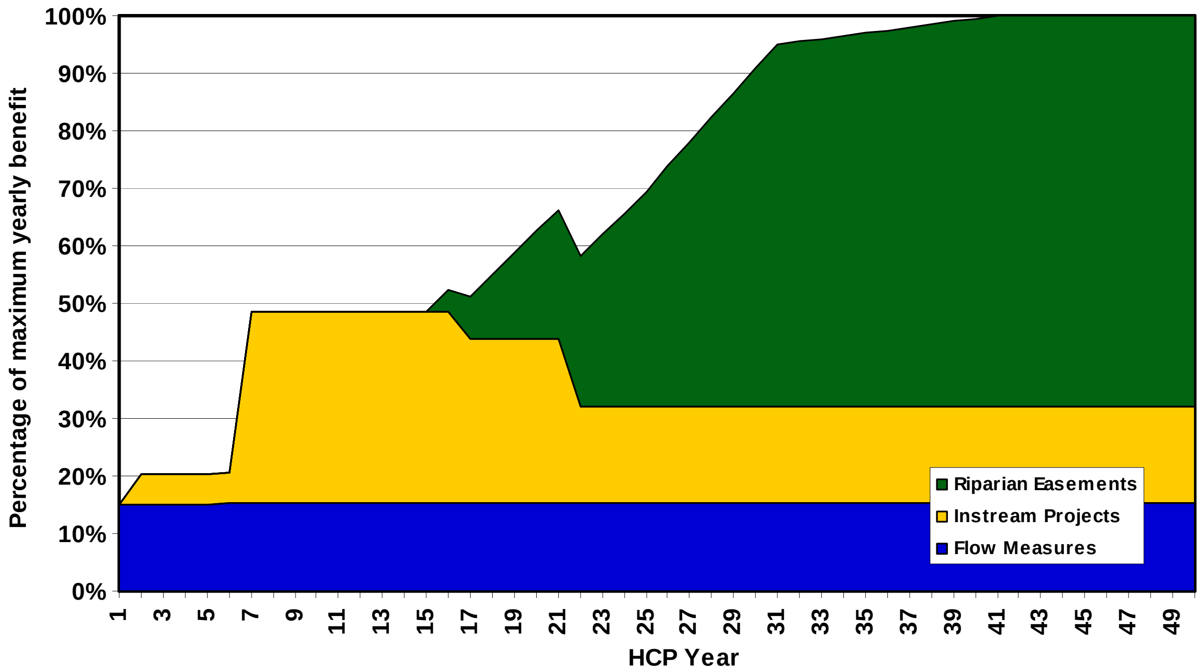


Figure 8-5. Accumulation of Predicted Benefits to Fall Chinook from HCP Measures over Time[a]

Source: EDT model runs, April 10, 2007.

[a]The accumulated benefits exclude benefits from the following measures: H-3—Little Sandy 1 and 2 LW Placement, P-2—Alder 1 Fish Passage, P-3—Alder 1A Fish Passage, H-25—Salmon 2 Carcass Placement, H-29—Zigzag 1A, 1B, and 1C Carcass Placement

The full fall Chinook benefits would be realized by approximately HCP Year 40. This maximum benefit level closely corresponds to the abundance number used in Table 8-11 for the "HCP Measures With Cedar Creek" scenario, but the benefit level excludes the benefits of large wood additions. Through the term of the HCP, the cumulative total benefits will be 21 percent from the flow measures, 28 percent from instream measures, and 51 percent from riparian easements.

The City believes the HCP, as a whole, meets ESA Section 10 requirements for fall Chinook.

8.2.2 Spring Chinook Habitat Effects

The HCP measures in the Bull Run watershed minimize the effects on juvenile and adult spring Chinook salmon in the lower Bull Run River to the maximum extent practicable. Offsite measures were selected to provide additional benefits for spring Chinook to help mitigate for the effects not avoided in the Bull Run. In addition, offsite measures that mitigate for impacts on other covered species also provide benefits for spring Chinook. Chapter 11 describes the City's commitment to fund the implementation of the necessary measures.

The potential effects of the City's Bull Run water supply operations on spring Chinook salmon are described in five subsections:

1. Effects in the lower Bull Run River—Describes the habitat effects of both the City's water supply operations and the HCP measures on lower Bull Run habitat for spring Chinook
2. Effects in the lower Sandy River—Describes the habitat effects of both the City's water supply operations and the HCP measures on habitat in the lower Sandy River for spring Chinook
3. Effects in the Columbia River— Describes the effects of using the City's groundwater supply at the Columbia South Shore Well Field on fish habitat in the Columbia River
4. Effects in Sandy River Basin watersheds—Describes the habitat effects of the offsite HCP measures on spring Chinook habitat in watersheds of the Sandy River Basin
5. Effects on the Sandy River populations, by VSP parameter—Describes the population effects of all of the HCP measures (those in the Bull Run and those in the Sandy River Basin offsite locations) on abundance, productivity, diversity, and spatial structure for spring Chinook
6. Comparison to a population benchmark—Compares estimates of spring Chinook abundance under historical conditions to estimated abundance after HCP implementation

Summaries for all subsections appear in gray shaded boxes. A detailed description of the effects for the species in the geographic location follows each summary. Conclusions about the habitat effects on spring Chinook from implementation of all HCP measures, including a discussion of the predicted accumulation of habitat benefits over time, are provided on page 8-77.

Summary of Effects on Spring Chinook in the Bull Run Watershed from Bull Run Water Supply Operations and HCP Measures

The City identified 10 types of effects that the conservation measures will have on spring Chinook salmon in the Bull Run Watershed. The City also analyzed the potential impacts on the base flow of the Columbia River from the HCP flow commitments.

- Impacts associated with fish access to the upper Bull Run watershed, low base flows, and low weighted usable areas will be reduced with the Bull Run conservation measures, but not all impacts will be avoided. Those impacts that are unavoidable will be offset by the Sandy offsite conservation measures.
- The HCP will avoid impacts on spawning gravel, flow downramping, and riparian function in the lower Bull Run. There will be some short-term water temperature impacts, but in the long term, the natural thermal potential of the lower river will be returned by the City's infrastructure and operational changes for its dams and reservoirs.
- The removal of large wood at the reservoirs is considered a small impact on spring Chinook and the City's riparian zone protective measures will improve large wood levels in the future.
- The City does not know whether TDG levels harm spring Chinook in the lower Bull Run but the species will be monitored under this HCP and addressed through adaptive management provisions described in Chapter 9.
- The City's flow measures will have an extremely small effect on the Columbia River base flows and spring Chinook habitat will not be affected.

Table 8-12 summarizes the effects of the water supply operations, the reference condition for each effect, and the predicted effects from the City's HCP conservation measures.

Table 8-12. Effects of the Bull Run Measures on Lower Bull Run River Habitat for Spring Chinook[a]		
Type of Effect	**Reference Condition**	**Habitat Effects of Conservation Measures**
Base flows Winter/Spring Period (Juvenile Rearing) Fall Period (Spawning)	Natural Bull Run base flows	HCP flows will be 77 to 81% of natural base flows during the juvenile rearing period. HCP flows will be 36 to 46% of natural base flows during the spawning period.
Weighted Usable Area (WUA) Juvenile Rearing (Summer) Juvenile Rearing (Winter) Spawning	Natural flow Weighted Usable Area	HCP WUAs for juvenile rearing in the summer will be 60 to 100% of the maximum WUA value. Projected HCP median flows will result in maximum WUA values for Chinook rearing from December through May. Impacts will be avoided. HCP WUAs for spawning will be 2 to 67% of the natural flow WUA levels.
Flow Downramping	Protective downramping rate: 2"/hour	The City will meet the protective downramping rate (2"/hour) and fish stranding effects will be minimal.
Little Sandy River Base Flows	Natural flow; free-flowing	City's commitment to forgo development of the Little Sandy water rights will ensure free-flowing conditions for approximately 10 new miles of stream habitat in the Little Sandy River.

Table 8-12. Effects of the Bull Run Measures on Lower Bull Run River Habitat for Spring Chinook[a], continued

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Water Temperature	ODEQ standard: natural thermal potential	There will be minor, short-term water temperature impacts prior to year 2012. By year 2012, the natural thermal potential of the lower Bull Run River will be met. Water temperature impacts for winter and summer rearing will be avoided. Under natural thermal potential, water temperatures for spring Chinook spawning will be too warm.
Large Wood	Natural wood routing and accumulation	Removal of large wood from the reservoirs to protect the water supply infrastructure does not substantially affect large wood in the lower Bull Run River because the channel is a transport reach.
Spawning Gravel	Natural levels of gravel recruitment	The City will replace the natural level of gravel recruitment in the lower Bull Run River. All impacts will be avoided.
Fish Access	Historical fish anadromy Total blocked stream miles in the Bull Run River watershed: 26.9 Blocked free-flowing miles in the Bull Run River watershed (excluding the Little Sandy River): 12.1	City will not provide access into the upper Bull Run River. Approximately 10 miles of river will be provided in the Little Sandy River, of which 8 miles could be used by spring Chinook.
Riparian Function	Mature riparian zones	City's lower Bull Run riparian lands are currently in good condition. Protective measures in the HCP will maintain and somewhat improve these conditions as younger trees mature.
Total Dissolved Gases (TDG)	ODEQ standard: maximum of 110% saturation at flows below the 7Q10 flow.	The City does not believe there are elevated TDG levels in the current range of anadromy at flows below the 7Q10 flow, but the City will continue monitoring to determine whether the ODEQ standard is being met.

[a]For the list of conclusions about the habitat effects of all HCP measures on spring Chinook, see page 8-77.

Habitat Effects in the Lower Bull Run River from Bull Run Measures

The effects on spring Chinook in the lower Bull Run River are described in the following categories: streamflow, water temperature, large wood, spawning gravel, access, and riparian function.

Streamflow

The City analyzed streamflow effects on spring Chinook by two means: comparing the effects of the HCP Bull Run base flows with the natural (pre-water-system) conditions; and determining the spring Chinook spawning and rearing WUA likely to result from Bull Run flow measures.

Bull Run Base Flows. The City compared an estimate of median monthly flows (50 percent exceedance flows) under natural conditions (i.e., no dams or diversions in the Bull Run watershed) with anticipated flows resulting from implementation of the HCP (assuming normal and critical years occur at the same frequency in the Bull Run as they have in the past). A 64-year hydrological record (1940–2004) was used for the analysis. The estimated median flows for the Bull Run River upstream of the Little Sandy River are shown in Figure 8-6; all flow amounts are relative to the USGS Gauge No. 14140000) located at RM 4.7 on the Bull Run River. The flow analysis considers spring Chinook utilization of habitat in the lower Bull Run River, as shown in the periodicity chart in Chapter 5 (Figure 5-18).

Table 8-13 lists the median natural flows and median flows anticipated from implementing the HCP. The comparison is for flows in two segments: upstream of the confluence with the Little Sandy River (RM 3.0—RM 5.8), and downstream of the Little Sandy River (RM 0–RM 3.0). For the portion of the Bull Run River downstream of the Little Sandy River, median flows were determined using the estimated Little Sandy median natural flows that would occur after the Little Sandy Dam is removed in 2008.

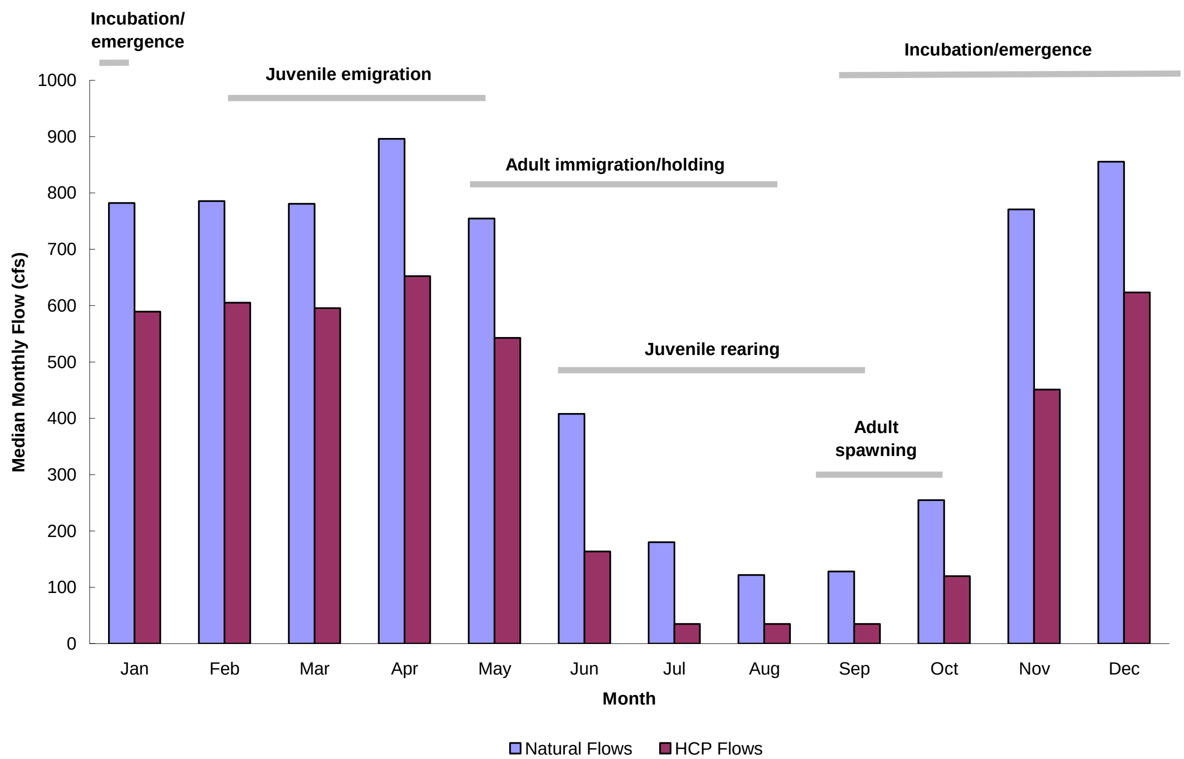


Figure 8-6. Median Monthly Flows and Peak Periods of Occurrence for Spring Chinook Salmon in the Lower Bull Run River above the Little Sandy River Confluence[a]

Source: Median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000 (RM 4.7).

[a]Although peak juvenile rearing period is shown here, spring Chinook rearing occurs all year. See Figure 5-18 for periods of occurrence in the lower Bull Run River.

Table 8-13. Natural and HCP Median Flows by Month for the Lower Bull Run River

	Flows above Little Sandy (cfs)[a]		Flows below Little Sandy (cfs)[b]	
Month	**Natural**	**HCP**	**Natural**	**HCP**
January	782	611	938	765
February	785	608	957	776
March	780	606	932	760
April	896	672	1,072	846
May	755	563	898	709
June	408	196	487	274
July	180	35	213	67
August	122	35	141	54
September	128	35	152	55
October	255	120	304	166
November	771	427	924	608
December	857	654	1,031	829

[a]Median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS No. Gauge 14140000, Bull Run River (RM 4.7).

[b]The sum of median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000, Bull Run River (RM 4.7) and median monthly flows taken at USGS Gauge No. 14141500, Little Sandy River (RM 1.95).

For September and October, the median HCP flow for the Bull Run River above the confluence with the Little Sandy River will be approximately 59 percent lower than the natural flow. For the Bull Run downstream of the Little Sandy River, the HCP flows will be approximately 51 percent lower than the natural flow levels.

June through September is the early summer transition and summer/early-fall periods for juvenile and holding adult spring Chinook. For the Bull Run River upstream of the Little Sandy River, the HCP flow is 64 percent lower than the natural median flow under the City's proposal. For the Bull Run downstream of the Little Sandy, the HCP median flow is 54 percent lower than the median natural flow.

Juvenile emigration occurs primarily in April and May before the flows decrease. For the Bull Run River downstream of the Little Sandy River, the median HCP flows will be 20 percent lower than the projected natural flows for January through May. Upstream of the Little Sandy River confluence, the median HCP flows will be approximately 23 percent lower than the projected median natural flows for that time period.

Although the HCP includes a provision to reduce flows in the fall during critically dry years, the frequency of these reductions will be limited by the City's commitment. Critical fall flows will only occur in 10 percent of the HCP years. The City's commitment will also limit the occurrence of critical fall flows to no more than two consecutive years. If critical fall flows are triggered, the City will not release critical fall flows in a specific year when most adult fish would return to their place of origin. When a critical fall flow year occurs, the City will not implement critical fall flows four years later regardless of whether the critical fall trigger occurs (see Measure F-2 in Chapter 7).

Effects of Base Flows on Spring Chinook Spawning. The primary spawning time for spring Chinook in the Bull Run River is from early September to mid-October (Beak 2000a, Clearwater BioStudies 2005). The City's flow measures will not significantly improve spawning conditions for spring Chinook because the lower Bull Run will still have reduced base flows and the primary limiting factor is warm water temperatures. The significance of the difference between natural and HCP flows for spring Chinook spawning activity is further described in the discussion titled Bull Run Weighted Usable Area (WUA), below. The water temperature impacts are discussed in the Water Temperature section below.

Effects of Base Flows on Spring Chinook Rearing. Juvenile spring Chinook rearing distribution is not well documented in the Sandy River Basin (ODFW 2001). Some studies suggest that spring Chinook fry emerge in mid- to late winter and begin to drift downstream, probably to rear in larger mainstem areas of the watershed. During snorkeling efforts in the lower Bull Run River from the last decade, few juvenile spring Chinook were ever observed.

The City's HCP flows are consistently highest during the winter and spring period, which will have a low effect on spring Chinook during that time. The HCP median flows for January through May would average approximately 610 and 770 cfs for the Bull Run River upstream and downstream, respectively, of the Little Sandy River. These relatively high flows will maintain ample water depths to protect egg incubation in and fry emergence from redds constructed during the preceding fall spawning period.

Adult spring Chinook migrate into the Bull Run River in late spring and early summer and have been observed as early as July (Beak 2000a). It is difficult to estimate the magnitude of the effects of flow on adult immigration because adult spring Chinook hold in large pools. The physical character of these large pools does not change much with changes in flow; therefore, the City concludes that adult holding habitat availability is not affected by different flow levels. The differences between natural flow and HCP flow levels for rearing spring Chinook are explained in the WUA discussion below.

It is suspected that warm water temperatures might be the primary limiting factor for spring Chinook; those effects are discussed in the Water Temperature section.

Bull Run Weighted Usable Area. WUA values were calculated from median flows for spring Chinook spawning and rearing to assess the effect of the HCP flow measures on the lower Bull Run River habitat. WUA estimates for natural flow conditions (i.e., no dams and no diversions) and for the HCP flows, both upstream and downstream of the Little Sandy River, are provided in Table 8-14.

R2 Resource Consultants (1998) estimated the flow-habitat relationships for spring Chinook spawning and juvenile rearing in the Bull Run River using the PHABSIM model. As described in Section 8.2.1, they generated estimates of WUA for up to 500 cfs in four segments of the Bull Run River. The four segments were combined into the two segments of the lower Bull Run River: upstream and downstream of the Little Sandy River. For flows greater than 500 cfs, goodness-of-fit curves were used to extrapolate WUA values. The WUA estimates for natural and HCP flows are compared using a “percentage of natural” metric. For example, if the HCP percentage of natural flow is 90 percent, the HCP median flow will yield a WUA value of 0.9 acre in a month, and the WUA value would be 1.0 acre in a month.

Extrapolation above 500 cfs. Extrapolation is considered to provide conservative WUA estimates (Carlson, pers. comm., 2005), although some uncertainty exists regarding extrapolation of Chinook spawning WUA values above 500 cfs. That is, the goodness-of-fit curves used to extrapolate WUA values for Chinook spawning continue to trend upward as flows increase above 500 cfs. However, WUA values for Chinook spawning may start to decline at higher flow levels, such as those observed by R2 Resource Consultants (1998) in the segment of the Bull Run River below the Bull Run powerhouse (i.e., segment 1). In this segment, PHABSIM modeling to 2,400 cfs was possible, and the modeled WUA values for Chinook spawning start to decline at flow levels above about 700 cfs (R2 Resource Consultants 1998).

Estimated WUA for Spawning. The City’s HCP flows will create a total spring Chinook spawning WUA that is 2 percent to 67 percent of the corresponding natural flow WUA (see Table 8-14). The City’s flow WUA levels are lowest in September for the section of the Bull Run River upstream of the Little Sandy River and highest in October for the section downstream of the Little Sandy River.

Table 8-14. Comparison of Chinook Spawning Weighted Usable Area (WUA) Values in the Bull Run River

Month	Natural Flow (cfs)	Natural Flow WUA (acres)	HCP Flow (cfs)	HCP Flow WUA (acres)	Percentage of Natural Flow WUA
Above the Little Sandy River (Upper Section)					
September	128	0.60	35	0.01	2
October	255	1.05	120	0.52	50
November	771	2.07	427	1.39	67
December	857	2.24	654	1.83	82
Below the Little Sandy River (Lower Section)					
September	152	0.79	55	0.39	49
October	304	1.19	166	0.82	67
November	924	1.41	608	1.40	99
December	1,031	1.41	829	1.41	100

Source: R2 Resource Consultants 1998a

The HCP includes a provision to reduce flows in the fall during water years with critical seasons (see Measure F-2 in Chapter 7). The frequency of these reductions will be limited by the City's commitment. Critical fall flows will only occur in 10 percent of the HCP years. The City's commitment will also limit the occurrence of critical fall flows to no more than two consecutive years. If critical fall flows are triggered, the City will not release critical fall flows in a specific year when most of the resulting adult fish would return to their place of origin. When a critical fall flow year occurs, the City will not implement critical fall flows four years later regardless of whether the critical fall trigger occurs. This will reduce impacts on spawning spring Chinook because normal fall flows will be provided when the majority of adults from a specific cohort return.

Even though the City's HCP flows will reduce WUA levels, high water temperatures are a more serious factor limiting spring Chinook spawning in the Bull Run. High water temperatures are caused by the reduced base flow levels and the release water temperature caused by Bull Run Dam 2, as discussed below.

Estimated WUA for Rearing. Spring Chinook juveniles rear from June through August. R2 Resource Consultants (1998) found that the estimated total habitat area (WUA value) for juvenile spring Chinook salmon increases at a rapid rate between zero and 100 cfs, with the most rapid increase occurring between 0 and 20 cfs (see Figure 5-12). The guaranteed minimum HCP flow in the summer is 20 cfs, although flows can vary from 20–40 cfs. The City's HCP flows will create WUA for spring Chinook rearing that will be approximately 60 to 100 percent of the WUA created by natural flows, as indicated in Table 8-15. Therefore, the City's HCP flows will have a beneficial effect on the summer rearing habitat for juvenile spring Chinook compared with current conditions, and limited effects compared with natural conditions.

Table 8-15. Comparison of Weighted Usable Area (WUA) Values for Spring Chinook Juvenile Rearing in the Bull Run River

Month	Natural Flow (cfs)	HCP Flow (cfs)	Natural Flow WUA	HCP Flow WUA	Percentage of Natural Flow WUA
Above the Little Sandy River (Upper Section)					
June	408	196	16.83	14.77	88
July	180	35	14.55	9.11	63
August	122	35	13.61	9.11	67
September	128	35	13.72	9.11	66
Below the Little Sandy River (Lower Section)					
June	487	274	12.23	13.58	>100
July	213	67	13.60	11.16	82
August	141	54	13.09	10.46	80
September	152	55	13.24	13.24	100

Source: R2 Resource Consultants

Spring Chinook fry typically emerge in middle to late winter, then migrate downstream to a large mainstem area for rearing. R2 Resource Consultants (1998) estimated that the total habitat area (WUA value) for juvenile Chinook reaches its maximum at approximately 350 cfs downstream of the Headworks (RM 6.3) to the PGE Powerhouse (RM 1.5). For the river downstream of the powerhouse, the total habitat area (WUA value) for juvenile Chinook reaches its maximum at approximately 110 cfs; the amount of habitat area then stays constant with increasing streamflow.

The HCP guaranteed minimum flow for December through June is 120 cfs; the projected median flow would be approximately 200 to 850 cfs (see Tables 7-1 and 8 13 respectively). The HCP flows will create a total WUA for spring Chinook rearing that is approximately 90 percent of the WUA created by natural flows in the lower Bull Run, depending on the month during this period (Table 8-15). Therefore, the City's HCP flows would minimize any impacts to rearing juvenile spring Chinook in the lower Bull Run during the winter and spring time periods.

Bull Run Peak Flows. The City assessed effects on peak flows in the lower Bull Run River by evaluating the annual peak winter flows since Water Year 1960. This data set was used for the peak flow analysis because the USGS gauge was in another location prior to 1960. The City estimated peak winter flows in the absence of the City's water supply diversions, peak winter flows with current (2006) water diversions, and peak winter flows with estimated 2025 water diversions based on Metro's population projections. The estimated change in annual total water yield diverted for supply is expected to increase from 20 percent currently to 22 percent in 2025.

The estimated magnitude of the annual peaks with no water diversions ranged from 4,010 to 25,420 cfs, depending on weather conditions. The estimated magnitude of the annual peaks for current water demands ranged from 3,880 to 25,100 cfs. The estimated magnitude of the annual peaks for 2025 water demands ranged from 3,863 to 25,094 cfs. Differences were determined by comparing flows on individual peak flow dates. The differences between no diversions and current diversions ranged from 0.3 percent to 3.3 percent. The differences between no diversions and estimated 2025 diversions ranged from 0.6 percent to 3.7 percent.

The City also characterized each peak flow event into a return frequency category (i.e., less than 2-year event, 2-5 year event, 5-10 year event, 10-25 year event, 25-50 year event, and 50-100 year event). The flow conditions experienced in those events were applied to current water diversions and 2025 estimated water diversions. In only one case did the increase in winter season water diversions in 2025 cause a change in the return frequency category for peak events. The January 5, 1969 weather year changed from a slightly greater than 2-year event to a slightly less than 2-year event.

The City concluded from this analysis that implementation of the HCP will not significantly change the magnitude of peak flow events in the lower Bull Run River. Peak flow events will continue to occur with a frequency and magnitude similar to current conditions and similar to conditions that would occur without water supply diversions.

Bull Run Scour Flows. The HCP flow regime will reduce the risk of scour in spring Chinook redds in the lower Bull Run River, compared with historical flows. Based on a recent analysis (Carlson 2005), flow sufficient to mobilize gravels will occur less frequently and

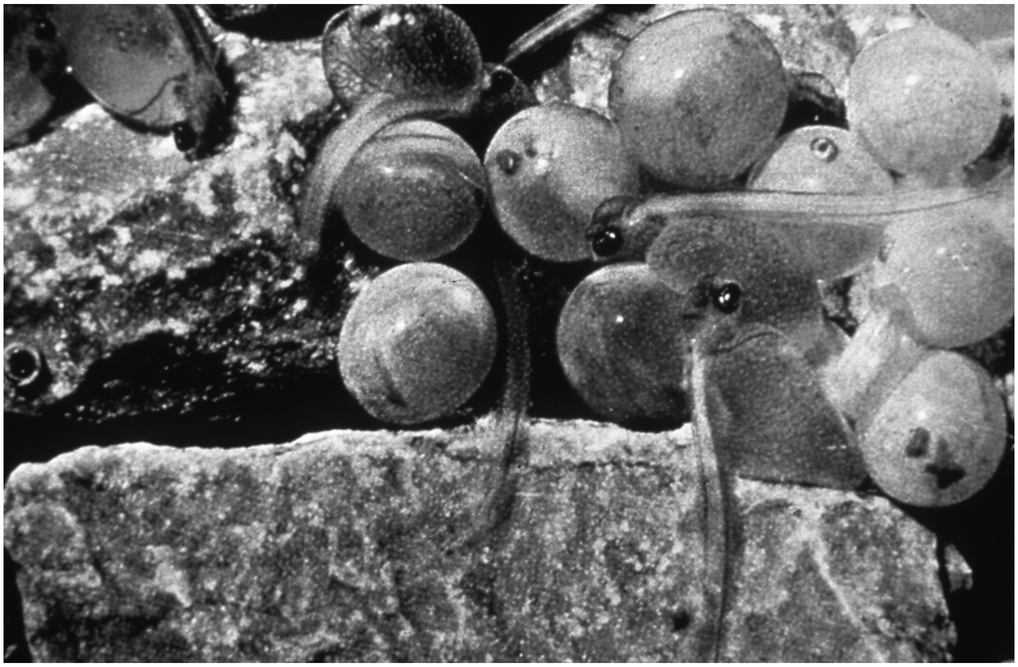


Photo courtesy of Bonneville Power Administration.

over fewer days during the HCP flows than during natural flows. The analysis focused on two time periods: primary egg incubation period for spring Chinook in the lower Bull Run from mid-October through December and fry emergence from January through mid-May, even though most of the spring Chinook will have emerged in the Bull Run from January through February.

A 25-year record (1980-2004) of mean daily flows in the lower Bull Run River was examined to determine the number of separate flow events large enough to mobilize spawning gravel. Those flows were contrasted with the flow regime estimated to occur under natural conditions (without City infrastructure and operations). Flows sufficient to mobilize gravels are expected to occur less frequently under the HCP flows than under natural flows. In addition, the rates of change during these peak events are likely to be lower under the HCP flows. This finding suggests that the HCP flow regime will reduce the risk of redd scour caused by peak flows compared with what would occur under natural conditions.

Even though the HCP flow measures are not anticipated to increase spring Chinook redd scour in the lower Bull Run River, the City will complete a redd scour study (see Chapter 9, Monitoring and Adaptive Management).

Bull Run Flow Downramping. The City's hydroelectric plant at the base of Dam 2 varies the streamflow in the lower Bull Run River during the winter and spring months when there is enough streamflow to run the facility. The current FERC license allows for a 2'/hour downramping rate for the lower Bull Run River, but the City is committing to a lower rate to protect juvenile salmonids.

The City studied juvenile salmonid stranding during different downramping events in the lower Bull Run River (Beak Consultants 1999; CH2M HILL 2002). The sites selected for monitoring included the widest areas of the channel considered most sensitive to ramping effects and potential stranding. Steelhead fry (about 40 mm average length) and yearling

(Age-1) juveniles were observed during the studies. No other salmonids were present during the stranding studies, and it is assumed that the behavior of juvenile steelhead is adequate for determining potential ramping rates effects. A ramping rate of no more than 2"/hour was recommended for the lower Bull Run River to protect salmonid fish. This rate is consistent with recommendations from the state of Oregon and others to protect against juvenile fish stranding (CH2M HILL 2002; Hunter 1992).

The City will minimize the risk of stranding juvenile spring Chinook by maintaining a maximum downramping rate of 2"/hour year-round for the hydroelectric powerhouse downstream of Bull Run Dam 2. All effects from flow downramping, however, cannot be avoided due to circumstances beyond the control of the City.

The City conducted a year-long evaluation of outages (Galida 2005) and determined that circumstances when the City would not meet the ramping rate occurred 0.4 percent of the time, which will have minimal effects on spring Chinook. These circumstances include natural storm flows, mechanical/control system failures that are impossible to predict, and FERC mandatory testing of project safety equipment. Out of the test period of approximately 8,800 hours of hydropower operations, the 2”/hour downramping rate was exceeded only for 35 hours. The exceedances occurred from mid-November through late-March and streamflow in the lower Bull Run River was 200-12,600 cfs. Natural stream flows were quite variable and since the reservoirs were full, the downramping rate could not be controlled by the City for approximately one-third of the 35 hours. Other exceedances can be attributed to equipment testing and operator error. Overall, the City was very successful in controlling the downward fluctuation of the lower Bull Run River.

The City’s commitment to a downramping rate of 2”/hour will result in minimal effects on spring Chinook. The occurrences of downramping greater than 2”/hour will rarely occur in the future, and if they do, they will happen during the winter months. This is after the spring Chinook have spawned. The redds will not be negatively affected because the streamflows will be high enough to protect them. Also, there will be a very low potential for stranding juvenile spring Chinook because the higher downramps would occur only infrequently and sporadically during the late winter and early spring.

The City will continue to monitor downramping in the lower Bull Run as part of the compliance monitoring efforts (see Chapter 9).

Little Sandy River Base Flows. Forgoing development of the City’s water rights on the Little Sandy River during the term of the HCP will help assure unimpeded natural flows on the Little Sandy River for spring Chinook. While the City acknowledges that the Little Sandy River probably did not historically produce a large number of spring Chinook due to its moderately confined channel width and dominance of the streambed by large cobbles, spring Chinook will have access to approximately 10 river miles of the Little Sandy River for spawning and rearing with this HCP.

Water Temperature

Spring Chinook salmon probably utilize the Bull Run River year-round, including the time periods with warm water temperatures such as the summer for juvenile rearing and the fall for spawning (see Figure 5-18 for the periodicity chart and Figure 8-7 for daily maximum temperatures).

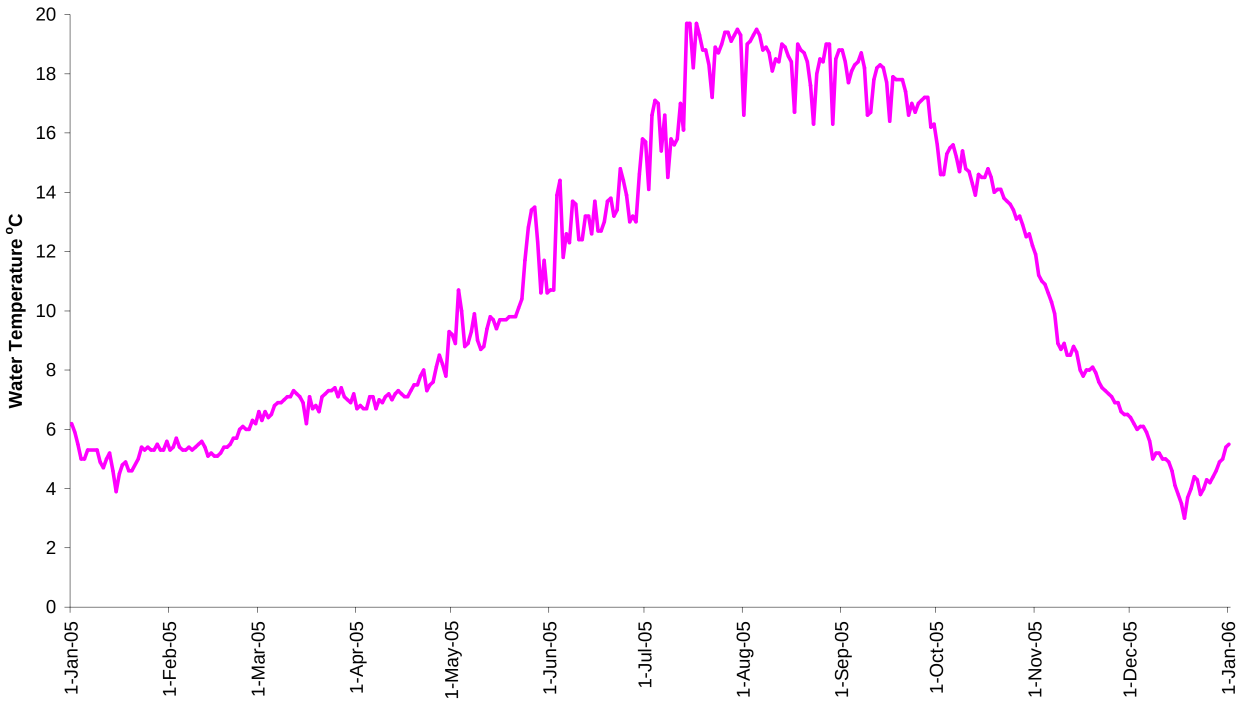


Figure 8-7. 2005 Daily Maximum Water Temperatures for the Lower Bull Run River as Measured at USGS Gauge No. 14140000 (RM 4.7)

Source: USGS Gauge No.14140000 on the Bull Run River (RM 4.7).

The reference condition for water temperature is the natural thermal potential of the lower Bull Run River. Natural thermal potential is defined by ODEQ in the Sandy River TMDL (ODEQ 2005) as the water temperatures that would occur in the Bull Run River if there were no dams or diversion. The City, in conjunction with ODEQ, has developed a method to establish the natural thermal potential of the lower Bull Run River and found that the current temperature regime of the Little Sandy River is a good surrogate for the Bull Run. (See temperature measure T-2 in Chapter 7 for more details.)

Pre-Infrastructure Water Temperature Effects. The City plans to make significant infrastructure improvements at Dam 2 to meet the natural thermal potential of the lower Bull Run River. However, prior to completion of the infrastructure improvements, water temperatures in the lower Bull Run River during the summer and September–October will exceed those preferred for rearing and spawning Chinook, as indicated in Figure 8-8.

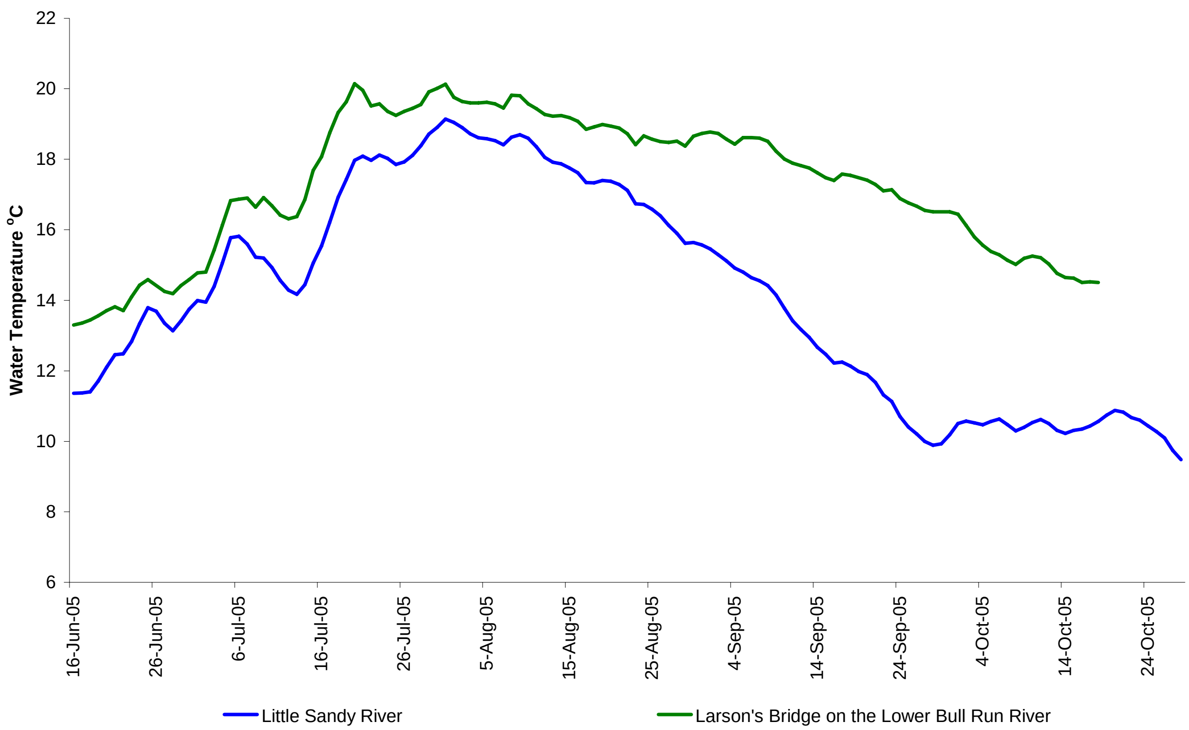


Figure 8-8. Seven-Day Maximum Average Water Temperatures for the Little Sandy and Lower Bull Run Rivers, June 16–October 24, 2005

Source: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8) and USGS Gauge No. 14140000 on the Bull Run River (RM 4.7).

The City will continue to carefully manage the amount of cool water in the reservoirs for downstream flow releases. Figure 8-8 indicates the water temperature performance that the City will be able to achieve in the first years of the HCP. For rearing spring Chinook in the summer and early fall, the City has established the interim goal of not exceeding 21 °C at Larson's Bridge on the lower Bull Run River. That target is cool enough to allow continued growth of spring Chinook. Although this temperature target is higher than the range preferred by rearing spring Chinook, it is the best performance outcome that the City can achieve with the current dam infrastructure. There will be some temporary effects on spring Chinook juveniles.

The City cannot provide favorable water temperatures during the prime spring Chinook spawning months of September and October. There is not enough cool water in the reservoir to meet the interim water temperature target of 21 °C for rearing spring Chinook and lower the water temperature in the fall for spawning. The water temperature of the lower Bull Run River, expressed at Larson's Bridge in Figure 8-8, would be approximately 16 °C—18 °C for the first two weeks of October, higher than ODEQ's water temperature criterion of 13 °C for spawning salmonids. The City has identified other offsite habitat compensation measures to mitigate for the impacts on spring Chinook salmon spawning in the lower Bull Run watershed.

Post-Infrastructure Water Temperature Effects. The City will complete infrastructure changes at the Dam 2 towers and the stilling basin and commit to daily operational flow management (Measure T-2). The City used the CE-QUAL-W2 water quality model to predict natural condition stream temperatures in the lower Bull Run River (City of Portland 2004). The model predicted that maximum stream temperatures would occur at Larson's Bridge (RM 3.8) in the lower Bull Run River. City staff and ODEQ staff evaluated modeling results and empirical data and concluded that natural stream temperatures in the lower Bull Run River could be estimated using the stream temperature of the Little Sandy River (see Figure 8-9).

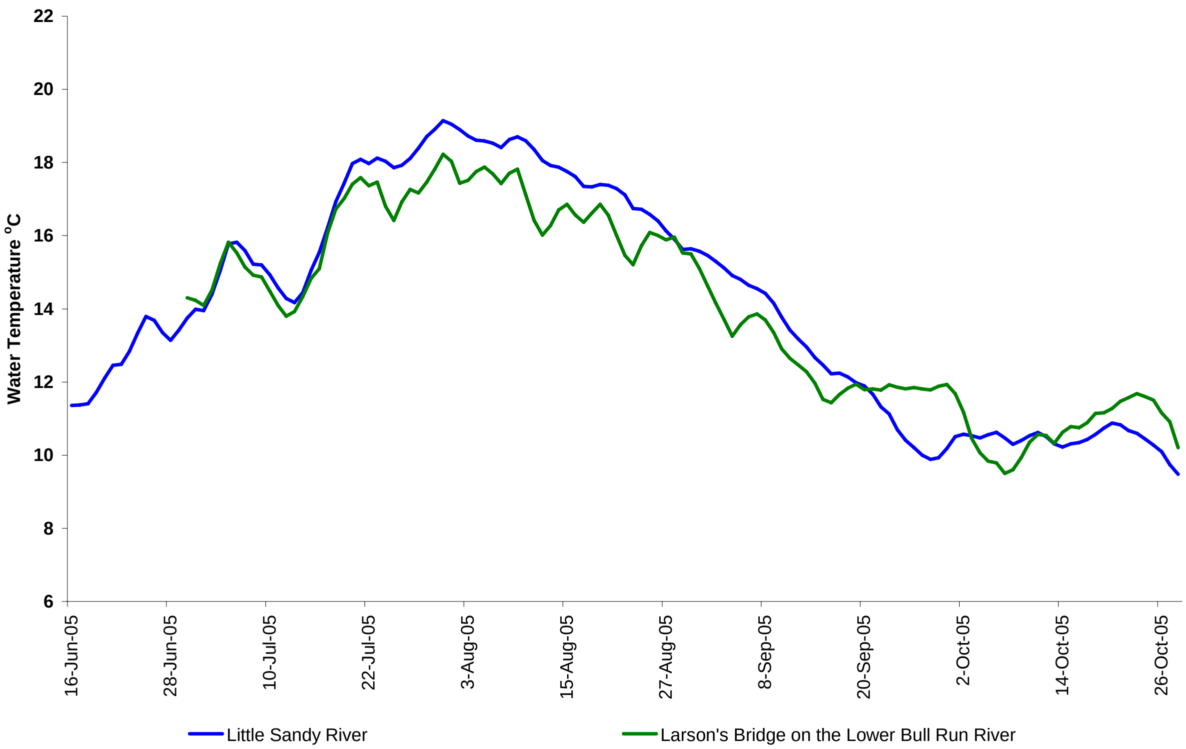


Figure 8-9. Comparison of Actual 7-Day Maximum Water Temperatures for the Little Sandy Compared with Predicted 7-Day Maximum Average Temperatures for the Lower Bull Run River, June 16–October 24, 2005

Source: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8) and CE-QUAL-W2 Modeled Temperatures (February 2006).

The summer and early fall water temperatures in 2005 shows that water temperatures at Larson's Bridge will be generally lower than temperatures in the Little Sandy but are within approximately 1 °C (see Figure 8-9). ODEQ has established water temperature criteria for the Larson's Bridge location under the authority of the Clean Water Act and the Sandy Basin TMDL (see Measure T-2 in Chapter 7).

Within five years of the start of the HCP, the infrastructure changes at Dam 2 will be completed and the natural thermal potential of the Bull Run River will be met. Water temperature impacts on spring Chinook would be minimized.

Diurnal Water Temperature Fluctuations. The City anticipates that the diurnal water temperature fluctuations in the lower Bull Run River will be less than what has been observed in recent years. The fluctuations likely to result from implementing the HCP measures were estimated using modeling and measured water temperatures from the lower Bull Run and Little Sandy rivers. Table 8-16 lists observed and expected temperature fluctuations for the summer and late summer months. These are the months when the City's operations will affect the diurnal temperature fluctuations due to the water temperature compliance measures described in this HCP. During other months of the year, the diurnal water temperatures fluctuations should not be affected. The fluctuations expected after implementing the HCP measures are predicted to be smaller than the fluctuations that would occur under natural conditions.

Table 8-16. Diurnal Water Temperature Fluctuations (°C)

Month	Bull Run Observed (current conditions)	Little Sandy Observed (natural conditions)	Expected HCP
June	4–6	0.5–5	2–3
July	4–6	1–5	2–3
August	3–5	1–5	2–3
September	2–3	1–4	1–2

Source: Bull Run observed temperatures: USGS Gauge No. 14140000 on the Bull Run River (RM 4.7); Little Sandy observed temperatures: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8); expected HCP temperatures: CE-QUAL-W2 Modeled Temperatures (February 2006).

The City reviewed available research that describes the influence of fluctuating water temperature on the growth of salmonids. Most of the studies focused on rainbow, steelhead, coho, and sockeye salmon. Experiments on steelhead and coho (Hahn 1977; Grabowski 1973; and Thomas et al. 1986) indicated that fluctuating water temperature tests and the constant temperature test exposures produced essentially equivalent results. The City concludes that these reductions in diurnal water temperature fluctuations will not affect spring Chinook or other salmonids that utilize the lower Bull Run River.

Large Wood

Large wood is removed from the upper end of Reservoir 1 to protect the downstream water supply dams from damage. USFS owns this wood because it is transported by tributaries from national forest land. Because this wood is not allowed to travel down the lower Bull Run River, a small amount of beneficial habitat is potentially lost for spring Chinook. The lower Bull Run River is, however, a high-order steep stream and is not likely to trap and store large wood. Photographs taken of the lower Bull Run in the late 1890s, before the dams and water diversions were constructed, show little large wood in the channel. The lower river is probably a transport reach for large wood.

The channel of the river is dominated by bedrock and boulders. This channel roughness supports diverse habitats, including about 27 percent pool habitat. The presence of this pool habitat suggests that large wood is not important for pool formation and that the addition of large wood would provide only a minor increase in pool habitat.

The City does not plan to artificially place large wood in the lower Bull Run River above Larson's Bridge because of concerns about the vulnerability of the water supply infrastructure (such as conduit trestles). The City will let natural recruitment of large wood occur in the lower Bull Run River downstream of Larson's Bridge. Trees that fall naturally will be left in place to modify the stream channel. This large wood could slightly improve habitat conditions for spring Chinook by creating pools in localized areas and trapping finer gravels in the lower 3.8 miles of the lower Bull Run River.

Spawning Gravel

Two Bull Run dams interrupt bedload and gravel movement to the lower Bull Run River, resulting in reduced spawning habitat for spring Chinook salmon and other species. The estimated historic gravel supply rate was roughly 30 to 1,000 cubic yards (CH2M HILL 2003b). The City will place approximately 1,200 cubic yards per year for the first five years and 600 cubic yards per year thereafter (see Measure H-1 in Chapter 7). The gravel replacement rate will be higher than the estimated natural accumulation. Placement of gravel in the lower Bull Run River under the HCP will significantly improve the spawning conditions for spring Chinook. The City will monitor the effects of the gravel placement to determine whether the measure should continue for the term of the HCP, or should be modified (see Section 9.4, Adaptive Management Program in Chapter 9).

Access

Spring Chinook were first blocked from the upper Bull Run watershed in 1921 by construction of the Diversion Dam (approximately RM 5.9). The dam was constructed to divert Bun Run water into water conduits to serve the greater Portland metropolitan area. In 1964, as part of the Dam 2 construction, a rock weir at RM 5.8 was built to create the Dam 2 plunge pool for energy dissipation. That structure is now the upstream limit for spring Chinook in the Bull Run watershed.

Spring Chinook access will remain blocked by the rock weir at RM 5.8 during the term of the HCP, preventing access to approximately 21.3 miles of the upper Bull Run River historically used by this species. Of these blocked miles, only 12.1 miles are free-flowing river; 9.2 miles are inundated by City reservoirs.

When PGE removes the Little Sandy Dam, spring Chinook will have access to an additional 5.6 miles of the mainstem Little Sandy River, and possibly 2.0 additional miles of tributary streams.[7] The City's agreement to maintain flows for fish in the Little Sandy (see Measure F-4, Chapter 7) will help retain habitat benefits from this renewed access to the historical habitat for spring Chinook.

[7] See Section 4.1.5 Water Quantity and Water Rights in Chapter 4 for more information on the Little Sandy Dam removal.

Photo courtesy of Char Corkran.

Riparian Function

The City owns land along 5.3 miles of the lower Bull Run River (1,650 acres). The City's land represents 82 percent of the riparian corridor below Dam 2. Managing these lands to protect riparian habitat (see Measure H-2 in Chapter 7) will slightly improve habitat for spring Chinook. Approximately 30 percent of the riparian corridor along the lower river is late-successional (late-seral) timber than can provide immediate large wood recruitment to the channel. In addition, 80 percent of the riparian corridor is of mid- to late-seral age that will provide wood to the channel at an increasing rate over the next 10 to 70 years (Cramer et al. 1997). The large trees that fall into the lower Bull Run will affect localized stream gradient, sort gravels, and create small pools that will be beneficial to spring Chinook. In the long-term, large wood will also route downstream to the mainstem Sandy River where it will create habitat for Chinook.

Analysis of shading in the lower Bull Run River indicates that riparian vegetation currently intercepts 40 to 60 percent of the total solar radiation that potentially could reach the water surface (Leighton 2002). This shading provides a substantial benefit by maintaining lower water temperatures. This shading benefit will become greater over time as the vegetation continues to mature. The mature vegetation in the lower Bull Run combined with the temperature measures (infrastructure changes to the intake towers and temperature management) will closely approximate natural water temperatures and reduce the effects of water system operations on spring Chinook.

Total Dissolved Gases

Oregon's Water Quality Standards state that TDG levels should not exceed 110 percent of saturation unless flows exceed the ten-year, seven day average flood (7Q10) flow for the site [OAR 340-041-0031]. The 7Q10 flow for the lower Bull Run River is 5,743 cfs. The City has monitored all water system structures, valves, or turbines that could elevate TDG levels since 2005, and has determined that spring Chinook are unlikely to be adversely affected by TDG levels in the Bull Run River. A 55-foot deep stilling pool at the base of the Dam 2 spillway is the site most likely to produce TDG levels that could affect spring Chinook. This location, however, is upstream of the range of anadromous fish. Monitoring by the City indicates that elevated levels of TDG quickly decrease as water passes over the rock weir below the stilling pool (RM 5.8). The City has never measured TDG levels that met or exceeded 110% in the anadromous portion of the Bull Run River, unless the 7Q10 flow was also exceeded. TDG levels further dissipate between the rock weir and Larson's Bridge, about 1 mile downstream (RM 4.7). Almost all of the spring Chinook observed in the lower Bull Run River were downstream of Larson's Bridge (Strobel 2007a, Clearwater BioStudies 1997; 2006; ODFW 1998; Beak Consultants 2000a,b). Spring Chinook are probably not impacted by TDG levels in the Bull Run River. The City, however, will continue to monitor TDG levels in the Bull Run as described in Chapter 9 and Appendix F, Monitoring Plans and Protocols.

Summary of Effects in the Lower Sandy River from Bull Run Water Supply Operations and HCP Measures

The City identified five types of effects that water supply operations could have on spring Chinook habitat in the lower Sandy River.

- Base flows in the lower Sandy would be reduced by continued water supply operations in the Bull Run but the weighted usable area for spring Chinook spawning and juvenile rearing habitat will be increased with the City's HCP flow measures.
- Flow downramping effects in the lower Sandy will be avoided because of the City's downramping commitments in the Bull Run.
- The City's HCP measures will probably have small beneficial effects on water temperatures in the lower Sandy.
- The City will also minimize the impact of removing large wood from the lower Bull Run by adding large wood directly into the lower Sandy.

Overall, the City's HCP measures will have positive effects on the habitat in the lower Sandy River. Table 8-17 summarizes the habitat effects of the Bull Run measures in the lower Sandy.

Table 8-17. Effects of the Bull Run Measures on Lower Sandy River Habitat for Spring Chinook[a]

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Base Flows	Natural Sandy River base flows	Flows after implementation of the HCP will be more than 80% of natural base flows.[b]
Weighted Usable Area (WUA)	Natural Sandy River base flows	Flows will increase WUA spawning habitat by up to 20 percent.[c] Lower Sandy River flows will have higher WUA values for rearing Chinook juveniles.
Flow Downramping	Protective downramping rate: 2"/hour	The City's water supply operations will have minimal effects on fish stranding due to downramping.
Water Temperature	ODEQ standard: natural thermal potential	The City's HCP measures will probably have small water temperature benefits.
Large Wood	Natural wood accumulation	Removal of large wood from the reservoirs reduces the amount of large wood loading to downstream Sandy River reaches and reduces channel complexity. City measures will increase large wood levels and habitat diversity, minimizing adverse effects of Bull Run operations in the Sandy River below the Bull Run confluence.

[a]For the list of conclusions about the habitat effects of all HCP measures on spring Chinook, see page 8-77.

[b]Based on flow data from 1985-2001, natural base flows were reduced by 4-19 percent (CH2M HILL 2002) .

[c]Based on flow data from 1985-2001, habitat for spawning was increased by 2-18 percent.

Habitat Effects in the Lower Sandy River from Bull Run Measures

The EDT database and model were used to identify limiting factors having the greatest effect on spring Chinook in the lower Sandy River below the confluence of the Bull Run River. The factors identified were food, habitat diversity, harvest, flow, channel stability, competition from the same species, predation, water temperature, pathogens, and sediment. Of these 10 factors, three are potentially affected by water supply operations in the Bull Run: flow, water temperature, and large wood recruitment (as a subfactor of habitat diversity). The other seven factors are not directly related to water supply operations.

Streamflow

A flow effects analysis for Chinook salmon in the lower Sandy River below the Bull Run focused on the potential effects of the City's Bull Run operation on base flows and flow fluctuations (ramping) (CH2M HILL 2002). The analysis used Bull Run flows from 1985 to 2001, which are lower than the HCP flows described in Chapter 7.

Base Flows. The City compared the WUA and monthly flow amounts without City operations to the WUA and monthly flows during the 1985 to 2001 period. Although City operations from 1985 to 2001 reduced base flows in the lower Sandy River by 4 to 19 percent (depending on month), the available usable habitat for spring Chinook juveniles in the lower Sandy River was higher for every month. The results were not examined for spawning activity Chinook because the primary spring Chinook spawning areas are upstream of the Marmot Dam site (ODFW 2001). The City's HCP flows will be higher than the flow releases analyzed in CH2M Hill (2002). The City's HCP should maintain or slightly improve habitat conditions in the lower Sandy River for spring Chinook compared with current habitat conditions.

Downramping. The CH2M HILL analysis indicates that the downramping rate of 2"/hour would eliminate juvenile salmonid stranding effects in the lower Sandy River reaches.

Water Temperature

Both ODEQ's and the City's water temperature modeling results indicate that the lower Sandy River reaches are in a state of relative equilibrium. City water supply operations have little influence on heating or cooling of the lower Sandy River. This conclusion is supported in the Sandy River Basin TMDL (ODEQ 2005).

Even though the City's operations in the Bull Run will not negatively affect water temperatures in the lower Sandy River, some of the City's offsite conservation measures will probably have small water temperature benefits over existing habitat conditions.

Large Wood

Removal of large wood from the Bull Run reservoirs reduces the amount of large wood loading to downstream Sandy River reaches and reduces channel complexity for spring Chinook. To mitigate for this impact, the HCP includes several large wood measures in the lower Sandy River (see Measures H-4, H-11, H-12, and H-13 in Chapter 7). Installing large log jams in the lower Sandy River (RM 0–RM 18) will slightly increase habitat diversity for migrating spring Chinook. Easements located in prime spring Chinook rearing areas will also improve riparian conditions in the Sandy River. None of the easement areas are in historical condition and as these riparian areas mature, large wood recruitment will increase. Collectively, these measures will improve habitat conditions for rearing or emigrating spring Chinook in the lower Sandy River (see Table 8-17).

Habitat Effects in the Columbia River from Use of Groundwater

The City will use groundwater from the Columbia South Shore Well Field, in conjunction with the Bull Run River flows, to provide the total amount of water needed to meet water supply demands and the HCP flow commitments. The Columbia River is located adjacent to the well field, so the City analyzed the effect groundwater use might have on flows in the Columbia River.

As context, only one instream flow commitment has been established for the lower Columbia River to maintain the persistence of ESA-listed species. This requirement is the FCRPS's minimum flows of roughly 125,000 cfs below Bonneville Dam, unless competing priorities preclude it (USCOE et. al. 2006). These minimum flows are increased by contributions from the Sandy and Washougal rivers before arriving at the Glenn Jackson Bridge (I-205 bridge), approximately 14 miles west of the mouth of the Sandy River.

The well field has an estimated sustainable capacity of approximately 85 mgd, which is equivalent to approximately 130 cfs. The actual amount and duration of pumping will vary according to the weather and supply conditions, but typically the amount pumped per day would be significantly less than the full capacity. The well field draws on four regional alluvial aquifers. Recharge for these aquifers occurs as far south as the Boring Hills (Hartford and McFarland 1989). These aquifers generally discharge into the Columbia River.

As a simplifying worst case assumption for this analysis, the City assumed that 85 mgd would be pumped from the well field and that this amount would be drawn into the aquifers from the Columbia River. (This is a significant overestimate because the water pumped would actually be drawn primarily or completely from the aquifers themselves and not from the river into the aquifers.) The assumed flow into the aquifers would reduce the assumed flow available in the Columbia River for fish.

If the City's groundwater pumping were to result in a 130 cfs reduction in Columbia River flows, that reduction would be at most 0.1 percent of the total river flow (based on the 125,000 cfs minimum flows mentioned above). To put this reduction in perspective, the typical margin of error on measured flows for the Columbia River is +/- 10 percent (see for example the gauge at the Columbia River at The Dalles, USGS 2003). This measurement error is significantly larger than the estimated flow reduction due to groundwater use. In addition, the mainstem Columbia River has tidal fluctuations that average approximately 1.7 feet (data from USGS Gauge No. 14144700). This natural daily change in river stage is many orders of magnitude greater than any potential reduction of Columbia River flows due to the City's use of groundwater. The City's conclusion is therefore that use of the Columbia South Shore Well Field, as a means to enable the HCP flow commitments in the lower Bull Run River, will have a negligible influence on the Columbia River base flows and associated habitat for spring Chinook salmon migrating in the river.

Summary of Effects in the Sandy River Basin from the HCP Offsite Measures

The primary spring Chinook spawning areas are in the upper Sandy River watershed above the Marmot Dam site. The City chose offsite measures to occur in the middle and upper Sandy River, the Salmon River, and the Zigzag River watersheds that have anchor habitat reaches for spring Chinook productivity.

For the middle Sandy, the City will implement measures to benefit spring Chinook, including riparian easements and improvements and large wood placement. Riparian easements will be implemented in the upper Sandy and Salmon rivers and Boulder Creek. In the Salmon River watershed, the City will acquire and restore the Miller Quarry. The City will also implement measures in the Zigzag River watershed to benefit spring Chinook, including reconstructing a natural channel, purchasing riparian easements, and placing salmon carcasses.

The effects of the offsite measures for spring Chinook are as follows:

- The improvements in the Little Sandy River will increase spawning habitat and reduce the risk of peak flow displacement for fry.
- Reduced risk of peak flow displacement, increased cover from predators, reduced impacts from limited food availability, increased rearing and overwintering habitat, and improved habitat diversity will benefit juveniles in the lower and middle Sandy River and Boulder Creek.
- Additional benefits to fish in Boulder Creek include additional spawning habitat and increased channel stability for incubating eggs.
- Small temperature benefits will improve parr productivity and egg incubation in the lower and middle Sandy River segments, respectively.
- In the upper Sandy River, all life stages will benefit from the increase in habitat diversity and the availability of food.
- The improvements in the Salmon River will increase key habitat for fry and overwintering juveniles, reduce bed scour, and provide modest temperature benefits.
- The channel redesign work and riparian easements in the Zigzag River will create additional rearing habitat and increase habitat diversity for fry. Over time, the riparian easements will also provide small temperature benefits.

Details of the specific improvements in spring Chinook habitat that will result from the offsite measures are described in this chapter and in Appendix E. Overall, the City's offsite conservation measures will improve habitat for spring Chinook in the Sandy River Basin.

Habitat Effects in the Sandy River Basin from the HCP Offsite Measures

The City's HCP includes 30 offsite conservation measures. Most of these measures address environmental problems affecting the production of more than one species. This analysis describes the effects of the HCP measures on spring Chinook. Effects are described by watershed, and both life stages and limiting factors are addressed. (See Chapter 5 for additional information on the spring Chinook salmon population in the Sandy River Basin and the habitat factors limiting production.)

Currently, the primary spring Chinook spawning areas are in the upper Sandy River watershed above the Marmot Dam site (ODFW 2001). Heaviest spawning occurs in the Salmon River below Final Falls Dam (RM 0 – RM 14.0), the lower 4.65 miles of its Boulder Creek tributary, the lower Zigzag River (RM 0 – RM 9.4), the lower 9.4 miles of its Still Creek tributary, and the upper Sandy mainstem above the Salmon River. Some spring Chinook spawn in several mainstem Sandy River tributaries above the Salmon River confluence and in the lower Bull Run River. The City chose some of the 27 offsite measures to occur in primary spring Chinook production areas.

Little Sandy River

The City's water supply operations do not affect the Little Sandy River because it is a tributary to the lower Bull Run River downstream of the City's dams and diversion. The City's large wood measure for the Little Sandy River was selected to improve habitat diversity for spawning and rearing salmonids but the primary focal species was not spring Chinook because the stream's size, geomorphology, and gradient probably do not favor usage by that species.

The City will place large wood in the Little Sandy River (see Measure H-3 in Chapter 7), which will slightly increase channel complexity and gravel sorting for spring Chinook and other fish species. The City believes that spawning spring Chinook spawning will slightly benefit from the large wood measure because the large wood will trap suitable spawning gravel and provide low-velocity areas for rearing during high flows.

Lower Sandy River Watershed

The lower Sandy River watershed consists of the 18.5 miles of the Sandy River mainstem between the Bull Run and Columbia river confluences (Sandy 1 and 2 reaches), plus the following tributaries: Beaver, Buck, Gordon, and Trout creeks. Although spring Chinook do not spawn in appreciable numbers in the lower Sandy mainstem or tributaries, they may use the tributaries for non-natal rearing as parr and for overwintering. The use of non-natal tributaries for rearing by spring Chinook is well established when tributaries provide a refuge from high concentrations of suspended sediment in the mainstem (Lestelle et al. 2005). The mainstem Sandy River is a vital migration corridor for all species in the Sandy River Basin.

The HCP offsite measures were selected in spring Chinook production areas with the intent to mitigate effects that cannot be avoided in the Lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The analysis considers beneficial effects for spring Chinook that are likely to result from measures designed primarily for other species.

The City will implement measures in the lower Sandy River to benefit spring Chinook, including a reconnected side channel, reestablished mouth, riparian restoration, and engineered log jams on the lower Sandy mainstem, and large wood placement and riparian enhancements in Gordon and Trout creeks. A detailed description of each measure and the affected reaches, by watershed, is presented in Chapter 7.

Table 8-18 lists the reaches affected by HCP measures planned in the lower Sandy River and the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-18. Habitat Benefits for Spring Chinook in the Lower Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Gordon 1A	Fine sediment in gravel patches	Decrease
	Backwater pools	Increase
	Large-cobble riffles	Decrease
	Pool habitat	Increase
	Pool habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Large wood	Increase
Gordon 1B	Backwater pools	Increase
	Pool habitat	Increase
	Pool-tail habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Large wood	Increase
Sandy 1	Artificial confinement	Reduction
	Off-channel habitat	Increase
	Riparian function	Improvement
	Large wood	Increase
Sandy 2	Off-channel habitat	Increase
	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Trout 1A	Large wood	Increase
Trout 2A	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

The riparian protection/enhancement projects in the mainstem reaches of the lower Sandy will increase large wood, improve riparian function, decrease confinement in Sandy 1, and improve temperature. A major impact of these measures is the very large increase in the amount of rearing and overwintering habitat provided by the reconnected side channels. Side-channel reconnection is also likely to aid adult passage.

The slow pools in the restored side channels will increase key habitat in Sandy 1 for overwintering juveniles. The combined effect of improved riparian function and increased large wood should significantly improve habitat diversity for parr. Additional large wood will help stabilize the stream channel, lessen peak flow displacement risks to overwintering juveniles, and provide escape cover from predators. Improved riparian function will somewhat reduce temperature impacts, thereby improving parr productivity. Increased riparian function should also lessen impacts attributed to limited food availability and competition with hatchery fish.

Key habitat for juveniles will dramatically increase in the pools, backwater pools, and pool tail-outs in Gordon Creek. Additional rearing habitat should reduce the effects of competition with hatchery fish. Additions of large wood will reduce habitat diversity effects on parr and overwintering juveniles. Gravel retention created by the 300 newly installed log structures will also improve channel stability. The riparian enhancement project on the lowermost reach will stabilize crumbling banks and filter out surface inputs of sediment to spawning substrate.

Middle Sandy River Watershed

Most of the Middle Sandy mainstem is carved through bedrock in a deep, steep-walled gorge. Spring Chinook primarily use this river segment as a migration corridor (SRBP 2005). The main impact to habitat quality in the mainstem middle Sandy has been Marmot Dam, which is outside the authority of the City and was decommissioned in July 2007.

Upstream of the Marmot Dam site, reach Sandy 6 provides exceptional spawning and rearing habitat with a low gradient, pools, riffles, side channels, and relatively abundant cobble/gravel substrate and large wood. The other reaches provide little habitat for spawning.

The portions of Alder and Cedar creeks that are accessible to spring Chinook support natural spring Chinook productivity. A weir constructed in the early 1950s partially blocks fish passage approximately 0.5 mile upstream from the mouth of Cedar Creek (SRBP 2005).

The City will implement measures to benefit spring Chinook in the middle Sandy River, including riparian easements and improvements, large wood placement, water rights purchases, and carcass placement. A detailed description of each measure and the affected reaches, by watershed, is presented in Chapter 7.

Table 8-19 lists the reaches affected by HCP measures planned in the middle Sandy River and the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-19. Habitat Benefits for Spring Chinook in the Middle Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Cedar 1	Dissolved oxygen	Increase
	Fish pathogens	Improvement
	Minimum water temperature	Decrease
	Maximum water temperature	Decrease
	Temperature moderation by groundwater	Improvement
Sandy 3	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Sandy 7	Carcasses per stream mile	Increase [a,b]
	Maximum water temperature	Decrease
	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

Riparian easements and improvements in the Sandy River and Cedar Creek will protect intact portions of the riparian corridor, improve the arboreal species composition (by culling hardwoods and planting conifers), and allow for related habitat improvements (such as large wood recruitment and decrease in temperature) to occur over time. Large wood placement will increase channel stability for all life stages, decrease the risk of juvenile displacement by peak flows, and improve habitat diversity. The modest improvement in temperature will improve egg incubation slightly. Salmon carcasses placed in the Salmon River will improve food availability for juveniles.

Upper Sandy River Watershed

Most of the upper Sandy River watershed is located in the Mt. Hood Wilderness and receives little anthropogenic disturbance. With the exception of the lowermost reach (Sandy 8), spring Chinook production is limited by naturally occurring conditions. The Sandy 8 reach was straightened, cleaned of large wood and large boulders, and confined between riprapped banks in response to the 1964 flood and due to development that had occurred between the communities of Zigzag and Brightwood.

The HCP measure in the upper Sandy River was selected with the intent to mitigate effects on spring Chinook that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river.

The City will implement one measure in the upper Sandy River watershed to benefit spring Chinook—a riparian easement. A detailed description of this measure and the affected reach is presented in Chapter 7. Table 8-20 lists the reach (Sandy 8) affected by HCP measures and the expected habitat benefits (see the tables in Appendix E for percentages for the reference condition and post-implementation values).

Table 8-20. Habitat Benefits for Spring Chinook in the Upper Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Sandy 8	Riparian function	Improvement
	Carcasses per stream mile	Increase[a,b]
	Maximum water temperature	Decrease
	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

The improvement in the riparian function and large wood will increase habitat diversity for all holding adults, fry, and parr. Over time, the increase in large wood will create a modest increase in pool habitats of various types, benefiting all three life stages. The carcasses that wash out of the Zigzag River into the Sandy River will boost food production for juveniles.

Salmon River Watershed

Most of the Salmon River watershed supporting spring Chinook spawning consists of the Salmon River reaches below Final Falls Dam (reaches 1, 2, and 3), and the lower 4.65 miles of Boulder Creek (Boulder 0 – Boulder 2 reaches). Reaches 1-3 of the Salmon River are also anchor habitat for spring Chinook (Sandy River Basin Working Group [SRBWG] 2005a).

The HCP measures for spring Chinook production areas were selected with the intent to mitigate effects that cannot be avoided in the Lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The City also considered the habitat factors that are limiting productivity of spring Chinook in a major tributary of the Salmon River, Boulder Creek. The analysis considers beneficial effects for spring Chinook that are likely to result from measures designed primarily for other species.

The City will implement six measures in the Salmon River watershed to benefit spring Chinook, including purchasing riparian easements, acquiring and restoring the Miller Quarry property, adding large wood to Boulder Creek, and adding salmon carcasses to the

Salmon River. A detailed description of each measure and the affected reaches is available by watershed in Chapter 7.

Table 8-21 lists the reaches affected by HCP measures planned in the Salmon River and the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-21. Habitat Benefits for Spring Chinook in the Salmon River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Boulder 0	Fine sediments by surface area	Decrease
	Maximum water temperature	Decrease
	Large wood	Increase
Boulder 1	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Salmon 1	Off-channel habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Carcasses per stream mile	Increase[a,b]
	Maximum water temperature	Decrease
	Large wood	Increase
Salmon 2	Average depth of bed scour	Reduction
	Artificial confinement	Reduction
	Off-channel habitat	Increase
	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Salmon 3	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

The measures affecting the Salmon River reaches will increase key habitat and reduce bed scour. Increased large wood loading, from reconnected side channels and riparian easements, will improve habitat diversity, particularly for fry and overwintering juveniles. Over time, the riparian easements will also improve water temperature, particularly in the lower Salmon River.

Large wood placed in Boulder Creek will increase channel stability for incubating eggs and create pools and spawning habitat. The scouring around artificial log jams and the stability of the gravels collected behind them should improve egg-to-fry productivity and reduce fry displacement during peak flow events. The additional key habitat, habitat diversity, and flow protection will also benefit overwintering juveniles. These benefits are assumed to propagate downstream.

The addition of salmon carcasses in the Salmon River will temporarily improve food availability for fry and overwintering juveniles. The food-related benefits of this action are also assumed to propagate downstream.

Zigzag River Watershed

Most of the watershed supporting spring Chinook consists of three reaches comprising 9.4 miles of the lower mainstem Zigzag River (Zigzag 1A, 1B, and 1C), 9.4 miles of lower Still Creek, and 4.0 miles of lower Camp Creek.

The lower Zigzag River mainstem has been damaged by floods occurring in 1964 and 1972 and by the flood control projects implemented afterwards. The floods scoured the channel and swept large wood downstream, and flood control measures removed the remaining large logs and boulders and deepened and straightened the cleaned channel, which cut off meanders, oxbows, and side channels. Tributaries Still and Camp creeks remain as high-quality spawning and rearing habitat for salmon (SRBP 2005).

The HCP measures were selected in spring Chinook production areas with the intent to mitigate effects that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The analysis considers beneficial effects for spring Chinook that are likely to result from measures designed primarily for other species.

The City will implement measures in the Zigzag River watershed to benefit spring Chinook, including reconstructing a natural channel, purchasing riparian easements, and placing salmon carcasses. A detailed description of each measure and the affected reaches, by watershed, is presented in Chapter 7.

Table 8-22 lists the reaches affected by HCP measures planned in the Zigzag River and the expected habitat benefits in each reach (see tables in Appendix E for the percentages for reference condition and post-implementation values).

Table 8-22. Habitat Benefits for Spring Chinook in the Zigzag River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Zigzag 1A	Artificial confinement	Reduction
	Harassment	Improvement
	Large-cobble riffles	Decrease
	Small-cobble riffles	Increase
	Pools	Increase
	Pool-tails	Increase
	Riparian function	Improvement
	Carcasses per stream mile	Increase[a]
	Large wood	Increase
Zigzag 1B	Carcasses per stream mile	Increase[a]
Zigzag 1C	Carcasses per stream mile	Increase[a]

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

The lower Zigzag channel reconstruction project will essentially restore the stream channel and floodplain to pre-1964 conditions. Resloped stream banks will reduce bank failure; floodplain connectivity and hydraulic connections between the main channel and disconnected oxbows and side channels will be reestablished; a natural meander amplitude and frequency will be restored to the channel; and instream structures will retain gravel. These actions will greatly reduce the degree to which redds are lost due to bedload movement, and will also create additional small gravel riffles and pool tail-outs for spawners.

The "remeandering" of the main channel will reduce stream gradient, thereby reducing water velocity, increasing habitat diversity for fry, and further reducing egg loss due to channel instability. The increased bends and reduced water velocities associated with remeandering will also transform the lower mainstem from a transport reach to a retention reach for large wood, thus increasing habitat diversity for juveniles, creating and stabilizing gravel bars, and scouring new pools. The general reduction of water velocity and bedload movement associated with channel restoration should allow for deposition of gravel-sized particles, thereby transforming large substrate "pocket water" riffles to small cobble/gravel spawning riffles. The reconnection of oxbows and side channels to the main river will provide badly needed habitat diversity and nursery habitat for fry.

The riparian easements and enhancements will protect vital, intact portions of riparian corridor and will improve riparian function by culling hardwoods and planting conifers. Over time, natural improvement in habitat conditions related to riparian vegetation (e.g., habitat diversity, large wood recruitment, security cover, and temperature) will improve.

The placement of 400 salmon carcasses per mile two times in the fall will temporarily improve food availability for spring Chinook juveniles, particularly as the reduced gradient and water velocity and the increased structural complexity of the channel should allow most carcasses to be retained. The benefits of this measure are low as the City is only committing funds to one year of carcass placements.

Summary of Population Effects and VSP Parameters

All VSP parameters for the Sandy River population of spring Chinook salmon will be increased by 12–16 percent under the HCP. The projected increases in the VSP parameters should also be considered as modest projections because they do not include any potential benefits to spring Chinook that may be derived from projects supported by the City's $9 million Habitat Fund (see Measure H-30, Chapter 7).

Population Effects and VSP Parameters

The HCP habitat measures were designed to mitigate the effects of the Bull Run water supply on spring Chinook and other covered species. This section describes the estimated effects of the City's HCP on the overall Sandy River spring Chinook population using parameters established in the NMFS recovery planning process, specifically the work of the LCR-TRT.

Sandy River spring Chinook are designated as a Core Population and a Genetic Legacy and are part of the Lower Columbia ESU (Cascade Zone) (McElhany, et al. 2003). This population is also considered by the LCRFRB (2004) to be a primary population for recovery in the Lower Columbia ESU. Primary populations are those that the TRT believe need to be restored to "High" or "Very High" viability levels in order to recover the species. Spring Chinook have been identified as needing to be restored to a "High" viability level, or 95–99 percent likelihood of persistence (LCRFRB 2004).

The EDT model was used to estimate the benefits for spring Chinook that are likely to result from implementing the HCP, as listed in Table 8-23. Although the model results are not absolute predictions of fish abundance, they do provide a relative comparison of the expected salmon population performance based on the best available science. The inputs to the model represent a combination of site-specific empirical habitat data and, when data were not available, the professional opinion of biologists intimately familiar with the Sandy River ecosystem.

The HCP measures are expected to result in substantial increases in all of the Sandy River spring Chinook VSP parameters. Increases in productivity, diversity, and abundance for spring Chinook are summarized in Table 8-23 and discussed in the following text. These estimates represent increases over what could be expected to result from current habitat conditions in the Sandy River Basin. Improvements in spatial structure are also discussed below. NMFS (in coordination with ODFW) has not yet developed a recovery plan for the

Lower Columbia ESU nor set clear objectives for each VSP parameter; therefore, the significance of these improvements is not yet known.

Table 8-23. Increases for Spring Chinook Expected Due to HCP Implementation[a]

	Productivity	Diversity	Abundance
Without Cedar Creek Weir Removal	12%	7%	16%
With Cedar Creek Weir Removal	12%	7%	16%

Source: EDT model run April 17, 2007

[a]Estimates do not include benefits from removing the Marmot Dam on the Sandy River.

Productivity

The estimated 12 percent increase in productivity results from increased quality of stream habitat in the Zigzag River, Salmon River, and Sandy River mainstem. This is a relatively substantial increase in productivity that should result in higher adult returns over time.

Diversity

The estimated 7 percent increase in life history diversity represents improvements in habitat conditions over time and space. Most of this improvement occurs in the Salmon River, Zigzag River, and Sandy River mainstem. Lesser improvements in spring Chinook diversity are produced in the Bull Run River.

Abundance

The estimated 16 percent improvement in adult spring Chinook abundance in the Sandy River Basin results from the increases in productivity and diversity. Increased abundance reduces extinction risk for the population. Higher abundance also results in increased ecological benefits. Salmonids improve both their physical and biological environments through various mechanisms. For example, adult spawners reduce fine sediment concentrations in gravels, and their carcasses provide a food source for other aquatic and terrestrial species.

Although the LCR-TRT has not yet established recovery goals for Sandy River spring Chinook, others have indicated that the Sandy River Basin has the potential to produce up to 5,200 adults (LCRFRB 2004). The City's HCP makes a significant contribution toward achieving this objective.

Spatial Structure

The viability of a salmon population depends not only on the population's productivity, abundance, and diversity, but also on its spatial structure (McElhany et al. 2000). The more watersheds in a basin that contain large numbers of spawners, the less likely that catastrophic events, such as landslides or human caused disasters, will result in the extinction of the population

Sandy River spring Chinook currently spawn primarily in the Salmon, Zigzag, and middle and upper Sandy River watersheds. Historically, this species was also found in the Bull Run River and may have spawned in small numbers in the lower Sandy River. The HCP actions will not increase access for spring Chinook in the Sandy River Basin. However, the actions will improve habitat in primary spawning and rearing areas for spring Chinook.

Because the upper Bull Run River is no longer accessible to spring Chinook, the actions in the HCP were spread out across the majority of the current distribution area. Offsite habitat improvement actions will be implemented in the lower and middle Sandy, Salmon, and Zigzag river watersheds. Habitat improvement projects that are expected to increase adult run size will also be implemented in the lower portion of the Bull Run.

The City’s actions are designed to improve riparian condition, increase the amount of large wood, open blocked habitat, or increase streamflow in four of the five watersheds where spring Chinook historically ranged. Because the combination of HCP actions targets all of the spatial structure objectives, the City’s plan will likely improve this VSP parameter for spring Chinook.

Improved habitat conditions in the Bull Run, Salmon, and Zigzag rivers, and the entire mainstem Sandy River increase the viability of the spring Chinook population. A complete loss of spawners in one of these watershed populations from a catastrophic event, although significant, would not result in population extinction because fish from the other watersheds would be able to recolonize this habitat over time.

Table 8-24 summarizes the population effects of the HCP measures on spring Chinook by the VSP parameters of abundance, productivity, diversity, and spatial structure.

Table 8-24. Effects of the HCP Measures on Sandy River Basin Spring Chinook Populations, by Viable Salmonid Population (VSP) Parameters

VSP Parameter	Reference Condition	Effect of Conservation Measures
Abundance	Current habitat conditions	Spring Chinook abundance for the Sandy River population is projected to increase by 16%.
Productivity	Current habitat conditions	Productivity for the Sandy River spring Chinook population is projected to increase by 12%.
Diversity	Current habitat conditions	Diversity for the Sandy River population is projected to increase by 7%.
Spatial Structure	Current habitat conditions	Spatial structure improves as actions are focused on increasing spawner abundance in all of the five watersheds historically occupied by spring Chinook. Increased adult abundance in multiple watersheds reduces effects of catastrophic events, which reduces extinction risk.

Sources: EDT model run April 17, 2007 for abundance, productivity, and diversity percentages; for spatial structure assessment, Kevin Malone, personal comm. 2006

Summary Comparison of Fish Abundance

The projection of adult spring Chinook abundance under the City's HCP is greater than the benchmark comparison scenario established for the Bull Run watershed.[8] This benchmark comparison indicates that the HCP will produce enough beneficial habitat changes for spring Chinook salmon to offset all potential impacts that could be caused by the City's water supply operations in the Bull Run.

Population Effects and Benchmark Comparison of Fish Abundance

The introduction to this HCP chapter describes a benchmark scenario the City developed to compare results of the HCP measures with production potential of the Bull Run River (see Section 8.1.1). The EDT model was used to generate the estimated abundance of spring Chinook and to compare the benchmark against the benefits of the City's HCP measures. The City believes that the Modified Historical Bull Run Condition estimate represents generous assumptions and the HCP estimate is an underestimate of probable HCP results (see Section 8.1.1).

Model results indicate that the HCP measures would improve habitat sufficiently to match or exceed the production potential of the Modified Historical Bull Run Condition (see Table 8-25).

Table 8-25. Model Results for Spring Chinook Abundance: Modified Historical Bull Run Condition Compared with HCP Measure Implementation[a]

Scenario	Adult Abundance
Modified Historical Bull Run Condition	6,489
HCP Measures Without Cedar Creek	6,798
HCP Measures With Cedar Creek	6,798

Source: EDT model run April 17, 2007

[a]Estimates do not include benefits from removing the Marmot Dam on the Sandy River.

The City believes these results help demonstrate that the HCP will provide the benefits for spring Chinook necessary to meet the ESA Section 10 requirements. However, the City does not propose to use EDT population estimates as an enforceable performance measure for spring Chinook. The City's HCP is purposefully habitat based. It is designed using measurable objectives, monitoring, and adaptive management triggers that relate to habitat condition, as described in other chapters of this document.

[8] See the subsection Sandy Basin Population Effects under Section 8.1.1 for an explanation of the benchmark comparison of fish abundance in the Bull Run watershed.

Conclusions about the Habitat Effects of HCP Measure Implementation

- **Effects in the Lower Bull Run River.** All of the HCP measures in the lower Bull Run River will benefit spring Chinook salmon. These measures avoid or minimize ongoing City impacts in the Bull Run River (as described in Table 7-1) to the maximum extent practicable. Impacts associated with blocked fish access to the upper watershed, reduced base flows, and elevated water temperature during spawning will not be completely addressed in the Bull Run but will be mitigated by offsite measures in the Sandy Basin. The benefits provided by the Bull Run HCP measures are summarized in Table 8-12.
- **Effects in the Sandy River Watersheds.** Substantial additional benefits for spring Chinook are provided by HCP measures in the upper Sandy River and its tributaries (e.g., Salmon and Zigzag rivers), the middle Sandy Basin, and the lower Sandy Basin. The upper Sandy has the primary spawning areas for spring Chinook in the Sandy River Basin and all anchor habitat reaches for spring Chinook are located in these areas. The primary limiting factors for spring Chinook for those areas include a lack of key habitat quantity and diversity, reduced channel stability and side-channel habitat, and reduced large wood levels. HCP measures H-18, H-19, H-20, H-21, H-23, H-24, H-27, H-28, and H-29 are targeted to address those limiting factors around the upper Sandy. Spring Chinook also use the mainstem Sandy River upstream and downstream of the Bull Run for juvenile rearing and migration. Measures in the middle and lower Sandy Basin benefit spring Chinook by improving riparian zone conditions through time and increasing large wood levels. Benefits provided by the offsite measures are summarized in Tables 8-18, 8-19, 8-20, 8-21, and 8-22, and in Appendix E, Tables E-5 and E-6.
- **Timing for Implementing Measures.** The timing for implementing measures relevant to spring Chinook and other species is provided in Tables 7-6 through 7-12. Measures in the upper and middle Sandy River are primarily scheduled for HCP Years 6-15. The City will be conducting effectiveness monitoring for the instream measures; the objective in those cases is to accrue 80 percent of the predicted habitat change within 15 years of implementing each measure (see Chapter 9).
- **Population Response.** Although the HCP is not intended to guarantee specific population responses, implementation of the HCP is expected to result in improved population conditions for spring Chinook. Table 8-24 describes the anticipated increases of the four VSP parameters: abundance, productivity, diversity, and spatial structure. The estimated population response compared to the Modified Historical Bull Run Condition also indicates that implementation of the HCP will likely result in a population response greater than the production potential in the Bull Run watershed. Neither of these estimates includes the habitat or population benefits that will result from the $9 million Habitat Fund.
- **Accumulation of Habitat Benefits.** The HCP conservation measures will accumulate benefits for spring Chinook at varying rates. Figure 8-10 describes the accumulation of benefits over the 50-year HCP term and the figure is based on EDT model results. The figure shows the predicted increase in adult spring Chinook abundance that could result from the habitat changes. Benefits are organized according to three general categories of

HCP measures: flow, instream actions, and riparian easements. Fish passage improvements for Cedar Creek are not anticipated to benefit spring Chinook. The City assumes that the benefits from large wood additions would only contribute to adult spring Chinook abundance for the first 15 years of their project life. This is a very conservative assumption because it is likely that the wood will be in the various stream reaches beyond 15 years and adding some habitat value for fish. Other instream actions, such as the opening of side channels and riprap removal, are considered permanent for the purpose of the HCP. Riparian easements are assumed to take 15 years before beginning to provide benefits and would not provide full benefits until 30 years after implementation. Flow measures will provide habitat for spring Chinook starting in Year 1 of the HCP.

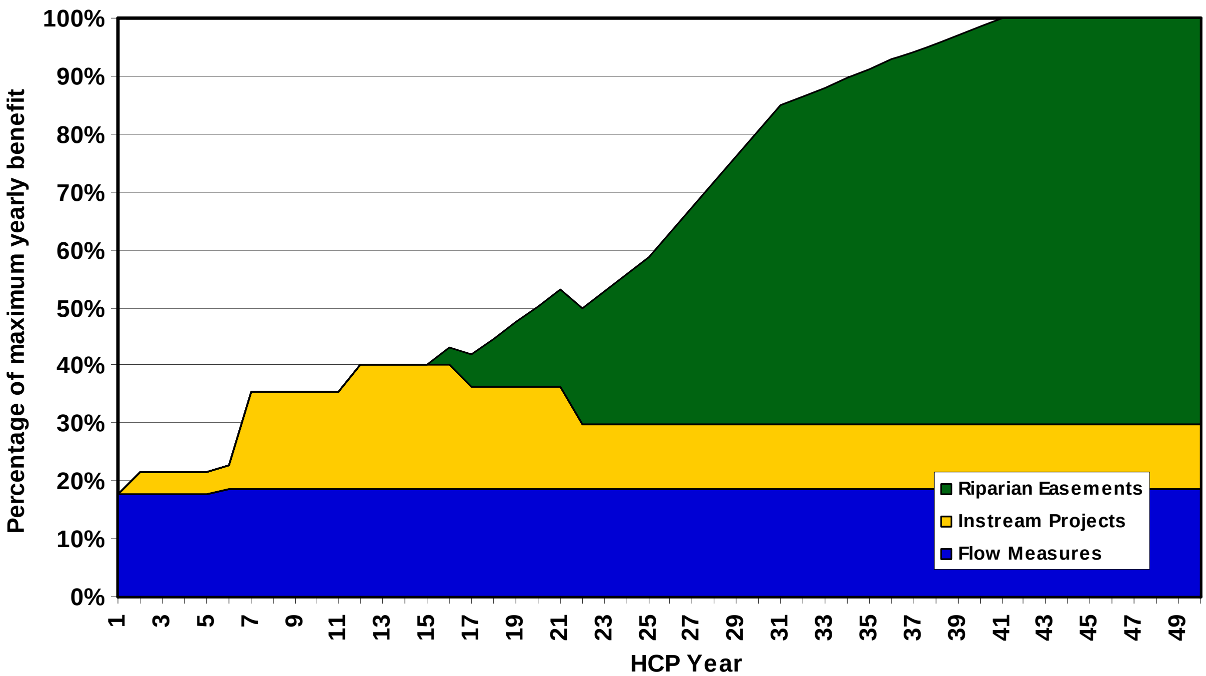


Figure 8-10. Accumulation of Predicted Benefits to Spring Chinook from HCP Measures Over Time[a]

Source: EDT model runs, April 10, 2007.

[a]The accumulated benefits exclude benefits from the following measures: H-3—Little Sandy 1 and 2 LW Placement, P-2—Alder 1 Fish Passage, P-3—Alder 1A Fish Passage, H-25—Salmon 2 Carcass Placement, H-29—Zigzag 1A, 1B, and 1C Carcass Placement

The full spring Chinook benefits would be realized by approximately HCP Year 40. This maximum benefit level closely corresponds to the abundance number used in Table 8-25 for the "HCP Measures with Cedar Creek" scenario, but the benefit level excludes the benefits of large wood additions. Through the term of the HCP, the cumulative total benefits will be 29 percent from the flow measures, 19 percent from instream measures, and 52 percent from riparian easements.

The City believes the HCP, as a whole, meets ESA Section 10 requirements for spring Chinook.

8.2.3 Winter Steelhead Habitat Effects

The HCP measures in the Bull Run watershed minimize the effects on juvenile and adult steelhead in the lower Bull Run River to the maximum extent practicable. Offsite measures were selected to provide additional benefits for steelhead to help mitigate for the effects not avoided in the Bull Run. In addition, offsite measures that mitigate for impacts on other covered species also provide benefits for steelhead. Chapter 11 describes the City's commitment to fund the implementation of the necessary measures.

The City recognizes that winter steelhead and resident rainbow trout are the same species and that their habitat requirements are similar. The effects of all HCP measures on winter steelhead and rainbow trout are assumed to be substantially the same, with the exception of effects on rainbow trout in the Bull Run reservoirs. Effects that specifically affect rainbow trout in the Bull Run reservoirs are described in Section 8.4.1, Rainbow Trout.

The potential effects of the City's Bull Run water supply operations on winter steelhead in the Sandy River Basin are described in six subsections:

1. Effects in the lower Bull Run River— Describes the habitat effects of both the City's water supply operations and the HCP measures on lower Bull Run habitat for winter steelhead
2. Effects in the lower Sandy River—Describes the habitat effects of both the City's water supply operations and the HCP measures on habitat in the lower Sandy River for winter steelhead
3. Effects in the Columbia River— Describes the effects of using the City's groundwater supply at the Columbia South Shore Well Field on fish habitat in the Columbia River
4. Effects in Sandy River Basin watersheds—Describes the habitat effects of the offsite HCP measures on winter steelhead habitat in watersheds of the Sandy River Basin
5. Effects on the Sandy River populations, by VSP parameter—Describes the population effects of all of the HCP measures (those in the Bull Run and those in the Sandy River Basin offsite locations) on abundance, productivity, diversity, and spatial structure for winter steelhead
6. Comparison to a population benchmark—Compares estimates of winter steelhead abundance under historical conditions to estimated abundance after HCP implementation

Summaries for all subsections appear in gray shaded boxes. A detailed description of the effects for the species in the geographic location follows each summary. Conclusions about the habitat effects on winter steelhead from implementation of all HCP measures, including a discussion of the predicted accumulation of habitat benefits over time, are provided on page 8-114.

Summary of Effects on Winter Steelhead in the Bull Run Watershed from Bull Run Water Supply Operations and HCP Measures

The City identified 10 types of effects that the conservation measures will have on steelhead in the Bull Run Watershed. The City also analyzed the potential impacts on the base flow of the Columbia River from the HCP flow commitments.

- Impacts associated with fish access to the upper watershed, low base flows, and low weighted usable areas will be reduced with the Bull Run conservation measures, but not all impacts will be avoided. Impacts that are unavoidable will be offset by the Sandy offsite conservation measures.
- The Little Sandy River flow commitment will increase habitat for steelhead for the term of the HCP.
- Impacts on spawning gravel, flow downramping, and riparian function will be avoided by the measures.
- There will be some short-term negative water temperature impacts, but long term, the natural thermal potential of the lower river will be returned by the City's infrastructure and operational changes for its dams and reservoirs.
- The removal of large wood at the reservoirs is considered a small impact to steelhead because the species depends on coarse gravel for hiding and resting habitat.
- The City does not know whether TDG levels harm steelhead in the lower Bull Run, but TDG levels will be monitored under this HCP and addressed through adaptive management provisions described in Chapter 9.
- The City's flow measures will have an extremely small effect on the Columbia River base flows, and steelhead habitat will not be affected.

Table 8-26 summarizes the effects of the water supply operations, the reference condition for the effect, and the predicted effects of the City's HCP conservation measures in the Bull Run watershed.

Table 8-26. Effects of the Bull Run HCP Measures on Lower Bull Run River Habitat for Steelhead[a]		
Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Base flows Winter/Spring Period (spawning, egg incubation, fry emergence, and rearing) Summer Period (rearing)	Natural Bull Run base flows	Projected HCP flows will be 77-81% of natural base flows during the winter/spring spawning, incubation, and fry rearing period. Projected HCP flows will be 36-46% of natural base flows during the summer rearing period.
Weighted Usable Area (WUA) 1. Winter/Spring Spawning 2. Summer Juvenile Rearing	Natural flow Weighted Usable Area	1. HCP WUA's for spawning will exceed the maximum WUA levels. All impacts will be avoided. 2. HCP WUAs for summer juvenile rearing will be 70-100% of the maximum WUA value.
Flow Downramping	Protective downramping rate: 2"/hour	The City will meet the protective downramping rate (2"/hour) and fish stranding effects will be minimal.
Little Sandy River Base flows	Natural flow; free-flowing	City's commitment to forgo development of the Little Sandy water rights will ensure free-flowing conditions for approximately 10 new miles of stream habitat in the Little Sandy River.
Water Temperature	ODEQ standard: natural thermal potential	There will be minor, short-term water temperature impacts prior to installation of infrastructure improvements at Dam 1. Once the infrastructure improvements are in place, City will meet the natural thermal potential of the lower Bull Run River.

Table 8-26. Effects of the Bull Run HCP Measures on Lower Bull Run River Habitat for Steelhead[a], continued

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Large Wood	Natural wood routing and accumulation	The City will allow the natural occurrence of large wood downstream of Larson's Bridge. The large wood will slightly benefit the habitat for rearing steelhead. The improvements will be modest because juvenile steelhead prefer coarse gravel for hiding habitat and finding lower water velocity areas.
Spawning Gravel	Natural levels of gravel recruitment	The City will replace the natural level of gravel recruitment in the lower Bull Run River. All impacts will be avoided.
Fish Access	Historical fish anadromy Total blocked stream miles in the Bull Run River watershed: 42 Blocked free-flowing miles in the Bull Run River watershed (excluding the Little Sandy River): 25	City will not provide access into the upper Bull Run River. Approximately 10 miles of river will be provided in the Little Sandy River, all of which could be used by winter steelhead. Additional stream miles for winter steelhead will be provided under the City's offsite habitat measures.
Riparian Function	Mature riparian zones	City's riparian lands along the lower Bull Run River are currently in good condition. Protective measures in the HCP will maintain and somewhat improve these conditions as younger trees mature.
Total Dissolved Gases (TDG)	ODEQ standard: maximum of 110% saturation at flows below the 7Q10 flow	The City does not believe there are elevated TDG levels in the current range of anadromy at flows below the 7Q10 flow, but the City will continue to monitor to determine whether the ODEQ standard is being met.

[a]For the list of conclusions about the habitat effects of all HCP measures on winter steelhead, see page 8-114.

Habitat Effects in the Bull Run Watershed from Bull Run Measures

Effects on winter steelhead in the lower Bull Run River are described in the following categories: streamflow, water temperature, large wood, spawning gravel, access, riparian function, and TDG.

Streamflow

The City's analyzed streamflow effects on winter steelhead by two means: comparing the effects of the HCP Bull Run base flows with the natural (pre-water-system) conditions, and determining the winter steelhead spawning and rearing WUA likely to result from Bull Run flow measures.

Bull Run Base Flows. The City compared an estimate of median monthly flows (50 percent exceedance flows) under natural conditions (i.e., no dams or diversions in the Bull Run watershed) with anticipated future flows during implementation of the HCP, assuming normal and critical years occur at the same frequency in the Bull Run as they have in the past. A 64-year hydrological record (1940–2004) was used for the analysis. The estimated median flows for the Bull Run River upstream of the Little Sandy River are shown in Figure 8-11; all flow amounts are relative to the USGS Gauge No. 14140000 located at RM 4.7 on the Bull Run River. The flow analysis considers winter steelhead utilization of habitat in the lower Bull Run River, as shown in Figure 8-11 and consistent with the periodicity chart in Chapter 5 (Figure 5-27).

Table 8-27 shows the median natural flows and median flows anticipated from implementing the HCP. The comparison is for flows in two segments: upstream of the confluence with the Little Sandy River (RM 3.0—RM 5.8), and downstream of the Little Sandy River (RM 0–RM 3.0). For the portion of the Bull Run River downstream of the Little Sandy River, median flows were determined using the estimated Little Sandy median natural flows that would occur after the Little Sandy Dam is removed.

Photo courtesy of Bonneville Power Administration.

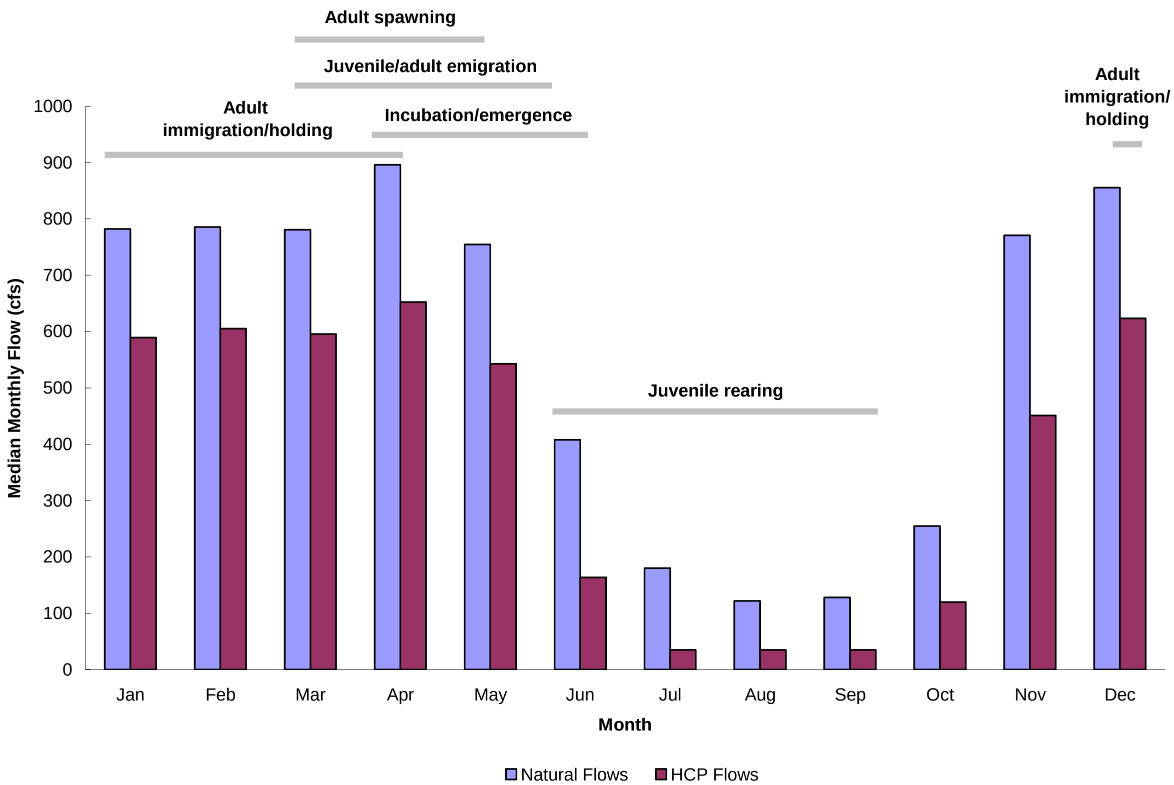


Figure 8-11. Median Monthly Flows and Peak Periods of Occurrence for Steelhead in the Lower Bull Run River above the Little Sandy River Confluence[a]

Source: Median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000 (RM 4.7).

[a]Although peak juvenile rearing period is shown here, steelhead rearing occurs all year. See Figure 5-27 for periods of occurrence in the lower Bull Run River.

Table 8-27. Natural and HCP Median Flows by Month for the Lower Bull Run River

	Flows above Little Sandy (cfs)[a]		Flows below Little Sandy (cfs)[b]	
Month	**Natural**	**HCP**	**Natural**	**HCP**
January	782	611	938	765
February	785	608	957	776
March	780	606	932	760
April	896	672	1,072	846
May	755	563	898	709
June	408	196	487	274
July	180	35	213	67
August	122	35	141	54
September	128	35	152	55
October	255	120	304	166
November	771	427	924	608
December	857	654	1,031	829

[a]Median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000, Bull Run River (RM 4.7).

[b]The sum of median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000, Bull Run River (RM 4.7) and median monthly flows taken at USGS Gauge No. 14141500, Little Sandy River (RM 1.95).

Upstream of the Little Sandy River confluence, median HCP flows will be approximately 77 percent of the natural flow (see Table 8-27) from January through May. Downstream of the Little Sandy, median HCP flows will be 81 percent of the natural flow.

Effects of Bull Run Flows on Winter Steelhead Spawning. The primary spawning period for wild winter steelhead is March to May (Figure 5-18) (ODFW 2001). R2 Resource Consultants (1998) indicated that near-optimal spawning conditions for winter steelhead occurred between flows of 130 and 200 cfs. With the minimum HCP flow of 120 cfs, the predicted median flows in the lower Bull Run River above and below the confluence with the Little Sandy River would range from approximately 550 to 850 cfs from March to May (see Table 8-27), providing ideal spawning and incubation conditions.

Effects of Bull Run Flows on Winter Steelhead Rearing. Flows during the summer and early fall will have moderate effects on juvenile rearing. Upstream of the Little Sandy River, the projected HCP flows will be 36 percent of the natural flows during June through September. Downstream of the Little Sandy confluence, the projected HCP flows will be 46 percent of natural flows. The significance of these flow differences is discussed below in terms of WUA for rearing winter steelhead.

Bull Run Weighted Usable Area. WUA values were calculated from median flows for winter steelhead spawning and rearing to assess the effect of the HCP flow measures on lower Bull Run River habitat. Table 8-28 compares WUA estimates for natural flow conditions (no dams and no diversions) with estimates of HCP flows, upstream and downstream of the Little Sandy River confluence.

R2 Resource Consultants (1998) estimated the flow-habitat relationships for spring Chinook spawning and juvenile rearing in the Bull Run River. Using the PHABSIM model, they generated estimates of WUA for up to 500 cfs in four segments of the Bull Run River. The four segments were combined into the two segments of the lower Bull Run River: upstream and downstream of the Little Sandy River. For flows greater than 500 cfs, goodness-of-fit curves were used to extrapolate WUA values.

The WUA estimates for natural and HCP flows are compared using a "percentage of natural" metric. For example, if the HCP percentage of natural flow is 90 percent, the HCP median flow will yield a WUA value of 0.9 acre in a month, and the WUA value would be 1.0 acre in a month.

Estimated WUA for Spawning. During the primary winter steelhead spawning period from March to May, the City's HCP minimum flow of 120 cfs will maintain good conditions for spawning and incubation. The City's predicted median flows in the lower Bull Run River would range from approximately 550 to 850 cfs (see Table 8-27). R2 Resource Consultants (1998) indicated that flows between 130 and 200 cfs create near-optimal conditions for creating total usable habitat values (WUA) for spawning steelhead (see Figure 5-29).

The HCP also includes a provision to reduce flows in the fall during water years with critical seasons (see Measure F-2 in Chapter 7). The frequency of these reductions will be limited by the City's commitment. Critical fall flows will only occur in 10 percent of the HCP years. The City's commitment will also limit the occurrence of critical fall flows to no more than two consecutive years. If critical fall flows are triggered, the City will not release critical fall flows in a specific year when most of the resulting adult fish would return to their place of origin. When a critical fall flow year occurs, the City will not implement critical fall flows four years later regardless of whether the critical fall trigger occurs. The reductions in flows during critical fall flows will not affect steelhead because the species does not spawn in the fall. The Bull Run River flows in the fall under the HCP will still provide good habitat for rearing steelhead (see WUA for Rearing below).

Estimated WUA for Rearing. Steelhead rear in the lower Bull Run from June through September. The guaranteed minimum HCP flow in the summer is 20 cfs, although flows can vary from 20–40 cfs. The projected median flow varies from 35 for low flows above the Little Sandy River to 274 cfs for high flows below the Little Sandy River. R2 Resource Consultants (1998) estimated that habitat area (WUA) for winter steelhead increases at a rapid rate with flows between 0 and 100 cfs, with the most rapid increase occurring between 0 and 20 cfs (see Figure 5-30). Under the City's HCP flows, the WUA values range from approximately 70 to 100 percent of the estimated natural flow WUA values for June through September (Table 8-28).

Table 8-28. Comparison of Winter Steelhead Median Flows and Juvenile Rearing Weighted Usable Area (WUA) Values

Month	Natural Flow (cfs)	HCP Flow (cfs)	Natural Flow WUA	HCP Flow WUA	Percentage of Natural Flow WUA
Above the Little Sandy River (Upper Section)					
June	408	196	14.32	14.68	>100
July	180	35	14.56	9.77	67
August	122	35	13.93	9.77	70
September	128	35	14.02	9.77	70
Below the Little Sandy River (Lower Section)					
June	487	274	14.46	14.88	>100
July	213	67	14.54	10.83	74
August	141	54	13.46	10.13	75
September	152	55	13.77	10.19	74

Source: EDT model run April 17, 2007

Bull Run Peak Flows. The City assessed effects on peak flows in the lower Bull Run River by evaluating the annual peak winter flows since Water Year 1960. This data set was used for the peak flow analysis because the USGS gauge was in another location prior to 1960. The City estimated peak winter flows in the absence of the City's water supply diversions, peak winter flows with current (2006) water diversions, and peak winter flows with estimated 2025 water diversions based on Metro's population projections. The estimated change in annual total water yield diverted for supply is expected to increase from 20 percent currently to 22 percent in 2025.

The estimated magnitude of the annual peaks with no water diversions ranged from 4,010 to 25,420 cfs, depending on weather conditions. The estimated magnitude of the annual peaks for current water demands ranged from 3,880 to 25,100 cfs. The estimated magnitude of the annual peaks for 2025 water demands ranged from 3,863 to 25,094 cfs. Differences were determined by comparing flows on individual peak flow dates. The differences between no diversions and current diversions ranged from 0.3 percent to 3.3 percent. The differences between no diversions and estimated 2025 diversions ranged from 0.6 percent to 3.7 percent.

The City also characterized each peak flow event into a return frequency category (i.e., less than 2-year event, 2-5 year event, 5-10 year event, 10-25 year event, 25-50 year event, and 50-100 year event). The flow conditions experienced in those events were applied to current water diversions and 2025 estimated water diversions. In only one case did the increase in winter season water diversions in 2025 cause a change in the return frequency category for peak events. The January 5, 1969 weather year changed from a slightly greater than 2-year event to a slightly less than 2-year event.

The City concluded from this analysis that implementation of the HCP will not significantly change the magnitude of peak flow events in the lower Bull Run River. Peak flow events will continue to occur with a frequency and magnitude similar to current conditions and similar to conditions that would occur without water supply diversions.

Bull Run Flow Downramping. The City's hydroelectric plant at the base of Dam 2 varies the streamflow in the lower Bull Run River during the winter and spring months when there is enough streamflow to run the facility. The current FERC license allows for a 2'/hour downramping rate for the lower Bull Run River, but the City is committing to a lower rate to protect juvenile salmonids.

The City has studied juvenile salmonid stranding during downramping events in the lower Bull Run River (Beak Consultants 1999; CH2M HILL 2002). The sites selected for monitoring included the widest areas of the channel considered most sensitive to ramping effects and stranding. Winter steelhead fry (about 40 mm average length) and yearlings (Age-1) juveniles were observed during the studies. Based on the studies, a ramping rate of no more than 2"/hour was recommended for the lower Bull Run River. This rate is generally what the state of Oregon and others have recommended to protect against juvenile fish stranding (CH2M HILL 2002; Hunter 1992).

The City will minimize the risk of fish stranding by maintaining a maximum downramping rate of 2"/hour year-round for the hydroelectric powerhouse downstream of Bull Run Dam 2. All effects from flow downramping, however, cannot be avoided due to certain circumstances beyond the control of the City.

The City conducted a year-long evaluation of downramping (Galida 2005) and determined that circumstances when the City would not meet the ramping rate occurred 0.4 percent of the time, which will have minimal effects on winter steelhead. These circumstances included natural storm flows, mechanical/control system failures that are impossible to predict, and FERC mandatory testing of project safety equipment. Out of the test period of approximately 8,800 hours of hydropower operations, the 2"/hour downramping rate was exceeded only for 35 hours. The exceedances occurred from mid-November through late-March and streamflow in the lower Bull Run River was 200-12,600 cfs. Natural streamflows were quite variable and since the reservoirs were full, the downramping rate could not be controlled by the City for approximately one third of the 35 hours. Other exceedances can be attributed to equipment testing and operator error. Overall, the City was very successful in controlling the downward fluctuation of the lower Bull Run River.

The City's commitment to a downramping rate of 2"/hour will result in minimal effects on steelhead. The occurrences of downramping greater than 2"/hour will rarely occur in the future, and if they do, they will happen during the winter months. The primary spawning period for winter steelhead in the Bull Run is February though mid-May (see Chapter 5), and near-optimal conditions for spawning and egg incubation occur between flows of 130 and 200 cfs (R2 Resource Consultants 1998). All downramping rate exceedances (>2"/hour) that the City observed were during flows greater than 200 cfs, and spawning/incubation of steelhead will not be harmed with the City's downramping measure. Also, there will be a very low potential for stranding juvenile steelhead because the higher downramps would occur only infrequently and sporadically during the late winter and early spring. Vulnerable steelhead fry (<40 mm) would be out of the gravel and susceptible to stranding only by late May and June. The City would shut down hydropower operations at Dam 2 during that time of year because reservoir inflows would be rapidly decreasing.

The City will continue to monitor downramping in the lower Bull Run as part of the compliance monitoring efforts (see Chapter 9).

Little Sandy River Base Flows. Foregoing development of the City's water rights on the Little Sandy River during the term of the HCP will help assure unimpeded natural flows on the Little Sandy River for winter steelhead. Winter steelhead will have access to approximately 7.3 river miles of the mainstem Little Sandy and approximately 2 miles of tributary habitat. This measure will significantly increase the spawning and rearing habitat for winter steelhead. These flows also contribute to higher flows in the lower Bull Run River below the Little Sandy confluence, as indicated in Tables 8-27 and 8-28.

Water Temperature

Winter steelhead utilize the Bull Run River year-round and most of the year the water temperatures are generally cool and acceptable for the species (see Figure 8-12). The species spawns in the lower Bull Run in the spring, emerges from the gravel in early summer, and rears throughout the year (see Figure 5-22 in Chapter 5). The only time of the year when the water temperatures are too warm for the species is during the summer and early fall.

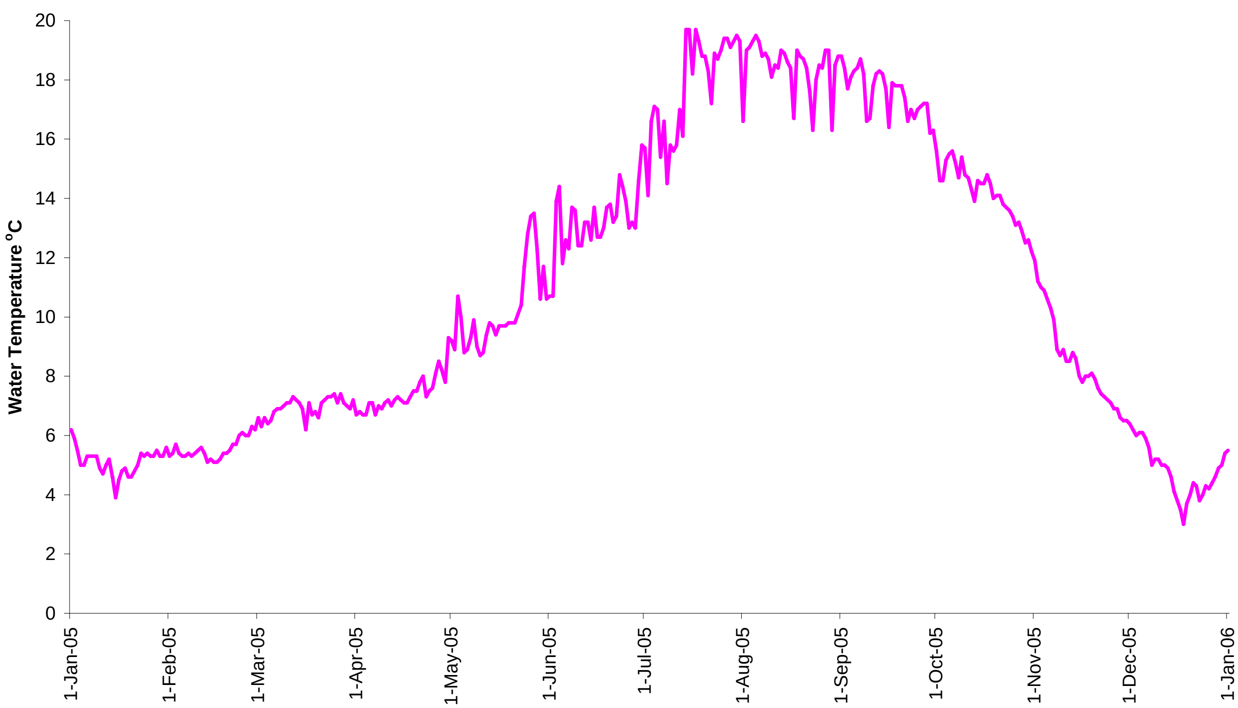


Figure 8-12. 2005 Daily Maximum Water Temperatures for the Lower Bull Run River as Measured at USGS Gauge No. 14140000 (RM 4.7)

Source: USGS Gauge No. 14140000 on the Bull Run River (RM 4.7).

The reference condition for water temperature is the natural thermal potential of the lower Bull Run River. Natural thermal potential is defined by ODEQ in the Sandy River TMDL (ODEQ 2005) as the water temperatures that would occur in the Bull Run River if there were no dams or diversion. The City, in conjunction with ODEQ, developed a method to determine the natural thermal potential of the lower Bull Run River and found that the current temperature regime of the Little Sandy River is a good surrogate for the Bull Run. (See temperature measure T-2 in Chapter 7 for more details.)

Pre-infrastructure Water Temperature Effects. The City plans to make significant infrastructure improvements at Dam 2 to meet the natural thermal potential of the lower Bull Run River. However, prior to completion of the infrastructure improvements, water temperatures in the lower Bull Run River during the summer and September-October will exceed those preferred for rearing steelhead (see Figure 8-13).

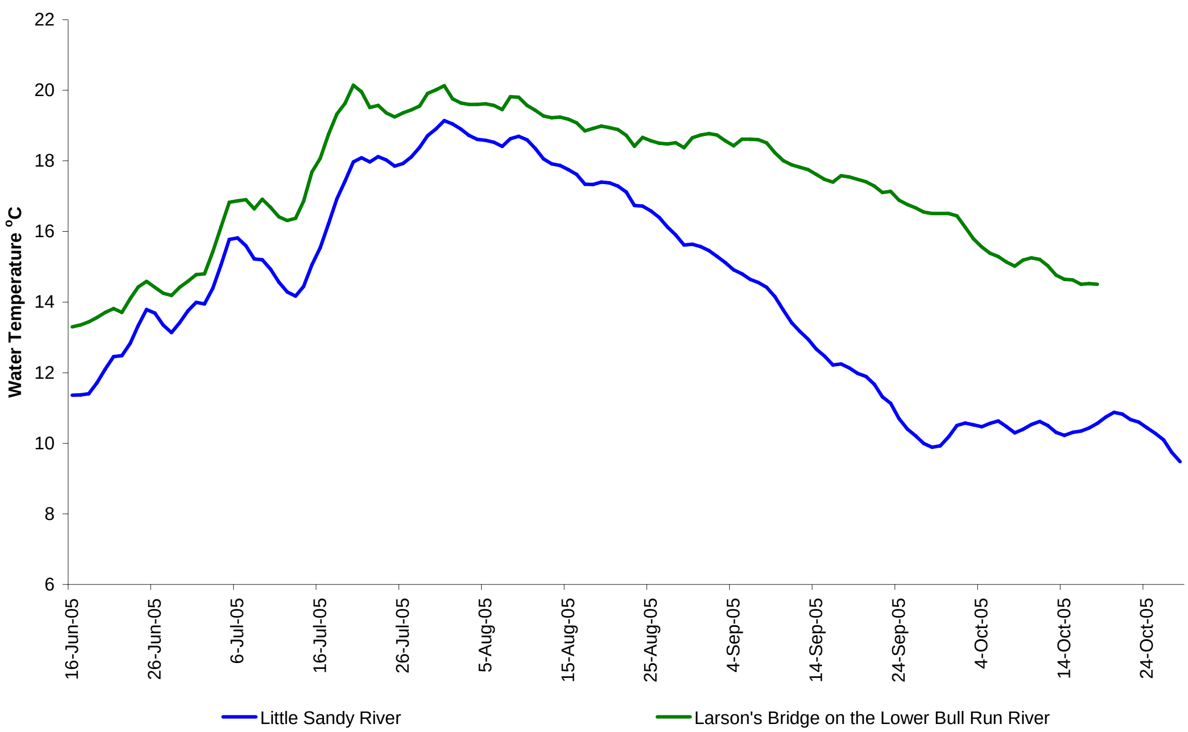


Figure 8-13. 7-Day Maximum Average Water Temperatures for the Little Sandy and Lower Bull Run Rivers, June 16–October 24, 2005

Source: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8) and USGS Gauge No. 14140000 on the Bull Run River (RM 4.7).

The City will continue to carefully manage the amount of cool water in the reservoirs for downstream flow releases. Figure 8-14 indicates the water temperature performance that the City will be able to achieve in the first years of the HCP. For rearing steelhead in the summer and early fall, the City has established the interim goal of not exceeding 21 °C at Larson's Bridge on the lower Bull Run River. That target is cool enough to allow continued growth of steelhead. While this temperature target is higher than the preferred range by rearing steelhead, it is the best performance outcome that the City can achieve with the current dam infrastructure. There will be some temporary effects on steelhead juveniles.

Post-infrastructure Water Temperature Effects. The City will complete infrastructure changes at the Dam 2 towers and the stilling basin and commit to daily operational flow management (Measure T-2). The City used the CE-QUAL-W2 water quality model to predict natural condition stream temperatures in the lower Bull Run River (City of Portland 2004). The model predicted that maximum stream temperatures would occur at Larson's Bridge (RM 3.8) in the lower Bull Run River. City staff and ODEQ staff evaluated modeling results and empirical data and concluded that natural stream temperatures in the lower Bull Run River could be estimated using the stream temperature of the Little Sandy River (see Figure 8-14).

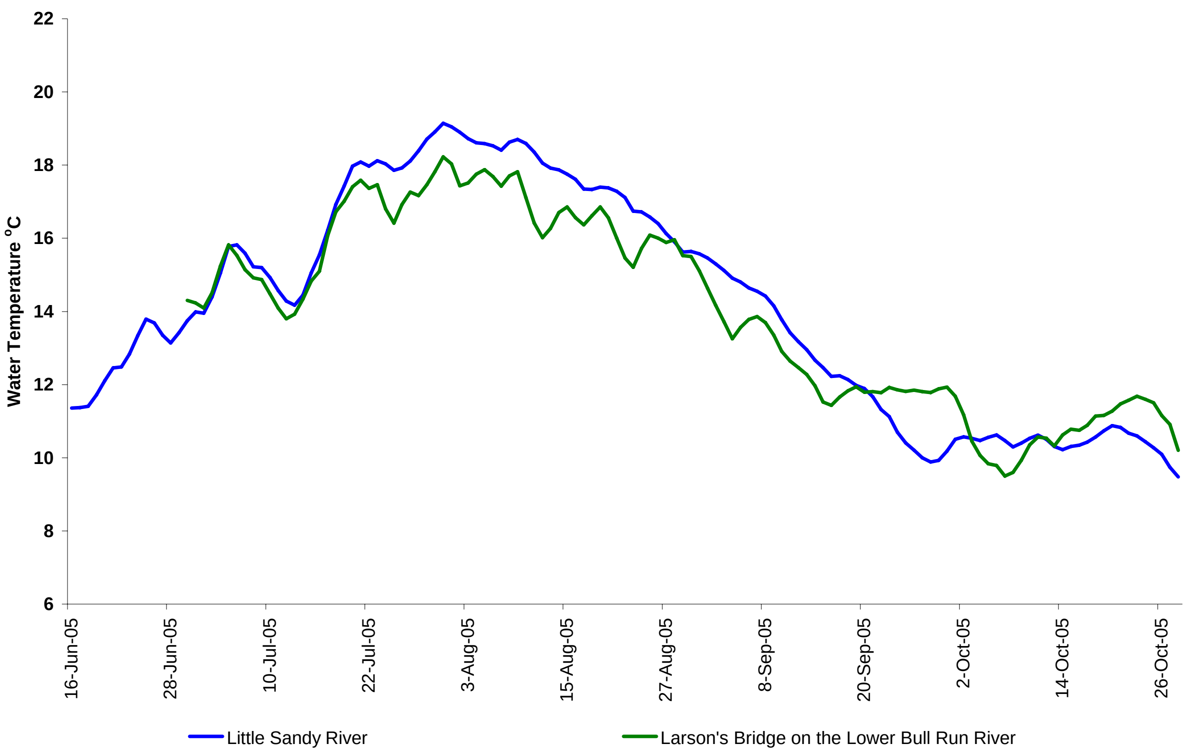


Figure 8-14. Comparison of Actual 7-Day Maximum Water Temperatures for the Little Sandy with Predicted 7-Day Maximum Average Temperatures Lower Bull Run River, June 16–October 24, 2005

Source: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8) and CE-QUAL-W2 Modeled Temperatures (February 2006).

The summer and early fall water temperatures in 2005 shows that water temperatures at Larson's Bridge will be generally lower than temperatures in the Little Sandy but are within approximately 1 °C (see Figure 8-14). ODEQ has established water temperature criteria for the Larson's Bridge location under the authority of the CWA and the Sandy Basin TMDL (see Measure T-1 in Chapter 7).

Within five years of the start of the HCP, the infrastructure changes at Dam 2 will be completed and the natural thermal potential of the Bull Run River will be met. Water temperature impacts on steelhead would be minimized.

Diurnal Water Temperature Fluctuations. The City anticipates that the diurnal water temperature fluctuations in the lower Bull Run River will be less than what has been observed in recent years. The fluctuations likely to result from implementing the HCP measures were estimated using modeling and measured water temperatures from the lower Bull Run and Little Sandy rivers. Table 8-29 lists observed and expected temperature fluctuations for the summer and late summer months. These are the months when the City's implementation of the water temperature measures (Measures T-1 and T-2) will affect diurnal temperature fluctuations. During other months of the year the diurnal water temperatures fluctuations should not be affected. The fluctuations expected after implementing the HCP measures are predicted to be smaller than the fluctuations that would occur under natural conditions.

Table 8-29. Diurnal Water Temperature Fluctuations (°C)

Month	Bull Run Observed (current conditions)	Little Sandy Observed (natural conditions)	Expected HCP
June	4-6	0.5-5	2-3
July	4-6	1-5	2-3
August	3-5	1-5	2-3
September	2-3	1-4	1-2

Source: Bull Run observed temperatures: USGS Gauge No. 14140000 on the Bull Run River (RM 4.7); Little Sandy observed temperatures: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8); expected HCP temperatures: CE-QUAL-W2 Modeled Temperatures (February 2006).

The City reviewed available research on the influence of fluctuating water temperature on the growth of salmonids. Experiments on steelhead and coho (Hahn 1977; Grabowski 1973; and Thomas et al. 1986) indicated that fluctuating water temperature tests and the constant test exposures produced equivalent results. The City concludes that the reductions in diurnal water temperature fluctuations will not affect winter steelhead or other salmonids that utilize the lower Bull Run River.

Large Wood

Large wood is removed from the upper end of Reservoir 1 to protect the downstream water supply dams from damage. The USFS owns this wood because it is transported by tributaries from national forest land. Since this wood does not travel down the lower Bull Run River, a small amount of beneficial habitat for winter steelhead is potentially lost. The lower Bull Run is, however, a high-order steep stream and is not likely to trap and store large wood. Photographs taken of the lower Bull Run in the late 1890s, before the dams and water diversions were constructed, show little large wood in the channel. The lower river is probably a transport reach for large wood.

The lower Bull Run River is dominated by bedrock and boulders. This channel roughness supports diverse habitats, including about 27 percent pool habitat. The presence of this pool habitat suggests that large wood is not an important requirement of pool formation, and the addition of large wood would provide only a minor increase in pool habitat.

Historically, large wood pieces may have formed some low-velocity areas that juvenile winter steelhead may have utilized during winter months and that helped trap suitable spawning gravel. The City does not believe that the low-velocity areas are important because winter steelhead usually prefer to burrow under substrate during the winter, and the lower Bull Run has suitable substrate for protecting winter steelhead.

The City does not plan to artificially place large wood in the lower Bull Run River above Larson’s Bridge because of concerns about the vulnerability of water supply infrastructure (such as conduit trestles). The City will let natural recruitment of large wood occur downstream of Larson’s Bridge. Trees that fall naturally will be left in place to modify the stream channel as long as the water conduits and bridges are not threatened. This large wood could slightly improve habitat conditions for winter steelhead by reducing the overall grain sizes and creating pools in localized areas in the lower 3.8 miles of the Bull Run River.

Spawning Gravel

The two Bull Run dams interrupt bedload and gravel movement to the lower Bull Run River, resulting in reduced spawning habitat for winter steelhead. The estimated historical gravel supply rate was roughly 30 to 1,000 cubic yards (CH2M HILL 2003b). The City will place approximately 1,200 cubic yards per year for the first five years and 600 cubic yards per year thereafter (see Measure H-1 in Chapter 7). The City will monitor the effects of the gravel placement to determine whether the measure should continue for the term of the HCP or should be modified. The gravel replacement rate will be higher than the estimated natural accumulation. Placement of gravel in the lower Bull Run River should significantly improve the spawning conditions for winter steelhead.

Access

Winter steelhead were first blocked from the upper Bull Run watershed in 1921 by construction of the Diversion Dam (approximately RM 5.8). The dam diverted Bull Run water into water conduits to serve the greater Portland metropolitan area. In 1964, as part of the Dam 2 construction, a rock weir was built at RM 5.8 to create the Dam 2 plunge pool for energy dissipation. That structure is now the upstream limit for winter steelhead distribution; however, there are resident populations of rainbow in upstream reservoirs and the upper Bull Run River. The City also blocks approximately 800 feet of Walker Creek, a tributary to the Bull Run River. Historically, this stream was probably used by winter steelhead and rainbow trout.

Winter steelhead access will remain blocked by the rock weir at RM 5.8 during the term of the HCP, preventing access to approximately 34 miles of the upper Bull Run River watershed for winter steelhead that were historically available. Of these blocked miles, 25 miles are free-flowing river; approximately 9 river miles are inundated by City reservoirs. This analysis is conservative and assumes that, historically, winter steelhead were able to migrate upstream of a series of three waterfalls on the mainstream Bull Run River located from RM 16–RM 16.65. The SRBTT concluded that winter steelhead might have been able to ascend the waterfalls under some circumstances, but such occurrences would have been infrequent. Beak (2000c) determined that one waterfall was probably a complete barrier to upstream-migrating winter steelhead. Nevertheless, the City assumed that winter steelhead once consistently passed the waterfalls, and the total river mileages reflect that assumption.

Under this HCP, the City will also open access to Walker Creek, which is a small tributary to the lower Bull Run River. Access to this tributary was probably blocked in the 1960s when the City constructed the Dam 2 facilities. A culvert or other appropriate structure that meets fish passage criteria will be constructed so that winter steelhead have access to approximately 800 feet of Walker Creek.

When PGE removes the Little Sandy Dam, winter steelhead will also have access to an additional 5.6 miles of the mainstem Little Sandy River and 2.0 miles of tributary streams.[9] The City's agreement to maintain flows for fish will help retain habitat benefits from this renewed access to the historical habitat for winter steelhead.

The City will also improve access for steelhead in Alder and Cedar creeks, which are tributaries to the middle Sandy River. These effects are described below in the Offsite Habitat Effects section.

Riparian Function

The City owns land along 5.3 miles of the lower Bull Run River (1,650 acres). The City's lands represent 82 percent of the riparian corridor below Dam 2. Managing these lands to protect riparian habitat (see Measure H-2 in Chapter 7) will improve habitat for winter steelhead. Approximately 30 percent of the riparian corridor along the lower river is in late-successional (late-seral) timber that can provide immediate large wood recruitment to the channel. Further, 80 percent of the riparian corridor is of mid- to late-seral age and will provide wood to the channel at an increasing rate over the next 10 to 70 years (Cramer et al. 1997).

Analysis of shading in the lower Bull Run River indicates that riparian vegetation currently intercepts 40 to 60 percent of the total solar radiation that potentially could reach the water surface (Leighton 2002). This shading provides a substantial benefit to maintaining water temperature and will become greater over time as the vegetation continues to mature. Even with mature vegetation in the lower Bull Run, however, water temperatures will not meet ODEQ's numeric water temperature criteria (see temperature effects analysis).

Total Dissolved Gases

Oregon's Water Quality Standards state that TDG levels should not exceed 110 percent of saturation unless flows exceed the ten-year, seven day average flood (7Q10) flow for the site [OAR 340-041-0031]. The 7Q10 flow for the lower Bull Run River is 5,743 cfs. The City has monitored all water system structures, valves, or turbines that could elevate TDG levels

[9] See Section 4.1.5 Water Quality and Water Rights for more information about the removal of the Little Sandy Dam.

since 2005, and has determined that winter steelhead are unlikely to be adversely affected by TDG levels in the Bull Run River. A 55-feet deep stilling pool at the base of the Dam 2 spillway is the site most likely to produce TDG levels that could affect winter steelhead. This location, however, is upstream of the range of anadromous fish. Monitoring by the City indicates that elevated levels of TDG quickly decrease as water passes over the rock weir below the stilling pool (RM 5.8). The City has never measured TDG levels that met or exceeded 110% in the anadromous portion of the Bull Run River, unless the 7Q10 flow was also exceeded. TDG levels further dissipate downstream of the rock weir. Winter steelhead are probably not impacted by TDG levels in the Bull Run River.The City will continue to monitor TDG levels in the Bull Run, as described in the Effectiveness Monitoring section in Chapter 9 and Appendix F, Monitoring Plans and Protocols.

Summary of Effects for Winter Steelhead in the Lower Sandy River from Bull Run Measures

The City identified five types of effects that water supply operations could have on steelhead habitat in the lower Sandy River.

- Base flows in the lower Sandy would be reduced under the HCP by continued water supply operations in the Bull Run, but the weighted usable area for steelhead will not be affected because there is limited spawning in the lower Sandy River.
- Flow downramping effects in the lower Sandy will be avoided because of the City's downramping commitments in the Bull Run HCP.
- The City's HCP measures will probably have small beneficial effects on water temperatures in the lower Sandy.
- The City will also minimize the impact of removing large wood from the lower Bull Run by adding large wood directly into the lower Sandy.

Overall, the City's HCP measures will have positive effects on habitat for winter steelhead in the lower Sandy River.

Table 8-30 summarizes the type of effect, reference conditions, and habitat effects of the HCP conservation measures for winter steelhead in the lower Sandy River.

Table 8-30. Effects of the Bull Run HCP Measures on Lower Sandy River Habitat for Winter Steelhead[a]

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Base flows	Natural Sandy River base flows	Flows after implementation of the HCP will be more than 80% of natural base flows.[b]
Weighted Usable Area	Natural Sandy River base flows	Flows will increase habitat for spawning by up to 14 percent during January–April and reduce habitat for spawning by 5 percent in May.[c] The City's Bull Run base flows will have minimal negative impact on steelhead spawning in the lower Sandy River because there is limited winter steelhead spawning in the lower Sandy.
Flow Downramping	Protective downramping rate: 2"/hour	The City's water supply operations will have minimal effects on fish stranding due to downramping.
Water Temperature	ODEQ standard: natural thermal potential	The City's HCP measures will probably have small water temperature benefits.
Large Wood	Natural wood routing	City measures will increase large wood levels and habitat diversity, minimizing adverse effects of Bull Run operations in the Sandy River below the Bull Run confluence. Collectively, the City's HCP measures will improve habitat conditions for steelhead/ rainbow trout in the lower Sandy River.

[a]For the list of conclusions about the habitat effects of all HCP measures on winter steelhead, see page 8-114.
[b]Based on flow data from 1985–2001, natural base flows were reduced by 4–19 percent (CH2M HILL 2002).
[c]Based on flow data from 1985–2001.

Habitat Effects in the Lower Sandy River from the Bull Run Measures

The EDT database and model were used to identify limiting factors having the greatest effect on winter steelhead in the lower Sandy River below the confluence of the Bull Run River. The factors identified were food, habitat diversity, harvest, flow, channel stability, competition from the same species, predation, water temperature, pathogens, and sediment. Of these 10 factors, three are potentially affected by water supply operations in the Bull Run: streamflow, water temperature, and large wood recruitment (as a subfactor in habitat diversity). The other seven factors are not directly related to water supply operations.

Streamflow

A flow effects analysis was completed for winter steelhead in the lower Sandy River below the Bull Run (CH2M HILL 2002). This analysis focused on the potential effects of the City's Bull Run operation on base flows and flow fluctuations (ramping). The analysis used Bull Run flows from 1985 to 2001, which are lower than the HCP flows described in Chapter 7.

Base Flows. The City compared the WUA and monthly flow amounts without City operations to the WUA and monthly flows during the 1985 to 2001 period. City operations from 1985 to 2001 reduced flows in the lower Sandy River by 4 percent to19 percent (depending on the month), but increased the total available habitat for winter steelhead by 2 percent to 14 percent (depending on the month). During January through April, spawning habitat would be increased by 1.6 percent to 6 percent. In May, the available habitat for winter steelhead spawners would be reduced by 5 percent. These results are conservative because the flows under the HCP are higher than the flows evaluated in the study. The HCP flows should maintain or slightly improve habitat conditions in the lower Sandy River for winter steelhead.

Downramping. The CH2M HILL analysis (2002) indicates that the downramping rate of 2"/hour would eliminate juvenile salmonid stranding effects in the lower Sandy River reaches. The downramping measure will prevent any effect on winter steelhead in the lower Sandy River.

Water Temperature

Both ODEQ's and the City's water temperature modeling results indicate that the lower Sandy River reaches are in a state of relative equilibrium. City water supply operations have little influence on heating or cooling of the lower Sandy River. This conclusion is supported in the Sandy River Basin TMDL (ODEQ 2005).

Even though the City's operations in the Bull Run will not negatively affect water temperatures in the lower Sandy River, some of the City's offsite conservation measures will probably have small water temperature benefits (see discussion for each reach in the subsection "Habitat Effects in the Sandy River Basin from the HCP Offsite Measures" for effects of offsite measures on lower Sandy watershed).

Large Wood

Removal of large wood from the Bull Run reservoirs reduces the amount of large wood loading to downstream Sandy River reaches and somewhat reduces channel complexity for salmonids. To mitigate for this impact, the HCP includes several large wood measures in the lower Sandy River (see Measures H-4, H-11, H-12, and H-13 in Chapter 7).

Habitat Effects in the Columbia River from Use of Groundwater

The City will use groundwater from the Columbia South Shore Well Field, in conjunction with the Bull Run River flows, to provide the total amount of water needed to meet water supply demands and the HCP flow commitments. The Columbia River is located adjacent to the well field, so the City analyzed the effect groundwater use might have on flows in the Columbia River.

As context, only one instream flow commitment has been established for the lower Columbia River to maintain the persistence of ESA-listed species. This requirement is the FCRPS's minimum flows of roughly 125,000 cfs below Bonneville Dam, unless competing priorities preclude it (USCOE et. al. 2006). These minimum flows are increased by contributions from the Sandy and Washougal rivers before arriving at the Glenn Jackson Bridge (I-205 bridge), approximately 14 miles west of the mouth of the Sandy River.

The well field has an estimated sustainable capacity of approximately 85 mgd, which is equivalent to approximately 130 cfs. The actual amount and duration of pumping will vary according to the weather and supply conditions, but typically the amount pumped per day would be significantly less than the full capacity. The well field draws on four regional alluvial aquifers. Recharge for these aquifers occurs as far south as the Boring Hills (Hartford and McFarland 1989). These aquifers generally discharge into the Columbia River.

As a simplifying worst-case assumption for this analysis, the City assumed that 85 mgd would be pumped from the well field and that this amount would be drawn into the aquifers from the Columbia River. (This is a significant overestimate because the water pumped would actually be drawn primarily or completely from the aquifers themselves and not from the river into the aquifers.) The assumed flow into the aquifers would reduce the assumed flow available in the Columbia River for fish.

If the City's groundwater pumping were to result in a 130 cfs reduction in Columbia River flows, that reduction would be at most 0. 1 percent of the total river flow (based on the 125,000 cfs minimum flows mentioned above). To put this reduction in perspective, the typical margin of error on measured flows for the Columbia River is +/- 10 percent (see for example the gauge at the Columbia River at The Dalles, USGS 2003). This measurement error is significantly larger than the estimated flow reduction due to groundwater use. In addition, the mainstem Columbia River has tidal fluctuations that average approximately 1.7 feet (data from USGS Gauge No. 14144700). This natural daily change in river stage is many orders of magnitude greater than any potential reduction of Columbia River flows due to the City's use of groundwater. The City's conclusion is therefore that use of the Columbia South Shore Well Field as a means to enable the HCP flow commitments in the lower Bull Run River will have a negligible influence on the Columbia River base flows and associated habitat for winter steelhead migrating in the river.

Summary of Effects on Winter Steelhead in the Sandy River Basin from the HCP Offsite Measures

The HCP offsite measures in steelhead production areas are included to mitigate effects that cannot be avoided in the lower Bull Run River.[10] The upper Sandy River, upstream of the Marmot Dam site, has most of the steelhead anchor habitat reaches.

The City will implement measures to benefit winter steelhead in the middle Sandy River watershed, including riparian easements and improvements, large wood placement, and removal of passage barriers on Alder and Cedar creeks. Although the HCP measures in the lower Sandy River were selected with the primary intent to improve habitat conditions for fall Chinook, some benefits will accrue for winter steelhead as well. Overall, the HCP measures planned for the Sandy River Basin will improve channel conditions, increase side channel habitat, and increase large wood loads over time.

- The improvements in the Little Sandy River will increase spawning and rearing habitat and provide cover for juveniles.
- Reduced risk of peak flow displacement, increased cover from predators, reduced impacts from limited food availability, increased rearing and overwintering habitat, and improved habitat diversity will benefit juveniles in the lower and middle Sandy River and Boulder Creek.
- Additional benefits to fish in Boulder Creek include a reduction in fine sediment which will improve habitat for incubating eggs.
- Small temperature benefits will improve parr productivity and egg incubation in the lower and middle Sandy River segments, respectively.
- The improvements in Gordon Creek will provide habitat diversity for rearing juveniles, reduce competition with hatchery fish, and reduce the amount of fine sediment in spawning gravel patches.
- In the upper Sandy River, all juvenile life stages will benefit from the increase in habitat diversity; overwintering juveniles and actively rearing parr will eventually benefit from the large wood loading which will create pool habitat. The one-year carcass placement in the Zigzag River will provide modest food benefits for juveniles as well.

[10] Effects in the lower Bull Run River include reduced base flows and weighted usable areas (WUAs) and blocked access to the upper Bull Run watershed.

- The improvements in the Salmon River will increase key habitat for parr and overwintering juveniles, increase spawning habitat, and provide some small temperature benefits for egg incubation.
- The channel redesign work and riparian easements in the Zigzag River will create additional rearing habitat, and increase habitat diversity for fry. Over time, the riparian easements will also provide small temperature benefits and cover for juveniles. Carcass placement will improve food availability for one year of HCP implementation.
- Passage improvements in Alder and Cedar creeks will add approximately 17 new stream miles for steelhead.
- Measures in Cedar Creek will improve base flows in the summer, increase habitat such as pools and off-channel habitat, and create modest temperature improvements—all benefits for juvenile winter steelhead.

Details of the specific improvements in winter steelhead habitat that will result from the offsite measures are described in this chapter and in Appendix E. Overall, the City's offsite conservation measures will improve habitat for winter steelhead in the Sandy River Basin.

Habitat Effects in the Sandy River Basin from the HCP Offsite Measures

The City's HCP includes 30 offsite habitat conservation measures. Most of these measures address environmental problems affecting the production of more than one species. This analysis describes the effects of the HCP measures on winter steelhead. Effects are described by watershed, and both life stages and limiting factors are addressed. (See Chapter 5 for additional information on the winter steelhead population in the Sandy River Basin and about the habitat factors limiting production.)

Little Sandy River

The City's water supply operations do not affect the Little Sandy River because it is a tributary to the lower Bull Run River downstream of the City's dams and diversion. The City's large wood habitat conservation measure for the Little Sandy River was selected to improve habitat diversity for spawning and rearing habitat for steelhead and other salmonids.

The City will place large wood in the Little Sandy River (see Measure H-3 in Chapter 7), which will slightly increase channel complexity and gravel sorting for steelhead and other fish species. The City believes that steelhead habitat will benefit slightly from the large wood measure. The large wood will modify the channel hydraulics of the Little Sandy River and trap suitable spawning gravel and will provide more overhead cover for the fish.

Lower Sandy River Watershed

The lower Sandy River watershed consists of the 18.5 miles of the Sandy mainstem between the Bull Run and Columbia river confluences (Sandy 1 and 2 reaches), plus the following tributaries: Beaver, Buck, Gordon, and Trout creeks. Winter steelhead spawn in the tributaries of the lower Sandy watershed, but this may be a result of years of releases from the Sandy Hatchery combined with historical passage difficulties below Marmot Dam. Winter steelhead are believed to spawn in the lower 7.3 miles of Gordon Creek and lower 0.75 mile of Trout Creek, and in lesser numbers in the lower half-mile of Buck Creek and the lower 7 miles of Beaver Creek. In the mainstem Sandy River, the majority of winter steelhead spawning occurs in reach Sandy 2, between Dabney Park and the Bull Run confluence.

HCP measures were selected in the lower Sandy River with the primary intent to improve habitat conditions for fall Chinook. However, the measures in the lower Sandy will also mitigate effects on rearing winter steelhead that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The City also considered the habitat factors that are limiting productivity of winter steelhead in the lower Sandy River. The analysis considers beneficial effects for winter steelhead likely to result from measures designed primarily for fall Chinook.

The City will implement measures, including a reconnected side channel, reestablished mouth, riparian restoration, and engineered log jams on the lower Sandy mainstem, as well as large wood placement and riparian enhancements in Gordon and Trout creeks. A detailed description of each measure and the affected reaches, by watershed, is presented in Chapter 7.

Table 8-31 lists the reaches affected by HCP measures planned in the lower Sandy River and the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-31. Habitat Benefits for Winter Steelhead in the Lower Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Beaver 1A	Riparian function	Improvement
	Large wood	Increase
Gordon 1A	Fine sediment in gravel patches	Decrease
	Backwater pools	Increase
	Large-cobble riffles	Decrease
	Pool habitat	Increase
	Pool-tail habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Large wood	Increase
Gordon 1B	Backwater pools	Increase
	Pool habitat	Increase
	Pool-tail habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Large wood	Increase
Sandy 1	Artificial confinement	Reduction
	Off-channel habitat	Increase
	Riparian function	Improvement
	Large wood	Increase
Sandy 2	Off-channel habitat	Increase
	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Trout 1A	Large wood	Increase
Trout 2A	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

The riparian protection/enhancement projects in the lower Sandy mainstem reaches will increase large wood, improve riparian function, decrease confinement in Sandy 1, and improve temperature. A major impact of these measures is the very large increase in the amount of rearing and overwintering habitat provided by the reconnected side channels. Side-channel reconnection is also likely to aid adult passage.

The slow pools in the restored side channels will increase key habitat in Sandy 1 for overwintering juveniles. The combined effect of improved riparian function and increased large wood should significantly improve habitat diversity for parr. Additional large wood will help stabilize the stream channel, lessen peak flow displacement risks to overwintering juveniles, and provide escape cover from predators. Improved riparian function will somewhat reduce temperature impacts, thereby improving parr productivity. Increased riparian function should also lessen impacts attributed to limited food availability and competition with hatchery fish.

Key habitat for juveniles will dramatically increase in Gordon Creek due to the additional pools, backwater pools, and pool tail-outs. This additional rearing habitat should reduce the effects of competition with hatchery fish. The large wood will also increase habitat diversity for parr and overwintering juveniles. Gravel retention by the 300 newly installed log structures will improve channel stability. The riparian enhancement project on the lowermost reach will stabilize crumbling banks and filter out surface inputs of sediment to spawning substrate.

Large wood measures in Trout Creek will directly increase the stability of gravel bars, thus aiding incubation and overwintering.

Middle Sandy River Watershed

Most of the Middle Sandy mainstem is carved through bedrock in a deep, steep-walled gorge. Winter steelhead primarily use this river segment as a migration corridor (SRBP 2005). The main impact to habitat quality in the mainstem middle Sandy has been Marmot Dam, which was decommissioned in July 2007.

Upstream of the Marmot Dam site, little spawning has occurred in the middle Sandy, except in the inflow reach of the Marmot Dam site. This reach (Sandy 6) provides exceptional mainstem spawning and rearing habitat with a low gradient, pools, riffles, side channels, and relatively abundant cobble/gravel substrate and large wood.

The portions of Alder and Cedar creeks that are accessible to winter steelhead support natural productivity. A weir constructed in the early 1950s partially blocks fish passage approximately 0.5 mile upstream from the mouth of Cedar Creek (SRBP 2005).

The HCP measures for winter steelhead production areas in the middle Sandy River were selected with the intent to mitigate effects that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The City also considered the habitat factors that are limiting productivity of winter steelhead in the middle Sandy River. In addition, the analysis considers beneficial effects for winter steelhead that are likely to result from measures designed primarily for other species.

The City will implement measures to benefit winter steelhead in the Middle Sandy River watershed, including riparian easements and improvements, carcass placement, large wood placement, removal of a passage barrier, and water rights purchases. A detailed description of each measure and the affected reaches, by watershed, is presented in Chapter 7.

The City will also modify structures in Cedar and Alder creeks, which are important tributaries to the middle Sandy River. After the modifications are made, approximately 5.5 river miles will be accessible for steelhead in Alder Creek, and approximately 12 miles will be opened for steelhead in Cedar Creek.

Table 8-32 lists the reaches affected by HCP measures planned in the middle Sandy River, and the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-32. Habitat Benefits for Winter Steelhead in the Middle Sandy River Watershed, by Reach

Reach	Reference Condition	Habitat Benefit
Alder 1	Large wood	Increase
	Blocked access	Increase
Alder 1A	Riparian function	Improvement
	Blocked access	Increase
	Large wood	Increase
Alder 2	Riparian function	Improvement
	Large wood	Increase
Cedar 1	Dissolved oxygen	Increase
	Fish pathogens	Improvement
	Minimum water temperature	Decrease
	Maximum water temperature	Decrease
	Temperature moderation by groundwater	Improvement
	Blocked access	Increase
Cedar 2	Dissolved oxygen	Increase
	Fish pathogens	Improvement
	Off-channel habitat	Increase
	Riparian function	Improvement
	Minimum water temperature	Decrease
	Maximum water temperature	Decrease
	Temperature moderation by groundwater	Improvement
	Large wood	Increase
Cedar 3	Dissolved oxygen	Increase
	Fish pathogens	Improvement
	Beaver pond habitat	Increase
	Off-channel habitat	Increase
	Pool habitat	Increase
	Riparian function	Improvement
	Minimum water temperature score	Decrease
	Maximum water temperature	Decrease
	Temperature moderation by groundwater	Improvement
	Large wood	Increase
	Maximum water temperature	Decrease

Table continued on next page

Table 8-32. Habitat Benefits for Winter Steelhead in the Middle Sandy River Watershed, by Reach, continued

Reach	Reference Condition	Habitat Benefit
Sandy 3	Riparian function	Improvement
	Large wood	Increase
Sandy 7	Carcasses per stream mile	Increase[a,b]
	Maximum water temperature	Decrease
	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

Riparian easements and improvements in the Sandy River and in Alder and Cedar creeks will protect intact portions of riparian corridor, improve the species composition (by culling hardwoods and planting conifers), and allow for related habitat improvements (such as large wood recruitment and decrease in temperature) to occur over time. Large wood placement will increase channel stability for all life stages, decrease the risk of juvenile displacement by peak flows, and improve habitat diversity. The modest improvement in temperature will improve incubation slightly. Salmon carcasses placed in the Salmon River will improve food availability for juveniles.

Modifying the fish passage barriers on Alder Creek will open up approximately five new stream miles for winter steelhead use.

Purchasing water rights on Cedar Creek will increase summer base flows for rearing. Rearing juveniles may also benefit from lower water temperatures after the fish passage is provided past the ODFW hatchery weir. The benefits from the water rights purchase are not represented in Table 8-32 because the effects were not calculated in the EDT model.

Upper Sandy River Watershed

Most of the upper Sandy River watershed is located in the Mt. Hood Wilderness and receives little anthropogenic disturbance. With the exception of the lowermost reach (Sandy 8), winter steelhead production is limited by naturally occurring conditions. Sandy 8 has been straightened, cleaned of large wood and large boulders, and confined between riprapped banks in response to the 1964 flood and due to development that has occurred between the communities of Zigzag and Brightwood.

The HCP measure in the upper Sandy River was selected with the intent to mitigate effects on rearing winter steelhead that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The City also considered the habitat factors that are limiting productivity of winter steelhead in the upper Sandy River.

The City will implement one measure in reach 8 of the upper Sandy River to benefit winter steelhead, a riparian easement. A detailed description of the measure and the affected reaches, by watershed, is presented in Chapter 7.

Table 8-33 lists the reach affected in the upper Sandy River and the expected habitat benefits (Tables in Appendix E show percentages for the reference and post-implementation conditions).

Table 8-33. Habitat Benefits for Winter Steelhead in the Upper Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Sandy 8	Riparian function	Improvement
	Carcasses per stream mile	Increase[a,b]
	Maximum water temperature	Decrease
	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

Improvement in riparian function and large wood will increase habitat diversity for all juvenile life stages and will reduce channel instability, thus improving the survival of overwintering juveniles. The least productive winter steelhead life stages in the lowermost reach of the upper Sandy River are actively rearing parr and overwintering juveniles. Both juvenile life stages are mainly affected by a lack of key habitat, particularly pools; both also suffer lesser impacts from a lack of habitat diversity and flow. The increase in large wood loading will eventually result in increased pool area, thereby creating key habitat for parr and overwintering juveniles. The improved riparian function and the carcasses that wash out of the Zigzag River into this reach will boost food production for all juveniles, but the carcass placement is only planned for a single year.

Salmon River Watershed

Winter steelhead spawn in the lower 13.2 miles of the Salmon River (reaches 1–3) and in the tributaries entering these reaches, including 4.4 miles of Boulder Creek. These reaches are clearwater streams that are important to steelhead for rearing.

The HCP measures were selected in winter steelhead production areas with the intent to mitigate effects that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The City also considered the habitat factors that are limiting productivity of winter steelhead in the Salmon River and its major tributary, Boulder Creek. In addition, the analysis considers beneficial effects for winter steelhead that are likely to result from measures designed primarily for other species. The City will implement measures in the Salmon River watershed to benefit winter steelhead, including purchasing riparian easements, acquiring and restoring the Miller Quarry property, adding large wood to Boulder Creek, and adding salmon carcasses. A detailed description of each measure and the affected reaches, by watershed, is presented in Chapter 7.

Table 8-34 lists the reaches affected by HCP measures planned in the Salmon River and the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-34. Habitat Benefits for Winter Steelhead in the Salmon River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Boulder 0	Fine sediments by surface area	Decrease
	Maximum water temperature	Decrease
	Large wood	Increase
Boulder 1	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Salmon 1	Off-channel habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Carcasses per stream mile	Increase[a,b]
	Maximum water temperature	Decrease
	Large wood	Increase
Salmon 2	Average depth of bed scour	Reduction
	Artificial confinement	Reduction
	Off-channel habitat	Increase
	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Salmon 3	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

The measures affecting the Salmon River reach significantly increase the amount and diversity of habitat for winter steelhead, particularly for parr and overwintering juveniles. These increases occur primarily as a result of increased large wood and increased off-channel habitat. Egg incubation is also benefited by increased spawning habitat (e.g., small cobble riffles), improved water temperatures, and increased channel stability.

Measures in Boulder Creek will dramatically increase large wood, which will improve habitat for winter steelhead fry. The measures will also create a small improvement in fine sediment which is a key limiting factor for steelhead incubation in lower Boulder Creek. Temperature improvements will propagate to some degree downstream to the lower Salmon River, where temperature is a continuing problem, especially for rearing fish in the lower Salmon River.

Zigzag River Watershed

Most of the Zigzag River watershed supporting winter steelhead consists of three reaches making up 9.4 miles of the lower mainstem Zigzag River (Zigzag 1A, 1B, and 1C), 9.4 miles of lower Still Creek, and 4.0 miles of lower Camp Creek.

The lower Zigzag River mainstem has been damaged by floods occurring in 1964 and 1972 and by the flood control projects implemented afterwards. Although the floods scoured the channel and swept large wood downstream, the flood control measures removed the remaining large logs and boulders and deepened and straightened the cleaned channel, thereby cutting off meanders, oxbows, and side channels. In contrast, Still Creek and Camp Creek are providing high quality spawning and rearing habitat for salmon and winter steelhead (SRBP 2005).

HCP measures were selected in the Zigzag River with the intent to mitigate effects on rearing winter steelhead that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The City also considered the habitat factors that are limiting productivity of winter steelhead in the Zigzag River.

The City will implement measures in the Zigzag River to benefit winter steelhead, including reconstructing natural channel, purchasing riparian easements, and placing salmon carcasses. A detailed description of each measure and the affected reaches is available, by watershed, in Chapter 7.

Table 8-35 lists the reaches affected by HCP measures planned in the Zigzag River and the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-35. Habitat Benefits for Winter Steelhead in the Zigzag River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Zigzag 1A	Artificial confinement	Reduction
	Harassment	Improvement
	Large-cobble riffles	Decrease
	Small-cobble riffles	Increase
	Pools	Increase
	Pool-tails	Increase
	Riparian function	Improvement
	Carcasses per stream mile	Increase[a,b]
	Large wood	Increase
Zigzag 1B	Carcasses per stream mile	Increase[a]
Zigzag 1C	Carcasses per stream mile	Increase[a,b]

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

The lower Zigzag channel reconstruction project will essentially restore the stream channel and floodplain to pre-1964 conditions. Resloped stream banks will reduce bank failure; floodplain connectivity and hydraulic connections between the main channel and disconnected oxbows and side channels will be reestablished; a natural meander amplitude and frequency will be restored to the channel; and instream structures will retain gravel. These actions will greatly reduce the degree to which winter steelhead eggs are lost due to bedload movement and will also create additional small gravel riffles and pool tail-outs for spawners.

The “remeandering” of the main channel will reduce stream gradient, thereby reducing water velocity, increasing habitat diversity for fry, and further reducing egg loss due to channel instability. The increased bends and reduced water velocities associated with remeandering will also transform the lower mainstem from a transport reach to a retention reach for large wood, thus increasing habitat diversity for juveniles, creating and stabilizing gravel bars, and scouring new pools. The general reduction of water velocity and bedload movement associated with channel restoration should allow for deposition of gravel-sized particles, thereby transforming large substrate “pocket water” riffles to small cobble/gravel spawning riffles. Reconnecting oxbows and side channels to the main river will provide badly needed habitat diversity and nursery habitat for fry.

The riparian easements and enhancements will protect intact portions of the riparian corridor and will improve riparian function by culling hardwoods and planting conifers. Over time, habitat conditions related to riparian vegetation (habitat diversity, large wood recruitment, security cover, and temperature) will improve.

Summary of Population Effects and VSP Parameters

The VSP parameters for productivity, diversity, and abundance for the Sandy River population of winter steelhead are projected to increase by 6–8 percent under the HCP.* The projected increases in the VSP parameters should also be considered as modest projections because they do not include any potential benefits to steelhead that may be derived from projects supported by the City's $9 million Habitat Fund (see Measure H–30, Chapter 7).

* If Cedar Creek weir removal is included, the VSP parameters are expected to increase by 7–15 percent.

Population Effects and VSP Parameters

The HCP habitat measures were designed to mitigate the effects of the Bull Run water supply on winter steelhead and other covered species. This section describes the estimated effects of the City's HCP on the overall Sandy River winter steelhead population using parameters established in the NMFS recovery planning process, specifically the work of the LCR-TRT.

Sandy River winter steelhead are part of the Lower Columbia River Distinct Population Segment (DPS); the population is considered by the LCR-TRT and the LCRFRB (LCRFRB 2004) to be a primary population for recovery in the Lower Columbia ESU. Primary populations are those that the TRT believes needs to be restored to "High" or "Very High" viability levels in order to recover the species. Winter steelhead have been identified as needing to be restored to a "High" viability level, or a 95–99 percent likelihood of persistence (LCRFRB 2004).

The EDT model was used to estimate the benefits for winter steelhead that are likely to result from implementing the HCP. Although the model results are not absolute predictions of fish abundance, they do provide a relative comparison of the expected salmon population performance based on the best available science. The inputs to the model represent a combination of site-specific empirical habitat data and, when data were not available, the professional opinion of biologists intimately familiar with the Sandy River ecosystem.

The HCP measures are expected to result in substantial increases in all of the Sandy River winter steelhead VSP parameters. Increases in productivity, diversity, and abundance for winter steelhead are presented in Table 8-36. These estimates represent increases over what could be expected to result from current habitat conditions in the Sandy River Basin. Improvements in spatial structure are discussed in the Spatial Structure subsection on the next page. NMFS (in coordination with ODFW) has not yet developed a recovery plan for the Lower Columbia ESU nor set clear objectives for each VSP parameter; therefore, the significance of these improvements is not yet known.

Table 8-36. Increases for Winter Steelhead Expected Due to HCP Implementation[a]

	Productivity	Diversity	Abundance
Without Cedar Creek Weir Removal	7%	6%	8%
With Cedar Creek Weir Removal	7%	15%	12%

Source: EDT model run April 17, 2007
[a]Estimates do not include benefits from removing the Marmot Dam on the Sandy River.

Productivity

The estimated 7 percent increase in productivity results from an increase in the quality of stream habitat located primarily in the Zigzag and Salmon rivers and the Sandy River mainstem. Smaller benefits accrue to winter steelhead in Boulder and Alder creeks. Protecting instream water rights for fish in Cedar Creek will also prevent a loss in overall population productivity. The 7 percent improvement in productivity increases population resilience to habitat degradation, thereby reducing population extinction risk.

Diversity

The estimated 6 percent to 15 percent increase in diversity represents improvements in habitat conditions over time and space. Most of these improvements occur in the Zigzag River, Gordon Creek, lower Bull Run River, and lower Sandy River.

Abundance

The estimated 8 percent to 12 percent improvement in winter steelhead abundance results from the increases in productivity and diversity. Increased abundance reduces extinction risk for the population. Higher abundance also results in increased ecological benefits. Salmonids improve both their physical and biological environments through various mechanisms. For example, adult spawners reduce fine sediment concentrations in gravels and their carcasses provide a food source for other aquatic and terrestrial species.

The LCR-TRT defines viability for Sandy River winter steelhead as 1,800 adults produced from the Sandy River Basin (McElhany et al. 2003). The City's HCP measures make a significant contribution toward achieving this objective (see the Population Effects subsection below for a population benchmark comparison).

Spatial Structure

The viability of a salmon population depends not only on the population's productivity, abundance, and diversity, but also on its spatial structure (McElhany et al. 2000). The more watersheds in a basin that contain large numbers of spawners, the less likely that catastrophic events such as landslides or human-caused disasters will result in the extinction of the population.

Winter steelhead currently spawn in all of the Sandy Basin watersheds to some degree, but tend to use the Sandy River above the former Marmot Dam site, the Salmon River watershed, and Still Creek most heavily. Spawning winter steelhead have also been found in the Sandy River downstream of the Marmot Dam site, the lower Bull Run River, and many of the middle and lower Sandy River tributaries, including Gordon, Trout, Cedar, and Alder creeks. Since 1998, the watershed above the Marmot Dam site has become a wild winter steelhead sanctuary. Historically, winter steelhead spawning and rearing was widely distributed throughout the Basin.

The HCP actions will increase steelhead distribution in Alder and Cedar creeks. About 18 river miles will be opened for steelhead usage. That is approximately an 11 percent increase in the current steelhead distribution for the Sandy River Basin.

The HCP improves spatial structure because actions are focused on increasing spawner access and abundance in all of the five watersheds that supported winter steelhead production historically. Increased adult abundance in multiple watersheds reduces population exposure to catastrophic events, and thus reduces extinction risk.

Table 8-37 summarizes the population effects of the HCP measures on steelhead by the VSP parameters of abundance, productivity, diversity, and spatial structure.

Table 8-37. Effects of the HCP Measures on Sandy River Basin Winter Steelhead by Viable Salmonid Population (VSP) Parameters

VSP Parameter	Reference Condition	Effect of Conservation Measures
Abundance	Current habitat conditions	Winter steelhead abundance for the Sandy River population is projected to increase by 8-12%.
Productivity	Current habitat conditions	Productivity for the Sandy River winter steelhead population is projected to increase by 7%.
Diversity	Current habitat conditions	Diversity for the Sandy River population is projected to increase by 6-15%.
Spatial Structure	Current habitat conditions	Spatial structure improves as actions are focused on increasing spawner abundance in five of the five watersheds that supported winter steelhead production historically. Increased adult abundance in multiple watersheds reduces population exposure to catastrophic events, and thus reduces extinction risk.

Sources: EDT model run April 17, 2007 for abundance, productivity, and diversity percentages; for spatial structure assessment, Kevin Malone, personal comm. 2006

Summary Comparison of Fish Abundance

The projection of adult steelhead abundance under the City's HCP is comparable, albeit somewhat lower, to the benchmark comparison scenario established for the Bull Run watershed. The projected increases in abundance should also be considered as a modest projection because it does not include any potential benefits to steelhead that may be derived from projects supported by the City's $9 million Habitat Fund (see Measure H-30, Chapter 7). This benchmark comparison indicates that the HCP will produce enough beneficial habitat changes for steelhead to offset all potential impacts that could be caused by the City's water supply operations in the Bull Run.

Population Effects and Benchmark Comparison of Fish Abundance

The introduction to this HCP chapter describes a benchmark scenario the City developed to compare results of the HCP measures with production potential of the Bull Run watershed (see Section 8.1.1). The EDT model was used to generate the estimated abundance of winter steelhead and to compare the benchmark against the benefits of the City's HCP measures. The City believes that the Modified Historical Bull Run Condition benchmark estimate represents generous assumptions and the HCP estimate is an underestimate of probable HCP results (see Section 8.1.1).

Model results indicate that the HCP measures would improve habitat sufficiently to approximately match the production potential of the Modified Historical Bull Run Condition (Table 8-38).

Table 8-38. Model Results for Winter Steelhead Abundance: Modified Historical Bull Run Condition Compared with HCP Measure Implementation[a]

Scenario	Adult Abundance
Modified Historical Bull Run Condition	3,880
HCP Measures Without Cedar Creek	3,575
HCP Measures With Cedar Creek	3,701

Source: EDT model run April 17, 2007
[a]Estimates do not include benefits from removing the Marmot Dam on the Sandy River.

The City believes these results help demonstrate that the HCP will provide the benefits for winter steelhead necessary to meet the ESA Section 10 requirements. However, the City does not propose to use EDT population estimates as an enforceable performance measure for winter steelhead. The City's HCP is purposefully habitat based. It is designed using measurable objectives, monitoring, and an adaptive management trigger that all relate to habitat condition, as described in other chapters of this document.

Conclusions about the Habitat Effects of HCP Measure Implementation

- **Effects in the Lower Bull Run River.** All of the HCP measures in the lower Bull Run River will benefit steelhead. These measures avoid or minimize ongoing City impacts in the Bull Run River (as described in Table 7-1) to the maximum extent practicable. Impacts associated with blocked fish access to the upper watershed and reduced base flows will not be completely addressed in the Bull Run but will be mitigated by offsite measures in the Sandy Basin. Benefits provided by the Bull Run HCP measures are summarized in Table 8-26.
- **Effects in the Sandy River Watersheds.** Substantial additional benefits for steelhead are provided by HCP measures in the upper Sandy River and its tributaries (e.g., Salmon and Zigzag rivers), the middle Sandy Basin, and the lower Sandy River Basin. The upper Sandy has the primary spawning areas for steelhead and most anchor habitat reaches for steelhead are upstream of the Marmot Dam site. The primary limiting factor for steelhead for that area is reduced habitat diversity. HCP measure H-18 will improve conditions for steelhead on the mainstem Sandy River and Measures H-19, H-20, H-21, H-22, H-23, H-24, H-27, H-28, and H-29 will improve habitat in important tributary streams like the Salmon and Zigzag rivers. For the middle Sandy Basin, Measures H-14, H-15, H-16, and H-17 will improve large wood levels, riparian zone conditions, and channel diversity for steelhead in the mainstem Sandy River and Cedar Creek. The HCP measures will also open new habitat for steelhead in Alder and Cedar creeks. HCP measures in the lower mainstem Sandy (H-11, H-12) will slightly improve habitat for migrating steelhead juveniles, and measures H-5, H-6, H-7, and H-13 will improve rearing habitat in lower Sandy tributaries. Benefits provided by the offsite measures are summarized in Tables 8-31 and 8-35 and in Appendix E, Tables E-5 and E-6.
- **Timing for Implementing Measures.** The timing for implementing measures relevant to winter steelhead and other species is provided in Tables 7-6 through 7-12. Measures in the upper Sandy River are primarily scheduled for HCP Years 11-15, with some of them in Years 6-10. Most of the measures for steelhead in the middle Sandy Basin will occur in HCP Years 6-10. The lower Sandy tributary actions and mainstem Sandy easement measures for steelhead will be done in HCP Years 1-5. The City will be conducting effectiveness monitoring for the instream measures; the objective in those cases is to accrue 80 percent of the predicted habitat change within 15 years of implementing each measure (see Chapter 9).
- **Population Response.** Although the HCP is not intended to guarantee specific population responses, implementation of the HCP is expected to result in improved population conditions for steelhead. Table 8-37 describes the anticipated increases of the four VSP parameters: abundance, productivity, diversity, and spatial structure. The estimated population response compared to the Modified Historical Bull Run Condition also indicates that implementation of the HCP will likely result in a population response that is approximately the same as the production potential in the Bull Run watershed. Neither of these estimates includes the habitat or population benefits that will result from the $9 million Habitat Fund.

- **Accumulation of Habitat Benefits.** The HCP conservation measures will accumulate benefits for steelhead at varying rates. Figure 8-15, based on EDT model results, depicts the accumulation of benefits over the 50-year HCP term. The figure shows the predicted increase in adult steelhead abundance that could result from the habitat changes. Benefits are organized according to four general categories of HCP measures: flow, fish passage improvements, instream actions, and riparian easements. The City assumes that the benefits from large wood additions would only contribute to adult steelhead abundance for the first 15 years of their project life. This is a very conservative assumption because it is likely that the wood will be in the various stream reaches beyond 15 years and adding some habitat value for fish. Other instream actions, such as the opening of side channels and riprap removal, are considered permanent for the purpose of the HCP. Riparian easements are assumed to take 15 years before beginning to provide benefits and would not provide full benefits until 30 years after implementation. Flow measures will provide habitat for steelhead starting in Year 1 of the HCP, and fish passage improvements for Cedar Creek should start benefiting steelhead in approximately Year 6 This analysis does not include benefits from providing fish passage in Alder Creek.

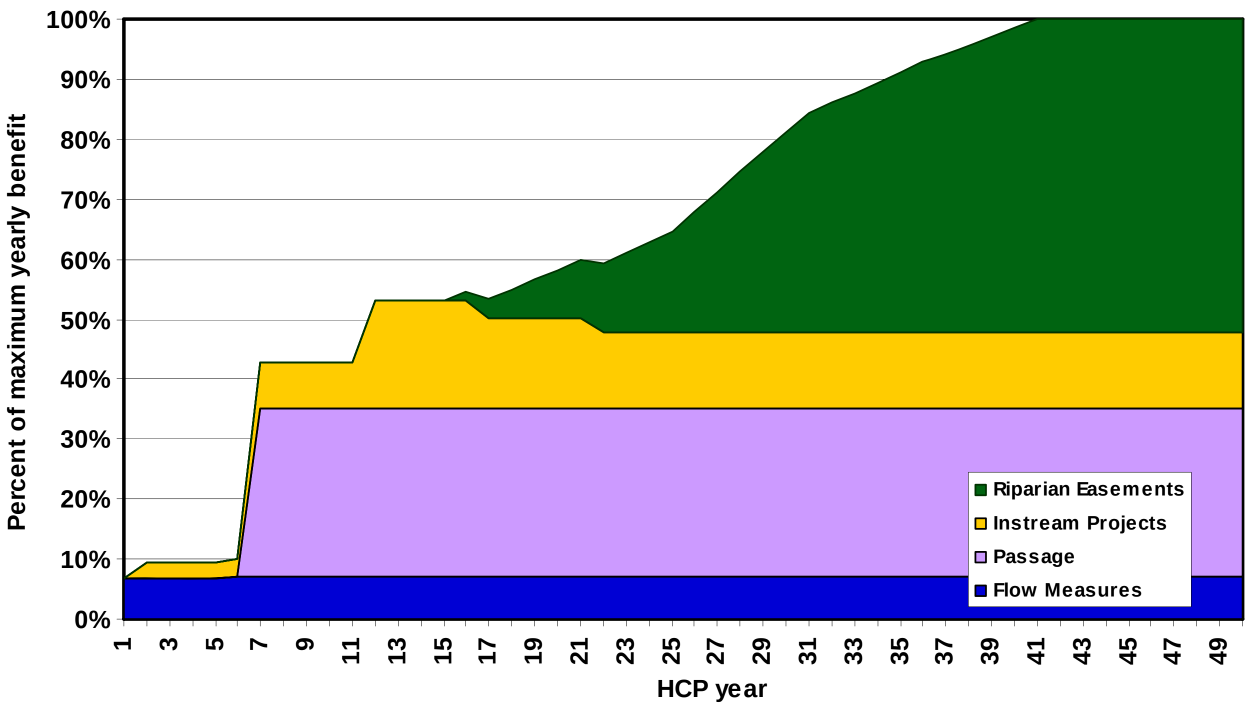


Figure 8-15. Accumulation of Predicted Benefits to Winter Steelhead from HCP Measures over Time[a]

Source: EDT model runs, April 10, 2007.

[a]The accumulated benefits exclude benefits from the following measures: H-3—Little Sandy 1 and 2 LW Placement, P-2—Alder 1 Fish Passage, P-3—Alder 1A Fish Passage, H-25—Salmon 2 Carcass Placement, H-29—Zigzag 1A, 1B, and 1C Carcass Placement

The full steelhead benefits would be realized by approximately HCP year 40. This maximum benefit level closely corresponds to the abundance number used in Table 8-38 for the "HCP Measures with Cedar Creek" scenario, but the benefit level excludes the benefits of large wood additions. Through the term of the HCP, the cumulative total benefits will be 11 percent from the flow measures, 17 percent from instream measures, 35 percent from riparian easements, and 37 percent from the Cedar Creek fish passage improvements.

The City believes the HCP, as a whole, meets ESA Section 10 requirements for steelhead.

8.2.4 Coho Habitat Effects

The HCP measures in the Bull Run watershed minimize the effects on juvenile and adult coho salmon in the lower Bull Run River to the maximum extent practicable. Offsite measures were selected to provide additional benefits for coho salmon to help mitigate for the effects not avoided in the Bull Run. In addition, offsite measures that mitigate for impacts on other covered species also provide benefits for coho. Chapter 11 describes the city's commitment to fund the implementation of the necessary measures.

The potential effects of the City's Bull Run water supply operations on coho salmon in the Sandy River Basin are described in this section. These effects are described in six subsections:

1. Effects in the lower Bull Run River—Describes the habitat effects of both the City's water supply operations and the HCP measures on lower Bull Run habitat for coho
2. Effects in the lower Sandy River— Describes the habitat effects of both the City's water supply operations and the HCP measures on habitat for coho in the lower Sandy River
3. Effects in the Columbia River— Describes the effects of using the City's groundwater supply at the Columbia South Shore Well Field on fish habitat in the Columbia River
4. Effects in Sandy River Basin watersheds—Describes the habitat effects of the offsite HCP measures on coho habitat in watersheds of the Sandy River Basin
5. Effects on the Sandy River populations, by VSP parameter—Describes the population effects of all of the HCP measures (those in the Bull Run and those in the Sandy River Basin offsite locations) on abundance, productivity, diversity, and spatial structure for coho
6. Comparison to a population benchmark—Compares estimates of coho abundance to under historical conditions to estimated abundance after HCP implementation

Summaries for all subsections appear in gray shaded boxes. A detailed description of the effects for the species in the geographic location follows each summary. Conclusions about the habitat effects on coho from implementation of all HCP measures, including the predicted accumulation of habitat benefits over time, are provided on page 8-151.

Summary of Effects on Coho Salmon in the Bull Run Watershed from Bull Run Water Supply Operations and HCP Measures

The City identified 10 types of effects that the HCP conservation measures will have on coho in the Bull Run watershed. The City also analyzed the potential impacts on the base flow of the Columbia River from the HCP flow commitments.

- Impacts associated with fish access to the upper Bull Run watershed, low base flows, and low weighted usable areas will be reduced with the Bull Run conservation measures, but not all impacts will be avoided. Impacts that are unavoidable will be offset by the Sandy offsite conservation measures.
- The Little Sandy flow commitment will increase habitat for coho for the term of the HCP.
- Impacts on spawning gravel, flow downramping, and riparian function will be avoided by the measures.
- There will be some short-term negative water temperature impacts, but long term, the natural thermal potential of the lower river will be returned by the City's infrastructure and operational changes for its dams and reservoirs.
- The removal of large wood at the reservoirs is considered a small impact on coho, and that effect will be mitigated by large wood placements in other streams of the Sandy River Basin that are prime coho production areas.
- The City does not know whether TDG levels harm coho in the lower Bull Run, but they will be studied under this HCP and addressed through adaptive management provisions described in Chapter 9.
- The City's flow measures will have an extremely small effect on the Columbia River base flows, and coho habitat will not be affected.

Table 8-39 summarizes the effects of the water supply operations, the reference condition for the effect, and the predicted effects of the City's HCP conservation measures in the Bull Run watershed for coho.

Table 8-39. Effects of the Bull Run Measures on Lower Bull Run River Habitat for Coho Salmon[a]

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Base flows Winter/Spring Period (egg incubation and juvenile rearing) Summer Period (juvenile rearing) Fall Period (spawning)	Natural Bull Run base flows	Projected HCP flows will be 77 to 81% of natural base flows during the egg incubation and juvenile rearing period from January to May. Projected HCP flows will be 36 to 46% of the natural base flows from June to September for juvenile rearing. Projected HCP flows will be 50 to 80% of natural base flows during the spawning period (October to December).
Weighted Useable Area (WUA) Winter/Spring Period (juvenile rearing) Summer Period (juvenile rearing) Fall Period (spawning)	Natural flow Weighted Usable Area	HCP WUAs for juvenile rearing from January to May will be close to 100% of the maximum WUA value. All impacts will be avoided. HCP WUAs for juvenile rearing from June to September will be 70 to 100% of natural flow WUA levels. HCP WUAs for spawning will be 75 to 100% of the natural flow WUA levels.
Flow Downramping	Protective downramping rate: 2"/hour	The City will meet the protective downramping rate (2"/hour), and fish stranding effects will be minimal.
Little Sandy Base flows	Natural flow; free-flowing	City measures will ensure access to approximately 10 new miles of stream habitat in the Little Sandy River.
Water Temperature	ODEQ standard: natural thermal potential	There will be minor, short-term water temperature impacts prior to installation of infrastructure improvements at Dam 1. Once the infrastructure improvements are in place, all water temperature impacts in the lower Bull Run River will be avoided.

Table 8-39. Effects of the Bull Run Measures on Lower Bull Run River Habitat for Coho Salmon,[a] continued

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Large Wood	Natural wood routing and accumulation	The natural accumulation of wood downstream of Larson's Bridge will slightly improve pool formation, gravel recruitment, and the creation of low-velocity habitat.
Spawning Gravel	Natural levels of gravel recruitment	The City will replace the natural level of gravel recruitment in the lower Bull Run River. All impacts will be minimized.
Fish Access	Historical fish anadromy Total blocked stream miles in the Bull Run River watershed: 26.9 Blocked free-flowing miles in the Bull Run River watershed (excluding the Little Sandy River): 12.1	City will not provide access into the upper Bull Run River. Approximately 10 miles of river will be provided in the Little Sandy River, of which 8 miles could be used by coho.
Riparian Function	Mature riparian zones	City's riparian lands along the lower Bull Run River are currently in good condition. Protective measures in the HCP will maintain and somewhat improve these conditions as younger trees mature.
Total Dissolved Gases (TDG)	ODEQ standard. Maximum of 110% saturation at flows below the 7Q10 flow	The City does not believe there are elevated TDG levels in the current range of anadromy at flows below the 7Q10 flow, but the City will continue monitoring to determine whether the ODEQ standard is being met.

[a]For the list of conclusions about the habitat effects of all HCP measures on coho, see page 8-151.

Habitat Effects in the Bull Run Watershed for Coho

The effects on coho salmon in the lower Bull Run River are described in the following categories: streamflow, water temperature, large wood, spawning gravel, access, riparian function, and TDG.

Streamflow

The City analyzed streamflow effects on coho salmon by two means: comparing the effects of the HCP Bull Run base flows with the natural (pre-water-system) conditions and by determining the coho spawning and rearing WUA likely to result from Bull Run flow measures.

Bull Run Base Flows. The City compared an estimate of median monthly flows (50 percent exceedance flows) under natural conditions (i.e., no dams or diversions in the Bull Run watershed) with anticipated future flows during implementation of the HCP, assuming normal and critical years occur at the same frequency in the Bull Run as they have in the past. A 64-year hydrological record (1940–2004) was used for the analysis. The estimated median flows are for the Bull Run River upstream of the Little Sandy River are shown in Figure 8-14; all flow amounts are relative to the USGS Gauge No. 14140000 located at RM 4.7 on the Bull Run River. The flow analysis considers coho salmon utilization of habitat in the lower Bull Run River, as shown in the periodicity chart in Chapter 5 (Figure 5-36) and Figure 8-16 on the next page.

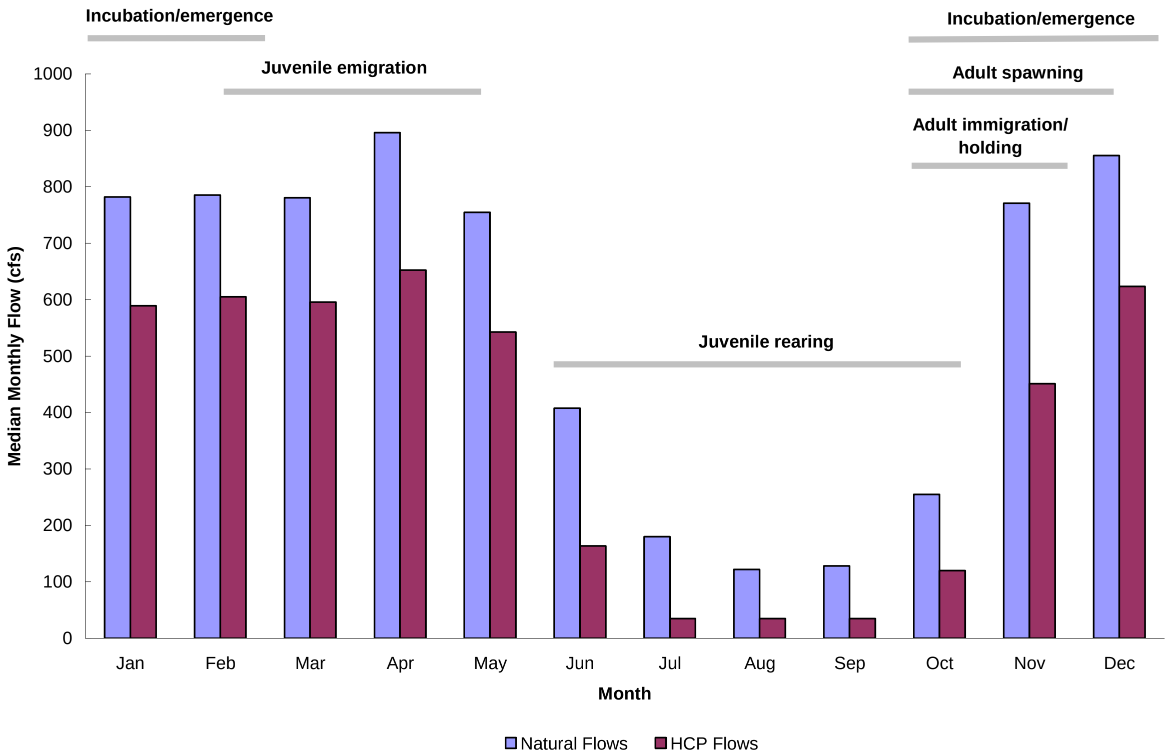


Figure 8-16. Median Monthly Flows and Peak Periods of Occurrence for Coho Salmon in the Lower Bull Run River above the Little Sandy River Confluence[a]

Source: Median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000 (RM 4.7).

[a]Although peak juvenile rearing period is shown here, coho rearing occurs all year. See Figure 5-37 for periods of occurrence in the lower Bull Run River.

Table 8-40 lists the median natural flows and median flows anticipated from implementing the HCP. The comparison is for flows in two segments: upstream of the confluence with the Little Sandy River (RM 3.0—RM 5.8), and downstream of the Little Sandy River (RM 0–RM 3.0). For the portion of the Bull Run River downstream of the Little Sandy River, median flows were determined using the estimated Little Sandy median natural flows that would occur after the Little Sandy Dam is removed.[11]

[11] See Section 4.1.5 Water Quality and Water Rights for more information about the removal of the Little Sandy Dam.

Table 8-40. Natural and HCP Median Flows by Month for the Lower Bull Run River

	Flows above Little Sandy (cfs)[a]		Flows below Little Sandy (cfs)[b]	
Month	**Natural**	**HCP**	**Natural**	**HCP**
January	782	611	938	765
February	785	608	957	776
March	780	606	932	760
April	896	672	1,072	846
May	755	563	898	709
June	408	196	487	274
July	180	35	213	67
August	122	35	141	54
September	128	35	152	55
October	255	120	304	166
November	771	427	924	608
December	857	654	1,031	829

[a]Median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000, Bull Run River (RM 4.7).
[b]The sum of median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000, Bull Run River (RM 4.7) and median monthly flows taken at USGS Gauge No. 14141500, Little Sandy River (RM 1.95).

Effects of Base Flows on Coho Spawning. The primary spawning period for coho salmon in the lower Bull Run River is October through mid-December (see Figure 5-37). The projected median streamflow under the City's HCP would be approximately 20-50 percent lower than the natural median flows for October through December. However, near optimal habitat conditions still will be provided for spawning coho based on the WUA analysis described below.

Effects of Base Flows on Coho Rearing. Flows are consistently highest during the winter and spring period, which will have a minimal effect on coho survival. Projected median flows under the HCP for January through May will be 80-90 percent of the historical median flows in the lower Bull Run River and will range from 600 to 850 cfs. These flows will provide good conditions for incubation and rearing for juvenile coho (R2 Resource Consultants 1998).

The City's HCP flows were also compared with natural flows to determine the difference for the early summer transition and summer/early-fall periods for juvenile coho (June through September). Upstream of the Little Sandy River, the HCP median flows will be 64 percent lower than the natural median flow. Downstream of the Little Sandy, the HCP median flow will be 54 percent lower than the natural median flow. Compared with historical median flows, the City's HCP flows will have a negative effect on juvenile coho during the summer/early-fall flow period. The differences in the two flow levels are further discussed in the following subjection.

Bull Run Weighted Usable Area. WUA values were calculated from median flows for coho spawning and rearing to assess the effect of the HCP flow measures on lower Bull Run River habitat. Table 8-41 compares WUA estimates for natural flow conditions (no dams and diversions) with estimates of HCP flows, both upstream and downstream of the Little Sandy River.

R2 Resource Consultants (1998) estimated the flow-habitat relationships for coho spawning and juvenile rearing in the Bull Run River. Using the PHABSIM model, they generated estimates of WUA for up to 500 cfs in four segments of the Bull Run River. The four segments were combined into the two segments of the lower Bull Run River: upstream and downstream of the Little Sandy River. For flows greater than 500 cfs, goodness-of-fit curves were used to extrapolate WUA values.

The WUA estimates for natural and HCP flows are compared using a "percentage of natural" metric. For example, if the HCP percentage of natural flow is 90 percent, the HCP median flow will yield a WUA value of 0.9 acre in a month, and the WUA value would be 1.0 acre in a month.

Extrapolation above 500 cfs. Extrapolation is considered to provide conservative WUA estimates (Carlson, pers. comm., 2005), although some uncertainty exists regarding extrapolation of coho spawning WUA values above 500 cfs. That is, the goodness-of-fit curves used to extrapolate WUA values for coho spawning continue to trend upward as flows increase above 500 cfs. However, WUA values for coho spawning may start to decline at higher flow levels, such as those observed by R2 Resource Consultants (1998) in the segment of the Bull Run River below the Bull Run powerhouse (i.e., segment 1). In this segment, PHABSIM modeling to 2,400 cfs was possible, and the modeled WUA values for coho spawning start to decline at flow levels above about 700 cfs (R2 Resource Consultants 1998).

Estimated WUA for Spawning. During the primary coho spawning period from October–December, the City's HCP flow measures will create a total coho spawning WUA ranging from 75 to more than 100 percent of the corresponding natural-flow WUA in the lower Bull Run River (Table 8-41). R2 Resource Consultants (1998) indicated that flows between 130 and 200 cfs create near-optimal conditions for creating total usable habitat values (WUA) for spawning coho (see Figure 5-39).

Table 8-41. Comparison of Coho Spawning Weighted Usable Area (WUA) Values in the Bull Run River

Month	Natural Flow (cfs)	Natural Flow WUA	HCP Flow (cfs)	HCP Flow WUA	Percentage of Natural Flow WUA
Above the Little Sandy River					
October	255	1.70	120	1.27	75
November	771	3.12	427	2.45	78
December	855	3.28	654	2.90	88
Below the Little Sandy River					
October	304	0.68	166	0.58	85
November	924	0.20	1.40	0.49	>100
December	1031	0.11	1.41	0.29	>100

Source: R2 Resource Consultants 1998a

The HCP also includes a provision to reduce flows in the fall during water years with critical seasons (see Measure F-2 in Chapter 7). The frequency of these reductions will be limited by the City's commitment. Critical fall flows will only occur in 10 percent of the HCP years. The City's commitment will also limit the occurrence of critical fall flows to no more than two consecutive years. If critical fall flows are triggered, the City will not release critical fall flows in a specific year when most of the resulting adult fish would return to their place of origin. When a critical fall flow year occurs, the City will not implement critical fall flows four years later regardless of whether the critical fall trigger occurs. The measure was developed primarily to protect Sandy River LRW fall Chinook spawning but will also benefit coho salmon. Although it is difficult to analyze the positive effect of this conservation measure on coho because they have a three-year life cycle in the Sandy River Basin (compared with a four- and five-year cycle for fall Chinook), there will be years when the City will provide higher normal year flows in the fall during the coho spawning season.

Estimated WUA for Rearing. Coho salmon rear in the lower Bull Run between June and September. The guaranteed minimum HCP flow during this period varies, but is 20 cfs to 40 cfs from July through September. The projected HCP median flow varies from approximately 35 cfs to 270 cfs.

R2 Resource Consultants (1998) estimated that habitat conditions for juvenile coho salmon increase at a rapid rate between 0 and 100 cfs, with the most rapid increase occurring between 0 and 20 cfs (see Figure 5-40). Under the City's HCP flows, the WUA values range from approximately 70 to more than 100 percent of natural flow WUA values for June through September (Table 8-42).

Table 8-42. Comparison of Weighted Usable Area (WUA) Values for Coho Juvenile Rearing in the Lower Bull Run River

Month	Natural Flow (cfs)	Natural Flow WUA	HCP Flow (cfs)	HCP Flow WUA	Percentage of Natural Flow WUA
Above the Little Sandy River					
June	408	13.84	196	12.89	93
July	180	12.67	35	8.17	64
August	122	11.89	35	8.17	69
September	128	11.99	35	8.17	68
Below the Little Sandy River					
June	487	9.61	274	10.31	>100
July	213	10.47	67	9.53	91
August	141	10.48	54	9.11	87
September	152	10.50	55	9.15	87

Source: EDT model run April 17, 2007

Bull Run Peak Flows. The HCP flow regime will slightly increase the amount of water diverted from the Bull Run watershed over the term of the HCP, but there will be little change to the magnitude of the Bull Run peak flows. The amount of flow diverted annually from the Bull Run is, on average, 20 percent of the total Bull Run water yield. That percentage is based on flow information from 1946-2004 and current (2006) water demands. Based on the median annual water demands with 2025 projected populations provided by Metro, the percentage of Bull Run diverted will increase to 22 percent. Population growth projections beyond 2025 are not available, and therefore the City could make no assumptions about the percentage of diverted Bull Run yield beyond that year.

The City assessed effects on peak flows in the lower Bull Run River by evaluating the annual peak winter flows since Water Year 1960. This data set was used for the peak flow analysis because the USGS gauge was in another location prior to 1960. The City estimated peak winter flows in the absence of the City's water supply diversions, peak winter flows with current (2006) water diversions, and peak winter flows with estimated 2025 water diversions based on Metro's population projections. The estimated change in annual total water yield diverted for supply is expected to increase from 20 percent currently to 22 percent in 2025.

The estimated magnitude of the annual peaks with no water diversions ranged from 4,010 to 25,420 cfs, depending on weather conditions. The estimated magnitude of the annual peaks for current water demands ranged from 3,880 to 25,100 cfs. The estimated magnitude of the annual peaks for 2025 water demands ranged from 3,863 to 25,094 cfs. Differences were determined by comparing flows on individual peak flow dates. The differences between no diversions and current diversions ranged from 0.3 percent to 3.3 percent. The differences between no diversions and estimated 2025 diversions ranged from 0.6 percent to 3.7 percent.

The City also characterized each peak flow event into a return frequency category (i.e., less than 2-year event, 2–5-year event, 5–10-year event, 10–25-year event, 25–50-year event, and 50–100-year event). The flow conditions experienced in those events were applied to current water diversions and 2025 estimated water diversions. In only one case did the increase in winter season water diversions in 2025 cause a change in the return frequency category for peak events. The January 5, 1969 weather year changed from a slightly greater than 2-year event to a slightly less than 2-year event. The City concluded from this analysis that implementation of the HCP will not significantly change the magnitude of peak flow events in the lower Bull Run River. Peak flow events will continue to occur with a frequency and magnitude similar to current conditions and similar to conditions that would occur without water supply diversions.

Bull Run Flow Downramping. The City's hydroelectric plant at the base of Dam 2 varies the streamflow in the lower Bull Run River during the winter and spring months when there is enough streamflow to run the facility. The current FERC license allows for a 2'/hour downramping rate for the lower Bull Run River, but the City is committing to a lower rate (2"/hour) to protect juvenile salmonids.

The City has studied juvenile salmonid stranding during different downramping events in the lower Bull Run River (Beak Consultants 1999; CH2M HILL 2002). The sites selected for monitoring included the widest areas of the channel that were considered most sensitive to ramping effects and stranding. Steelhead fry (about 40 mm average length) and yearlings (Age-1) juveniles were observed during the studies. No other salmonids were present during the stranding studies, and the City has assumed that the observations of juvenile steelhead behavior are adequate for determining potential ramping rates effects. Based on these studies, a ramping rate of no more than 2"/hour was recommended as being protective of salmonids for the lower Bull Run River. This rate is generally what the state of Oregon and others have recommended to protect against juvenile fish stranding (CH2M HILL 2002; Hunter 1992).

The City will avoid or minimize the risk of stranding coho juveniles by maintaining a maximum downramping rate of 2"/hour year-round for the hydroelectric powerhouse downstream of Bull Run Dam 2. Not all impacts from downramping can be avoided, however, due to certain circumstances beyond the control of the City.

The City conducted a year-long evaluation of downramping (Galida 2005) and determined that circumstances when the City would not meet the ramping rate occurred 0.4 percent of the total time. These circumstances included natural storm flows, mechanical/control system failures that are impossible to predict, and FERC mandatory testing of project safety equipment. Out of the test period of approximately 8,800 hours of hydropower operations, the 2"/hour downramping rate was exceeded only for 35 hours. The exceedances occurred from mid-November through late-March, and streamflow in the lower Bull Run River was 200-12,600 cfs. Natural streamflows were quite variable and since the reservoirs were full, the downramping rate could not be controlled by the City for approximately one-third of the 35 hours. Other exceedances can be attributed to equipment testing and operator error. Overall, the City was very successful in controlling the downward fluctuation of the lower Bull Run River.

The City's commitment to a downramping rate of 2"/hour will result in minimal effects on coho. The occurrences of downramping greater than 2"/hour will rarely occur in the future, and if they do, they will happen during the winter months. The primary spawning period for coho in the Bull Run is October and November (see Chapter 5), and near-optimal conditions for spawning and egg incubation occur between flows of 130 and 200 cfs (R2 Resource Consultants 1998). All downramping rate exceedances (>2"/hour) that the City observed were during flows of greater than 200 cfs, and spawning/incubation of coho will not be harmed with the City's downramping measure. Also, there will be a very low potential for stranding juvenile coho because the higher downramps would occur only infrequently and sporadically during the late winter and early spring.

The City will continue to monitor downramping in the lower Bull Run as part of the compliance monitoring efforts (see Chapter 9).

Little Sandy River Base Flows. Forgoing development of the City's water rights on the Little Sandy River during the term of the HCP will assure unimpeded natural flows on the Little Sandy River for coho. Coho will have access to approximately 7.3 river miles of the mainstem Little Sandy River and approximately 2 miles of tributary habitat. This measure will increase spawning and rearing habitat for coho, as well as contribute to higher flows in the lower Bull Run River below the Little Sandy confluence, as indicted in Tables 8-41 and 8-42.

Water Temperature

Coho salmon probably utilize the Bull Run River year-round and most of the year the water temperatures are generally cool and acceptable for the species (Figure 8-17). The species spawns in the lower Bull Run in the October through mid-December, emerges from the gravel in the spring, and rears throughout the year (see Figure 5-37 in Chapter 5). The only time of the year when the water temperatures are too warm for the species is during the summer and early fall.

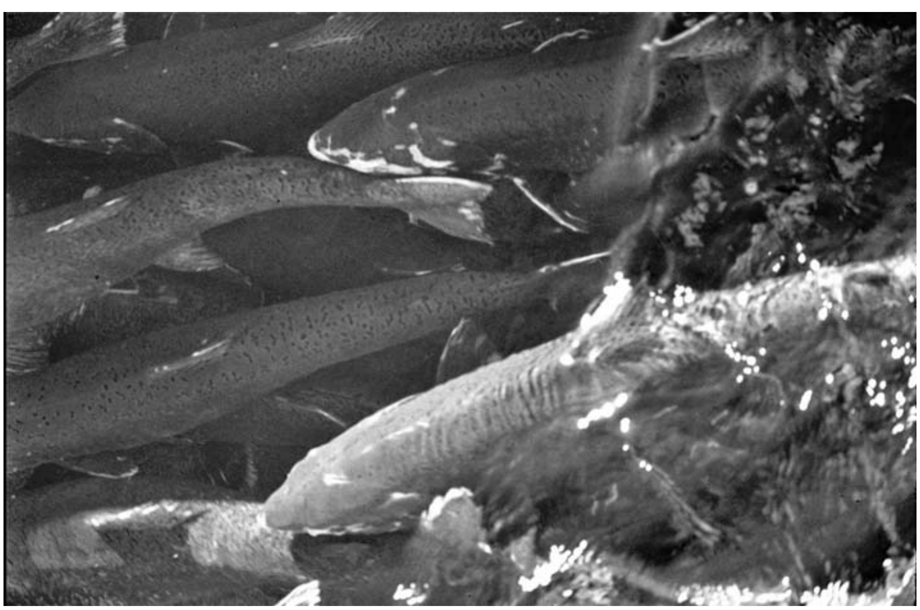


Photo courtesy of Bonneville Power Administration.

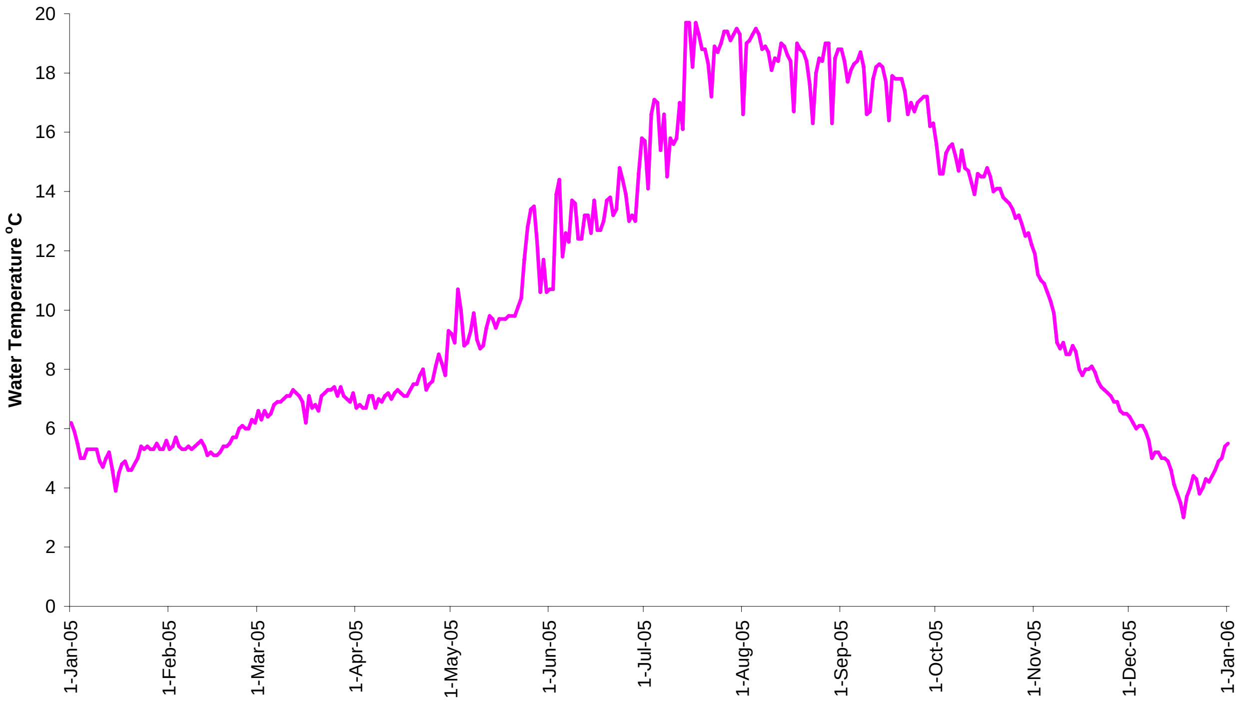


Figure 8-17. 2005 Daily Maximum Water Temperatures for the Lower Bull Run River as Measured at USGS Gauge No. 14140000 (RM 4.7)

Source: USGS Gauge No. 14140000 on the Bull Run River (RM 4.7).

The reference condition for water temperature is the natural thermal potential of the lower Bull Run River. Natural thermal potential is defined by ODEQ in the Sandy River TMDL (ODEQ 2005) as the water temperatures that would occur in the Bull Run River if there were no dams or diversion. The City, in conjunction with ODEQ, developed a method to determine the natural thermal potential of the lower Bull Run River and found that the current temperature regime of the Little Sandy River is a good surrogate for the Bull Run. See Measure T-2 in Chapter 7 for more details.

Pre-Infrastructure Water Temperature Effects. The City plans to make significant infrastructure improvements at Dam 2 to meet the natural thermal potential of the lower Bull Run River. However, prior to completion of the infrastructure improvements, water temperatures in the lower Bull Run River during the summer and the early part of the spawning season will exceed those preferred by coho (Figure 8-18).

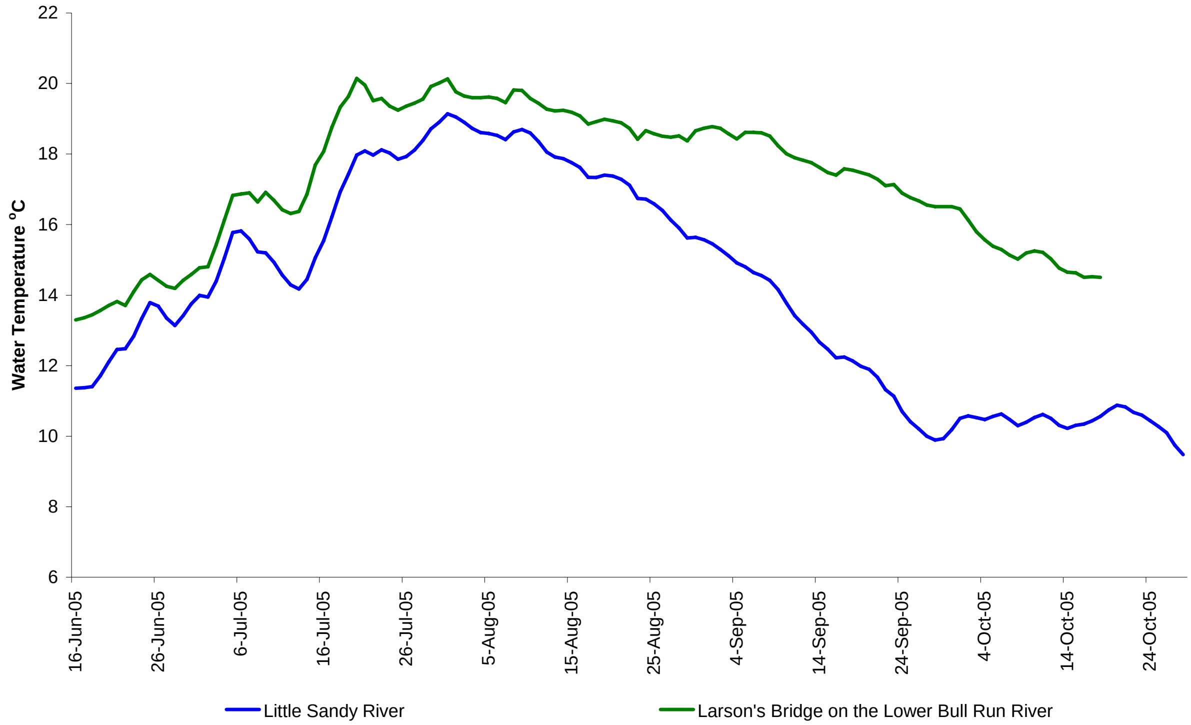


Figure 8-18. 7-Day Maximum Average Water Temperatures for the Little Sandy and Lower Bull Run Rivers, June 16–October 24, 2005

Source: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8) and USGS Gauge No. 14140000 on the Bull Run River (RM 4.7).

The City will continue to carefully manage the amount of cool water in the reservoirs for downstream flow releases. Figure 8-18 indicates the water temperature performance that the City will be able to achieve in the first years of the HCP. For spawning coho, the water temperature of the lower Bull Run River, expressed at Larson's Bridge in Figure 8-19, would be approximately 14—16 °C for the first two weeks of October. That is slightly higher than ODEQ's water temperature criterion of 13 °C for spawning salmonids. For rearing coho in the summer and early fall, the City has established the interim goal of not exceeding 21 °C at Larson's Bridge on the lower Bull Run River. That target is cool enough to allow continued growth of coho. While this temperature target is higher than the range preferred by rearing coho, it is the best performance outcome that the City can achieve with the current dam infrastructure. With the City's temperature management, there will be some temporary effects on coho.

Within five years of the start of the HCP, the infrastructure changes at Dam 2 will be completed and the natural thermal potential of the Bull Run River will be met. The pre-infrastructure water temperature effects should be minimal because the water temperature will not be significantly higher than ODEQ's criterion and these conditions should only last approximately five years.

Post-Infrastructure Water Temperature Effects. The City will complete infrastructure changes at the Dam 2 towers and the stilling basin and commit to daily operational flow management (Measures T-1 and T-2). The City used the CE-QUAL-W2 water quality model to predict natural condition stream temperatures in the lower Bull Run River (City of Portland 2004). The model predicted that maximum stream temperatures would occur at Larson's Bridge (RM 3.8) in the lower Bull Run River. City staff and ODEQ staff evaluated modeling results and empirical data and concluded that natural stream temperatures in the lower Bull Run River could be estimated using the stream temperature of the Little Sandy River (Figure 8-19).

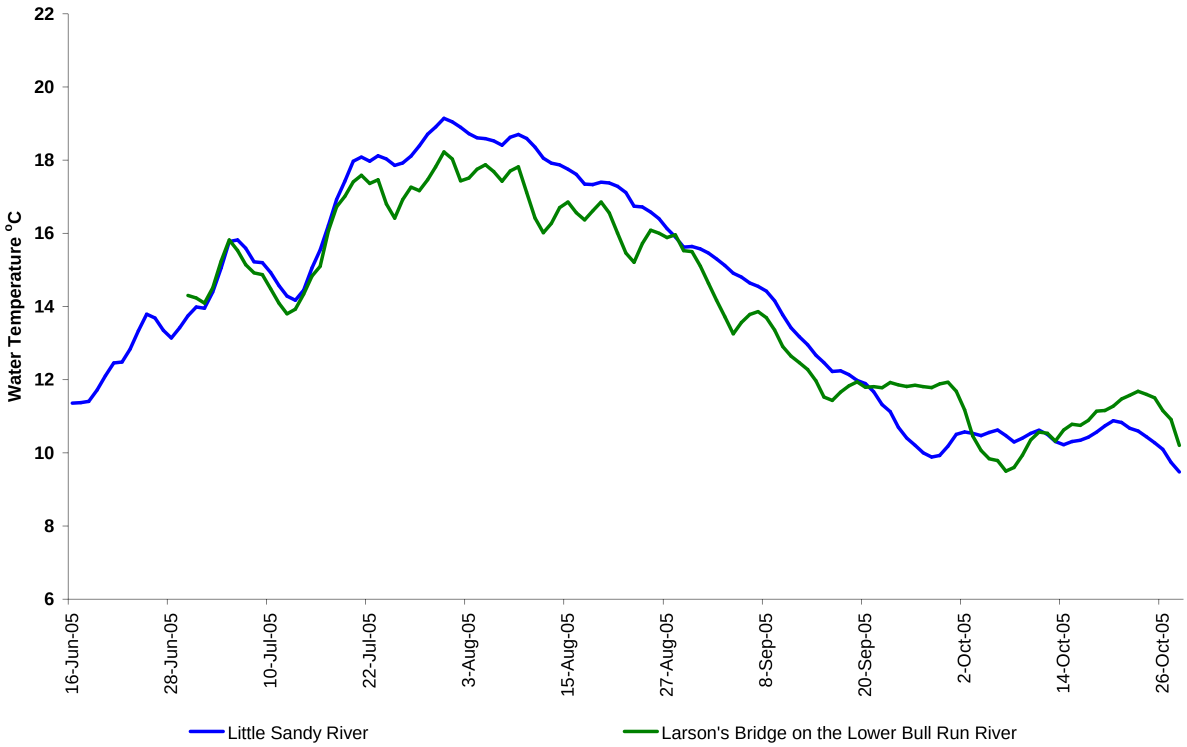


Figure 8-19. Comparison of Actual 7-Day Maximum Water Temperatures for the Little Sandy Compared with Predicted 7-Day Maximum Average Temperatures for the Lower Bull Run River, June 16–October 24, 2005

Source: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8) and CE-QUAL-W2 Modeled Temperatures (February 2006).

The summer and early fall water temperatures in 2005 indicate that water temperatures at Larson's Bridge will be generally lower than temperatures in the Little Sandy but are within approximately 1 °C (see Figure 8-19). ODEQ has established water temperature criteria for the Larson's Bridge location under the authority of the CWA and the Sandy River Basin TMDL (see Measure T-2 in Chapter 7).

Within 5 years of the start of the HCP, the infrastructure changes at Dam 2 will be completed and the natural thermal potential of the Bull Run River will be met. Water temperature impacts on coho would be minimized.

Diurnal Water Temperature Fluctuations. Diurnal water temperature fluctuations likely to result from implementing the HCP measures were estimated using modeling and measured Little Sandy River water temperatures. Table 8-43 lists observed and expected temperature fluctuations for the summer and late summer months. These are the months when the City's implementation of the water temperature measure (Measures T-1 and T-2) will affect diurnal temperature fluctuations. The fluctuations expected after implementing the HCP measures are predicted to be smaller than the fluctuations that would occur under natural conditions.

Table 8-43. Diurnal Water Temperature Fluctuations (°C)

	Temperature Fluctuations (°C)		
Month	**Bull Run Observed (current conditions)**	**Little Sandy Observed (natural conditions)**	**Expected Under HCP**
June	4-6	0.5-5	2-3
July	4-6	1-5	2-3
August	3-5	1-5	2-3
September	2-3	1-4	1-2

Source: Bull Run observed temperatures: USGS Gauge No. 14140000 on the Bull Run River (RM 4.7); Little Sandy observed temperatures: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8); expected HCP temperatures: CE-QUAL-W2 Modeled Temperatures (February 2006).

The City reviewed available research on the influence of fluctuating water temperature on the growth of salmonids. Experiments on steelhead and coho (Hahn 1977; Grabowski 1973; and Thomas et al. 1986) indicated that fluctuating water temperature tests and the constant test exposures produced equivalent results. The City concludes that the reductions in diurnal water temperature fluctuations will not affect coho salmon or other salmonids that utilize the lower Bull Run River.

Large Wood

Large wood is removed from the upper end of Reservoir 1 to protect the downstream water supply dams from damage. USFS owns this wood because it is transported by tributaries from national forest land. Because the wood is not allowed to travel down the lower Bull Run River, a small amount of beneficial habitat for coho may be lost. The lower Bull Run River is, however, a high-order steep stream, and is not likely to trap and store large wood. Photographs taken of the lower Bull Run in the late 1890s, before the dams and water diversions were constructed, show little large wood in the channel. The lower river is probably a transport reach for large wood.

The lower Bull Run River is dominated by bedrock and boulders. This channel roughness supports diverse habitats, including about 27 percent pool habitat. The presence of this pool habitat suggests that large wood is not an important requirement of pool formation, and the addition of large wood would provide only a minor increase in pool habitat.

The City does not plan to artificially place large wood in the lower Bull Run River above Larson's Bridge because of concerns about the vulnerability of water supply infrastructure (i.e., conduit trestles). The City will let natural recruitment of large wood occur downstream of Larson's Bridge. Trees that fall naturally will be left in place to modify the stream channel as long as the water conduits and bridges are not threatened. This large wood could slightly improve habitat conditions for coho by reducing the overall grain sizes and creating pools in localized areas in the lower 3.8 miles of the Bull Run River.

Spawning Gravel

The two Bull Run dams interrupt bedload and gravel movement to the lower Bull Run River, resulting in reduced spawning habitat for coho salmon and other salmonid species. The estimated historic gravel supply rate was roughly 30—1,000 cubic yards (CH2M HILL 2003b). The City will place approximately 1,200 cubic yards per year for the first five years and 600 cubic yards per year thereafter (see Measure H-1 in Chapter 7). The City will monitor the effects of the gravel placement to determine whether the measure should continue for the term of the HCP or should be modified. The gravel replacement rate will be higher than the estimated natural accumulation. Placement of gravel in the lower Bull Run River should significantly improve the spawning conditions for coho salmon.

Access

Coho salmon were first blocked from the upper Bull Run watershed in 1921 by construction of the Diversion Dam (approximately RM 5.9). That dam diverted Bull Run water into conduits to serve the greater Portland metropolitan area. In 1964, as part of the Dam 2 construction, a rock weir was built at RM 5.8 to create the Dam 2 plunge pool for energy dissipation. The rock weir is now the upstream limit for coho. Coho access is also blocked at the mouth of Walker Creek, a tributary to the Bull Run River. Historically, about 800 feet of this stream was probably used by coho salmon.

Coho access will remain blocked at the rock weir (RM 5.8). Continued operation of the City's water supply operation will block coho access to approximately 21.3 miles of the upper Bull Run River. Of these blocked miles, 12.1 are free-flowing river and 9.2 river miles are inundated by City reservoirs. The City will provide access to Walker Creek as part of its HCP. A culvert or other appropriate structure that meets fish passage criteria will be constructed so that coho will have access to this tributary of the Bull Run River.

When PGE removes the Little Sandy Dam, coho will have access to an additional 5.6 river miles of the mainstem Little Sandy River and possibly 2.0 miles of tributary streams. The City's agreement to maintain flows for fish in the Little Sandy (see Measure F-4, Chapter 7) will help retain habitat benefits from this renewed access to historic coho habitat.

The City will also improve access for coho in Alder Creek, which is a tributary to the middle Sandy River. This effect is described below in the Offsite Habitat Effects section.

Riparian Function

The City owns land along 5.3 miles of the lower Bull Run River (1,650 acres). The City's lands represent 82 percent of the riparian corridor below Dam 2. Managing these lands to protect riparian habitat (see Measure H-2 in Chapter 7) will improve habitat for coho salmon. Approximately 30 percent of the riparian corridor along the lower river is in late-successional (late-seral) timber that can provide immediate large wood recruitment to the channel. Further, 80 percent of the riparian corridor is of mid- to late-seral age and will provide wood to the channel at an increasing rate over the next 10 to 70 years (Cramer et al. 1997).

Additional analysis of shading in the lower Bull Run River indicates that riparian vegetation currently intercepts 40 to 60 percent of the total solar radiation that potentially could reach the water surface (Leighton 2002). This level of shading provides a substantial benefit by maintaining lower water temperatures. This shading benefit will become greater over time as the vegetation continues to mature. The mature vegetation in the lower Bull Run combined with the results the temperature measures (infrastructure changes to the intake towers and temperature management) will closely approximate natural water temperatures and reduce the effects of water system operations on coho salmon.

Total Dissolved Gases

Oregon’s Water Quality Standards state that TDG levels should not exceed 110 percent of saturation unless flows exceed the ten-year, seven day average flood (7Q10) flow for the site [OAR 340-041-0031]. The 7Q10 flow for the lower Bull Run River is 5,743 cfs. The City has monitored all water system structures, valves, or turbines that could elevate TDG levels since 2005 and has determined that coho are unlikely to be adversely affected by TDG levels in the Bull Run River. A 55-foot deep stilling pool at the base of the Dam 2 spillway is the site most likely to produce TDG levels that could affect coho. This location, however, is upstream of the range of anadromous fish. Monitoring by the City indicates that elevated levels of TDG quickly decrease as water passes over the rock weir below the stilling pool (RM 5.8). The City has never measured TDG levels that met or exceeded 110% in the anadromous portion of the Bull Run River, unless the 7Q10 flow was also exceeded. TDG levels further dissipate between the rock weir and Larson’s Bridge. All of the coho observed in the lower Bull Run River were downstream of Larson’s Bridge (Strobel 2007a, Clearwater BioStudies 1997; 2006, ODFW 1998; Beak Consultants 2000a,b). Coho are probably not impacted by TDG levels in the Bull Run River. The City will continue to monitor TDG levels in the Bull Run as described in the Effectiveness Monitoring section in Chapter 9 and Appendix F, Monitoring Plans and Protocols.

Summary of Effects on Coho Salmon in the Lower Sandy River from Bull Run Water Supply Operations and HCP Measures

The City identified four types of effects that water supply operations and the HCP measures will have on coho habitat in the lower Sandy River.

- Base flows in the lower Sandy would be reduced by continued water supply operations in the Bull Run watershed. Under the City's HCP measures, these base flows will not have negative effects on coho in the lower Sandy River.
- Flow downramping effects in the lower Sandy will be avoided because of the City's downramping commitments in the Bull Run.
- The City's HCP measures will probably have small beneficial effects on water temperatures in the lower Sandy.
- The City will also minimize the impact of removing large wood from the lower Bull Run by adding large wood directly into the lower Sandy.

Overall, the City's HCP measures will have positive effects on coho habitat in the lower Sandy River. Table 8-44 summarizes the habitat effects of the Bull Run measures in the lower Sandy.

Table 8-44. Effects of the Bull Run Measures on Lower Sandy River Habitat for Coho Salmon[a]

Type of Effect	Reference Condition	Habitat Effects of Conservation Measures
Base Flows	Natural Sandy River base flows	Flows after implementation of the HCP will be more than 80% of natural base flows.[b]
Weighted Usable Area	Natural Sandy River base flows	No adverse effects are expected for coho (R2 Resource Consultants 1998).
Flow Downramping	Protective downramping rate: 2”/hour	The City’s water supply operations will have minimal effects on fish stranding caused by downramping.
Water Temperature	ODEQ standard: natural thermal potential	The City’s HCP measures will probably have small water temperature benefits.
Large Wood	Natural wood accumulation	Removal of large wood from the reservoirs reduces the amount of large wood loading to downstream Sandy River reaches and reduces channel complexity. City measures will increase large wood levels and habitat diversity, minimizing adverse effects of Bull Run operations in the Sandy River below the Bull Run confluence.

[a]For the list of conclusions about the habitat effects of all HCP measures on coho salmon, see page 8-151.
[b]Based on flow data from 1985-2001, natural base flows were reduced by 4-19 percent (CH2M Hill 2002).

Habitat Effects in the Lower Sandy River from the Bull Run Measures

The EDT database and model were used to identify limiting factors having the greatest impact on coho salmon in the lower Sandy River below the confluence with the Bull Run River. The factors identified were food, habitat diversity, harvest, flow, channel stability, competition from the same species, predation, water temperature, pathogens, and sediment. Of these 10 factors, three are potentially affected by water supply operations in the Bull Run: flow, water temperature, and large wood recruitment (as a subfactor in habitat diversity). The other seven factors are not directly related to water supply operations.

Streamflow

The City includes several flow measures to improve conditions for coho in the lower Sandy River, but information specific to coho utilization is lacking. A flow effects analysis was completed for Chinook salmon and steelhead in the lower Sandy River below the Bull Run (CH2M HILL 2002).[12] The City assumes that the general benefits described for Chinook and steelhead would also benefit coho. Coho primarily use the Sandy River below the Bull Run confluence for rearing and emigration; very little coho spawning occurs in the lower Sandy River mainstem. The CH2M HILL analysis focused on the potential effects of the City's Bull Run operations on base flows and on flow fluctuations (ramping). The analysis used Bull Run flows from 1985 to 2001, which are lower than the HCP flows as described in Chapter 7.

Base Flows. The City compared the WUA (for Chinook and steelhead) and monthly flow amounts without City operations to the WUA and monthly flows during the 1985 to 2001 period. City operations from 1985 to 2001 reduced base flows in the lower Sandy River by 4 to 19 percent (depending on month), but increased habitat for Chinook and steelhead spawners. The CH2M HILL analysis (2002) concluded that Chinook and steelhead spawning and rearing in the lower Sandy River would not be adversely affected by the City's operations, even at lower flows than those described in Measure F-1 in Chapter 7. R2 Resources Consultants (1998) similarly concluded that flow enhancement in the lower Bull Run River would have little or no beneficial effect on spawning and rearing salmon and steelhead in the lower Sandy River.

Downramping. The CH2M HILL (2002) analysis indicates that a downramping rate of 2"/hour would eliminate juvenile salmonid stranding in the lower Bull Run River. Given the analysis above about base flow effects, the HCP downramping measure is also expected to minimize any potential juvenile stranding effect in the lower Sandy River.

Water Temperature

Both ODEQ's and the City's water temperature modeling results indicate that the lower Sandy River reaches are in a state of relative equilibrium. City water supply operations have little influence on heating or cooling of the lower Sandy River. This conclusion is supported in the Sandy River Basin TMDL (ODEQ 2005).

Although the City's operations in the Bull Run will not negatively affect water temperatures in the lower Sandy River, some of the City's offsite conservation measures will probably have small water temperature benefits (see page 8-140 for effects on the lower Sandy watershed).

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[12] The CH2M HILL study was based on an instream flow study completed for the lower Sandy River (Beak 1985). The Beak study did not develop flow versus habitat relationships for coho salmon.

Large Wood

Removal of large wood from the Bull Run reservoirs reduces the amount of large wood loading to downstream Sandy River reaches and reduces channel complexity for salmonids. To mitigate for this impact, the HCP includes several large wood measures in the lower Sandy River (see Measures H-4, H-11, H-12, and H-13 in Chapter 7).

Habitat Effects in the Columbia River from Use of Groundwater

The City will use groundwater from the Columbia South Shore Well Field in conjunction with the Bull Run River flows to provide the total amount of water needed to meet water supply demands and the HCP flow commitments. The Columbia River is adjacent to the well field, so the City analyzed the effect groundwater use might have on flows in the Columbia River.

As context, only one instream flow commitment has been established for the lower Columbia River to maintain the persistence of ESA-listed species. This requirement is the FCRPS's minimum flows of roughly 125,000 cfs below Bonneville Dam, unless competing priorities preclude it (USCOE et. al. 2006). These minimum flows are increased by contributions from the Sandy and Washougal rivers before arriving at the Glenn Jackson Bridge (I-205 bridge), approximately 14 miles west of the mouth of the Sandy River.

The well field has an estimated sustainable capacity of approximately 85 mgd, which is equivalent to approximately 130 cfs. The actual amount and duration of pumping will vary according to the weather and supply conditions, but typically the amount pumped per day would be significantly less than the full capacity. The well field draws on four regional alluvial aquifers. Recharge for these aquifers occurs as far south as the Boring Hills (Hartford and McFarland 1989). These aquifers generally discharge into the Columbia River.

As a simplifying worst-case assumption for this analysis, the City assumed that 85 mgd would be pumped from the well field and that this amount would be drawn into the aquifers from the Columbia River. (This is a significant overestimate because the water pumped would actually be drawn primarily or completely from the aquifers themselves and not from the river into the aquifers.) The assumed flow into the aquifers would reduce the assumed flow available in the Columbia River for fish.

If the City's groundwater pumping were to result in a 130 cfs reduction in Columbia River flows, that reduction would be at most 0. 1 percent of the total river flow (based on the 125,000 cfs minimum flows mentioned above). To put this reduction in perspective, the typical margin of error on measured flows for the Columbia River is +/- 10 percent (see, for example, the gauge at the Columbia River at The Dalles, USGS 2003). This measurement error is significantly larger than the estimated flow reduction due to groundwater use. In addition, the mainstem Columbia River has tidal fluctuations that average approximately 1.7 feet (data from USGS Gauge No. 14144700). This natural daily change in river stage is many orders of magnitude greater than any potential reduction of Columbia River flows due to the City's use of groundwater. The City's conclusion is, therefore, that use of the Columbia South Shore Well Field as a means to enable the HCP flow commitments in the lower Bull Run River will have a negligible influence on the Columbia River base flows and associated habitat for coho salmon migrating in the river.

Summary of Effects on Coho Salmon in the Sandy River Basin from the HCP Offsite Measures

The HCP offsite measures in coho production areas are included to mitigate effects that cannot be avoided in the lower Bull Run River.[13] The upper Sandy River Basin, upstream of the Marmot Dam site, has almost all of the coho anchor habitat reaches. The HCP measures in the upper Sandy will improve riparian zone and channel conditions, increase side channel habitat, and increase large wood loads over time. The City will implement measures to benefit coho in the Middle Sandy River watershed, including riparian easements and improvements, large wood placement, and removal of passage barriers on Alder and Cedar creeks. Although the HCP measures in the lower Sandy River were selected with the primary intent to improve habitat conditions for fall Chinook, some benefits will accrue for coho as well.

- The improvements in the Little Sandy River will increase spawning and rearing habitat and provide cover for juveniles.
- Reduced risk of peak flow displacement, increased rearing and overwintering habitat, and improved habitat diversity will benefit juveniles in the lower and middle Sandy River and Boulder Creek.
- The HCP measures in the lower Sandy River will also provide escape cover for juveniles and improve adult passage.
- Small temperature benefits in the lower and middle Sandy River will improve parr productivity and egg incubation, respectively.
- The improvements in Gordon Creek will provide habitat diversity for rearing juveniles, provide habitat for overwintering juveniles, and improve egg incubation.
- Passage improvements in Alder and Cedar creeks will provide access to approximately 17 new stream miles for coho.
- In the upper Sandy River, all juvenile life stages will benefit from the increase in habitat diversity; rearing parr, fry, and spawners will benefit from the large wood loading, which will create pool habitat.
- The improvements in the Salmon River will increase the amount and diversity of key habitat for juveniles and increase spawning habitat. Over time, the riparian easements will provide small slight temperature benefits and cover for juveniles, and will help reduce bed scour. Carcass placement will improve food availability in the first year.
- Details of the specific improvements in coho habitat that will result from the offsite measures are described in this chapter and in Appendix E. Overall, the City's offsite conservation measures will improve habitat for coho in the Sandy River Basin.

[13] Effects in the lower Bull Run River include reduced base flows and weighted usable areas and blocked access to the upper Bull Run watershed.

Habitat Effects in the Sandy River Basin from the HCP Offsite Measures

The City's HCP includes 30 offsite habitat conservation measures. Most of these actions address environmental problems affecting the production of more than one species. This analysis describes the effects of the HCP measures on coho salmon. Effects are described by watershed and address both coho life stages and limiting factors. (See Chapter 5 for additional information on the coho population in the Sandy River Basin and the habitat factors that limit production.)

Little Sandy River

The City's water supply operations do not affect the Little Sandy River because it is a tributary to the lower Bull Run River downstream of the City's dams and diversion. The City's large wood habitat conservation measure for the Little Sandy River was selected to improve habitat diversity for spawning and rearing habitat for coho and other salmonids.

The City will place large wood in the Little Sandy River (see Measure H-3 in Chapter 7), which will slightly increase channel complexity and gravel sorting for coho and other fish species. Coho habitat should slightly improve with the large wood additions. The large wood will add channel complexity and create low-velocity areas for overwintering coho juveniles and will modify the channel hydraulics of the Little Sandy River and trap suitable spawning gravel.

Lower Sandy River Watershed

The lower Sandy River watershed consists of the 18.5 miles of the Sandy mainstem between the Bull Run and Columbia river confluences (Sandy 1 and 2 reaches), plus the following tributaries: Beaver, Buck, Gordon, and Trout creeks. Coho spawn in the tributaries of this watershed but not in the mainstem Sandy River to an appreciable degree. This may be a result of years of releases from Sandy Hatchery combined with historical passage difficulties below the former Marmot Dam. Currently, coho spawn in the lower 7.3 miles of Gordon Creek and the lower 0.75 mile of Trout Creek, and in lesser numbers in the lower 0.5 mile of Buck Creek and the lower 7 miles of Beaver Creek.

HCP measures were selected in the lower Sandy River with the intent to mitigate effects on coho salmon that cannot be avoided in the Lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The analysis considers beneficial effects for coho that are likely to result from measures designed primarily for other species.

The City will implement measures in this watershed to benefit coho, including a reconnected side channel, reestablished mouth, riparian restoration, and engineered log jams on the lower Sandy mainstem, as well as large wood placement and riparian enhancements in Gordon and Trout creeks. A detailed description of each measure and the affected reaches is available, by watershed, in Chapter 7.

Table 8-45 lists the reaches affected by HCP measures planned in the lower Sandy River and the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-45. Habitat Benefits for Coho in the Lower Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Beaver 1A	Riparian function	Improvement
	Large wood	Increase
Gordon 1A	Fine sediment in gravel patches	Decrease
	Backwater pools	Increase
	Large-cobble riffles	Decrease
	Pool habitat	Increase
	Pool-tail habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Large wood	Increase
Gordon 1B	Backwater pools	Increase
	Pool habitat	Increase
	Pool-tail habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Large wood	Increase
Sandy 1	Artificial confinement	Reduction
	Off-channel habitat	Increase
	Riparian function	Improvement
	Large wood	Increase
Sandy 2	Off-channel habitat	Increase
	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Trout 1A	Large wood	Increase
Trout 2A	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

The City's HCP measures will substantially increase large wood in the mainstem Sandy River, improve riparian function, and create a large quantity of key side-and off-channel habitat for juvenile coho. The additional large wood will stabilize the stream channel to some degree, lessen peak flow displacement risks to fry and overwintering juveniles, and provide escape cover from predators. The improved riparian function will moderate temperatures to some degree, which in turn will improve parr productivity.

In Gordon and Trout creeks, the increase in large wood will have a commensurate increase in pools, backwater pools, and pool tail-outs for parr and overwintering juveniles. The gravel trapped by the newly installed log structures will also improve channel stability for incubation and overwintering juveniles. In Gordon Creek, the riparian enhancement project on the lowermost reach will stabilize crumbling banks and reduce the amount of sediment in spawning gravels.

Middle Sandy River Watershed

Most of the middle Sandy River mainstem is carved through bedrock in a deep, steep-walled gorge. Coho primarily use this river segment as a migration corridor (SRBP 2005). The main impact to habitat quality in the mainstem middle Sandy has been Marmot Dam, which is outside the authority of the City and was decommissioned in July 2007.

Upstream of the Marmot Dam site, little spawning occurs in the middle Sandy, except in the inflow reach of the Marmot Dam site. This reach (Sandy 6) provides exceptional mainstem spawning and rearing habitat with a low gradient, pools, riffles, side channels, and relatively abundant cobble/gravel substrate and large wood.

The portions of Alder and Cedar creeks that are accessible to coho support natural productivity. A weir constructed in the early 1950s partially blocks fish passage approximately 0.5 mile upstream from the mouth of Cedar Creek (SRBP 2005).

The HCP measures were selected in the middle Sandy River with the intent to mitigate effects on coho salmon that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The analysis considers beneficial effects for coho that are likely to result from measures designed primarily for other species.

The City will implement measures that will benefit coho in the middle Sandy River watershed, including riparian easements and improvements, carcass placement, large wood placement, and water rights purchases. A detailed description of each measure and the affected reaches, by watershed, is presented in Chapter 7.

The City will modify two structures in Alder Creek and one in Cedar Creek, which are tributaries to the middle Sandy River. The City will also purchase available water rights in Cedar Creek (see Measure F-5, Chapter 7) to improve habitat conditions for coho and other species. Currently, coho use the lowest reach of Cedar Creek. After the modifications are made, approximately 5.5 river miles will be accessible for coho salmon in Alder Creek and approximately 12 miles in Cedar Creek.

Table 8-46 lists the reaches affected by HCP measures planned in the middle Sandy River and summarizes the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-46. Habitat Benefits for Coho in the Middle Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Alder 1	Large wood	Increase
	Blocked access	Increase
Alder 1A	Riparian function	Improvement
	Blocked access	Increase
Alder 2	Riparian function	Improvement
	Large wood	Increase
Cedar 1	Dissolved oxygen	Increase
	Fish pathogens	Improvement
	Minimum water temperature	Decrease
	Maximum water temperature	Decrease
	Temperature moderation by groundwater	Improvement
	Blocked access	Increase
Cedar 2	Dissolved oxygen	Increase
	Fish pathogens	Improvement
	Off-channel habitat	Increase
	Riparian function	Improvement
	Minimum water temperature	Decrease
	Maximum water temperature	Decrease
	Temperature moderation by groundwater	Improvement
	Large wood	Increase
Cedar 3	Dissolved oxygen	Increase
	Fish pathogens	Improvement
	Beaver pond habitat	Increase
	Off-channel habitat	Increase
	Pool habitat	Increase
	Riparian function	Improvement
	Minimum water temperature	Decrease
	Maximum water temperature	Decrease
	Temperature moderation by groundwater	Improvement
	Large wood	Increase
Sandy 3	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase

Table continued on next page

Table 8-46. Habitat Benefits for Coho in the Middle Sandy River Watershed, by Reach, continued

Reach	Reference Condition	Habitat Benefit
Sandy 7	Carcasses per stream mile	Increase[a,b]
	Maximum water temperature	Decrease
	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

The City does not know how much flow might be returned to Cedar Creek from purchasing existing surface water rights, and therefore the benefits of the action can only be generally described as an increase in base flows over existing conditions as a result of the City's commitments.

The riparian easements and improvements in the middle Sandy River and Cedar and Alder creeks will protect intact portions of the riparian corridor, improve the arboreal species composition (by culling hardwoods and planting conifers), and allow for related habitat improvements (such as large wood recruitment, decrease in temperature, and increase in food availability) to occur over time. Large wood placement will increase channel stability to some degree for all life stages, decrease the risk of displacement by peak flows for fry and overwintering juveniles, and improve habitat diversity for juveniles. Large wood placement above the hatchery weir in Cedar Creek will increase key habitat for fry and parr substantially. The elimination of two migration barriers in Alder Creek will give coho access to approximately five new stream miles.

Upper Sandy River Watershed

Most of the upper Sandy River watershed is located in the Mt. Hood Wilderness and receives little anthropogenic disturbance. With the exception of the lowermost reach (Sandy 8), coho production is limited by naturally occurring conditions. Sandy 8 has been straightened, cleaned of large wood and large boulders, and confined between riprapped banks in response to the 1964 flood and due to development that has occurred between the communities of Zigzag and Brightwood.

The City will implement a measure in reach Sandy 8 to benefit coho salmon, a riparian easement. A detailed description of the measure and the affected reach is available in Chapter 7.

Table 8-47 lists the reach affected by the HCP measure planned in the upper Sandy River watershed and summarizes the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-47. Habitat Benefits for Coho in the Upper Sandy River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Sandy 8	Riparian function	Improvement
	Carcasses per stream mile	Increase[a,b]
	Maximum water temperature	Decrease
	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

The improvement in riparian function and large wood will improve habitat diversity for all juvenile life stages and will reduce channel instability, thus improving incubation. The increase in large wood loading will result in increased pools and pool tail-outs, thereby creating key habitat for fry, parr, and, to a lesser degree, spawners. The improved riparian function and carcasses that wash out of the Zigzag River into the upper Sandy reaches will boost food production for all juveniles.

Salmon River Watershed

Coho spawn and rear in the lower 13.2 miles of the Salmon River (reaches 1–3), as well as the lower 4.4 miles of its Boulder Creek tributary.

HCP measures were selected in the Salmon River with the intent to mitigate effects on coho salmon that cannot be avoided in the lower Bull Run River. These effects include reduced base flows, elevated water temperature, reduced habitat diversity, reduced spawning habitat, and impaired access to the upper reaches of the river. The City also considered the habitat factors that are limiting productivity of coho in Boulder Creek. The analysis considers beneficial effects for coho that are likely to result from measures designed primarily for other species. The City will implement measures in the Salmon River watershed to benefit coho salmon, including purchasing riparian easements, acquiring and restoring the Miller Quarry property, adding large wood to Boulder Creek, and adding salmon carcasses. A detailed description of each measure and the affected reaches, by watershed, is presented in Chapter 7.

Table 8-48 lists the reaches affected by HCP measures planned in the Salmon River and summarizes the expected habitat benefits in each reach (see tables in Appendix E for percentages for reference condition and post-implementation values).

Table 8-48. Habitat Benefits for Coho in the Salmon River Watershed by Reach

Reach	Reference Condition	Habitat Benefit
Boulder 0	Fine sediments by surface area	Decrease
	Maximum water temperature	Decrease
	Large wood	Increase
Boulder 1	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Salmon 1	Off-channel habitat	Increase
	Small-cobble riffles	Decrease
	Riparian function	Improvement
	Carcasses per stream mile	Increase[a,b]
	Maximum water temperature	Decrease
	Large wood	Increase
Salmon 2	Average depth of bed scour	Reduction
	Artificial confinement	Reduction
	Off-channel habitat	Increase
	Riparian function	Improvement
	Maximum water temperature	Decrease
	Large wood	Increase
Salmon 3	Large wood	Increase

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach (see Appendix E).

[a]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[b]Salmon carcass placement is a one-time treatment.

The measures implemented in the Salmon River watershed will increase the amount and diversity of habitat for coho juveniles. The riparian easements and enhancements will protect important and intact portions of the riparian corridor, improve the arboreal species composition (by culling hardwoods and planting conifers), and allow the natural improvements in habitat (such as habitat diversity, large wood recruitment, security cover, food production, and temperature moderation) to occur over time.

The Miller Quarry actions will restore connectivity of the mainstem Salmon River with flood plains and side channels which will add key habitat, reduce bed scour, and increase large wood loading, benefiting all juvenile life stages.

The riparian enhancements and large wood placement in Boulder Creek will increase habitat diversity for all juvenile life stages and reduce fry displacement during peak flow events. Some measure of these benefits will propagate downstream.

The salmon carcasses that will be placed in the Salmon River will temporarily reduce food scarcity both in the Salmon River and downstream reaches.

Summary of Population Effects and VSP Parameters

The VSP parameters for productivity, diversity, and abundance for the Sandy River population of coho are projected to increase by 4–17 percent under the HCP.* The projected increases in the VSP parameters should also be considered as modest because they do not include any potential benefits to steelhead that may be derived from projects supported by the City's $9 million Habitat Fund (see Measure H-30, Chapter 7).

*If Cedar Creek weir removal is included, the VSP parameters are expected to increase by 4 to 25 percent.

Population Effects and VSP Parameters

The HCP habitat conservation measures were designed to mitigate the effects of the Bull Run water supply on coho salmon and other covered species. This section describes the estimated effects of the City's HCP on the overall Sandy River coho salmon population using parameters established in the NMFS recovery planning process, specifically the work of the LCR-TRT.

Sandy River coho are part of the Lower Columbia ESU. The benefits to the Lower Columbia ESU from this HCP cannot be overstated, as Sandy River coho are one of only two extant populations in the ESU with appreciable natural production. The LCRFRB (2004) considered Sandy coho to be a primary population for recovery in the Lower Columbia ESU. Primary populations are those that the TRT believe need to be restored to “High” or “Very High” viability levels in order to recover the species. Sandy River coho have been identified (LCRFRB 2004) as needing to be restored to a “Very High” viability level, or >99 percent likelihood of persistence.

The EDT model was used to estimate the benefits for coho salmon that are likely to result from implementing the HCP. Although the model results are not absolute predictions of fish abundance, they do provide a relative comparison of the expected salmon population performance based on the best available science. The inputs to the model represent a combination of site-specific empirical habitat data and, when data were not available, the professional opinion of biologists intimately familiar with the Sandy River ecosystem. See Appendix D for an explanation of the theory and information structure as well as the habitat rating rules for the EDT model.

The EDT model was run for two sets of scenarios: current habitat conditions and the projected future habitat conditions after the City's HCP measures have been implemented. The projections for the VSP parameters were then compared and expressed as an increase (by percentage) in productivity, diversity, and abundance. In general, there is less information available on how spatial processes relate to salmonid viability than there is for the other VSP parameters, but historical spatial processes should be preserved (McElhany et al. 2000). For purposes of the spatial structure analysis, the City determined whether coho distribution would be enhanced in the known primary spawning reaches or whether the current distribution of the species would be increased from the HCP measures. The HCP measures are expected to result in increases in all of the coho salmon VSP parameters.

Increases in productivity, diversity, and abundance for coho are summarized in Table 8-49, below. These estimates represent increases over what could be expected to result from current habitat conditions in the Sandy River Basin. Improvements in spatial structure are discussed below. NMFS (in coordination with ODFW) has not yet developed a recovery plan for the Lower Columbia ESU nor set clear objectives for each VSP parameter; therefore, the significance of these improvements is not yet known.

Table 8-49. Increases for Coho Expected Due to HCP Implementation[a]

	Productivity (%)	Diversity (%)	Productivity (%)
Without Cedar Creek Weir Removal	4	16	17
With Cedar Creek Weir Removal	4	21	25

Source: EDT model run April 17, 2007
[a]Estimates do not include benefits derived from removing the Marmot Dam on the Sandy River.

Productivity

The estimated 4 percent improvement in coho salmon productivity results from improved rearing and migration conditions in the mainstem Sandy and Salmon rivers. Improved population productivity allows the species to rebound quickly from periods of low ocean or freshwater survival, thereby reducing extinction risk. The 4 percent improvement in productivity increases the probability that the population can maintain abundance levels above those that are deemed viable.

Diversity

The estimated 16 to 21 percent improvement in coho diversity represents improvements in habitat conditions over time and space. Most of this improvement occurs in the lower Sandy River, lower Bull Run, and Cedar Creek. Populations that exhibit a wide range of life histories are more resilient to environmental change.

Abundance

The estimated 17 to 25 percent improvement in coho abundance in the Sandy River Basin results from the increases in productivity and diversity. Increased coho abundance reduces extinction risk for the population. Coho numbers increase as a result of improved migration and rearing conditions in the lower Sandy River, lower Bull Run River, and Cedar Creek.

Higher abundance also results in increased ecological benefits. Salmonids improve both their physical and biological environments through various mechanisms. For example, adult spawners reduce fine sediment concentrations in gravels and their carcasses provide a food source for other aquatic and terrestrial species.

The Interior Columbia River Basin Technical Recovery Team defines viability for Sandy River coho salmon as adult returns exceeding 600 fish (2005). The 17 to 25 percent improvement in coho adult abundance makes a significant contribution toward meeting the minimum viable population abundance value proposed by the LCR-TRT (McElhany, et al. 2000).

Spatial Structure

The viability of a salmon population depends not only on the population's productivity, abundance and diversity, but also on its spatial structure (McElhany et al. 2000). The more watersheds in a basin that contain large numbers of spawners, the less likely catastrophic events such as landslides or human-caused disasters will result in the extinction of the population.

Coho currently spawn and rear in the lower Salmon River and Still Creek, and in the Sandy mainstem between the Salmon and Zigzag river confluences. Historically, coho spawning and rearing occurred in most of the accessible reaches of the Sandy River Basin.

The HCP actions will increase coho distribution in Alder and Cedar creeks. About 18 river miles will be opened for coho usage. That is approximately an 11 percent increase in the current coho distribution for the Sandy River Basin.

The HCP measures are designed to increase fish access, improve riparian condition, increase the amount of large wood, and increase streamflow in one or all of the watersheds inhabited by coho. Removing barriers to coho access in Alder and Cedar creeks and the Little Sandy River will further increase coho abundance and distribution throughout their historic range. The HCP improves spatial structure, as actions are focused on increasing spawner abundance in all of the five watersheds that historically supported coho production. Increased adult abundance in multiple watersheds reduces population exposure to catastrophic events and thus reduces population extinction risk. Table 8-50 summarizes the population effects of the HCP measures on coho by the VSP parameters of abundance, productivity, diversity, and spatial structure.

Table 8-50. Effects of the HCP Measures on Sandy River Basin Coho Salmon by Viable Salmonid Population (VSP) Parameters

VSP Parameter	Reference Condition	Effect of Conservation Measures
Abundance	Current habitat conditions	Coho abundance for the Sandy River population is projected to increase by 17-25%.
Productivity	Current habitat conditions	Productivity for the Sandy River coho population is projected to increase by 4%.
Diversity	Current habitat conditions	Diversity for the Sandy River population is projected to increase by 16-21%.
Spatial Structure	Current habitat conditions	Spatial structure will improve as actions are focused on increasing spawner abundance in all five of the watersheds that supported coho production historically. Increased adult abundance in multiple watersheds will reduce population exposure to catastrophic events, and thus reduce extinction risk

Sources: EDT model run April 17, 2007 for abundance, productivity, and diversity percentages; for spatial structure assessment, Kevin Malone, personal comm. 2006

Summary Comparison of Fish Abundance

The projection of adult coho abundance under the City's HCP is greater than the benchmark comparison scenario established for the Bull Run watershed. This benchmark comparison indicates that the HCP will produce enough beneficial habitat changes for coho to offset all potential impacts that could be caused by the City's water supply operations in the Bull Run.

Population Effects and Benchmark Comparison of Fish Abundance

The introduction to this HCP chapter describes a benchmark scenario the City developed to compare results of the HCP measures with production potential of the Bull Run watershed (see section 8.1.1). The EDT model was used to generate the estimated abundance of coho salmon and to compare the benchmark against the benefits of the City's HCP measures.

The City believes that the Modified Historical Bull Run Condition estimate represents generous assumptions and the HCP estimate is an underestimate of probable HCP results (see Section 8.1.1).

Model results indicate that the HCP measures would improve habitat sufficiently to match or exceed the production potential of the Modified Historical Bull Run Condition (see Table 8-51).

Table 8-51. Model Results for Coho Abundance: Modified Historical Bull Run Condition Compared with HCP Measure Implementation[a]

Scenario	Adult Abundance
Modified Historical Bull Run Condition	2,551
HCP Measures Without Cedar Creek	2,842
HCP Measures With Cedar Creek	3,037

Source: EDT model run April 17, 2007

[a]Estimates do not include benefits from removing the Marmot Dam on the Sandy River.

The City believes these results help demonstrate that the HCP will provide the benefits for coho necessary to meet the ESA Section 10 requirements. However, the City does not propose to use EDT population estimates as an enforceable performance measure for coho. The City's HCP is purposefully habitat based. It is designed using measurable objectives, monitoring, and an adaptive management trigger that all relate to habitat condition, as described in other chapters of this document.

Conclusions about the Habitat Effects of HCP Measure Implementation

- **Effects in the Lower Bull Run River.** All of the HCP measures in the lower Bull Run River will benefit coho. These measures avoid or minimize ongoing City impacts in the Bull Run River (as described in Table 7-1) to the maximum extent practicable. Impacts associated with blocked fish access to the upper watershed and reduced base flows will not be completely addressed in the Bull Run but will be mitigated by offsite measures in the Sandy Basin. Benefits provided by the Bull Run HCP measures are summarized in Table 8-47.
- **Effects in the Sandy River Basin.** Substantial additional benefits for coho are provided by HCP measures in the upper Sandy River and its tributaries (e.g., Salmon and Zigzag rivers), the middle Sandy River, and the lower Sandy River. The upper Sandy has the primary spawning areas and most anchor habitat reaches for coho are upstream of the Marmot Dam site. The primary limiting factor for coho for that area is reduced habitat diversity, side channel habitat, and riparian zone conditions. HCP measure H-18 will improve conditions for coho on the mainstem Sandy River; Measures H-19, H-20, H-21, H-22, H-23, H-24, H-27, H-28, and H-29 will improve habitat in important tributary streams such as the Salmon and Zigzag rivers. For the middle Sandy Basin, measures H-14, H-15, H-16, and H-19 will improve large wood levels, riparian zone conditions, and channel diversity for coho in the mainstem Sandy River and Cedar Creek. HCP measures will also open new habitat for coho in Alder and Cedar creeks. HCP measures in the lower mainstem Sandy (H-11, H-12) will slightly improve habitat for migrating coho juveniles, and measures H-5, H-6, H-7, and H-13 will improve rearing habitat in lower Sandy River tributaries. Benefits provided by the offsite measures are summarized in Tables 8-49 and 8-51 and in Appendix E, Tables E-5 and E-6.
- **Timing for Implementing Measures.** The timing for implementing measures relevant to coho and other species is provided in Tables 7-6 through 7-12. Measures in the upper Sandy River are primarily scheduled for HCP Years 11-15, with some of them occurring in Years 6-10. Most of the measures for coho in the middle Sandy Basin will occur in HCP Years 6-10. The lower Sandy tributary actions and mainstem Sandy easement measures for coho will be implemented in HCP Years 1-5. The City will conduct effectiveness monitoring for the instream measures; the objective in those cases is to accrue 80 percent of the predicted habitat change within 15 years of implementing the measures (see tables in Chapter 9).
- **Population Response.** Although the HCP is not intended to guarantee specific population responses, implementation of the HCP is expected to result in improved population conditions for coho. Table 8-53 describes the anticipated increases of the four VSP parameters: abundance, productivity, diversity, and spatial structure. The estimated population response compared to the Modified Historical Bull Run Condition also indicates that implementation of the HCP will likely result in a population response that is greater than the production potential in the Bull Run watershed. Neither of these estimates includes the habitat or population benefits that will result from the $9 million Habitat Fund.

- **Accumulation of Habitat Benefits.** The HCP conservation measures will accumulate benefits for coho at varying rates. Figure 8-20, which is based on EDT model results, describes the accumulation of benefits over the 50-year HCP term. The figure shows the predicted increase in adult coho abundance that could result from the habitat changes. Benefits are organized according to four general categories of HCP measures: flow, fish passage improvements, instream actions, and riparian easements. The City assumes that the benefits from large wood additions would only contribute to adult coho abundance for the first 15 years of their project life. This is a very conservative assumption because it is likely that the wood will be in the various stream reaches beyond 15 years and adding some habitat value for fish. Other instream actions, such as the opening of side channels and riprap removal, are considered permanent for the purpose of the HCP. Riparian easements are assumed to take 15 years before beginning to provide benefits and would not provide full benefits until 30 years after implementation. Flow measures will provide habitat for coho starting in Year 1 of the HCP, and fish passage improvements for Cedar Creek should start benefiting coho in approximately Year 6.

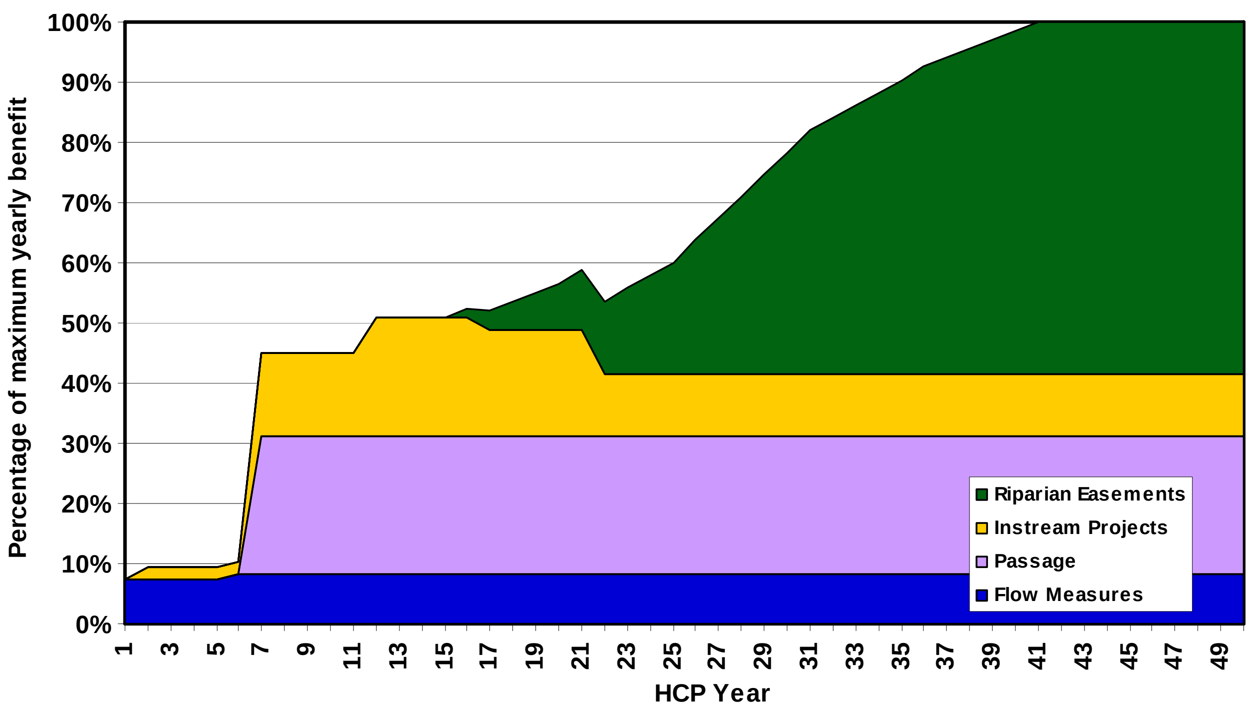

Figure 8-20. Accumulation of Predicted Benefits to Coho from HCP Measures over Time[a]

Source: EDT model runs, April 10, 2007.

[a]The accumulated benefits exclude benefits from the following measures: H-3—Little Sandy 1 and 2 LW Placement, P-2—Alder 1 Fish Passage, P-3—Alder 1A Fish Passage, H-25—Salmon 2 Carcass Placement, H-29—Zigzag 1A, 1B, and 1C Carcass Placement

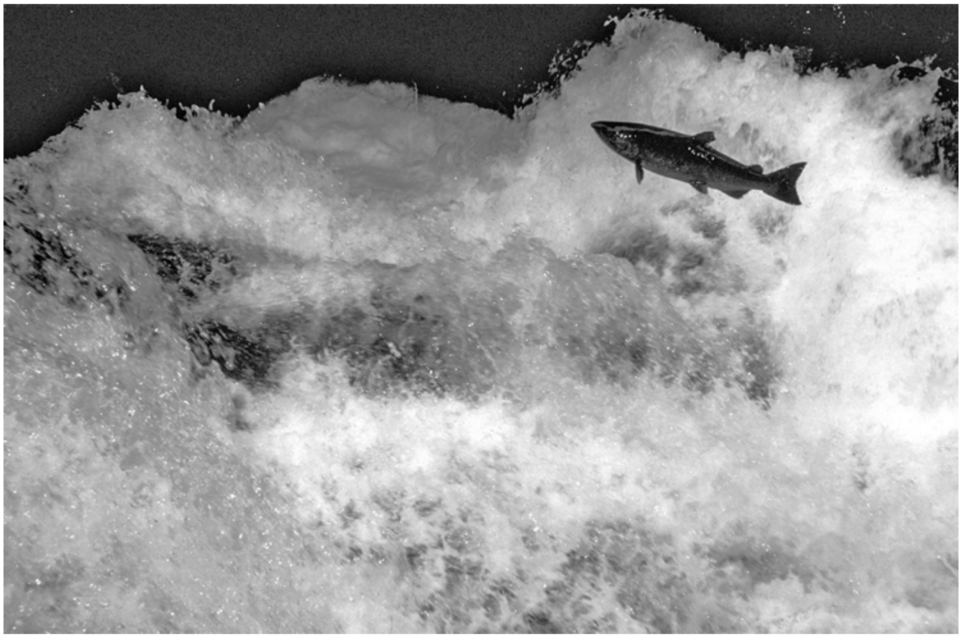

Photo courtesy of Bonneville Power Administration.

The full coho benefits would be realized by approximately HCP Year 40. This maximum benefit level closely corresponds to the abundance number used in Table 8-49 for the "HCP Measures with Cedar Creek" scenario, but the benefit level excludes the benefits of large wood additions. Through the term of the HCP, the cumulative total benefits will be 12 percent from the flow measures, 17 percent from instream measures, 40 percent from riparian easements, and 30 percent from the Cedar Creek fish passage improvements.

The City believes the HCP, as a whole, meets ESA Section 10 requirements for coho.

8.3 Other Covered Fish Species

The City is requesting ESA coverage for chum salmon and eulachon in addition to the four primary species discussed above. Less information is available about these species, but the same types of effects are described:

- Effects on habitat from Bull Run operations and HCP measures in the lower Bull Run River
- Effects on habitat in the Columbia River
- Effects on habitat in Sandy River Basin Watersheds from the HCP offsite measures
- Estimated effects of the HCP measures on the Sandy River populations, expressed in terms of VSP parameters

8.3.1 Chum Salmon

Effects on Habitat in the Lower Bull Run River

The City does not believe that the Bull Run watershed was utilized historically by chum salmon. Therefore, the City's water supply operations do not negatively affect chum salmon habitat. Only the offsite HCP measures implemented in other reaches of the Sandy River Basin will have an effect on habitat that chum salmon may have once used.

Effects on Habitat in the Columbia River

Chum salmon spawn and rear in the lower Columbia River. Two focal points for spawning are located just upstream of the I-205 bridge (Wood's Landing and Rivershore development). Both sites are associated with shallow groundwater discharges into the river. The Wood's Landing groundwater emerges from a series of springs. The Rivershore groundwater originates in a nearby creek and emerges as hyporheic flow (Rawding and Hillson 2002). The groundwater used by the City for water supply (near the I-205 bridge) is from deeper aquifers approximately 300-500 feet below ground surface (e.g., the Troutdale Sandstone Aquifer and the Sand and Gravel Aquifer). These groundwater sources are not directly connected to the shallow groundwater at Wood's Landing or Rivershore. The City's use of groundwater will have no effect on chum salmon spawning in the Columbia River nor will it affect migrating chum in the Columbia River (see the analysis of the effects of groundwater use on Columbia River flows in Section 8.2).

Effects on Habitat from the HCP Offsite Measures

Specific information on habitat utilization for chum salmon in the Sandy River Basin is extremely scarce. Because chum salmon and fall Chinook have similar timing for adult spawning and juvenile habitat preferences, the City assumes that habitat preferences for chum would be similar to those for fall Chinook salmon.

Historically, it is believed that chum salmon used the low-gradient mainstem Sandy River reaches below the gorge that starts at Revenue Bridge (RM 24) (Kostow, ODFW, pers.

comm., 2005) and the lower end of Beaver Creek (Mattson 1955). The City has planned measures along the mainstem Sandy River reaches, both upstream and downstream of the confluence with the Bull Run River, which should improve habitat for chum.

Six specific offsite conservation measures will be implemented in the mainstem middle and lower Sandy River reaches (from the mouth of the river to Revenue Bridge) that should improve habitat conditions for chum salmon. The effects of these measures are summarized in Tables 8-6 and 8-7 in the discussion of offsite habitat effects for fall Chinook (Section 8.2.1). The measures include riparian easements, placement of large wood, and opening the historical mouth of the Sandy River and other side-channel areas.

The conservation measures in the mainstem Sandy River reaches will improve several habitat parameters for chum salmon. The riparian easements, engineered log jams, and large wood will improve habitat conditions over existing conditions in the lower Sandy River. The channel reconnection will improve fish access and reopen approximately one mile of new habitat. This additional side-channel habitat will provide low-velocity rearing habitat for chum and other salmonids.

Population Effects and VSP Parameters

The effects of the City's habitat measures on chum salmon were not modeled. It is assumed that the benefits to this species would be similar to those described previously for fall Chinook. For fall Chinook, the HCP measures are expected to produce increases in the abundance, productivity, and diversity for the Sandy River population (see Population Effects and VSP Parameters section for fall Chinook). The City assumes that chum will benefit similarly from the conservation measures. For spatial structure, the HCP measures will not increase the distribution of chum salmon in the Sandy River Basin. However, habitat conditions in the lower portions of the mainstem Sandy River will improve and that should benefit chum.

Conclusions About the Habitat Effects of HCP Measure Implementation

The City believes that chum did not historically use lower Bull Run River habitat but did use the lower Sandy River. The benefits that accrue to chum as a result of implementation of this HCP are similar to the benefits for fall Chinook in the lower mainstem Sandy River.

Collectively, the City's HCP conservation measures in the mainstem Sandy River reaches should improve conditions and have a positive effect on chum habitat in the lower Sandy River watershed.

8.3.2 Eulachon

Effects on Habitat in the Lower Bull Run River

The lower Bull Run River was not used historically (and is not currently used) by eulachon. Therefore, the City's water supply operations do not negatively affect eulachon habitat. Only the offsite HCP measures implemented in other reaches of the Sandy River Basin will have an effect on habitat that eulachon may use.

Effects on Habitat in the Columbia River

Eulachon spawn in the Cowlitz River and the lower mainstem of the Columbia River from RM 25 to immediately downstream of Bonneville Dam. Periodic spawning also occurs in tributaries such as the Sandy River. The City's use of groundwater will have no effect on eulachon spawning in the Columbia River or on eulachon movements in the Columbia River.

Effects on Habitat from the HCP Offsite Measures

Specific information on habitat utilization for eulachon in the Sandy River Basin is not available. Eulachon have been observed in the first few miles of the Sandy River, perhaps up to the lower end of Beaver Creek. Spawning substrates range from silt, sand, or gravel to cobble and detritus. Spawning rivers may be turbid or clear.

The City has planned measures along the mainstem Sandy River reaches that should improve habitat for eulachon. The measures include riparian easements, placement of large wood, and opening the historical mouth of the Sandy River and other side-channel areas. These measures will increase habitat complexity and provide approximately one mile of new habitat. The additional side-channel habitat will provide low-velocity spawning habitat. The effects of these measures are summarized in Tables 8-6 and 8-7 in the discussion of offsite habitat effects for fall Chinook.

Population Effects and VSP Parameters

The effects of the City's habitat measures on eulachon were not modeled, and very little information is available about the population parameters for this species. The City assumes that eulachon will benefit from the habitat improvements, but too little is known about their habitat needs to quantify this relationship.

Conclusions About the Habitat Effects of HCP Measure Implementation

The City believes that eulachon will not be affected from measures in the Bull Run River, but will benefit from measures in the lower Sandy River Basin because of the improvements to habitat conditions.

8.4 Other Fish Species Addressed by the HCP

This HCP addresses five fish species in addition to the covered fish species: rainbow trout, cutthroat trout, Pacific lamprey, western brook lamprey, and river lamprey. Where possible, the description of effects for each of these fish species follows a pattern similar to that for the four primary covered species:

- Effects on habitat from Bull Run operations and HCP measures in the lower Bull Run River (or Bull Run reservoirs)
- Effects on habitat from Bull Run operations and HCP measures in the lower Sandy River
- Effects on habitat in the Columbia River
- Effects on habitat in Sandy River Basin watersheds from the HCP offsite measures
- Estimated effects of the HCP measures on the Sandy River populations, expressed in terms of VSP parameters

The information available for these species varies, therefore the habitat effects descriptions also vary in length.

8.4.1 Rainbow Trout

Table 8-52 summarizes the historical distribution of rainbow trout in the Bull Run watershed.

Table 8-52. Historical Distribution of Rainbow Trout in the Bull Run River

River Segment	River Miles
Lower Bull Run River	
Bull Run River (mouth to Dam 2 spillway weir)	5.8
Walker Creek	0.15
Little Sandy River (mouth to Little Sandy Dam)	1.7
Little Sandy River (Little Sandy Dam to middle waterfalls)	5.6
Little Sandy River Tributaries (upstream of Little Sandy Dam)	2.0 (est.)
Upper Bull Run River	
Bull Run River (Dam 2 spillway weir up through reservoirs)	9.2
Bull Run River (free-flowing river to waterfall at RM 16.3)	1.3
South Fork Bull Run River	2.7
Cedar Creek (tributary to South Fork Bull Run River)	8.1

Table 8-52. Historical Distribution of Rainbow Trout in the Bull Run River, continued

River Segment	River Miles
Bull Run River (RM 16.3 to 80' waterfall)	5.4
Camp Creek	0.6
Fir Creek	0.5
Bear Creek	0.3
Cougar Creek	0.7
Deer Creek	0.5
North Fork Bull Run River	0.8
Log Creek	0.2
Falls Creek	0.8
West Branch Falls Creek	0.3
Blazed Alder Creek	2.4
Blazed Alder Tributaries	0.4 (est.)

Source: USFS, 1999

Rainbow trout are now present year-round in Reservoir 1. Cutthroat trout and cutthroat/rainbow hybrids are also present in Reservoir 1. Rainbow trout have not been found in Reservoir 2.

Effects on Habitat in the Lower Bull Run River

Rainbow trout and steelhead are the same species, and the City assumes that the HCP effects on rainbow in the lower Bull Run River would be much the same as for steelhead.

Effects on Habitat in the Bull Run Reservoirs

The City will operate the reservoirs during the term of the HCP in a manner expected to minimize impacts to rainbow trout (see Measure R-1 – Reservoir Operations). Operating the City's water system could have four types of effects on resident rainbow trout in Reservoir 1:

1. Access to reservoir tributary streams for spring spawning
2. Reservoir water quality
3. Entrainment through the water intakes in Reservoir 1
4. Ramping rates downstream of the Dam 1 powerhouse

Each of the four types of effects is described below.

Access to Reservoir Tributary Streams

The City conducted a survey of the margins of both reservoirs in the spring during the peak rainbow and cutthroat trout spawning period in 2003. The survey results indicated that access to the tributary streams was easily available when reservoir water level elevations were within a few feet of full-pool elevations (full-pool elevations for Reservoirs 1 and 2 are 1,045 feet and 860 feet, respectively).[14] Only Deer Creek on Reservoir 1 could be blocked for fish access when the reservoir elevation decreases below 1,042 feet. Since the City always fills Reservoir 1 in the spring, rainbow trout will be able to access the spawning tributaries. Reservoir 1 will be operated to reach full-pool levels every spring, so future operations will ensure access to reservoir tributaries for spawning rainbow trout.

Reservoir Water Quality

The City conducted a study in 2001 comparing water temperature and dissolved oxygen conditions throughout the depths of the reservoirs with conditions in 1996 (Beak 2001a). Water quality conditions in the reservoirs in 1996 were used as the reference condition because these conditions represent the approximate time period when fish were placed on the Endangered Species list, and are indicative of whether reservoir habitat was limiting fish production.

The study results indicated that Reservoir 1 undergoes thermal stratification as the year progresses from early spring into summer. The water temperatures are within the suitable range for rainbow trout and other salmonids throughout the year. An additional study of fish growth and feeding in Reservoirs 1 and 2 concluded that trout growth was excellent and that food availability did not appear to be a limiting factor (Beak 2001b).

The vertical dissolved oxygen profiles show the potential effects of operating the water system. The study indicated that dissolved oxygen concentration in Reservoir 1 was well mixed in the early spring and began to drop as the season progressed and reservoir temperatures began to rise (Beak 2001a). Figure 8-21 shows that dissolved oxygen levels in both reservoirs are within the suitable range for salmonids throughout the year.

Environmental Protection Agency (EPA) research on dissolved oxygen requirements for six salmonid species shows that the influence of dissolved oxygen on growth is negligible above 7 milligrams per liter (mg/L). EPA proposed 7- and 30-day mean criteria of 5 and 6.5 mg/L, respectively, for protecting other than early life stages and suggested an 8 mg/L threshold as the 30-day mean criterion to protect juvenile/adult life stages as well as developmental stages (1986). ODEQ has established a state standard that dissolved oxygen may not be less than 8 mg/L for waters with cold-water aquatic life (OAR 340-041-0019).

Dissolved oxygen may not fall below 8 mg/L as a 30-day mean minimum, 6.5 mg/L as a 7-day mean minimum, and 6 mg/L as an absolute minimum (OAR 340-041-0019). Figure 8-21 shows that dissolved oxygen in the Bull Run reservoirs exceeds 8 mg/L throughout the water column of both reservoirs except in August–September. Even during this period, dissolved oxygen exceeds 8 mg/L in about the top 5 meters (approximately 16 feet) of the water column and exceeds 6 mg/L in all but about the middle 20 percent of the water column.

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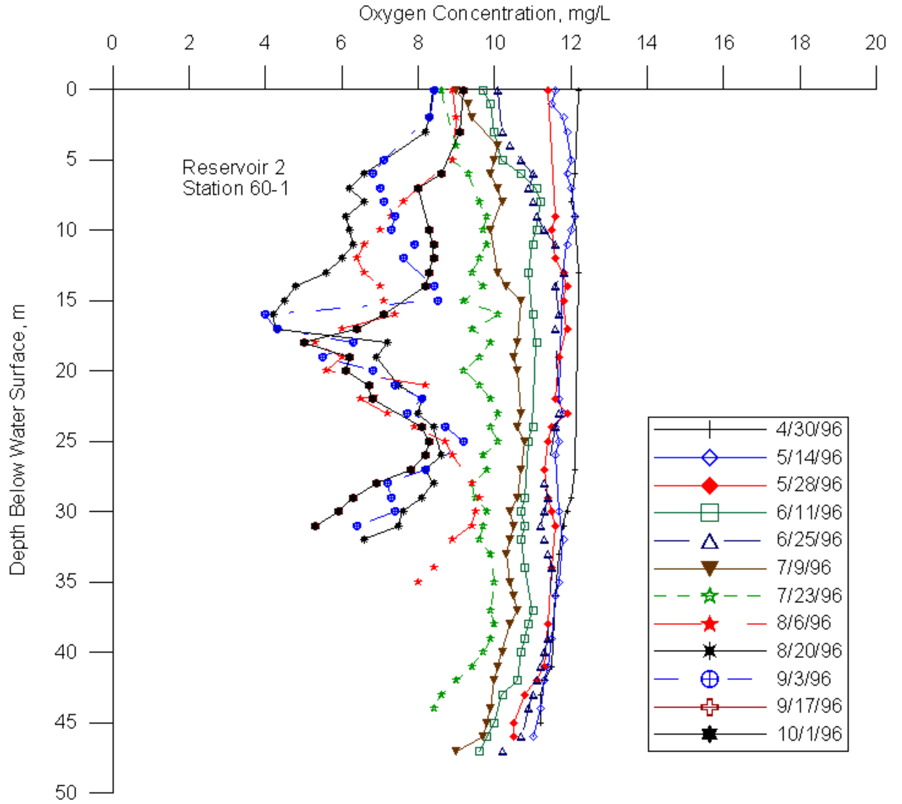
[14] In about 15 percent of years, unusually dry spring conditions may cause reservoir drawdown to begin in late May. However, the City expects to maintain water levels at or just below full-pool elevations until mid-May in all years, including the 15 percent of years with unusually dry spring conditions.



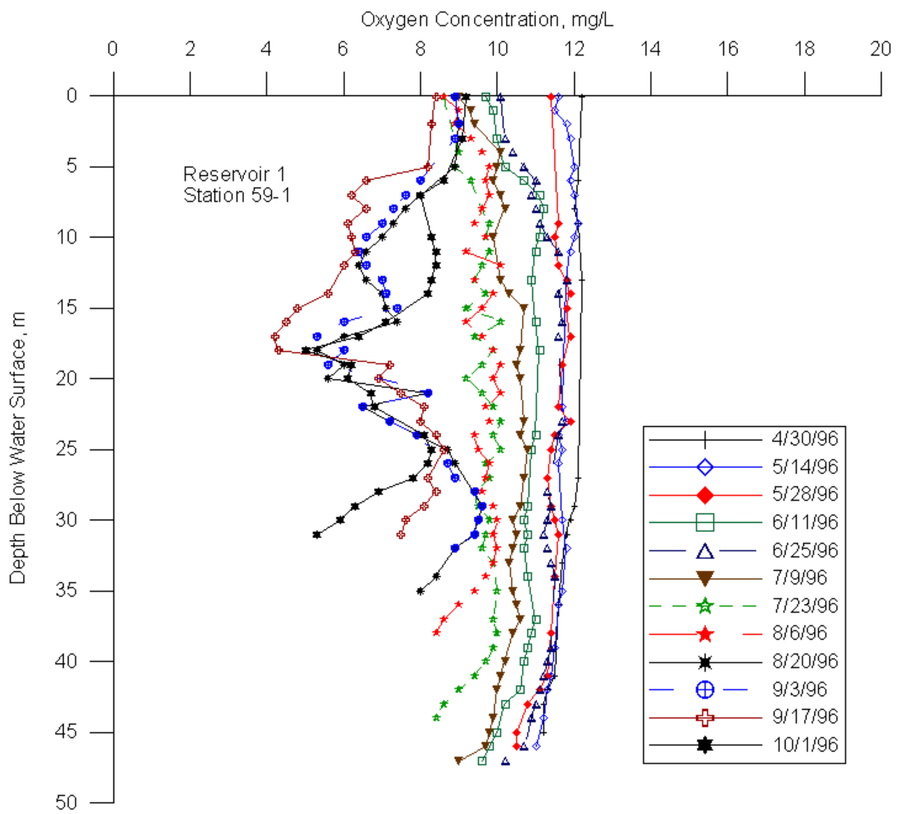


Figure 8-21. Vertical Dissolved Oxygen Profiles for Reservoirs 1 and 2

Source: Beak 2001a

Overall, the City's continuing operations in the Bull Run River are likely to have minimal effects on the water quality of the reservoirs. Water temperatures and dissolved oxygen levels present in the reservoirs will continue to support populations of rainbow trout.

Entrainment at the Water Intakes

Rainbow trout are in Reservoir 1 and the City does not have fish screens on its water intake structures that meet current fish screening criteria. However, the City believes that entrainment of rainbow trout in Reservoir 1 is very low, and it is not negatively affecting the reservoir population of fish. That conclusion is based on the following:

1. The rainbow trout in Reservoir 1 no longer would demonstrate strong anadromous or fluvial life-history patterns because they have been isolated in the upper Bull Run watershed for a long time.

   All anadromous fish were blocked from the upper Bull Run River in 1921 from construction of the diversion dam on City property at RM 6.0. Construction of Reservoir 1 in the 1920s further isolated the rainbow trout. Because the trout have been isolated for over 80 years in the upper Bull Run, it is unlikely that there would be significant numbers of fish trying to smolt and migrate downstream, so entrainment rates at Dam 1 would be related to random encounters of fish at the water intakes.

2. Rainbow trout do not concentrate near the Dam 1 water intakes.

   The City conducted a hydroacoustic survey in 1999 (HTI 2000), and the fish were distributed significantly away from the dam, even though the reservoir was drawn way down for water supply reasons. The City applied a chi-square statistical test and determined that fish density was much lower next to the dam and water intakes.

3. Only larger rainbow trout would randomly encounter the Dam 1 intakes and they are less susceptible to entrainment.

   Adfluvial rainbow and cutthroat trout tend to remain in their natal tributaries for the first year or two (Quinn 2005, Trotter 1989, Nowak et al. 2004). All natal tributaries are located a significant distance from the Dam 1 water intakes. Fry and juveniles in lakes tend to be associated with the banks where they can find cover (Tabor and Wurtzbaugh 1999, Bozek and Rahel 1991). Small fish that venture into open water probably would experience a high risk of predation before they reach the water intakes because of the adult rainbow and cutthroat trout's piscivorous behavior (Nowak et. al. 2004). For these reasons, the City does not believe that small rainbow would likely encounter the water intakes and be entrained. Larger fish, which could randomly encounter the intakes, would be better able to resist the approach velocities at the intake gates.

4. The City's operational protocols for running water though the Dam 1 water intakes will minimize the potential entrainment of rainbow trout.

   The City does not run the Reservoir 1 hydroelectric powerhouse continuously, and that dictates the amount of water that is pulled from the reservoir. During the summer when the reservoir is drawn down, powerhouse use occurs primarily in the

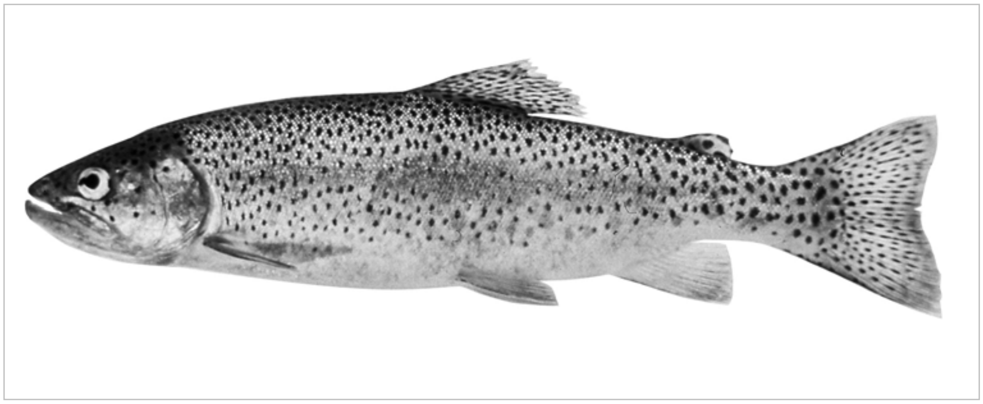


Photo courtesy of Bonneville Power Administration

morning and evening to keep the reservoir elevation within a target range. When reservoir inflows are low, the powerhouse tends to be operated only once per day for a few hours.

The City believes that entrainment is not significantly affecting the rainbow or cutthroat trout in Reservoir 1.

Ramping Rates Downstream of Dam 1

The City believes that few fish, if any, are stranded due to hydropower generation from the Dam 1 powerhouse. Dam 1 is at the upper end of Reservoir 2, which is approximately 4.5 miles long. Over the entire length of the reservoir, only about 1,000 feet of riverine habitat is not inundated, less than 5 percent of the lineal distance between the dams. This is the only area where trout stranding could occur as a result of hydropower operations.

A hydroacoustic survey of Reservoir 2 (HTI 2000) showed that rainbow (and cutthroat) trout are distributed throughout the lineal distance of the reservoir and are not concentrated in the upper end where there could be stranding effects. Also, the City's hydropower operations can only lower the top two feet of Reservoir 2, which restricts the area affected by downramping in the upper portion of Reservoir 2. Based on the small amount of habitat in which fish could be stranded and the 2"/ hour restriction for lowering the reservoir elevation, continued hydropower operations at Dam 1 are not likely to negatively affect the population of rainbow trout in Reservoir 2.

Conclusions about the Habitat Effects of HCP Measure Implementation

The City assumes that the effects on habitat from the HCP offsite measures for rainbow trout would be the same as those for steelhead which are discussed in Section 8.2.3. Conclusions regarding the habitat effects of implementing the HCP for winter steelhead are listed on page 8-114.

The HCP is expected to result in both short- and long-term benefits to rainbow trout. All of the HCP measures in the lower Bull Run River and the Bull Run reservoirs will benefit rainbow trout. Substantial additional benefits for rainbow trout are provided by HCP measures in the upper Sandy River and its tributaries. The City also assumes that the Sandy

River rainbow population will benefit by the HCP measures since all VSP parameters will increase for steelhead.

With the additional benefits that will accrue above and beyond the core HCP measures, the City considers the HCP as a whole package to be more than adequate to compensate for impacts to rainbow trout in the Bull Run watershed.

8.4.2 Cutthroat Trout

Coastal cutthroat trout have habitat preferences that overlap both those of steelhead and rainbow trout, and also those of coho salmon (Trotter 1989). In streams where cutthroat, rainbow, and steelhead occur, cutthroat trout tend to dominate in relative numbers in higher elevation portions of streams, while steelhead and rainbow dominate in lower portions of the same streams (Nicolas 1978, Campton and Utter 1985). This appears, however, to be attributable to partitioning of spawning reaches, not a difference in habitat requirements (Campton and Utter 1985). Cutthroat trout and steelhead in the Sandy River both spawn from February through May, depending on temperature and location in the watershed, and emerge from April through July (Figure 8-11). Because of their intermediate adaptations, cutthroat trout tend to be displaced from pool habitats by coho and from swifter water habitats by steelhead (Bisson et al. 1988). In lakes, populations of cutthroat and rainbow trout living in isolation from one another both make broad, overlapping use of resources and space, but partition both when they live together (Nilsson and Northcote 1981). Steelhead and cutthroat trout were also found to respond similarly to habitat alterations in Oregon coastal streams (Solazzi et al. 2000).

Although there is almost no specific information on cutthroat trout in the Sandy River, this effects analysis assumes that cutthroat trout prefer habitat conditions that are completely overlapped by those preferred by coho and especially steelhead and rainbow trout, as described above. For the cutthroat trout effects analysis, the City examined habitat information specific for the species. When information was not available, effects were inferred from analogous analyses for steelhead or coho salmon.

Effects on Habitat in the Lower Bull Run River

The key habitat metrics for cutthroat trout in the lower Bull Run River include streamflow, water temperature, large wood, spawning gravel, access, riparian function, and total dissolved gases.

Streamflow

The City analyzed streamflow effects on cutthroat trout by two means: comparing the effects of the HCP Bull Run base flows with the natural (pre-water-system) conditions and by determining the cutthroat spawning and rearing WUA likely to result from Bull Run flow measures.

Bull Run Base Flows. The City compared an estimate of median monthly flows (50 percent exceedance flows) under natural conditions (i.e., no dams or diversions in the Bull Runwatershed) with anticipated future flows during implementation of the HCP, assuming normal and critical years occur at the same frequency in the Bull Run as they have in the past. A 64-year hydrological record (1940–2004) was used for the analysis. The estimated median natural and HCP flows for the Bull Run River upstream of the Little Sandy River are shown in Figure 8-22, with peak periods of life-stage occurrence, as documented in the periodicity chart in Chapter 5 (Figure 5-41) and Figure 8-22 below. All flow amounts are relative to the USGS Gauge No. 14140000 located at RM 4.7 on the Bull Run River.

Table 8-56 shows the median natural flows and median flows anticipated from implementing the HCP. The comparison is for flows in two segments: upstream of the confluence with the Little Sandy River (RM 3.0—RM 5.8), and downstream of the Little Sandy River (RM 0–RM 3.0). For the portion of the Bull Run River downstream of the Little Sandy River, median flows were determined using the estimated Little Sandy median natural flows that would occur after the Little Sandy Dam is removed.[15]

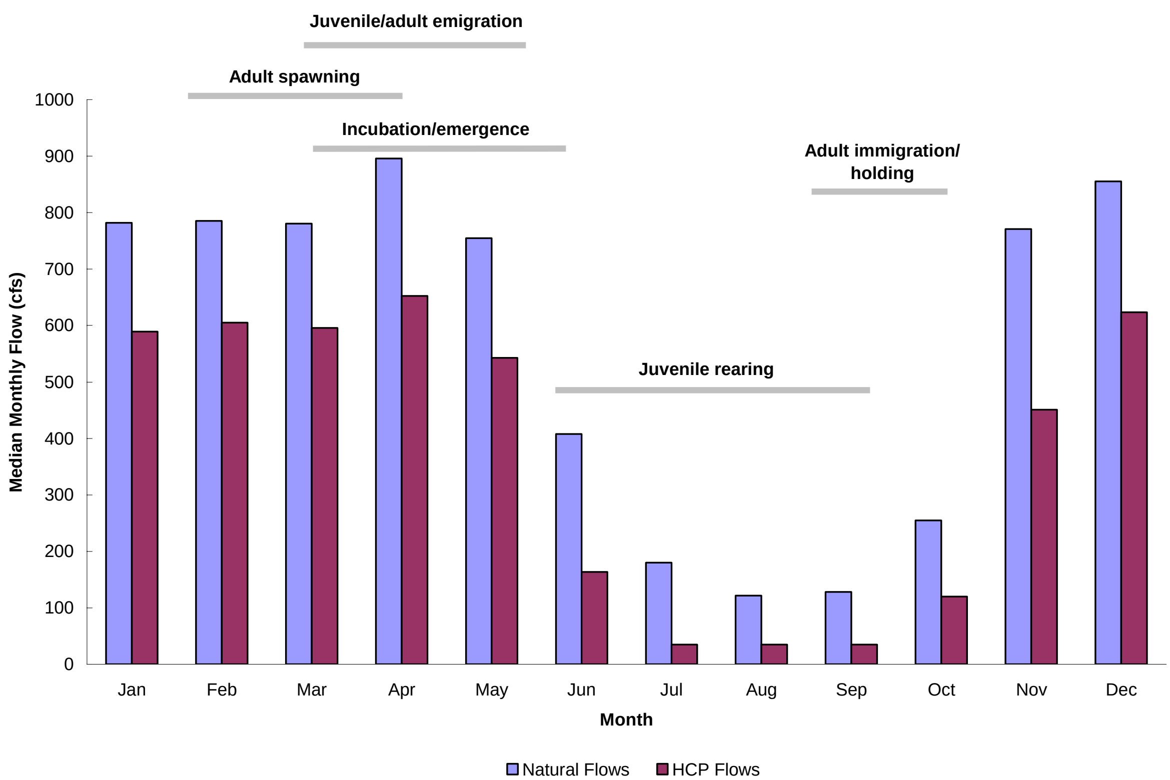


Figure 8-22. Median Monthly Flows and Peak Periods of Occurrence for Cutthroat Trout in the Lower Bull Run River above the Little Sandy River Confluence[a]

Source: Median monthly flows for the upper reach of the Lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000 (RM 4.7).

[a]Although peak juvenile rearing period is shown here, cutthroat trout rearing occurs all year. See Figure 5-32 for periods of occurrence in the lower Bull Run River.

[15] See Section 4.1.5 Water Quality and Water Rights for more information about the removal of the Little Sandy Dam.

Table 8-53. Natural and HCP Median Flows by Month for the Lower Bull Run River

	Above Little Sandy River		Below Little Sandy River	
Month	**Natural (cfs)**	**HCP (cfs)**	**Natural (cfs)**	**HCP (cfs)**
January	782	611	938	765
February	785	608	957	776
March	780	606	932	760
April	896	672	1,072	846
May	755	563	898	709
June	408	196	487	274
July	180	35	213	67
August	122	35	141	54
September	128	35	152	55
October	255	120	304	166
November	771	427	924	608
December	857	654	1,031	829

[a]Median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS Gauge No. 14140000, Bull Run River (RM 4.7).

[b]The sum of median monthly flows for the upper reach of the lower Bull Run River (1940–2004) taken at USGS gauge 14140000, Bull Run River (RM 4.7) and median monthly flows taken at USGS Gauge No. 14141500, Little Sandy River (RM 1.95).

Effects of Flows on Spawning. The peak spawning period for coastal cutthroat trout in Oregon streams is February (Trotter 1989). During the winter and spring period, the City's HCP flows, with a minimum flow of 120 cfs, would support cutthroat trout spawning, egg incubation, and fry emergence.

Upstream of the Little Sandy confluence, the City's HCP flows from January to May will be 23 percent lower than the median natural flow. Downstream of the Little Sandy River, the City's HCP flows will be 19 percent lower than the proposed flow. Even with the difference between the natural flows and the HCP flows, there will be a minimal effect on cutthroat spawning, egg incubation, and fry emergence. Based on WUA results for steelhead/rainbow trout discussed in Section 8.2.3, near-optimal habitat conditions for spawning steelhead were predicted to occur between flows of 130 and 200 cfs (R2 Resource Consultants 1998). These flows levels are also thought to be protective of cutthroat trout.

Coastal cutthroat trout, like steelhead/rainbow trout, can spend several years rearing in fresh water before smolting. Most emigrate at ages 2, 3, and 4 (Trotter 1989). The cutthroat summer rearing period is June through September. For the cutthroat rearing period in the Bull Run River above the confluence with the Little Sandy River, the projected HCP flows are 64 percent lower than the natural flows. Downstream of the Little Sandy River, the projected HCP flows are 54 percent lower than the natural flows. The significance of flow differences for cutthroat trout is further discussed by referring to WUA for rearing steelhead/rainbow in the following subsection.

Bull Run Weighted Usable Area. WUA values do not exist for cutthroat trout in the Sandy River Basin. For this analysis, the City assumed that the impacts to steelhead/rainbow trout WUA values would be applicable to cutthroat because the species have very similar life history traits and habitat preferences. WUA values were calculated for steelhead/rainbow trout spawning and rearing to assess the effect of the HCP flow measures on lower Bull Run River habitat. Table 8-28 compares WUA estimates for natural flow conditions (no dams and no diversions) and for HCP flows, upstream and downstream of the Little Sandy River. Median flows were used to generate the WUA estimates.

R2 Resource Consultants (1998) estimated the habitat-flow relationships for steelhead/rainbow trout spawning and rearing in the Bull Run River. Using the PHABSIM model, they generated estimates of WUA for up to 500 cfs for four segments of the Bull Run River. The four segments were combined into the two segments of the lower Bull Run River: upstream and downstream of the Little Sandy River. For flows greater than 500 cfs, goodness-of-fit curves were used to extrapolate WUA values.

The WUA estimates for natural and HCP flows are compared using a “percentage of natural” metric. For example, if the HCP percentage of natural flow is 90 percent and the natural WUA value is 1.0 acre in a particular month, the HCP median flow will yield a WUA value of 0.9 acre in that month.

Cutthroat trout spawn from late winter through spring, depending on the life history type and water temperature. The WUA analysis for steelhead/rainbow spawning conditions supports the assertion that the City’s minimum flows are protective of cutthroat trout. The City’s minimum flow of 120 cfs from December 1 through June 15 will maintain optimal spawning and incubation conditions for steelhead/rainbow, which are projected for cutthroat as well.

WUA values for steelhead/rainbow were used to determine the potential HCP effects on rearing cutthroat in the lower Bull Run River from June through September. R2 Resource Consultants estimated that habitat area (WUA) for steelhead/rainbow trout increases at a rapid rate between 0 and 100 cfs, with the most rapid increase occurring between 0 and 20 cfs (R2 Resource Consultants 1998). With HCP flows, the WUA values range from approximately 70 to 100 percent of natural flow WUA values for June through September. The HCP flows would have a small effect on rearing habitat conditions for cutthroat trout in the lower Bull Run River.

Downramping Rates. The City has studied juvenile salmonid stranding during different downramping events in the lower Bull Run River (Beak Consultants 1999; CH2M HILL 2002). The sites selected for monitoring included the widest areas of the channel considered most sensitive to downramping effects and stranding. Rainbow trout fry (about 40 mm average length) and yearlings (Age-1) juveniles were observed during the studies. Based on the studies, a ramping rate of no more than 2"/hour was recommended for the lower Bull Run River. This rate is generally what the state of Oregon and others have recommended to protect against juvenile fish stranding (CH2M HILL 2002; Hunter 1992).

The City will avoid or minimize the risk of fish stranding by maintaining a maximum downramping rate of 2"/hour year-round. Not all effects from flow downramping can be avoided, however, due to certain circumstances beyond the control of the City. These circumstances include natural storm flows beyond the City's control, mechanical/control system failures that are impossible for the City to predict, and FERC mandatory testing of project safety equipment. The City did a year-long evaluation (Galida 2005) and determined that these conditions occurred less than 1 percent of the time, which will have minimum effects on cutthroat.

Little Sandy River Base Flows. Forgoing development of the City's water rights on the Little Sandy River for the term of the HCP will help assure unimpeded natural flows on the Little Sandy River for cutthroat trout. Cutthroat trout will have access to approximately 7.3 river miles of the mainstem Little Sandy and 2 miles of tributary habitat. This measure will significantly increase the spawning and rearing habitat for coastal cutthroat trout.

Water Temperature

Cutthroat utilize the lower Bull Run River watershed most of the year, with peak periods for spawning, incubation, and emergence from February through July. After infrastructure changes to the Bull Run are completed, the HCP flow and temperature management measures will closely approximate the natural water temperature regime (Figure 8-23).

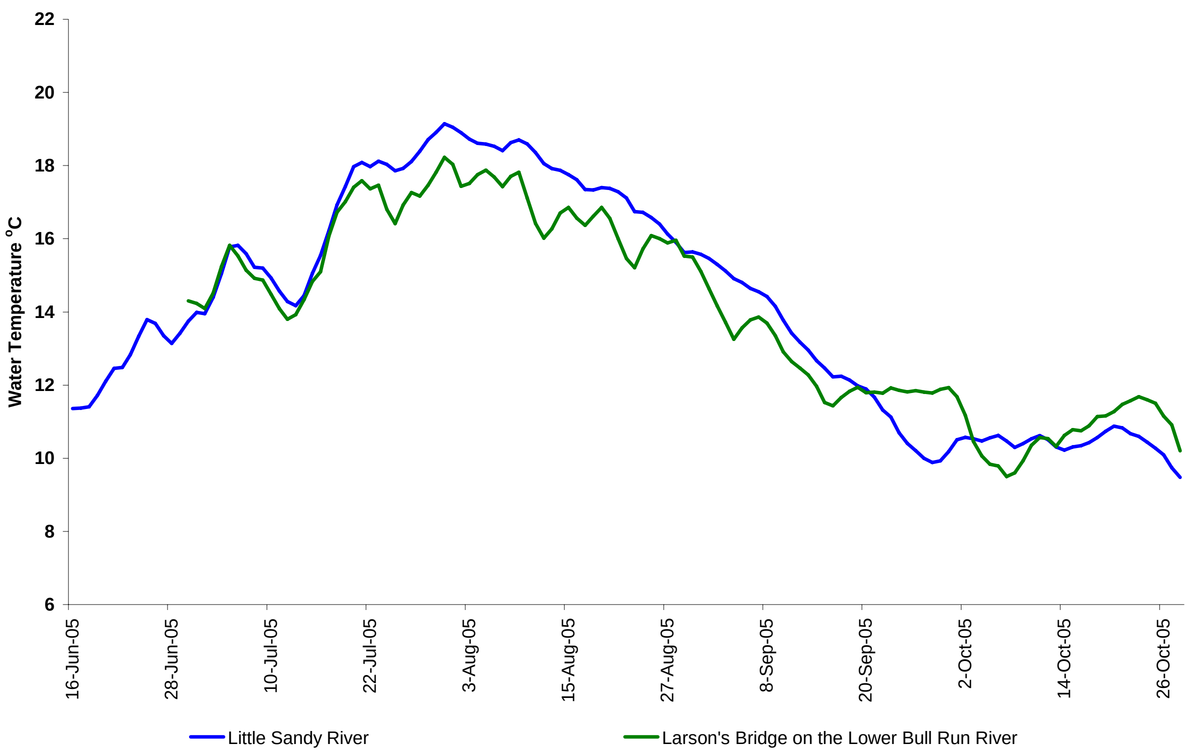


Figure 8-23. Comparison of Actual 7-Day Maximum Water Temperatures for the Little Sandy with Predicted 7-Day Maximum Average Temperatures Lower Bull Run River, June 16–October 24, 2005

Source: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8) and CE-QUAL-W2 Modeled Temperatures (February 2006)

Diurnal Water Temperature Fluctuations. Diurnal water temperature fluctuations likely to result from implementing the HCP measures were estimated using modeling results and measured Little Sandy River water temperatures. Table 8-54 lists observed and expected temperature fluctuations for the summer and late summer months. These are the months when the City's implementation of the water temperature measure (Measures T-1 and T-2) will affect diurnal temperature fluctuations. The fluctuations expected after implementing the HCP measures are predicted to be smaller than the fluctuations that would occur under natural conditions.

Table 8-54. Diurnal Water Temperature Fluctuations (°C)

Month	Bull Run Observed (current conditions)	Little Sandy Observed (natural conditions)	Expected HCP
June	4-6	0.5-5	2-3
July	4-6	1-5	2-3
August	3-5	1-5	2-3
September	2-3	1-4	1-2

Source: Bull Run observed temperatures: USGS Gauge No. 14140000 on the Bull Run River (RM 4.7); Little Sandy observed temperatures: USGS Gauge No. 14141500 on the Little Sandy River (RM 3.8); expected HCP temperatures: CE-QUAL-W2 Modeled Temperatures (February 2006).

The City reviewed available research on the influence of fluctuating water temperature on the growth of salmonids. Experiments on steelhead and coho (Hahn 1977; Grabowski 1973; and Thomas et al. 1986) indicated that fluctuating water temperature tests and the constant test exposures produced equivalent results. The City concludes that the reductions in diurnal water temperature fluctuations will not affect cutthroat trout or other salmonids that utilize the lower Bull Run River.

Large Wood

Large wood is removed from the upper end of Reservoir 1 to protect the downstream water supply dams from damage. The USFS owns this wood because it is transported by tributaries from national forest land. Since this wood is not allowed to travel down the lower Bull Run River, a small amount of beneficial habitat for cutthroat trout is potentially lost. The lower Bull Run is, however, a high-order confined stream and is not likely to trap and store large wood. Photographs taken of the lower Bull Run in the late 1890s, before the dams and water diversions were constructed, show little large wood in the channel. The lower river is probably a transport reach for large wood.

The lower Bull Run River is dominated by bedrock and boulders. This channel roughness supports diverse habitats, including about 27 percent pool habitat. The presence of this pool habitat suggests that large wood is not an important requirement of pool formation, and the addition of large wood would provide only a minor increase in pool habitat.

Historically, large wood pieces may have helped trap suitable spawning gravel and form some low-velocity areas that juvenile steelhead/rainbow trout may have utilized during

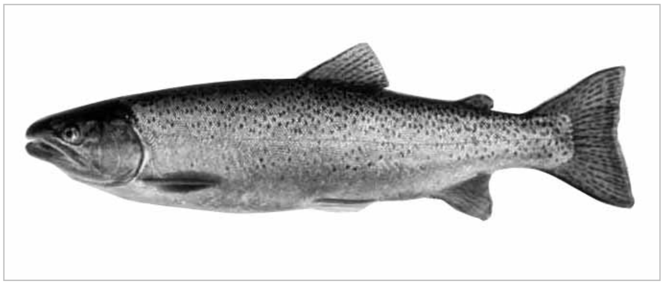


Photo courtesy of
Bonneville Power Administration

winter months. Cutthroat trout also use off-channel pools and side channels as winter habitat (Bustard and Narver 1975, Sedell et al. 1984, Hartman and Brown 1987).

The City does not plan to artificially place large wood in the lower Bull Run River above Larson's Bridge because of concerns about the vulnerability of water supply infrastructure (i.e., conduit trestles). The City will let natural recruitment of large wood occur downstream of Larson's Bridge. Trees that fall naturally will be left in place to modify the stream channel as long as the water conduits and bridges are not threatened.

Spawning Gravel

The two Bull Run dams interrupt bedload and gravel movement to the lower Bull Run River, resulting in reduced spawning habitat for steelhead/rainbow trout. The estimated historical gravel supply rate was roughly 30—1,000 cubic yards (CH2M HILL 2003b). The City will place approximately 1,200 cubic yards per year for the first 5 years and 600 cubic yards per year thereafter (see Measure H-1 in Chapter 7). The gravel replacement rate will be higher than the estimated natural accumulation for the first 5 years of the HCP. Gravel of various sizes will be placed in the lower Bull Run River that can be used by cutthroat trout. The placement of gravel in the lower Bull Run River to improve spawning habitat for Chinook and steelhead, however, may have little effect on cutthroat trout spawning. Cutthroat choose very small tributaries or headwaters for spawning. Johnston (1981) suggested they do this to minimize interactions with other salmonids. The City will monitor the effects of gravel placement to determine whether the measure should continue for the term of the HCP or should be modified.

Access

Resident cutthroat trout are found in many of the streams of the Sandy River Basin. However, the anadromous form of the coastal cutthroat has been limited in its distribution by dams and other structures. Anadromous cutthroat trout were first blocked from the upper Bull Run watershed in 1921 by construction of the Diversion Dam (approximately RM 5.9). That dam was constructed to divert Bull Run water into water conduits to serve the greater Portland metropolitan area. In 1964, as part of the Dam 2 construction, a rock weir at RM 5.8 was built to create the Dam 2 plunge pool for energy dissipation. That structure is now the upstream limit for anadromous cutthroat distribution; however, there are resident populations of cutthroat in upstream reservoirs and the upper Bull Run River reaches.

The City also blocks approximately 800 feet of Walker Creek, a tributary to the Bull Run River. Historically, this stream was probably used by anadromous cutthroat trout. Table 8-55 summarizes the historical distribution of anadromous cutthroat trout in the Bull Run watershed.

Table 8-55. Historical Distribution of Cutthroat Trout in the Bull Run River

River Segment	River Miles
Lower Bull Run River	
Bull Run River (mouth to Dam 2 spillway weir)	5.8
Walker Creek	0.15
Little Sandy River (mouth to Little Sandy Dam)	1.7
Little Sandy River (Little Sandy Dam to middle waterfalls)	5.6
Little Sandy River Tributaries (upstream of Little Sandy Dam)	2.0 (est.)
Upper Bull Run River	
Bull Run River (Dam 2 spillway weir up through reservoirs)	9.2
Bull Run River (free-flowing river to waterfall at RM 16.3)	1.3
South Fork Bull Run River and Cedar Creek	10.8

Source: USFS, Stream Reports on the Bull Run River Watershed

Under this HCP, anadromous cutthroat access will still remain blocked at the rock weir (RM 5.8). Continued operation of the City's water supply will block approximately 21.3 miles of the upper Bull Run watershed for anadromous cutthroat. Of the total miles blocked, 12.1 miles are free-flowing river, and approximately nine river miles are inundated by City reservoirs. The effects of continued blocked access for anadromous cutthroat in the Bull Run watershed will be mitigated through other offsite conservation measures, as described in the Effects on Habitat from the HCP Offsite Measures section. Fish access to Walker Creek will be provided under the HCP. A culvert or other appropriate structure that meets fish passage criteria will be constructed so that cutthroat will have access to Walker Creek.

When PGE removes the Little Sandy Dam, anadromous cutthroat will have access to an additional 5.6 miles of the mainstem Little Sandy River and 2.0 miles of tributary streams. The City's agreement to maintain flows for fish will help retain habitat benefits from this renewed access to the historical habitat for cutthroat trout.

Riparian Function

The City owns land along 5.3 miles of the lower Bull Run River (1,650 acres). The City's land represents 82 percent of the riparian corridor below Dam 2. Managing these lands to protect riparian habitat (see Measure H-2 in Chapter 7) will improve habitat for cutthroat trout. Approximately 30 percent of the riparian corridor along the lower river is in late-successional (late-seral) timber that can provide immediate large wood recruitment to the channel. Further, 80 percent of the riparian corridor is of mid- to late-seral age and will provide wood to the channel at an increasing rate over the next 10 to 70 years (Cramer et al. 1997).

Analysis of shading in the lower Bull Run River indicates that riparian vegetation currently intercepts 40 to 60 percent of the total solar radiation that potentially could reach the water surface (Leighton 2002). This shading provides a substantial benefit to maintaining water temperature and will become greater over time as the vegetation continues to mature. Even with mature vegetation in the lower Bull Run, however, water temperatures will not meet ODEQ's numeric water temperature criteria (see the temperature effects analysis In Appendix G).

Total Dissolved Gases

Oregon's Water Quality Standards, as enforced by ODEQ, state that TDG levels should not exceed 110 percent of saturation unless flows exceed the ten-year, seven day average flood (7Q10) flow for the site [OAR 340-041-0031]. The 7Q10 flow for the lower Bull Run is 5,743 cfs. The 7Q10 flow at the upstream end of Reservoir 2 is similar, though slightly less. The City has evaluated the water system structures, valves, and turbines that could elevate TDG levels since the fall of 2005 and determined that cutthroat trout probably have very little exposure to TDG levels above 110% in the Bull Run River. There are two structures where the City has found that high levels of TDG can occur that could affect cutthroat trout, the Dam 2 spillway stilling pool and the Dam 1 spillway. Elevated TDG levels, however, rapidly dissipate at both locations. Monitoring by the City has shown that TDG supersaturation drops significantly as water passes over the rock weir at the downstream end of the stilling pool, restricting the highest exposures to a single pool. TDG levels further dissipate downstream of the rock weir. Similarly, elevated TDG levels measured in the Dam 1 spillway had dissipated to below 110% at the tailout of the spillway pool. Elevated TDG levels were also restricted to only certain parts of either spillway pool. In both spillway pools, cutthroat trout had easy access to relatively calm water where TDG levels were consistently below 110%.

Cutthroat trout are probably not impacted by TDG levels in the Bull Run River. The City, however, will continue to monitor TDG levels in the Bull Run, as described in the Effectiveness Monitoring section in Chapter 9 and Appendix F, Monitoring Plans and Protocols.

Effects on Habitat in the Bull Run Reservoirs

The City will operate the reservoirs during the term of the HCP to minimize impacts to both cutthroat and rainbow trout (see Measure R-1, Reservoir Operations).

The two Bull Run reservoirs have populations of cutthroat trout, rainbow trout, and cutthroat/rainbow hybrids. Operating the City's water system may have effects on cutthroat trout in five areas:

1. Access to reservoir tributary streams for spring spawning
2. Reservoir water quality
3. Entrainment through the water intakes in Reservoirs 1 and 2
4. Trapping of fish in the Dam 2 spillway approach canal during reservoir drawdown
5. Ramping rates downstream of the Dam 1 powerhouse

The following analysis is organized according to these five types of possible effects.

Access to Reservoir Tributary Streams

The City conducted a study of the margins of both reservoirs in the spring during the peak rainbow and cutthroat trout spawning period in 2003. The study results indicated that access to the tributary streams was easily available when reservoir water level elevations were within a few feet of full-pool elevations (full-pool elevations for Reservoirs 1 and 2 are 1,045 feet and 860 feet, respectively). Only Deer Creek on Reservoir 1 would be blocked for fish access when the reservoir elevation decreases below 1,042 feet. For every year of City operations in the Bull Run, the reservoirs have reached full-pool levels. Therefore, the City's similar continued operation of the reservoirs will ensure consistent access to reservoir tributaries for trout spawners.

Reservoir Water Quality

The City conducted a study in 2001 comparing water temperature and dissolved oxygen conditions throughout the depths of the reservoirs with conditions in 1996. Water quality conditions in the reservoirs in 1996 were used as the reference condition, and are indicative of whether reservoir habitat was limiting fish production.

The study results indicated that Reservoir 1 undergoes thermal stratification as the year progresses from early spring into summer. The temperature of Reservoir 2 remains relatively constant throughout its depth. The water temperatures are within the suitable range for cutthroat trout and other salmonids throughout the year. An additional study of fish growth and feeding in Reservoirs 1 and 2 concluded that trout growth was excellent and that food availability did not appear to be a limiting factor (Beak 2001b).

The vertical dissolved oxygen profiles in Figure 8-24 show the potential effects of operating the water system. The study indicated that dissolved oxygen concentration in both reservoirs was fairly uniform across depths in the early spring and began to drop at all depths as the season progressed and reservoir temperatures began to rise (Figure 8-24). A slight stratification developed in both reservoirs in the late summer, with the lowest levels of dissolved oxygen at intermediate depths (Beak 2001a).

Figure 8-24 shows that dissolved oxygen levels in the reservoirs are within the suitable range for salmonids throughout the year.

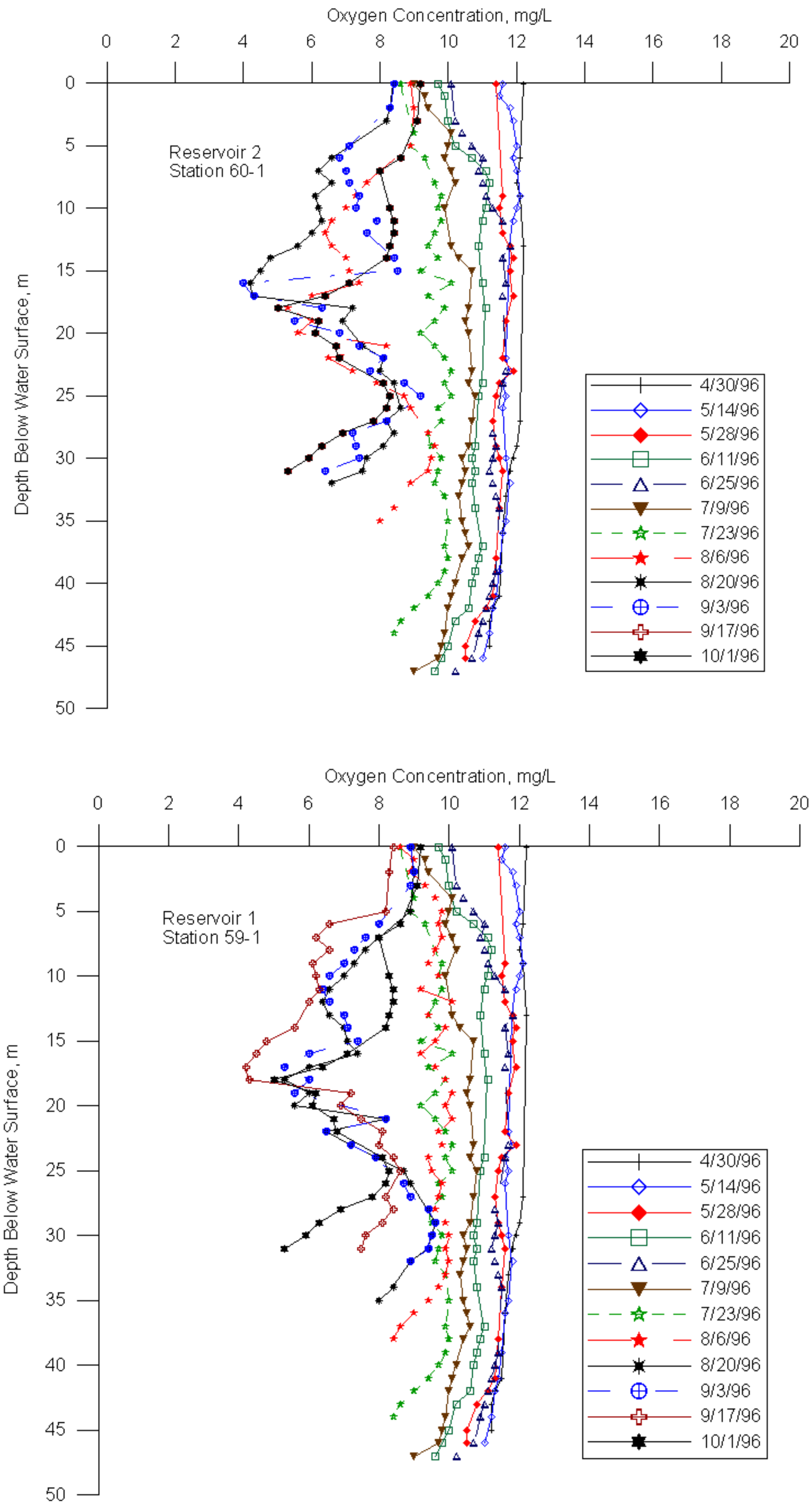


Figure 8-24. Vertical Dissolved Oxygen Profiles for Reservoirs 1 and 2

Source: Beak 2001a

Research on dissolved oxygen requirements for six salmonid species by EPA (1986) shows that the influence of dissolved oxygen on growth is negligible above 7 mg/L. EPA (1986) proposed 7- and 30-day mean criteria of 5 and 6.5 mg/L, respectively, for protecting other than early life stages. EPA (1986) suggested an 8 mg/L threshold as the 30-day mean criterion to protect juvenile/adult life stages, as well as developmental stages. ODEQ has established a state standard that dissolved oxygen may not be less than 8 mg/L for waters with cold-water aquatic life (OAR 340-041-0019).

At ODEQ's discretion, where adequate information exists, dissolved oxygen may not fall below 8 mg/L as a 30-day mean minimum, 6.5 mg/L as a 7-day mean minimum, and 6 mg/L as an absolute minimum. Figure 8-20 shows that dissolved oxygen in the Bull Run reservoirs exceeds 8 mg/L throughout the water column of both reservoirs, except in August–September. Even during this period, dissolved oxygen exceeds 8 mg/L in about the top 5 meters of the water column and exceeds 6 mg/L in all but about the middle 20 percent of the water column.

Overall, the City's continuing operations in the Bull Run River should have minimal effects on the water quality of the reservoirs. The analysis of water quality in the Bull Run reservoirs in 1996 (Beak 2001a) indicated that the water temperature and dissolved oxygen would support populations of rainbow trout. The City contends that cutthroat trout will also be supported due to their similar requirements.

Entrainment at the Water Intakes

The City does not have fish screens on its water intake towers in Reservoir 1 or 2 that meet current fish screening criteria. However, the City believes that entrainment of cutthroat trout in the reservoirs is very low and it is not negatively affecting the reservoir populations of fish. That conclusion is based on the following:

1. The cutthroat trout in Reservoir 1 and 2 no longer would demonstrate strong anadromous or fluvial life-history patterns because they have been isolated in the upper Bull Run watershed for a long time.

   All anadromous fish were blocked from the upper Bull Run River in 1921 from construction of the Diversion Dam on City property at RM 6.0. Construction of Reservoir 1 in the 1920s and Reservoir 2 in the 1960s further isolated the cutthroat trout. Since the trout have been isolated for over 80 years in the upper Bull Run, it is unlikely that significant numbers of fish would be trying to smolt and migrate downstream, so entrainment rates at the two dams would be related to random encounters of fish at the water intakes.

2. Only larger cutthroat trout would randomly encounter the dam intakes and they are less susceptible to entrainment.

   Adfluvial rainbow and cutthroat trout tend to remain in their natal tributaries for the first year or two (Quinn 2005, Trotter 1989, Nowak et al. 2004). All natal tributaries to Reservoir 1 and 2 are located a significant distance from the water intakes. Fry and juveniles in lakes tend to be associated with the banks where they can find cover

(Tabor and Wurtzbaugh 1999, Bozek and Rahel 1991) and small fish that venture into open water probably would experience a high risk of predation. Before they reach the water intakes, most would probably be eaten because of adult rainbow and cutthroat trout's piscivorous behavior (Nowak et al. 2004). For these reasons, the City does not believe that small cutthroat would likely encounter the reservoir water intakes and be entrained. Larger fish, which could randomly encounter the intakes, would be better able to resist the approach velocities at the intake gates.

3. The City's operational protocols for running water though the Dam 1 or 2 water intakes will minimize the potential entrainment of cutthroat trout.

   The City does not run the reservoir powerhouses, which are located just downstream of Dams 1 and 2, continuously and that dictates the amount of water that is pulled from the reservoirs. During the summer when the reservoirs are drawn down, powerhouse use occurs primarily in the morning and evening to keep the reservoir elevations within a target range. When reservoir inflows are low, the powerhouse tends to be operated only once per day for a few hours.

4. Cutthroat entrainment at Reservoir 2 appears to be very low.

   In Reservoir 2, some cutthroat do go through the intake towers and end up in the diversion pool immediately downstream of Dam 2. In 2000, City staff drained the pool for the first time in 10 years and observed approximately 17 trapped cutthroat, from 4 to 14 inches long. City staff who are at the Headworks site 24 hours a day have never observed dead fish in the Diversion Pool. The City also conducted a hydroacoustic study of entrainment in Resevoir 2 in 2007 (Strobel 2007b). The study estimated that up to 472 fish may be entrained annually, based on very conservative assumptions of how fish would be drawn into the water intake tower. The actual number of fish entrained was probably much lower and may have been near zero. The study also estimated productivity in the reservoir and modeled the population dynamics of its cutthroat trout. The productivity calculations and modeling suggest the productivity in the reservoir could offset as much as four times the estimated maximum level of entrainment. Based on the number of fish observed in 2000 in the diversion pool and the City's hydroacoustic study, the amount of entrainment at the Dam 2 intake towers may be extremely low and the viability of the population should not be threatened.

The City believes that entrainment is not significantly affecting the cutthroat trout populations in Reservoir 1 or 2.

Trapping of Fish

The City will retrieve live cutthroat trout and other salmonids, if found, from the Dam 2 spillway approach canal and return them to Reservoir 2. The fish will be retrieved and returned as soon as possible after the canal has become isolated (when Reservoir 2 drops to an elevation of about 855 feet). The trapping will occur annually unless the trapping cannot be conducted early enough in the drawdown season because of high reservoir elevations, and the trapped fish would be stressed by the trapping process; or the trapping-related mortality is too high.

This conservation measure will minimize trout mortality resulting from the City's water supply operations.

Ramping Rates Downstream of Dam 1

The City believes that few cutthroat are stranded due to hydropower generation from the Dam 1 powerhouse. Dam 1 is located at the upper end of Reservoir 2, which is approximately 4.5 miles long. Over the entire length of the reservoir, only about 1,000 feet of riverine habitat is not inundated, less than 5 percent of the lineal distance between the dams. This is the only area where trout stranding could occur as a result of hydropower operations.

A hydroacoustic survey of Reservoir 2 (HTI 2000) shows that cutthroat trout are not concentrated in the upper end where there could be stranding effects. Also, the City's hydropower operations can only lower the water surface of Reservoir 2 by a maximum of 20 feet during drawdown, which restricts the area affected by downramping in the upper portion of Reservoir 2 to approximately 0.2 miles during most of the year and a maximum of 0.5 mile. Based on the small amount of habitat in which fish could be stranded and the restriction for lowering the reservoir elevation, the City believes that continued hydropower operations at Dam 1 should not negatively affect the population of cutthroat trout in Reservoir 2.

Effects on Habitat from the HCP Offsite Measures

Cutthroat trout are probably the most common trout species in the Sandy River Basin, and the resident form is generally abundant in the Sandy River's smaller and average-sized tributaries (Taylor 1998). However, production of anadromous cutthroat is believed to be very low (Taylor 1998; ODFW 2001). Little is known about the cutthroat trout that historically used the Sandy River. Historically, approximately 20 to 30 sea-run cutthroat trout entered the Sandy Hatchery on Cedar Creek each fall, but none do so now (Hooton 1997). No large cutthroat have been counted upstream past Marmot Dam since 1977, when counting facilities became available (Cramer, PGE, pers. comm., 2005).

For this analysis, the City's potential effects on cutthroat trout were determined by examining the effects on steelhead/rainbow and coho salmon. Life history traits of cutthroat and steelhead/rainbow are very similar, and adult spawning and juvenile migration periods overlap. The habitat requirements of cutthroat also overlap with both steelhead/rainbow and coho. Each species requires high-quality spawning gravels and relatively low stream water temperatures. Cutthroat use both the slow water and off-channel habitats preferred by coho and the swift water habitats preferred by steelhead. As the habitat measures result in improved spawning and rearing habitat for steelhead/rainbow and coho salmon, so benefits to cutthroat trout should also be substantial. The habitat effects described for steelhead and rainbow trout and coho apply to cutthroat trout in the Sandy River Basin (see the sections for steelhead and coho, Habitat Effects in the Sandy River Basin from the HCP Offsite Measures, beginning on page 8-101 for steelhead and page 8-140 for coho, and Tables E-13 through E-17 for steelhead and Tables E-18 through E-20 for coho in Appendix E).

Population Effects and VSP Parameters

The U.S. Fish and Wildlife Service (USFWS), Tacoma Power, City, Washington Department of Fish and Wildlife, and Mobrand Biometrics provided funding and assistance in developing a set of biological rules to conduct analyses on resident and anadromous coastal cutthroat trout for the Sandy River Basin. Through a series of workshops, a draft set of rules was used to run the EDT model for cutthroat trout in December 2003 (City of Portland, Bureau of Water Works, 2004).

The EDT model run results did not produce good estimates of the VSP parameters for cutthroat because coastal cutthroat trout use very small tributaries as their primary spawning area, and habitat data were not available for many of these small streams. Without information on spawning habitat, the EDT model was unable to calculate an abundance value. Therefore, the model runs were deemed not very useful in estimating cutthroat abundance, production, or capacity.

As a surrogate for VSP parameters for cutthroat trout, the City used the VSP values generated for steelhead. As stated previously, both species have similar life histories and habitat preferences. For steelhead, productivity, diversity, and abundance would increase 7, 6, and 8 percent, respectively, with implementation of the City's Bull Run and offsite HCP measures.[16] The City asserts that habitat conditions for cutthroat and the associated VSP parameters would also improve from the HCP measures.

Benchmark Comparison of Fish Abundance

Model run projections of the cutthroat abundance that may accrue from the HCP measures were not possible to obtain because cutthroat trout use very small tributaries as spawning areas, and habitat data were not available for these areas. The City relied on the results of the steelhead and coho modeling efforts to project the potential effects on cutthroat. Overall, the EDT model predicted that approximately 3,880 adult steelhead could be produced under the Modified Historical Bull Run Condition scenario compared with approximately 3,560 adult fish that could be produced under the City's HCP measures.[17] For reasons stated earlier, the model predictions are very conservative. The estimate for the Modified Historical Bull Run Condition is probably very high, and the estimate for the City's HCP measures is probably low. The EDT model predicted that approximately 2,551 adult coho could be produced under the Modified Historical Bull Run Condition scenario compared with approximately 2,822 adult fish that could be produced under the City's HCP measures. Because the habitat needs of cutthroat trout are completely overlapped by those of the combination of steelhead and coho, and both steelhead and coho are predicted to benefit from the City's HCP measures, the City concludes that cutthroat trout will also benefit, although to what degree cannot be quantitatively estimated.

[16] These VSP figures assume that the Cedar Creek weir will not be removed. If the Cedar Creek weir is removed, as expected, the predicted increases in productivity, diversity, and abundance are 7, 15, and 12 percent, respectively.

[17] The estimate of abundance under the HCP measures does not take into account the removal of the Cedar Creek weir. With the additional habitat resulting from the removal of Cedar Creek weir, the abundance estimate from the City's HCP rises to 3,037.

Conclusions about the Habitat Effects of HCP Measure Implementation

The City assumes that the effects on habitat from the HCP offsite measures for cutthroat trout would be similar to those for steelhead and coho, since the species have overlapping habitat needs. Predicted steelhead responses illustrate particularly well how cutthroat trout are expected to benefit because their life-history traits are also so similar. Those effects are discussed in this chapter, beginning on page 8- 79 for steelhead and page 8-117 for coho. Conclusions regarding the habitat effects of implementing the HCP are listed for steelhead on page 8-114 and for coho on page 8-151.

The HCP is expected to result in both short- and long-term benefits to cutthroat trout. The conservation measures in the HCP will improve the natural processes important for creating and maintaining habitat for coastal cutthroat in the Bull Run watershed and in other areas of the Sandy River Basin.

With the additional benefits that will accrue above and beyond the core HCP measures, the City considers the HCP as a whole package to be more than adequate to compensate for impacts on cutthroat in the Bull Run watershed.

8.4.3 Pacific, Western Brook, and River Lamprey

Little information is available from which to discuss the potential effects of the HCP conservation measures on Pacific, western brook, and river lamprey in the Sandy River Basin as individual species. The species, however, do share some life history patterns and habitat preferences that are similar to other species covered by this HCP.

Even though Pacific, western brook, and river lamprey are widely distributed along the Pacific Coast, there is very little information on the species. Pacific and river lamprey are anadromous and parasitic during the time that they are in the ocean. Western brook lamprey do not appear to move much during their lives, and most movement is passive downstream movement when they leave the deep burrows that they entered after metamorphism.

Pacific and western brook lamprey, and probably river lamprey, spawn in the spring and construct redds in a fashion similar to anadromous salmonids. Spawning Pacific lamprey have been observed during steelhead spawning surveys (Jackson et al. 1996). The lamprey's eggs hatch quickly, and juvenile lampreys then burrow into mud or sand. The ammocoetes generally remain buried in the substrate for five or six years and feed by filtering organic matter and algae (Moyle 1976).

Effects on Habitat in the Lower Bull Run River

Bull Run Base Flows

The City's flow commitments will increase spawning and rearing habitat for several ESA-listed salmonid species; those flow commitments should increase habitat for Pacific, western brook, and river lamprey in the Bull Run watershed. Pacific and western brook lamprey, and probably river lamprey, spawn in the spring like steelhead/rainbow trout, therefore

Photo courtesy of Char Corkran.

inferences about benefits to the lamprey species can be drawn from the potential benefits of the HCP measures for steelhead/rainbow trout. The City's minimum flow of 120 cfs from December 1 through June 15 will maintain ideal spawning and incubation conditions for steelhead/rainbow trout. Since Pacific lamprey have been observed spawning in habitat similar to that preferred by steelhead (Jackson et al. 1996; Foley 1998), the City believes that spawning habitat for the three lamprey species will improve under the HCP.

Juvenile lamprey prefer mud or sand substrates for rearing habitat, and the Bull Run River has very little of that type of habitat. However, the HCP's minimum flow levels should maintain the wetted channel of the river and protect juvenile lamprey.

Downramping Rates

Substrate is the most significant factor contributing to stranding of salmonid fry (Hunter 1992). When the water surface drops, fry maintain their position and become trapped in pockets of water between cobbles. With smoother substrates, fry tend to swim around the smaller rocks. Juvenile lamprey prefer mud and sand substrates, so it is unlikely that they will get stranded in the lower Bull Run River. The City's maximum downramping rate of 2"/hour downstream of Dam 2 will ensure this outcome.

Water Temperature

The City will implement a variety of measures that will reduce water temperatures for fish in the lower Bull Run River, as discussed earlier for several anadromous salmonids. Collectively, these measures will improve water temperatures for lamprey as well.

Little information is known about the water temperature preferences of Pacific, western brook, or river lamprey. Nonanadromous western brook lamprey spawn in the spring and early summer over a temperature range of 7.8—20 °C (Scott and Crossman 1973). Those water temperatures will be maintained with the HCP water temperature measures; the City assumes that water temperatures under the HCP will be protective of spawning conditions for Pacific and river lamprey. The City was not able to determine lamprey water temperature preferences for the long period when the ammocoetes are in the fine substrate. However, the City assumes that Pacific, western brook, and river lamprey in the Sandy River

Basin have evolved with the native salmonids and prefer the natural water temperatures conditions of the various Basin streams.

Under Measure T-2, the City will complete infrastructure changes at the Dam 2 towers and the stilling basin and will commit to daily operational flow management. These changes will reduce water temperatures in the lower Bull Run River, and the City will meet the natural (historical) water temperature conditions. With these commitments, all water temperature effects on Pacific, western brook, and river lamprey will be avoided.

Access

The City assumes that Pacific, western brook, and river lamprey could have had the same historic distribution as steelhead in the Bull Run watershed. That assertion is supported by others who are familiar with the passage capabilities of the lamprey (Kostow, ODFW, pers. comm., 2005). Table 8-56 summarizes the historical distribution of lamprey in the Bull Run watershed.

Table 8-56. Historical Distribution of Lamprey in the Bull Run River

River Segment	River Miles
Lower Bull Run River	
Bull Run River (mouth to Dam 2 spillway weir)	5.8
Walker Creek	0.15
Little Sandy River (mouth to Little Sandy Dam site)	1.7
Little Sandy River (Little Sandy Dam site to middle waterfalls)	5.6
Little Sandy River Tributaries (upstream of Little Sandy Dam site)	2.0 (est.)
Upper Bull Run River	
Bull Run River (Dam 2 spillway weir up through reservoirs)	9.2
Bull Run River (free-flowing river to waterfall at RM 16.3)	1.3
Bull Run River (RM 16.3 to 80-ft waterfall)	5.4
South Fork Bull Run River	2.7
Cedar Creek (tributary to South Fork Bull Run River)	8.1
Camp Creek	0.6
Fir Creek	0.5
Bear Creek	0.3
Cougar Creek	0.7
Deer Creek	0.5
North Fork Bull Run River	0.8
Log Creek	0.2
Falls Creek	0.8
West Branch Falls Creek	0.3
Blazed Alder Creek	2.4
Blazed Alder tributaries	0.4 (est.)

Source: USFS, Stream Reports on the Bull Run River Watershed, 1999

The City constructed a lamprey barrier at approximately RM 5.9 on the mainstem Bull Run River to keep adult lamprey and ammocoetes out of the Diversion Pool where unfiltered water enters the conduits for Portland's drinking water. Under this HCP, lamprey access will remain blocked at the lamprey barrier, preventing lamprey access to approximately 34 miles of the upper Bull Run watershed. Of the total miles blocked, 25 miles are free-flowing river and approximately 9 river miles are inundated by City reservoirs. This analysis is very conservative and assumes that lamprey historically were able to migrate upstream of a series of three waterfalls on the mainstream Bull Run River at RM 16 – RM 16.65.

Fish access to Walker Creek will be provided under the HCP. A culvert or other appropriate structure that meets fish passage criteria will be constructed so that lamprey will have access to Walker Creek.

Once PGE removes the Little Sandy Dam, lamprey will be able to utilize an additional 7.3 miles of the mainstem Little Sandy River and 2 miles of tributary streams.[18] The City will maintain flow conditions in the Little Sandy River to benefit lamprey and other fish species (see Measure F-4, Chapter 7).

This HCP has several conservation measures that will increase the available miles of lamprey habitat in other streams in the Sandy River Basin. Those effects are discussed in the following section.

Effects on Habitat from the HCP Offsite Measures

The conservation measures in the HCP are expected to maintain the natural processes important for creating and conserving habitat for Pacific, western brook, and river lamprey in the Sandy River Basin. The HCP is expected to result in short- and long-term benefits to lamprey, compared with the current conditions.

This HCP contains 30 conservation measures outside of the Bull Run watershed that will improve habitat conditions for lamprey. The five general types of measures, fish passage, carcass placement, riparian improvements, water rights acquisition, and in-channel improvements, are discussed below.

Fish Passage

Fish passage improvements at Alder Creek will increase the available space and habitat distribution of lamprey in the Sandy River Basin.

Carcass Placements

Carcass placements will provide short-term benefits for lamprey in the Sandy River Basin. This conservation measure will increase nutrient levels, primary and secondary aquatic productivity, and, subsequently, the survival, growth, and abundance of lamprey.

[18] See Section 4.1.5 Water Quality and Water Rights for more information about the removal of the Little Sandy Dam.

Riparian Improvements

The City HCP riparian improvement projects in 19 stream reaches with predicted improvements to habitat conditions in 21 offsite Sandy River Basin reaches. The riparian improvements will provide wood recruitment, shade, bank stabilization, and runoff filtration capacity over time that will increase the survival, abundance, and productivity of lamprey in the Basin.

Water Rights Acquisition

The city will pursue purchasing water rights in Cedar Creek to increase flows for fish, including lamprey.

In-channel Improvements

The City has identified in-channel improvements in 13 stream reaches of the Little Sandy and Sandy rivers. The work includes large wood placements and introductions, log jam creation, instream enhancement, channel design, channel reconstruction, river mouth reestablishment, bank restoration, side-channel construction, and channel restoration. All of the in-channel improvements should increase the survival, abundance, and productivity of lamprey in the Sandy River Basin.

Population Effects and VSP Parameters

There is no information to determine the population status of the three lamprey species addressed in this HCP.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP measures within the Bull Run watershed and elsewhere in the Sandy River Basin are expected to maintain the natural processes important for creating and maintaining habitat for the three lamprey species. The flow commitments in the HCP will result in both short- and long-term benefits to lamprey that represent improvements over the habitat conditions in place for the Bull Run River prior to the City releasing flows for salmonids (in the late 1990s).

8.5 Amphibians and Reptiles

In this HCP, the City addresses the following amphibians and reptiles: western toad, Cascades frog, northern red-legged frog, coastal tailed frog, Cope's giant salamander, Cascade torrent salamander, clouded salamander, Oregon slender salamander, the western painted turtle, and the northwestern pond turtle. The effects of the City's HCP on these species are described in the following subsections:

- Effects of the Bull Run water supply operations and related activities
- Effects of the Bull Run HCP measures
- Effects of the offsite HCP measures

8.5.1 Western Toad *(Bufo boreas)*

The only known breeding site in the Sandy River Basin is the north side of Bull Run Reservoir 1, where an extensive bench is inundated when the reservoir is at full pool.

Effects of Bull Run Water Supply Operations and Related Activities

The permanent water supply facilities will continue to have slight, negative long-term effects on western toads. The dams and large reservoirs pose impediments to migration of adult toads and dispersal of metamorphs. While the dams can be circumnavigated, the large bodies of water make hazardous crossings because of the presence of trout, river otters, and other predators. The presence of the log booms, roads, bridges, power lines, and other facilities has no known effect on western toads.

Normal operation of the water supply will continue to have positive long-term effects on western toads in the Bull Run watershed. Water stored in the reservoirs, which inundates the benches at the upper end of Reservoir 1, creates ideal breeding habitat that is used annually by this species. Over decades of continued water storage, extensive bars of fine debris have built up at the reservoir's head, which may be increasing the available breeding habitat. However, the recent invasion of reed canarygrass *(Phalaris arundinacea)* has reduced the value of the site. This exotic grass covers the organic mud and fine debris used by the toads for egg deposition, tadpole foraging, and dispersal of metamorphs. It also shades the water and substrate, which slows the temperature-dependent development of eggs and larvae. Withdrawal of water from the Bull Run River below the reservoirs will continue to have negligible long-term effects on western toads. Riparian forests are used by some toads for migration and summer foraging, with the wetted edge of the river being used for water absorption and some foraging. Having to travel farther from the forest to get to water increases the toads' exposure to predation; however, few individual toads will use the lower Bull Run River.

Annual operation of the reservoirs has positive effects on the western toads because it mimics a natural water regime. The local toad population has adjusted its breeding time to June to take advantage of the seasonal dam gate closure, inundation of the bench habitat, and gradual summer drawdown of the water level in Reservoir 1. In drought years, some tadpoles are stranded on the debris flats by early drawdown, but this is a natural phenomenon that occurs at all toad breeding sites. At least one pool on the north bench retains water even through drought summers and produces western toad metamorphs in most years.

Other annual activities such as routine maintenance, use of boats on the reservoirs, driving on project roads and bridges, and hydropower generation have little or no effect on western toads. Removal of floating logs from Reservoir 1 decreases the available hiding cover for toadlets and basking sites for adults. Not all logs are removed, however, and before the dams were built, many logs would have been transported away from the site by high river flows. Boats generally do not disturb the extreme north shallows of Reservoir 1 where eggs are laid in June and tadpoles congregate in summer. Because this breeding site is not near any project roads, neither migrating adult toads nor dispersing metamorphs are especially vulnerable to being run over by vehicles (the nearest USFS road is also at a safe distance away). The light foot traffic that occurs on the Station 18 Trail at the time of toadlet dispersal does not constitute a threat to annual recruitment to the population.

Effects of the Bull Run Measures

The habitat conservation measures in the HCP will have negligible long-term effects on the western toad population because few individuals use the affected areas. Instream flow commitments for the lower Bull Run River will have little influence on summer water levels in Reservoir 1. Higher instream flows will decrease the distance to water for the few adult toads that may summer in riparian areas, thus minimizing their exposure to predators. Cold water allocations to the lower Bull Run River will have little effect on adult toads that may summer there because water temperature is not a factor for water absorption, and because the water will not be cold enough to limit numbers of invertebrate prey used by the toads.

The City will cut reed canarygrass annually from three areas along the upper end of Reservoir 1 to improve breeding conditions for western toads. Annual cutting of the invasive grass will allow the side-channel benches to warm up enough for successful toad breeding and rearing. Other Bull Run habitat improvement and preservation measures will have limited positive effects on western toads because the majority of the Bull Run toad population is higher up in the watershed. Gravel placement will not affect toads because they do not use the stream substrate. Preservation of riparian areas will maintain summer habitat for the few adults likely to use these river reaches during summer.

Effects of the HCP Offsite Measures

Offsite habitat enhancement and protection will have limited positive effects on western toads in the Sandy River Basin because most measures will occur in areas not frequently used by this species. Easements and enhancements on the Salmon River could positively affect the few adult toads that may travel into that area from an adjacent river basin because these measures will protect riparian habitat that may be used for summer foraging. Control of invasive plant species in the Sandy River Basin, associated with the HCP's riparian easements, could have positive effects on western toads over the long term if it improves habitat in areas used by this species, but negative effects in the short term if it involves tools or techniques that are harmful to toads.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP will have mostly positive effects on western toads in the Sandy River Basin. The Bull Run population primarily uses Reservoir 1 and the upper Bull Run watershed rather than the other tributaries of the Sandy River; however, toads are known to travel long distances and may spend summers in riparian areas more than three miles from breeding sites (Thompson 2004). Consequently, most of the activities covered by this HCP will affect few, if any, individual western toads.

8.5.2 Cascades Frog *(Rana cascadae)*

Effects of Water Supply Operations and Related Activities

The permanent water supply facilities will have no effect on Cascades frogs because the species does not occur in the reservoirs or near the dams. Project roads, bridges, power lines, and other facilities have no known influence on the species.

Normal operation and maintenance of the project will have no effect on Cascades frogs because they do not occur in the immediate area of these activities. Water storage in the reservoirs, withdrawal of water from the lower Bull Run River, annual filling and drawdown of Reservoir 1, debris removal, use of boats on the reservoirs, driving on project roads and bridges, hydropower generation, and routine facility maintenance will occur outside of the known geographic range of this species.

Photo courtesy of Char Corkran.

Effects of the Bull Run HCP Measures

The habitat conservation measures in the HCP will have limited positive effects on Cascades frogs because the measures will occur outside or at the lower edge of the known geographic range of the species. Instream flow commitments and cold water allocations to the lower Bull Run River, as well as onsite habitat improvement and preservation measures in the lower Bull Run River and lower Little Sandy River, will not affect Cascades frogs, which have never been found in those areas.

Effects of the HCP Offsite Measures

A few of the offsite habitat improvement and preservation measures will slightly benefit Cascades frogs. Adults from populations breeding near the headwaters of Cedar Creek probably summer along the upper portions of Cedar and Alder creeks. Riparian easements and improvements in these areas will preserve and enhance summer foraging and migration habitat for frogs as well as fish. Similarly, riparian easements on the upper sections of the Zigzag and Salmon rivers will preserve summer habitat for frogs that breed nearby, and placement of salmon carcasses will increase invertebrate prey abundance. Control of invasive plant species in the Sandy River Basin, associated with the HCP'S riparian easement, could have positive effects on Cascades frogs over the long term if it improves habitat in areas used by this species, but negative effects in the short term if it involves tools or techniques harmful to frogs.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP will have limited positive effects on Cascades frogs in the Sandy River Basin. Because this is primarily a high-elevation species, few individual Cascades frogs are present in the areas affected by the covered activities.

8.5.3 Northern Red-legged Frog *(Rana aurora aurora)*

Effects of Water Supply Operations and Related Activities

The permanent project facilities will continue to have minor, negative long-term effects on northern red-legged frogs. The dams and large reservoirs somewhat hinder the migration of adult frogs and dispersal of metamorphs. Although the dams can be circumnavigated by this very active species, crossing the reservoirs makes frogs vulnerable to trout, river otters, and other predators. The log booms, roads, bridges, power lines, and other facilities have no known effect on northern red-legged frogs.

Normal operation of the water supply will continue to benefit northern red-legged frogs. Storage of water in the Bull Run reservoirs provides breeding habitat at the upper end of Reservoir 1, particularly the bench at the mouth of Fir Creek. Long-term water storage has resulted in extensive bars of fine debris, which may be increasing available breeding habitat. However, the reservoirs also provide habitat that attracts American beaver (Castor canadensis) whose activity affects the growth of small willows used for egg attachment by the frogs in the limited shallow habitat. Recent invasion by reed canarygrass could impact native sedges and other vegetation used by red-legged frogs for egg deposition and larval development.

Withdrawal of water from the Bull Run River below the reservoirs will continue to have slight, negative long-term effects on northern red-legged frogs. From the large breeding population near the south side of Reservoir 2, some adult frogs are likely to use the riparian forest and stream edge along the lower Bull Run River for summer foraging, migration corridors, and possibly winter residency. The drop in the water level increases the distance from water to forest, which increases the frogs' exposure to predation and may reduce moisture in logs and vegetation used for cover.

Annual operation of the reservoirs has mostly positive effects on red-legged frogs because it creates natural flow cycles and therefore provides usable habitats at appropriate times of year. The water level in Reservoir 1 is kept at least 10 feet below full pool during the winter when northern red-legged frogs gather for breeding. At that water level, vegetation used for egg attachment is at appropriate water depths, although some areas probably approach the maximum usable depth. By the time the gates on Dam 1 are closed in spring and the reservoir is at full pool, eggs in shallower water have already hatched and the small larvae can follow the water line to find optimum conditions for rapid growth. Hatching success of egg masses in the deeper water areas has not been monitored after the reservoir is at full pool, but hatching is delayed by colder conditions and therefore some eggs may not hatch at all. The gradual summer drawdown in Reservoir 1 follows a natural pattern that warms the water in the shallows and fosters growth of tadpoles and their food. In years with a dry spring, some egg masses are stranded by receding water levels, which is a normal phenomenon. Even in years with a dry spring and summer, some pools retain water long enough for tadpoles to complete metamorphosis.

Other project-related activities, such as routine maintenance, use of boats on the reservoirs, driving on project roads and bridges, and hydropower generation, have little or no effect on red-legged frogs. Removal of floating logs from Reservoir 1 decreases the available hiding cover, but not all logs are removed, and the dams artificially prevent logs from being transported away from the site by high river flows. Boats generally do not enter the shallows of Reservoir 1 when eggs are present in February, and the usual timing of debris removal occurs after the few egg masses in the shallows near the upper log boom have already hatched. Summer use of boats generally does not disturb tadpoles congregating in the shallowest edges. Because the primary breeding sites are not near any project roads, neither migrating adult frogs nor dispersing metamorphs are particularly vulnerable to being run over by vehicles (the nearest USFS road is also at a safe distance away).

Effects of the Bull Run Measures

Instream flow commitments in the lower Bull Run River will benefit frogs residing in the riparian zone because increased flows will reduce the distance from forest to water, thereby reducing the frogs' exposure to predation and retaining more moisture in substrate and cover objects near the forest edge. Cold water allocations to the lower Bull Run River will benefit resident adult frogs because this species prefers cool, moist conditions, yet the water will not be cold enough to limit numbers of invertebrate prey.

The City will cut reed canarygrass annually from three areas along the upper end of Reservoir 1 to improve breeding conditions for red-legged frogs. Annual cutting of the invasive grass will allow the side-channel benches to warm up enough for successful frog breeding and rearing.

Bull Run habitat improvement and preservation measures will have positive long-term effects on northern red-legged frogs. Gravel placement will briefly disturb resident adult frogs but will have no long-term effect because the frogs do not use the river substrate except for occasional escape from terrestrial or aerial predators. Preservation of riparian areas will maintain habitat used for much of the year by resident adult frogs.

Effects of the HCP Offsite Measures

Offsite habitat enhancement and protection measures will have positive long-term effects on northern red-legged frogs in the Sandy River Basin. Riparian easements and improvements including large wood placement will benefit frogs where they occur in the lower reaches of the Sandy and Salmon Rivers and in all the creeks where activities are planned. Improving fish passage will not affect red-legged frogs because the frogs rarely enter the streams and because the species can withstand occasional predation by native salmon and steelhead with which it evolved. Placement of salmon carcasses will increase invertebrate prey abundance for frogs. Channel reconstruction and reestablishment of the mouth of the Sandy River may benefit red-legged frogs because increasing the influence of river flows through the delta may favor native fish species over introduced fish and American bullfrogs, both of which pose unnatural risks of predation, competition, and disease. Control of invasive plant species in the Sandy River Basin, associated with the HCP’s riparian easements, could benefit red-legged frogs over the long term by replacing stands of weed species with diverse native plant communities that may harbor more diverse and numerous invertebrate prey for adult frogs and provide better hiding cover. Weed control measures could have short-term impacts on red-legged frogs if the measures temporarily remove vegetation and/or physically displace or kill frogs.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP will have mostly positive long-term effects on northern red-legged frogs in the Sandy River Basin. The species occurs throughout the lower portions of the Basin where most of the covered activities will occur. Large breeding sites occur in and near the Bull Run reservoirs. The species is closely associated with riparian forests (Blaustein et al. 1995; Hallock and McAllister 2005).

8.5.4 Coastal Tailed Frog *(Ascaphus truei)*

The coastal tailed frog occurs in many of the headwater and tributary streams in the Basin, some of which are influenced by the covered activities. These frogs are apparently dependent on undisturbed riparian and old-growth conifer forests associated with moderate or high gradient streams (Bury et al. 1991a; Bury et al. 1991b; Welsh 1990).

Effects of Water Supply Operations and Related Activities

The permanent project facilities will continue to have slight, negative effects on coastal tailed frogs. The dams and large reservoirs are slight impediments to the movement of adults and metamorphs. Although the frogs may circumnavigate the dams, crossing the reservoirs makes them vulnerable to trout, river otters, and other predators. Furthermore, the reservoirs may be sinks for larvae that are carried in from the Bull Run River and from small streams because the reservoir may become too warm, have insufficient oxygen, have silt covering the rocks, and may not provide appropriate food sources for larval survival. Culverts may impose barriers to migration of adults and dispersal of metamorphs. The log booms, roads, bridges, power lines, and other facilities have no known effect on coastal tailed frogs.

Normal operation of the water supply will continue to have slight, negative effects on coastal tailed frogs. Withdrawal of water from the lower Bull Run River will have low impact because most tadpoles and adults occur in and adjacent to smaller streams. Tadpoles carried into this river section from small tributaries may be negatively impacted by the relatively warmer, shallower water in these reaches because the water is beyond the shade of adjacent trees and flanked by heat-holding rocks. The following activities have no known effects on the coastal tailed frog: annual operations that result in fluctuations in the reservoir levels, debris removal, use of boats, driving on project roads, hydropower generation, and routine maintenance activities.

Effects of Measures in the Bull Run Watershed

Bull Run habitat improvement and preservation measures will have only slight positive long-term effects on coastal tailed frogs because few larvae and even fewer adults occur in and along the lower sections of either the Bull Run or Little Sandy rivers. Gravel will be placed in deeper water than is normally used by adult frogs, and larvae are more apt to use coarser substrate. Preservation of riparian areas will maintain habitat for the few adult frogs using stream edges.

Effects of the HCP Offsite Measures

Coastal tailed frogs are present in several of the Sandy River Basin streams where offsite habitat enhancement and protection measures are planned. Riparian easements and enhancements on Gordon, Trout, Alder, and Cedar creeks will maintain shade, protect soil, and provide future sources of large wood. Both larval and adult tailed frogs will benefit from cool silt-free water and logs for hiding cover. Placement of large wood will provide cover for the short term. Instream enhancements and improved fish passage will not seriously affect tadpoles or adult frogs. Although the frog population may retreat somewhat from lower stream sections because of predation from fish that will again be able to access higher reaches, coastal tailed frogs evolved in the presence of these fish species and are capable of avoiding excessive predation pressure. Control of invasive plant species in the Sandy River Basin, associated with the HCP's riparian easements could have positive effects on tailed frogs over the long term if it improves habitat in areas used by this species, but negative effects in the short term if it involves tools or techniques harmful to frogs.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP will have minor, mostly positive long-term effects on coastal tailed frogs in the Sandy River Basin. Both instream flow commitments and cold water allocations for the lower Bull Run River will create stream conditions somewhat better able to support any tadpoles that are carried in from small tributaries.

8.5.5 Cope's Giant Salamander *(Dicamptodon copei)* and Cascade Torrent Salamander *(Rhyacotriton cascadae)*

Both the Cope's giant salamander and Cascade torrent salamander occur in at least several of the headwater and small tributary streams in the Basin, while most activities covered in the HCP will take place lower in the Basin. These two salamander species are dependent on cold silt-free streams that are usually associated with undisturbed riparian and old-growth conifer forests (Bury and Corn 1988; Bury et al. 1991b; Corn and Bury 1989; Corkran unpublished data).

Effects of Water Supply Operations and Related Activities

The permanent project facilities will have slight, negative long-term effects on Cope's giant salamanders and Cascade torrent salamanders. The dams and large reservoirs are slight impediments to dispersal between tributary streams. Although Cope's giant salamander occasionally is found in large cold lakes, the substrate of the reservoirs is too silty to provide appropriate habitat. Crossing the reservoirs also makes both salamander species vulnerable to trout, river otters, and other predators. Culverts can impose barriers to movement of all aquatic salamanders within streams and limit foraging opportunities. The log booms, roads, bridges, power lines, and other facilities have no known effect on these two species.

Normal operation of the water supply will have slight, negative long-term effects on Cope's giant salamander and Cascade torrent salamander. Withdrawal of water from the lower Bull Run River will have no impact because neither species occurs there. Annual operations that result in fluctuations in the reservoir levels, debris removal, use of boats, hydropower generation, and routine maintenance activities will continue to have no known effects on these two species. Driving on project roads could threaten dispersing salamanders attempting to cross these roads.

Effects of the Bull Run Measures

Instream flow commitments and cold water allocations for the lower Bull Run River will have no effect because neither species occur in the river. If there are seeps, springs, or small tributaries along the lower Bull Run River, either or both species could occur; however, neither the water flow level nor the water temperature would affect habitat occupied by these two species.

Bull Run habitat improvement and preservation measures probably will have no effect because these two species do not occur in the lower Bull Run River and are not known to occur in the Little Sandy River. However, if there are seeps, springs, or small tributaries in a

Photo courtesy of Char Corkran.

planned project area along either the lower Bull Run River or the Little Sandy River, then these species may be present. If present, they would not be affected by gravel placement because it would be placed only in the main channels. In addition, both species would benefit from riparian preservation because it would retain shade and bank stability at the mouths of small tributaries, as well as the lower Bull Run and Little Sandy rivers.

Effects of the HCP Offsite Measures

Offsite habitat enhancement and protection measures will slightly benefit Cope's giant salamanders and Cascade torrent salamanders where these two species occur. Riparian easements and enhancements on Gordon, Trout, Alder, Boulder, and Cedar creeks will maintain shade, protect soil, and provide future sources of large wood. Both salamander species are known or suspected to occur at the heads of these streams and may occur where covered activities are planned. These two species would benefit from riparian easements and enhancement projects because such measures would maintain or improve cold silt-free water and would provide logs for hiding cover and nest sites. Instream enhancements and improved fish passage will not seriously impact either of these salamander species. Although they may retreat somewhat from lower stream sections because of predation from fish that will again be able to access higher reaches, Cope's giant salamander and Cascade torrent salamander evolved in the presence of these fish species and have adapted to avoid excessive predation pressure.

Control of invasive plant species in the Sandy River Basin, associated with the riparian easements, could have positive effects on these salamanders over the long term if it improves habitat in areas used by the species; effects could be negative in the short term if the control involves tools or techniques harmful to salamanders. Invasive plants can adversely affect salamanders by reducing diversity and abundance of invertebrate prey species, although these salamanders mostly occur in undisturbed areas that have not been severely impacted by invasive plants.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP will have minor, mostly positive effects on Cope's giant salamanders and Cascade torrent salamanders in the Sandy River Basin.

8.5.6 Clouded Salamander *(Aneides ferreus)* and Oregon Slender Salamander *(Batrachoseps wrightorum [= wrighti])*

Clouded salamanders and Oregon slender salamanders occur primarily in upland coniferous forests, while the activities covered by the HCP will take place predominantly in riverine and riparian forest habitats.

Effects of Water Supply Operations and Related Activities

The permanent project facilities will have slight, negative long-term effects on clouded salamanders and Oregon slender salamanders. The dams may slightly impede dispersal and foraging travel, but these two species are not known to travel long distances or along riparian forest corridors. The large reservoirs are similar to rivers in hindering dispersal, although it is possible that salamanders hiding in logs that slid downhill could be transported more easily across a reservoir than across a river. The project roads and the power lines may impose barriers to dispersal of clouded and Oregon slender salamanders, neither of which is normally found out in the open, even at night. Roads offer no hiding cover and make salamanders vulnerable to predation when crossing. Power lines are maintained to prevent growth of large trees that provide logs, and these salamanders may have difficulty traveling far enough to cross them without logs to provide habitat for foraging and resting along the way. Culverts, log booms, bridges, and other facilities have no known effect on these two species.

Normal operation of the water supply will have negligible effects on clouded salamanders and Oregon slender salamanders. Storage of water will have the same effects as discussed above for the presence of the reservoirs. Withdrawal of water from the lower Bull Run River will have no impact because these two species do not occur in rivers and are not reliant on riparian forests that could be dried by reduction in flows. Driving on project roads could impact salamanders that attempt to cross them, although most driving occurs during the day, and the salamanders are primarily nocturnal. Other annual operations that result in fluctuations in the reservoir levels, use of boats, hydropower generation, routine maintenance activities, and debris removal will have no known effects on these species because they do not use the reservoirs or other facilities.

Removal of logs from the reservoirs would not deprive the salamanders of habitat because once the logs slide or fall into the river or reservoir they would not be used by these upland species. It is possible, however, that occasionally salamanders could be inside logs when they entered the reservoir. If these logs were removed and transported to rivers at other locations in the Sandy River Basin, those few individuals might not survive the drying associated with log storage and might not be capable of traveling from the new position in a river to appropriate terrestrial habitat.

Effects of the Bull Run Measures

The habitat conservation measures in the HCP will have slight, positive long-term effects on clouded salamanders and Oregon slender salamanders. Instream flow commitments and cold water allocations for the lower Bull Run River will have no effect because these species do not occur in rivers and are not dependent on riparian forests influenced by the higher flows.

Bull Run habitat improvement and preservation measures will have only slight positive long-term effects on clouded salamanders and Oregon slender salamanders because the measures will not affect the primary habitat of these species. Placement of gravel will occur in the rivers, but these salamanders are entirely terrestrial. Preservation of riparian areas will maintain habitat and provide sources of future logs for the few individuals of these two species that may use these areas.

Effects of the HCP Offsite Measures

Offsite habitat enhancement and protection measures will only slightly benefit clouded salamanders and Oregon slender salamanders in the Sandy River Basin because these species primarily occur in upland forests. Riparian easements on tributary streams in the Basin will maintain and provide future sources of logs. Neither placement of large wood nor enhancements that improve fish passage will affect these species because they do not use rivers.

Control of invasive plant species in the Sandy River Basin, associated with the riparian easement, could have positive effects over the long term if it improves habitat in areas used by these two species, but it could have negative effects in the short term if tools or techniques harmful to salamanders are used. Invasive plants can adversely affect salamanders by reducing diversity and abundance of invertebrate prey species, although the salamanders mostly occur in undisturbed areas that have not been severely impacted by invasive plants.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP will have minor, mostly positive effects on clouded salamanders and Oregon slender salamanders in the Sandy River Basin.

8.5.7 Western Painted Turtle *(Chrysemys picta belli)* and Northwestern Pond Turtle *(Emys [= Clemmys] marmorata marmorata)*

The western painted turtle occurs near the mouth at the Sandy River delta, and individual northwestern pond turtles may be present at the delta.

Effects of Water Supply Operations and Related Activities

Normal operation of the water supply will have little effect on western painted turtles and northwestern pond turtles. Storage of water will not affect them because they do not occur near the reservoirs. Similarly, withdrawal of water from the lower Bull Run River will have little impact because neither turtle species occurs in the Bull Run River. They have not been documented in the Sandy River near its mouth, but only in ponds in the Sandy River delta, which are not affected by withdrawal of water from the Bull Run River. If the two turtle species did use the Sandy River at its mouth, withdrawal might be slightly beneficial because it would decrease flow and allow warming of the water. Annual operations that result in fluctuations in the reservoir levels, debris removal, use of boats, driving on project roads, hydropower generation, and routine maintenance activities will have no effect on the two species because they do not occur where the covered activities will take place.

Effects of the Bull Run Measures

The habitat conservation measures in the HCP will have little effect on western painted turtles and northwestern pond turtles. Instream flow commitments and cold water allocations for the lower Bull Run River will be unlikely to affect these species because they do not occur in the Bull Run River, and they primarily use ponds rather than the Sandy River near its mouth. If the two species did use the Sandy River at its mouth, instream flow commitments and cold water allocations might be slightly detrimental because the turtles prefer warm water.

Bull Run habitat improvement and preservation measures will have no effect on western painted turtles and northwestern pond turtles because neither species occurs in the Bull Run or Little Sandy rivers.

Effects of the HCP Offsite Measures

Offsite habitat enhancement and protection measures will provide slight long-term benefit to the two turtle species because the species do not occur where most of the activities will take place. An exception is the planned channel reconstruction and reestablishment of the mouth of the Sandy River. Reconnecting the east channel, which is now a slough blocked at its upstream end, will cause short-term disturbance to turtles using that area. Nest surveys should be conducted prior to initiating the work. However, the project may have long-term benefits because it will restore conditions for salmonids and make the area less suitable for introduced warm-water fish and American bullfrogs, which then might also be eradicated from the isolated ponds on the delta. If the channel restoration also creates more natural overflows and channel banks, the two turtle species may make further use of the area.

Control of invasive plant species in the Sandy River Basin, associated with riparian easements, could have positive effects on turtles over the long term if it improves habitat in areas used by the species; the control could have negative effects in the short term if tools or techniques harmful to turtles are used. Invasive plants, such as Himalayan blackberry (Rubus discolor) and reed canarygrass, are detrimental to sites for these two turtle species because they create shade and barriers to movement on banks of ponds and rivers used by these species, and their roots interfere with digging into the soil for nest building. Control of these plants will restore suitable basking, dispersal, and nesting conditions.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP will have very limited positive effects on western painted turtles and northwestern pond turtles in the Sandy River Basin. Most activities covered in the HCP will occur higher in the basin than in western painted turtle and northwestern pond turtle habitat. The permanent project facilities, including dams, reservoirs, culverts, log booms, project roads and bridges, power lines, and other facilities will have no effect on the two turtle species because neither one occurs in the area of the facilities.

8.6 Birds and Mammal

In this HCP, the City addresses two birds and one mammal: the bald eagle, the northern spotted owl, and the fisher. The effects of the City's HCP on these species are described in the following subsections:

- Effects of water supply operations and related activities
- Effects of the HCP measures
- Conclusions about the habitat effects of HCP measure implementation

8.6.1 Bald Eagle *(Haliaeetus leucocephalus)*

Effects of Water Supply Operations and Related Activities

As described in Chapter 5, bald eagle presence in the Bull Run watershed is limited to occasional use of the reservoirs by transient bald eagles and to a single nesting territory below the confluence with the Little Sandy River (outside the area directly affected by the water supply system). Existing water system facilities, with the possible exception of power lines, will have little direct effect on bald eagles.

Overhead power lines can impact bald eagles through collisions and electrocutions (Franson et al. 1995). Avian electrocutions occur more frequently from distribution lines than from transmission lines, because the closely spaced conductors of the former are more easily bridged by birds (Avian Power Line Interaction Committee 1996, cited in Hunting 2002b; Dorin et al. 2005). Distribution line locations are described in Section 8.7, Table 8-57. Generally, these lines are located adjacent to the lower Bull Run River along the main road downstream of Dam 1.

The potential for bald eagles to be affected by power lines covered by the HCP is currently considered low due to the relatively low resident bald eagle population and the bald eagle's ability to avoid collisions with overhead power lines except during periods of poor visibility. The low potential is supported by the absence of any reported bald eagle collisions with power lines in the Bull Run watershed (Marheine, PGE, pers. comm., January 30, 2006). The potential for collision and/or electrocution does exist, however, and could increase in the future if the bald eagle population increases. Power line mortality, however, is generally not considered to cause a measurable population decline in otherwise healthy bald eagle populations (Olendorff et al. 1989, cited in Herbert et al. 1995). This appears to be the case in Oregon, where bald eagle populations have been stable or increasing in recent years despite the presence of numerous power lines.

Routine covered activities such as vehicle traffic on regularly used roads and daily human activity near developed facilities are not expected to disturb bald eagles. These activities occur in relatively confined areas, and bald eagles would become accustomed to such activities or could readily avoid the areas. Less frequent activities, such as right-of-way maintenance and the use and maintenance of roads with little regular traffic, would have the potential to cause a low level of disturbance to bald eagles, depending on the season and the proximity to nesting, roosting, and foraging areas. These activities are restricted to relatively

Photo courtesy of Char Corkran.

defined areas (e.g., roadways, existing structures) where human activity is a regular occurrence and bald eagle activity is expected to be limited. The potential for disturbance-related impacts to bald eagles from these activities would be minimized or avoided altogether by seasonal restrictions and disturbance buffers required under Measure W-2. In cases when these activities cannot be scheduled to avoid disturbing bald eagles (such as emergency repairs to roads or power lines), minor levels of disturbance could occur. It is not anticipated that these levels of disturbance would result in nest failure, nest-site abandonment, or disruption of roosting.

Periodic cutting of trees will occur to avoid hazards to people and infrastructure. If cutting a nest or roost tree becomes necessary, it will occur when bald eagles are not present as described in Chapter 7, Measure W-2. With this safeguard, operation and maintenance activities pose a very low potential for direct adverse impact to bald eagles.

Effects of the HCP Measures

Conservation measures implemented as part of the HCP to improve instream and riparian conditions for salmon will benefit bald eagles. Salmon are a major food source for bald eagles in the Pacific Northwest. Improved stream and riparian habitats will help sustain salmon populations and provide a reliable food source for bald eagles. The implementation of riparian conservation measures could cause short-term disturbance and temporarily decrease the availability of perch trees, but the disturbance will be localized, of short duration, and not regularly repeated in any one location.

Currently, there are no known bald eagle nests or communal winter night roosts in areas proposed for riparian conservation measures. If a nest or winter night roost did occur in the vicinity of a conservation measure location, impacts to bald eagles would be minimized by Conservation Measure W-2, which would restrict activity during the times bald eagles are present. Implementing stream and riparian conservation measures, even with potential short-term disturbance, will benefit bald eagles over the long term.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP will have little effect on individual bald eagles or on the regional bald eagle population. Bald eagle presence on covered lands is limited to occasional use of the reservoirs by transient bald eagles. No new construction or upland habitat modification is planned under the HCP that might alter bald eagle nesting or winter roosting habitat. The aquatic and riparian conservation measures will improve stream habitat conditions for spawning and rearing salmon, thereby benefiting foraging bald eagles.

8.6.2 Northern Spotted Owl *(Strix occidentalis caurina)*

Effects of Water Supply Operations and Related Activities

The existing water system facilities will not directly or indirectly affect spotted owls. The HCP will not involve the development of any new facilities or alteration of suitable spotted owl habitat. Power lines can cause bird mortality through collision and electrocution, but spotted owls are not generally at risk of either. Birds that are highly maneuverable flyers, such as owls, are less susceptible to collisions than other birds, and most power lines (including those in the Bull Run) are designed to prevent the electrocution of birds up to the size of large raptors. A bird's size is the primary factor influencing its risk of electrocution (Olendorff et al. 1981). Other aspects of a bird's behavior can also increase its vulnerability, such as nesting on power poles or frequently perching on them (Hunting 2002b). Since the spotted owl is a medium-sized raptor that does not nest on them and likely does not frequently perch on power poles, the risk of its being electrocuted is considered low.

Operation and maintenance of water-system facilities, including road use and routine maintenance (activities conducted on an annual or semiannual basis that move through an area or are completed in a relatively short period, such as ditch cleaning, brushing, grading, routine landscape and building maintenance, and boat/barge traffic), will not modify or affect spotted owl habitat in any way. Similarly, operation and maintenance of the water system will have a low likelihood of disturbing individual spotted owls. The owls are not particularly sensitive to human activity, and all existing spotted owl territories in the Bull Run were established since the water system went into operation in the early 20th century. These birds are likely habituated to the levels and locations of human activity that will continue under the HCP. Spotted owls have been reported killed by vehicles elsewhere within their range, but this source of mortality is infrequent, and most vehicle traffic occurs during daylight hours when spotted owls are less active.

Maintenance activities that are less frequent and require a more sustained use of heavy equipment in one location (e.g., road, large culvert and bridge reconstruction, major exterior building, and right-of-way maintenance) have the potential to disturb spotted owls if conducted during the nesting period and close to an active nest. However, seasonal restrictions and disturbance buffers in Measure W-1 will minimize or avoid the potential for disturbance related impacts. The potential for water system operation and maintenance to disturb spotted owls is therefore low and should not affect local spotted owl populations.

Conclusions About the Habitat Effects of HCP Measure Implementation

Conservation measures implemented as part of the HCP are not expected to adversely affect spotted owls. Approximately four spotted owl sites may be relatively close (0.5 mile) to stream reaches scheduled for restoration activities. Such activities will be conducted along stream corridors, either within the stream or the adjacent riparian area, and affect a relatively small portion of the landscape relative to a typical spotted owl home range. Since these activities (like many of the maintenance activities) will be localized, of short duration, and not regularly repeated in any one area, the conservation measures are not expected to impact northern spotted owls.

8.6.3 Fisher *(Martes pennanti)*

Effects of Water Supply Operations and Related Activities

The existing water system facilities will not affect the fisher. No new facilities are planned under the HCP, so there will be no removal or fragmentation of suitable fisher habitat. If a fisher population is reestablished in the project area, such establishment would be with the current facilities in place.

Operation and maintenance activities may potentially adversely affect fishers, should a population be reestablished in the future. Vehicle traffic along roads could directly affect fisher through collisions. However, the potential for vehicle collision involving fisher is very low because fisher are less active during the day when water system-related traffic is at its highest.

Conclusions About the Habitat Effects of HCP Measure Implementation

The HCP will not adversely affect the fisher. Fishers are not currently known to be present in the areas affected by the HCP or in the northern Cascade Mountains of Oregon. Further, the HCP will not remove or modify suitable fisher habitat.

Conservation measure W-3 in the HCP may benefit the fisher if the species becomes reestablished in the Sandy River Basin. A number of the other conservation measures will increase the volume of downed logs and the number of conifer trees in riparian areas. Both changes will improve habitat conditions for fishers over the long term.

The lack of a known local population and the limited amount of habitat modification that will occur under the HCP will result in limited, if any, effects on the fisher.

8.7 Effects of Covered Activities

Table 8-57 provides additional descriptive detail about the covered activities listed in Chapter 3, Section 3.4, and the associated effects on the habitat of the species that are covered and addressed in this HCP. In some cases, the activity and the effects are more fully described in other chapters. In those cases, cross-references are provided. This section is intended to complement, not repeat, the information provided by species elsewhere in this chapter and in the HCP.

Table 8-57. Description of Covered Activities and Associated Potential Impacts, Conservation Measures, and Effects

Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Operation, Maintenance, and Repair of the Water Supply System			
Storage of water in system reservoirs and regulation of reservoir surface elevations ***Adjustment of water intake depth to regulate temperature, turbidity, and color*** (See Chapter 2 for more description.)	• Inundated riverine habitat and blocked access to the upper Bull Run watershed • Potential for limited access to spawning tributaries for cutthroat and rainbow trout • Potential for water quality effects on rearing resident trout in the reservoirs	• Reservoir Operations measure R-1 • Fish Passage measures P-1, P-2, P-3, and P-4 • Temperature measures T-1, T-2	Effects are described in subsections 8.4.1 and 8.4.2, and sections 8.2, 8.3, 8.4, and 8.5. Effects will be minimized.
Diversion of water for water supply ***Release of water from reservoirs into the Bull Run River*** ***Alternation of flows downstream from the water supply dams and diversion*** ***Seasonal closure of gates at Dam 1 spillway to store additional water*** (See Chapter 2 for more description.)	• Reduced base flows for fish in the lower Bull Run River • Potential for stranding juvenile fish in the lower Bull Run River	• Flow measures F-1, F-2 • Temperature measures T-1, T-2 • Reservoir Operation measure R-1 • Downramping measure F-3	Effects are described in sections 8.2, 8.3, 8.4, and 8.5. Effects will be avoided or minimized.

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Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Operation, Maintenance and Repair of the Water Supply System			
Removal of wood from reservoirs Booms are used in both reservoirs to trap debris from winter storms and thereby avoid damage to the dams and associated spillways. Debris is defined as large and small logs and trees that wash down into the reservoirs. The majority of the material is collected at the upper boom in Reservoir 1. Water Bureau staff remove this material each spring at a landing near the upper boom. An excavator/loader is used to lift and remove the large wood and debris. The wood is transported by winter storm flows from tributaries on federal land. The resulting wood is owned by the Forest Service. The Water Bureau has an agreement with the Forest Service to sort the material and to inform Forest Service staff if material suitable for Forest Service uses (e.g., fish habitat improvement and repair of historic structures) is available.	• Reduction in habitat diversity in the lower Bull Run and Sandy rivers • Potential for small releases of petroleum products into reservoirs	• Large wood measures H-3, H-4, H-5, H-6, H-7, H-17, H-26, and H-27 • Spill Prevention measure O&M-2	Effects are described in sections 8.2, 8.3, and 8.4. Effects will be avoided or mitigated.
Operation of boats and barges on reservoirs A boat is used once a week on each reservoir to take routine water quality samples. The boat is lashed to the log boom or stored in an on-shore boat house when not in use. Infrequently, boats or small barges are used to complete maintenance or repair projects (e.g., to repair a broken boom).	• Potential for small releases of petroleum products into the reservoirs • Potential for erosion from equipment on lake shore	• Spill Prevention measure O&M-2	Effects will be avoided, or minimized.

Table continued on next page.

Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Operation, Maintenance, and Repair of the Water Supply System			
Operation of boats and barges on reservoirs *(continued)* Boats are moved from the boat house to the reservoir on a two-rail track to avoid erosion. The Water Bureau uses 4-cycle engines and avoids fuel spills given the potential water quality impacts to drinking water. Spill containment booms are stored in the boat houses located at each reservoir. Maintenance staff carry spill control kits in their vehicles.			
Delivery and storage of fuel and lubricants Fuel and lubricants are delivered to the Headworks facility. All deliveries are made via the road that parallels the lower Bull Run River. Fuel trucks use one of two paved routes and are guided by a pilot car. Fuel pumps are housed in concrete bunkers to avoid fuel releases. Secondary containment is provided to contain leaks if they occur. Containment basins are inspected, typically when the tanks are filled, and can be pumped if needed.	• Potential for releases of petroleum products into river or reservoirs	• Spill Prevention measure O&M-2	• Effects will be avoided or minimized.

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Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Operation, Maintenance, and Repair of the Water Supply System			
Delivery and storage of chlorine The Water Bureau uses chlorine gas to disinfect water diverted for water supply. Containers of gas (2,000 lbs. each) are delivered weekly during the summer and every two weeks during the winter. Trucks delivering the chlorine use one of two paved routes and are guided by a pilot car. If a release of a reportable quantity (10 lbs.) were to occur, the Portland Fire Bureau would serve as incident commander, and the incident would be reported to the Oregon Emergency Response System (OERS). The chlorine treatment system is equipped with chlorine scrubbers, so release of a reportable quantity is unlikely once the tanks are in use. *Note: The City does not offload any other bulk chemicals into storage tanks at Headworks. The City's drinking water treatment also involves aqueous ammonia (as part of disinfection) and sodium hydroxide (to control corrosion). These chemicals are added at the City's Lusted Road facility, which is located outside the Sandy River Basin. The City is not requesting coverage for this facility in the HCP.*	• Potential release of chlorine gas If a release occurred and owls or eagles were in the immediate vicinity of the spill, they could be harmed or killed by directly breathing the gas. The dense gas would seek low elevations but would not affect the water quality of the streams.	• Chlorine handling is regulated by the U.S. Environmental Protection Agency and Occupational Safety and Health Administration (OSHA). No HCP measure is necessary.	• Effects will be avoided or minimized.

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Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Operation, Maintenance, and Repair of the Water Supply System			
Draining of water supply conduits Sections of the conduits are drained periodically for maintenance and repair or after operational shutdowns. The drained water is dechlorinated and then released into the nearest waterway. Water can be released at 52 locations between Headworks and Lusted Hill. The City uses diffusers to provide energy dissipation and to help prevent erosion. Dechlorination is done according to ODEQ "Guidelines for Disposal of Chlorinated Water."	• Potential discharge of chlorinated water	• Regulated by National Pollutant Discharge Elimination System permit. No HCP measure necessary.	Effects will be avoided or minimized.
General landscape maintenance Water Bureau staff maintain landscaping at Bear Creek house, at Kaiser Park (an area that was once used for staff housing below Dam 2, near the spillway pool), and at Sandy River Station. No pesticides or herbicides are used.	• Potential use of chemicals	• No measure needed	Potential effects will be avoided.
Habitat Conservation, Research and Monitoring Measures			
Habitat conservation measures are described in Chapters 7 and 9. Methodologies for research and monitoring measures are described in Appendix F.			Effects of the measures are described in this chapter. Effects will be avoided or minimized.

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Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Incidental Land Management Activities The City owns approximately 3,800 acres of land in the Bull Run Watershed Management Unit, which includes land around and downstream of Reservoir 2. The City owns 1,200 acres of additional land along the lower Bull Run River and/or near the confluence of the Bull Run and Sandy Rivers, including at Dodge Park and the adjacent Sandy River Station maintenance facility. In total, this land fronts approximately 5.6 stream miles of the Bull Run and Sandy rivers.			
Management of City-owned riparian lands in the Bull Run watershed See also description below for management of conduit and bridges that traverse City-owned riparian lands.	• Potential reduction in large wood accumulation and instream habitat	• Riparian Land Protection measure H-2 • Terrestrial Wildlife measures W-1 and W-2 See also measures below for operation and maintenance of Sandy River Station and yard.	Effects will be avoided or minimized.
Operation, maintenance, and repair of power lines Two power line rights-of-way are included in the covered facilities: the City's power-line right-of-way and a Bonneville Power Administration (BPA) high-voltage line right-of-way on City land in the lower Bull Run watershed. <u>City's power line right-of-way</u> There are approximately 10 miles of 57-kV high-voltage power transmission lines in the watershed.	• Potential loss of habitat due to removal of trees that pose a specific hazard to the power lines • Potential bird collisions (See also description of potential collision impacts in Chapter 5, Section 5.3.1) • Potential runoff of herbicides into river	• Terrestrial Wildlife measures W-1 and W-2	Effects on bald eagles described in Section 8.6.1 Effects will be minimized.

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Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Incidental Land Management Activities			
Operation, maintenance, and repair of power lines *(continued)* From Dam 1 to Dam 2, the transmission lines closely follow the alignment of USFS roads and water conduit alignments. These lines connect to PGE's distribution system at the PGE Bull Run Hydroelectric Project Powerhouse on the lower Bull Run River. A separate distribution system power line, operated and maintained by PGE, provides electrical service to the City's Headworks facility. Vegetation management along the right-of-way occurs approximately once every three years. For the sections where the transmission lines share the alignment with the City's water supply conduits, City staff remove brush from the right-of-way. For the other sections, PGE hires contract staff to remove brush growing up under the power lines and trees that pose a specific hazard to the power lines. No herbicides are used. Maintenance and repair of the lines and poles occur after storm damage. Trees, from time to time, fall into the lines during storms. PGE dispatches line repair crews to replace damaged poles and repair or replace lines as needed.			

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Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Incidental Land Management Activities			
Operation, maintenance, and repair of power lines *(continued)* BPA high-voltage line right-of-way on City land One BPA 500-kV high-voltage power transmission line transects lands covered in the HCP. This north-south running power line easement crosses the lower Bull Run River at RM 2.1. BPA staff use all-terrain vehicles to access the easements so road maintenance is minimal. Vegetation management occurs approximately once every five years. BPA staff remove trees that pose a hazard to the power lines or to staff that maintaining the power lines, and BPA removes brush. BPA has an agreement with the Forest Service not to use any chemical methods on federal land inside the Bull Run management unit. In response to a request from BPA, the Water Bureau has agreed to the use of Garlon 3A in a limited manner on the BPA transmission line easement on City land (located below the water supply intakes). The herbicide is used only as a stump treatment on hardwood tree species.			

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Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Incidental Land Management Activities			
Maintenance and repair of roads, bridges, culverts, parking lots, and conduit rights-of way on non-federal land City staff maintain and repair roads on non-federal land. The most frequent maintenance activities have low noise impacts and produce transient sources of noise (i.e., mechanical removal of brush along primary roadways). Other activities are louder and can last for a longer period of time (i.e., bridge replacements). See wildlife measures W-1 and W-2 for a more thorough description of the road maintenance activities and the City's approach to avoiding or minimizing the impacts on spotted owls and bald eagles. The water conduits cross the lower Bull Run River on three City-owned bridges: Headworks Bridge, Larson's Bridge, and Bowman's Bridge. The foundation footings for these bridges are located above the ordinary high water level and do not impede water flow or fish passage. The City recently upgraded these bridges for seismic protection reasons. Footings were replaced. Lead-based paint was removed, and the conduits and bridges repainted. The bridges were enclosed with tents and tarps during these projects to protect the river from failing debris and paint chips.	• Potential release of paint and debris into river • Potential erosion and sedimentation, and elevated water turbidity • Potential loss of bird habitat due to removal of trees that pose a hazard to the conduits or to staff • Potential spills of chemicals or discharge of contaminated water	• Bull Run Infrastructure Operations and Maintenance measure O&M-1 • Terrestrial Wildlife measures W-1 and W-2	Effects will be avoided or minimized.

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Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Incidental Land Management Activities			
Maintenance and repair of roads, bridges, culverts, parking lots, and conduit rights-of way on non-federal land *(continued)* Conduit maintenance involves inspections, minor repair, and painting where the conduit pipes are exposed, as well as removal of brush that hinders inspection and removal of trees that pose a hazard to the conduits or to staff. Right-of-way maintenance on non-federal land is primarily for the water supply conduits. Three conduits are located downstream of Dam 2. Approximately 2,500 feet of conduit is exposed to the surface in the lower Bull Run River watershed (primarily near bridges); most of the conduit length is buried. Maintenance mostly involves removal of hazard trees. The three conduits cross the mainstem Sandy River on two bridges near Dodge Park. The Water Bureau is planning to replace one of these bridges with a tunnel crossing within the next five years. The third conduit will remain on a bridge, which will be seismically upgraded. The City is not requesting ESA coverage for the conduit crossings on the Sandy River; ESA compliance will be addressed separately. The only parking lot inside the management unit is located at Headworks. The parking lot is paved. Stormwater from the parking lot is discharged into the Bull Run River.			

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Covered Activity	Primary Historical or Potential Future Impacts Addressed[a]	Associated Habitat Conservation Measures[b]	Effects of Implementing HCP Measures[c]
Incidental Land Management Activities			
Operation and maintenance of the Sandy River Station and yard Sandy River Station is an approximately 5.5-acre maintenance facility located adjacent to the mainstem Sandy River, upstream of the mouth of the Bull Run River. Approximately 17 staff work out of this facility on a daily basis. Facilities include an office, a repair shop, fuel pumps/tanks, indoor storage (barn), parking, and outdoor equipment, vehicle, and materials storage. All chemicals (e.g., paint, vehicle repair, fuel for chainsaws) used at this site are in small quantities (one gallon fuel cans and drums less than 20 gallons). Chemicals are stored indoors and on paved surfaces. Spill absorbent kits are available. Fuel tanks (diesel and gasoline) pumps and tanks are located in the yard and within the floodplain of the Sandy River. Secondary containment is provided to contain leaks. Containment basins are inspected, typically when the tanks are filled, and can be pumped if needed. The parking lot is part gravel and part pavement. Storm water is discharged to the Sandy River.	• Potential discharge of contaminated storm water • Potential discharge of petroleum products into Sandy River during flood conditions • Potential loss of riparian habitat due to removal of trees that threaten City facilities or pose a significant risk to human safety	• Bull Run Infrastructure Operations and Maintenance measure O&M-1	Effects will be minimized.

[a]Not comprehensive; see also background information in Chapters 2, 4, and 5.
[b]See descriptions in Chapter 7.
[c]See also description of current best management practices in column 1.

Chapter 9. Monitoring, Research, and Adaptive Management Programs

9. Monitoring, Research, and Adaptive Management Programs

9.1 Introduction

Monitoring, research, and adaptive management measures for the Habitat Conservation Plan (HCP) are described in this chapter. The monitoring measures were designed to document compliance and verify progress toward meeting the goals and objectives defined in Chapter 6. Through research, the City of Portland (City) will collect information about fish population trends in adults and juveniles. The adaptive management program will guide the response if monitoring and research information indicate the need for a modified approach.

The City has identified measurable habitat objectives for each conservation measure. The measurable objectives are more detailed than the goals and objectives described in Chapter 6 and the measure descriptions in Chapter 7. The measurable objectives can be used as benchmarks for the City's progress on the conservation measures.

Annual Reports

The City will provide a report to describe progress toward implementing the HCP conservation measures. The report will be issued annually, or at a frequency mutually agreeable to the City and NMFS, for the life of the HCP. These annual compliance reports will be submitted within 120 days following the end of the calendar year. The first annual report will cover the period from the effective date of the HCP until the end of the first full calendar year following that date.

HCP compliance reports will contain summaries of all significant HCP-related activities and associated data and information. Anticipated components include planning and implementation of measures, expenditures, compliance and effectiveness monitoring, research, and any plans or actions related to changed circumstances and/or adaptive management.

After NMFS has approved the annual compliance report, the City will make it available on the bureau's web site or by other appropriate means.

Progress Meetings

The City anticipates convening formal progress meetings approximately every five years, beginning in Year 5 of the HCP. At these meetings, the City will discuss with NMFS and the Oregon Department of Environmental Quality (ODEQ) the progress to date and any new information affecting successful implementation of the HCP. If appropriate, the HCP Implementation Committee will also be invited. Although adaptive management will be discussed at these meetings and minor adaptive management decisions might be made, major adaptive management decisions will be made at Years 20, 30, and 35, as described in later in Chapter 9, and specifically in Table 9-4. If significant changes occur in the Basin or if significant compliance problems arise during the interim between the five-year progress meetings, the City or NMFS can convene a progress meeting at any time.

9.2 Monitoring Program

The monitoring program includes two components: compliance monitoring and effectiveness monitoring. Compliance monitoring tracks implementation of the HCP measures and documents completion. Compliance monitoring will be done for every measure in the HCP. Effectiveness monitoring is focused on measures for which the habitat outcomes are somewhat uncertain. The effectiveness monitoring data will enable an assessment of whether or not the measurable habitat objectives have been met. Protocols for compliance and effectiveness monitoring are described in Appendix F of this HCP.

9.2.1 Compliance Monitoring

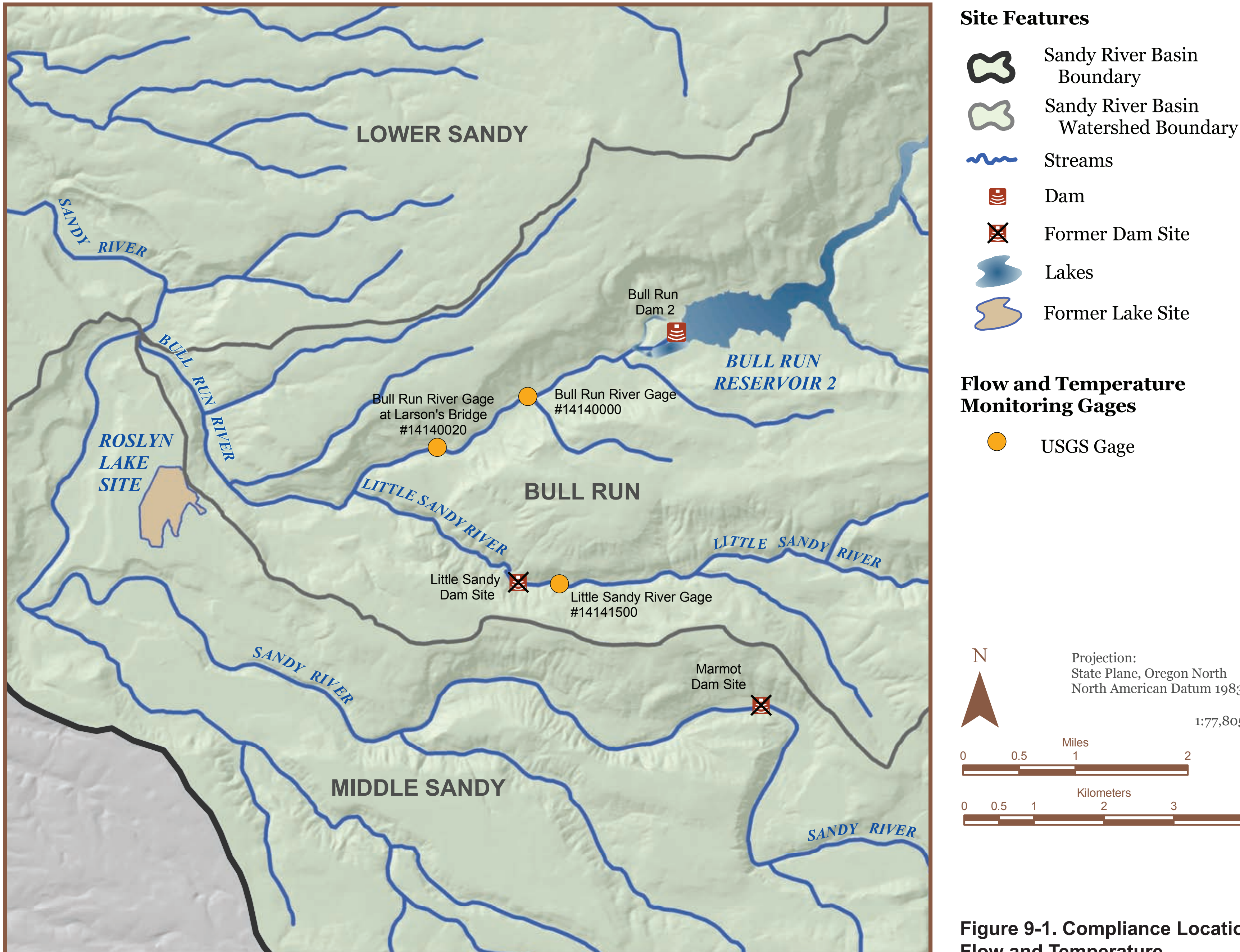
Most of the HCP measures pose very little uncertainty as to whether implementing the measures will meet the objectives. For these, the City will conduct compliance monitoring only (see also Section 9.2.2, Effectiveness Monitoring). Compliance monitoring results will be reported in the annual report.

Compliance Monitoring for Bull Run Conservation Measures

Compliance monitoring for the Bull Run conservation measures is described in Table 9-1. Almost all of these conservation measures will affect habitat in the lower 5.8 miles of the Bull Run River; a few will improve conditions for fish in the Bull Run reservoirs.

Compliance Locations for Flow and Temperature

The City will use established United States Geological Survey (USGS) sites on the lower Bull Run and Little Sandy rivers to monitor flow and water temperature. Compliance for flow measures will be based on flows recorded at USGS Gauge No. 14140000 (Bull Run River at RM 4.7). This site will also be used to determine compliance with the downramping rate. Compliance with temperature measures will be based on water temperatures recorded at Larson's Bridge site on the lower Bull Run River (USGS Gauge No. 14140020, RM 3.8), and at the Little Sandy Dam site (USGS Gauge No. 14141500, Little Sandy River at RM 1.95).



Temp_Flow_Monitoring in Bull_Run_Little_Sandy_Rivers_08.mxd

Figure 9-1. Compliance Locations for Flow and Temperature

Table 9-1. Compliance Monitoring for Bull Run Measures

#	Measure	Measurable Habitat Objective[a]	Compliance Monitoring[b]
F-1 **F-2**	**Minimum Instream Flow, Normal Water Years** **Minimum Instream Flows, Water Years with Critical Seasons**	Provide instream flows	Record hourly flows at USGS Gauge No. 1414000[c]
F-3	**Flow Downramping**	Maintain 2”/hour rate for downramping	
F-4	**Little Sandy Flow Agreement**	Avoid conflicts with natural instream flows	Document completion of flow agreement
T-1	**Pre-infrastructure Temperature Management**	Pre-infrastructure objective: Maintain water temperatures at or below 21 °C at Larson’s Bridge	Record water temperatures hourly for the lower Bull Run River and Little Sandy River Document implementation and completion of Dam 2 tower and spillway rock weir improvements (tower improvements will be complete and operational by 2013)
T-2	**Post-infrastructure Temperature Management**	Post-infrastructure objective: Maintain water temperatures at their natural thermal potential	
P-1	**Walker Creek Fish Passage**	Provide year-round upstream and downstream passage for steelhead and coho	Document passage conditions compared with NMFS design criteria
R-1	**Reservoir Operations**	Avoid or minimize mortality of cutthroat and rainbow trout	Document reservoir surface elevations
R-2	**Cutthroat Trout Rescue**	Prevent mortality of cutthroat trout in spillway canal	Document any fish mortality that occurs in the canal and/or during handling (prior to release)
R-3	**Reed Canarygrass Removal**	Improve one-third acre of habitat for western toad, red-legged frog, and northwestern salamander through annual removal of reed canarygrass	Provide photo documentation of sites after reed canarygrass removal
H-1	**Spawning Gravel Placement**	Supply spawning gravel in amounts equivalent to natural accumulation	Survey the lower Bull Run River (RM 1.5–RM 6.0) in Years 1, 2, 3, 5, 7, and 10 after initial gravel placement and every five years thereafter Document the amount of gravel placed, the placement locations, and amount of gravel usable for spawning by fish in annual report as described in Appendix F

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Table 9-1. Compliance Monitoring for Bull Run Measures, continued

#	Measure	Measurable Habitat Objective[a]	Compliance Monitoring[b]
H-2	**Riparian Land Protection**	Preserve the riparian forest on City land along the lower Bull Run River	Survey riparian forest condition during annual spawning and gravel surveys; document results in annual report
O&M-1	**Bull Run Infrastructure Operations and Maintenance**	Avoid or minimize the effects of operations and maintenance activities on covered lands in the Bull Run watershed	Document any releases of sediment or debris to the reservoirs, the lower Bull Run River, or to any tributary streams Document changes in stormwater facilities at Sandy River Station, if needed Document tree planting and success of revegetation efforts
O&M-2	**Bull Run Spill Prevention**	Avoid or minimize effects of spills from water supply operations on covered species in the Bull Run River and the Sandy River below the confluence with the Bull Run	Document any spills to the reservoirs, the lower Bull Run River, or to any tributary streams

[a]The measure descriptions in Chapter 7 provide the definitions and details of the measurable habitat objectives listed in this table.

[b]Compliance monitoring methods are described in Appendix F, Monitoring and Research Protocols.

[c]USGS calibrates and maintains the equipment that records stream flow, publishes provisional flow data in near-real-time on the USGS website, and publishes final flow data annually.

Compliance Monitoring for Offsite Conservation Measures

The City will implement conservation measures on private land in various locations throughout the Sandy River Basin. Compliance monitoring and the measurable habitat objective for each measure are described in Table 9-2. The measures are categorized by type: riparian easements and improvements, acquisition of water rights, fish passage, carcass placement, large wood and log jam placement, channel restoration, and terrestrial wildlife habitat conservation. The measures are organized by type, rather than by watershed, because the objectives and monitoring measures for each type are similar.

When applicable, the measurable habitat objective defines a number of acres for riparian easements. The intent for the easements is to provide 100-foot-wide buffers from the top of the mean high-water level in the reach specified. The total acres per reach may or may not be contiguous depending on the willing-seller opportunities available. Compliance will be determined by the acres specified aggregated into three portions of the Basin: upper Sandy, middle Sandy, and lower Sandy.

Table 9-2. Compliance Monitoring for Offsite Measures

#	Measure	Measurable Habitat Objective[a]	Compliance Monitoring[b]
Riparian Easements and Improvements			
H-11	**Sandy 1 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 11 acres (with 100-foot buffer widths) within 15 years	Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site potential forest is established
H-12	**Sandy 2 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 62 acres (with 100-foot buffer widths) within 15 years	

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Table 9-2. Compliance Monitoring for Offsite Measures, continued

#	Measure	Measurable Habitat Objective[a]	Compliance Monitoring[b]
Riparian Easements and Improvements			
H-13	**Gordon 1A and 1B Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 78 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site potential forest is established
H-14	**Sandy 3 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 7 acres (with 100-foot buffer widths) within 15 years of establishment of easement	
H-15	**Cedar 2 and 3 Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 49 acres (with 100-foot buffer widths) within 15 years of establishment of easement	
H-16	**Alder 1A and 2 Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 43 acres (with 100-foot buffer widths) within 15 years of establishment of easement	
H-18	**Sandy 8 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 25 acres (with 100-foot buffer widths) within 15 years of establishment of easement	
H-19	**Salmon 1 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 23 acres (with 100-foot buffer widths) within 15 years of establishment of easement	
H-20	**Salmon 2 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 36 acres (with 100-foot buffer widths) within 15 years. of establishment of easement	

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Table 9-2. Compliance Monitoring for Offsite Measures, continued

#	Measure	Measurable Habitat Objective[a]	Compliance Monitoring[b]
Riparian Easements and Improvements			
H-21	**Salmon 3 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 12 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site-potential forest is established
H-22	**Boulder 1 Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 15 acres (with 100-foot buffer widths) within 15 years of establishment of easement	
H-28	**Zigzag 1A/1B Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 12 acres (with 100-foot buffer widths) within 15 years of establishment of easement	
H-24	**Salmon 2 Miller Quarry Acquisition**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 40 acres (with 100-foot buffer widths) within 15 years of acquisition	Document purchase of the site in annual report Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site potential forest is established
Water Rights Acquisition			
F-5	**Cedar Creek Purchase Water Rights**	During HCP Years 6-10, purchase approximately 50% of the current surface water rights that currently decrease June-September flows to increase June-September flows	Document the rights purchased and the estimated amount of additional flow for fish

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Table 9-2. Compliance Monitoring for Offsite Measures, continued

#	Measure	Measurable Habitat Objective[a]	Compliance Monitoring[b]
Fish Passage			
P-2	**Alder 1 Fish Passage**	Provide year-round upstream and downstream passage for steelhead and coho	Document passage conditions compared with NMFS design criteria once every three years after project implementation
P-3	**Alder 1A Fish Passage**		
P-4	**Cedar Creek 1 Fish Passage**	Provide year-round upstream and downstream passage for steelhead, coho salmon, cutthroat trout	
Carcass Placement			
H-25	**Salmon 2 Carcass Placement**	Place 1,800 salmon carcasses in one season	Document number of carcasses, release sites, and year of implementation
H-29	**Zigzag 1A, 1B, and 1C Carcass Placement**	Place 1,800 salmon carcasses in one season	

Table continued on next page

Table 9-2. Compliance Monitoring for Offsite Measures, continued

#	Measure	Measurable Habitat Objective[a]	Compliance Monitoring[b]
Large Wood and Log Jam Placement			
H-3	**Little Sandy 1 and 2 LW Placement**	Place 50 key pieces of LW and achieve 80% of predicted woody debris levels within 15 years of placement	Tag all pieces of LW at the time of placement for later identification Monitor number of pieces of wood in the stream as described in Appendix F
H-4	**Sandy 1 and 2 Log Jams**	Place 10 engineered log jams in reaches Sandy 1 and 2	
H-5	**Gordon 1A and 1B LW Placement**	Place 300 key pieces of LW in reaches Gordon 1A and 1B and achieve 80% of predicted woody debris levels within 15 years of placement	
H-6	**Trout 1A LW Placement**	Place 25 key pieces of LW and achieve 80% of predicted woody debris levels within 15 years of placement	
H-7	**Trout 2A LW Placement**	Place 20 key pieces of LW in reach Trout 2A and achieve 80% of predicted woody debris levels within 15 years of placement	
H-17	**Cedar 2 and 3 LW Placement**	Place 600 key pieces of LW in reaches Cedar 2 and 3 and achieve 80% of predicted woody debris levels within 15 years of placement	
H-26	**Boulder 0 and 1 LW Placement**	Place 65 key pieces of LW in reaches Boulder 0 and 1 and achieve 80% of predicted woody debris levels within 15 years of placement	
Channel Restoration			
H-8	**Sandy 1 Reestablishment of River Mouth**	Create one additional mile of stream by reconnecting with original river mouth	Document reestablishment of the historic Sandy River mouth

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Table 9-2. Compliance Monitoring for Offsite Measures, continued

#	Measure	Measurable Habitat Objective[a]	Compliance Monitoring[b]
Channel Restoration			
H-9	**Sandy 1 Channel Reconstruction**	Open one-third river miles of side-channel habitat Place 25 logs in side channel	Tag all side-channel logs at the time of placement for later identification Once every three years, resurvey the stream to document seasonal flooding of the side-channel habitat and determine how many pieces of LW are still within the side-channel
H-10	**Sandy 1 Turtle Survey and Relocation**	Avoid direct impacts to western painted turtles and northwestern pond turtles	Document surveys of potential turtle habitat. Document all turtle relocations (species, number, locations, and dates) Note: Measure H-10 is only necessary for projects conducted in the Sandy River delta
H-27	**Zigzag 1A Channel Redesign**	Maintain one-third mile of floodplain habitat for steelhead, coho, and spring Chinook Place 25 pieces of LW in reaches Zigzag 1A and 1B	Tag all pieces of LW at the time of placement for later identification Once every three years, resurvey the stream to determine how many pieces of LW are still within the side channel
Terrestrial Wildlife Habitat Conservation			
W-1	**Minimize Impacts to Spotted Owls**	Avoid disturbance of active nesting habitat	Survey protocols for owls, eagles, and fishers have not yet been determined Protocols will be available within six months of the start of the HCP term
W-2	**Minimize Impacts to Bald Eagles**	Avoid disturbance of active winter night roosts or nests	
W-3	**Minimize Impacts to Fishers**	Avoid disturbance of fisher habitat	

[a]The measure descriptions in Chapter 7 provide additional definitions and details.
[b]Compliance monitoring methods are described in Appendix F, Monitoring and Research Protocols.

9.2.2 Effectiveness Monitoring

The City will conduct effectiveness monitoring for some of the HCP conservation measures. The effort will focus on measures for which there is some degree of uncertainty about the biological effectiveness. In some cases, the City does not plan to do effectiveness monitoring because the outcomes are already known and well supported by the available scientific literature. The rationale for those decisions is described in this section.

The effectiveness monitoring measures were developed to respond to the following guidance from NMFS:

- Provide detail about anticipated physical "endpoints"
- Collect data at stream sites where field work is done
- Conduct more robust analysis of physical habitat changes over time for instream projects (e.g., channel design or large wood placements) compared with other types of projects
- Gather pre-project habitat condition data to aid in determining project effectiveness
- Compare post-project field data with the habitat changes expected to result from the project (i.e., estimated habitat changes documented in the Ecosystem Diagnosis and Treatment (EDT) database)

Measures for Which Effectiveness Monitoring is Not Necessary

Four categories of Sandy offsite projects involve minimal uncertainty about biological effectiveness. The categories are fish passage improvements, carcass placements, riparian improvements, and a water rights purchase. The City believes only compliance monitoring is needed. The rationale for this conclusion is discussed by category below. Hypotheses for the expected results are provided.

Fish Passage Improvements

Four fish passage measures will be implemented in the first 15 years of the HCP. One project is on Walker Creek, a tributary to the lower Bull Run River. Two projects are on Alder Creek, where passage is restricted by a Highway 26 crossing (RM 0.1) and obstructed upstream near a diversion dam (RM 1.7). The fourth project is at the Sandy Fish Hatchery on Cedar Creek at RM 0.5.

> **Working Hypothesis:** Fish passage improvements in Walker, Alder, and Cedar creeks will increase the available space for upstream distribution of listed and unlisted native salmonid fish stocks in the Sandy River Basin.

This hypothesis is supported by an extremely large body of scientific literature (Roni et al. 2002) for streams in the Pacific Northwest. The evidence indicates salmonid fish colonization of new habitat can be fairly rapid (Pess 2005; Iversen et al. 1993; Bryant et al. 1999; Glen 2002), and a similar result is expected for Alder Creek, Walker Creek and Cedar Creek. Source populations are present immediately downstream of these sites. Effectiveness monitoring is not necessary.

Carcass Placements

The City will place carcasses along five reaches in the Salmon and Zigzag Rivers. These measures are one-time treatments and depend upon carcass availability. The intent is to make a contribution to planned efforts by other Sandy River Basin Partners.

> **Working Hypothesis:** Carcass placements will increase nutrient levels; increase primary and secondary aquatic productivity; and, subsequently, increase the survival, growth, and abundance of listed and unlisted salmonid fish stocks in the Sandy River Basin.

Scientific literature and available research clearly document that carcass introductions have a direct positive influence on nutrient levels, aquatic productivity, and fish species response (Bilby et al. 1998 and 2001; Cedarholm et al. 1999; Washington Department of Fish and Wildlife [WDFW] 2001; Wipfli et al. 1999 and 2001; Shively 2001; Ashley and Slaney 1997; Reimchen et al. 2003; Johnston et al. 2004). Carcass placement programs are a key strategy under the Oregon Plan for Salmon and Watersheds (Oregon Department of Fish and Wildlife [ODFW] 2000) and are also supported by the State of Washington and the Canadian province of British Columbia (BC Ministry of Fisheries 2000).

Effectiveness monitoring is not necessary, based on the literature cited above, and because the measures are one-time treatments, monitoring would have no effect on later HCP implementation decisions.

Riparian Improvements

Riparian improvement measures are planned in 12 stream reaches. The measures include riparian easements and silvicultural enhancements. Habitat conditions are expected to improve in 16 Sandy River Basin reaches.

> **Working Hypothesis:** Protecting and enhancing riparian zones will increase wood recruitment, shade, bank stabilization, and runoff filtration capacity over time that will increase the survival, abundance, and productivity of covered species in the Sandy River Basin.

This hypothesis is supported by an extensive scientific record. The benefits of improving and protecting riparian areas for enhanced biological productivity are well established in the literature (Platts et al. 1987; Murphy and Koski 1998; McDade et al. 1990; Sullivan et al. 1990; VanSickle and Gregory 1990) and are key components of other approved HCPs across the region. All of the riparian measures in this HCP include replanting as necessary. With the establishment of the coniferous vegetation in the riparian zones, the multiple fish benefits enumerated in the hypothesis will begin to accrue. Effectiveness monitoring is not necessary.

Water Rights Purchase

The City will purchase water rights in Cedar Creek to increase flows for fish. This measure will affect three reaches, and will be done only after the weir at the Sandy Fish Hatchery is modified to allow fish passage.

> **Working hypothesis:** Purchasing surface water rights in Cedar Creek will increase streamflow and habitat for covered species.

The value of streamflow to fish and amphibians has been thoroughly documented in the scientific literature (Stoker 1950; Bovee et al. 1985; Kelley et al. 1987; California Department of Fish and Game 1987 and 1993; Electric Power Research Institute 2000). Most western states, including Oregon, recognize that streamflow is important for aquatic species conservation and have promulgated instream flow regulations (ORS 537.330).

Compliance monitoring will document the estimated change in flows. Effectiveness monitoring is not necessary.

Effectiveness Monitoring for Offsite Measures

As discussed above, in-channel improvements pose some biological uncertainty. The City will monitor the effectiveness of these in-channel measures.

The City has defined specific improvements in habitat conditions anticipated for each in-channel measure. For example, reaches Sandy 1 and 2 log jams are expected to improve pool and off-channel habitat, in addition to increasing the amount of large wood. Improvements in the actual stream conditions (pool and off-channel habitat) are variables that will be monitored. The same working hypothesis applies for all of the offsite projects:

> **Working hypothesis:** At least 80 percent of the projected changes in the key habitat variables (pre-project versus post-project conditions) will occur in each affected stream reach.

To test this hypothesis, two key questions are relevant:

- Are the habitat variable ratings in the current EDT database representative of pre-project habitat conditions?
- Are the projected increases in habitat ratings (as described in Appendix E) an accurate representation of post-project habitat conditions?

To answer these questions, the City will implement the following protocol:

- Gather baseline habitat surveys (pre-project information)
- Conduct project effectiveness evaluation (post-project surveys)
- Compare results with measurable habitat objectives (as described in Table 9-3)

Each of the three elements of the protocol is described in more detail below.

Baseline Habitat Surveys

Although a thorough reach-specific habitat database already exists, the City will verify baseline pre-project conditions for each reach where in-channel measures are planned. A standardized ODFW Aquatic Inventory Project protocol will be used to assess existing habitat conditions (Moore et al. 2002) The habitat parameters proposed for measurement during the stream channel surveys are EDT Level 2 environmental attributes (see Appendix D, EDT Limiting Factor and Habitat Attribute Definitions and Relationships). The City will collect two years of pre-project stream habitat survey data and average them to establish the baseline for comparing the post-project treatment results. The City will also use the pre-project information to determine variance estimates around the habitat parameters to be analyzed as part of the effectiveness monitoring. A more detailed description of the protocol is provided in Appendix F, Monitoring and Research Protocols.

Project Effectiveness Evaluation

The study design for the in-channel projects is anticipated to include habitat surveys in the form of a Before/After with Controls Included (BACI) assessment (Roni et al. 2005). The City will use upstream reach controls (either upstream of the treated portion of the reach or in the immediate upstream EDT reach) to minimize the influence of external factors, channel disturbance regimes, and weather on the outcomes of the before and after project comparisons. The controls will be chosen to include habitat representative of current conditions in untreated sections of the reaches. A more detailed description is provided in Appendix F, Monitoring and Research Protocols.

Comparison with Measurable Objectives

In-channel mitigation measures will influence habitat variables and environmental attributes in 13 reaches encompassing approximately 51 lineal miles of stream habitat. Professional biologists familiar with the Sandy Basin rated habitat variables for each EDT reach and estimated the change in the rating that would occur after HCP measure implementation. The ability to accurately measure each habitat attribute and the expected change depends on many factors, including the following:

- Characteristics of the attribute
- Natural variability
- Sampling methodology
- Observer error

Because variance terms are not currently available for each of these four factors, it is not possible to clearly define the level of precision achievable with a monitoring program.

The City will statistically evaluate key EDT habitat attributes for each of the in-channel treatment reaches because these factors offer the greatest projected magnitude of change attributable to the in-channel treatment measures, and the variance concerning their estimates and operator errors are anticipated to be sufficiently small. The key habitat attributes include the following:

- Woody debris
- Backwater pool percentage
- Off-channel habitat factor
- Beaver pond percentage
- Pool percentage
- Large cobble riffle percentage
- Pool tail percentage
- Small cobble riffle percentage

The HCP conservation measures are also expected to provide beneficial changes in additional habitat variables, including the following:

- Fine sediment
- Bed scour
- Confinement-hydromodifications
- Riparian function

The City believes, however, that these variables exhibit either a high variance or a relatively low anticipated magnitude of change (i.e., less than 10 percent post-treatment change), which will make statistical assessment difficult. The City does not plan to collect or evaluate effectiveness data on these variables and will instead focus on the key attributes listed that are associated with the greatest predicted benefits to fish. The predicted habitat changes for each of the primary covered species are discussed in more detail in Chapter 8 and in Appendix E.

The monitoring measures, measurable habitat objectives, and monitoring methods are described in Table 9-3. Additional details of the protocols are provided in Appendix F.

Table 9-3. Effectiveness Monitoring for Offsite Measures

#	Measure	Measurable Habitat Objective[a]	Effectiveness Monitoring [b]
Large Wood and Log Jam Placement			
H-12	**Trout 1A LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol
H-13	**Trout 2A LW Placement**		

Table continued on next page

Table 9-3. Effectiveness Monitoring for Offsite Measures, continued

#	Measure	Measurable Habitat Objective[a]	Effectiveness Monitoring[b]
Large Wood and Log Jam Placement			
H-3	**Little Sandy 1 and 2 LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation Achieve 80% of predicted increase in backwater pools, pools, and pool-tail habitat within 15 years of implementation Achieve 80% of predicted increase in percentage of total habitat that is large-cobble riffles, within 15 years of implementation	Conduct habitat surveys per monitoring protocol
H-5	**Gordon 1A and 1B LW Placement**		
H-26	**Boulder 0 and 1 LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation.	
H-4	**Sandy 1 and 2 Log Jam Placements**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol
H-17	**Cedar 2 and 3 LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation Achieve 80% of predicted increase in percentage of off-channel, beaver pond and pool habitat within 15 years of implementation	

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Table 9-3. Effectiveness Monitoring for Offsite Measures, continued			
#	**Measure**	**Measurable Habitat Objective**[a]	**Effectiveness Monitoring**[b]
Channel Restoration			
H-9	**Sandy 1 Channel Reconstruction**	Achieve 80% of predicted increase in percentage of off-channel habitat within 15 years of implementation	Every three years, resurvey the site to determine whether the gradient control structure is maintaining flow in the side channel and the river
H-24 **H-24**	**Salmon 2 Miller Quarry Acquisition and Restoration**	Achieve 80% of predicted improvements in off-channel habitat within 15 years of implementation	Once every three years after measure implementation, survey opened floodplain area and side channels
H-27	**Zigzag 1A Channel Design**	Achieve 80% of predicted habitat improvements within 15 years of implementation	Conduct habitat surveys per monitoring protocol

[a]Monitoring protocols are described in detail in Appendix F, Monitoring Plans and Protocols.
[b] Predicted habitat changes for each reach are defined in Chapter 8.
[a]Predicted habitat changes for each reach are defined in Chapter 8 and in Appendix E.

9.3 Research Program

The City's research program has four components in the Bull Run River watershed, and one component in the larger Sandy River Basin. In the Bull Run watershed, the City will study placement of spawning gravel, degree of Chinook spawning gravel scour, concentrations of total dissolved gases (TDG), and abundance of spawning Chinook adults. For the Sandy River Basin, the City will collaborate with ODFW, Mt. Hood National Forest, Bureau of Land Management (BLM), and ODEQ to measure the number of juvenile salmonids outmigrants (JOMs) in the Sandy River Basin.

9.3.1 Research in the Bull Run Watershed

Spawning Gravel Placement and Bed Scour Research

Most of the City's conservation measures in the Bull Run River watershed are associated with a high degree of biological certainty that the actions will provide the habitat improvements necessary to meet the HCP's goals and objectives. The benefits of placing spawning gravel are not as well known. The City will evaluate the effectiveness of gravel placements by conducting research on gravel placement and gravel scour.

Gravel Placement Research

The City will place spawning gravel in the lower Bull Run River to increase spawning habitat, primarily for Chinook salmon and steelhead. The gravel placement rate will be higher than the estimated natural range of gravel accumulation in the lower Bull Run River. The estimated historic gravel supply rate was roughly 30—1,000 cubic yards per year (CH2M HILL 2003); the City will place approximately 1,200 cubic yards per year for the first 5 years and 600 cubic yards per year thereafter. The City will evaluate the gravel placements annually to determine the resulting surface area covered by spawning gravels of suitable size for Chinook salmon and steelhead. A more detailed version of the gravel placement research protocol is provided in Appendix F, Monitoring and Research Protocols.

Chinook Spawning Gravel Scour Research

The City recently completed an analysis of gravel (or potential redd) scour in the Bull Run River based on existing streamflow and scour velocity information (CH2M HILL 2003b). The study indicated that the flows sufficient to mobilize gravels will occur less frequently and for fewer days under the HCP flow regime than with natural flows, and will therefore reduce the risk of redd scour caused by peak flows. The CH2M HILL study relied on existing information; no new field data were incorporated. The City will augment this information by completing a Chinook redd scour study.

The City will study redd scour in the lower Bull Run River using sliding bead-type scour measuring devices. The lower river, RM 1.5–RM 4.7, will be stratified into stream reaches based on channel and geomorphic characteristics. The City has surveyed this section of the river in the past for spring and fall Chinook spawning. The City will sample a total of 10 Chinook redds a year in the lower river, distributed as evenly as possible among the reaches. Ten redds represent approximately 33 percent of the total redds observed in previous years.

The redd scour study will take place after 5 years of gravel placement, and in each of 3 years between Year 5 and Year 10 of the HCP. The study years might not be consecutive because high flows are needed to generate useful data, and those flows do not occur every year.

A more detailed version of the Chinook spawning gravel scour research protocol is provided in Appendix F, Monitoring and Research Protocols.

Total Dissolved Gas Research

Oregon's Water Quality Standards state that TDG levels should not exceed 110 percent of saturation unless flows exceed the ten-year, seven day average flood (7Q10) flow for the site [OAR 340-041-0031]. The City has evaluated all water system structures, valves, or turbines that could elevate TDG levels since 2005. There are two structures where the City has found that high levels of TDG can occur, the Dam 2 spillway stilling pool and the Dam 1 spillway. Elevated TDG levels, however, rapidly dissipate at both locations. TDG levels immediately downstream of the Dam 2 stilling pool, for instance, have not exceeded the 110% standard unless the 7Q10 flow for the lower Bull Run River was also exceeded. Similarly, high TDG levels measured in the Dam 1 spillway dissipate to below 110% by the downstream end of the spillway pool. It is not yet known to what extent the short-term elevated TDG levels at these two locations affect fish habitat in the Bull Run River, so additional study is needed.

The City will continue to study TDG levels in the Bull Run River to determine the extent and duration of TDG concentrations. If TDG levels exceed water quality standards, the City will work with ODEQ to develop a water quality management plan. A more detailed version of the TDG research protocol is provided in Appendix F, Monitoring and Research Protocols.

Bull Run River Chinook Population Research

The City understands the importance of tracking the status of the ESA-listed fish populations in the Sandy River Basin. A variety of partner organizations in the Sandy River Basin need fish population information to evaluate population trends and track recovery of the Endangered Species Act (ESA)-listed fish populations. Although this HCP is habitat based and not focused on the specific population responses of the species, the City will partially fund research on the status of the species in conjunction with other partners.[1] The results of the City's research will be evaluated with monitoring results to determine the City's adaptive management response over time.

The City will collect adult Chinook salmon information for the lower Bull Run River. The City will conduct an annual survey of the lower river from RM 0—RM 5.8 to count adult spring and fall Chinook salmon from August through November. This time period covers the spawning period of spring Chinook and Late River Wild fall Chinook. The reach can be safely surveyed because the City can somewhat control (i.e., reduce) flow levels. A portion of this reach, from the Little Sandy River (RM 2.8) to Larson's Bridge (RM 3.7), corresponds to one of ODFW's probabilistic, randomly selected reaches for the Sandy River Basin snorkel surveys (see Section 9.3.2).

[1] Chapter 2 describes the City's habitat-based approach and rationale in greater detail.

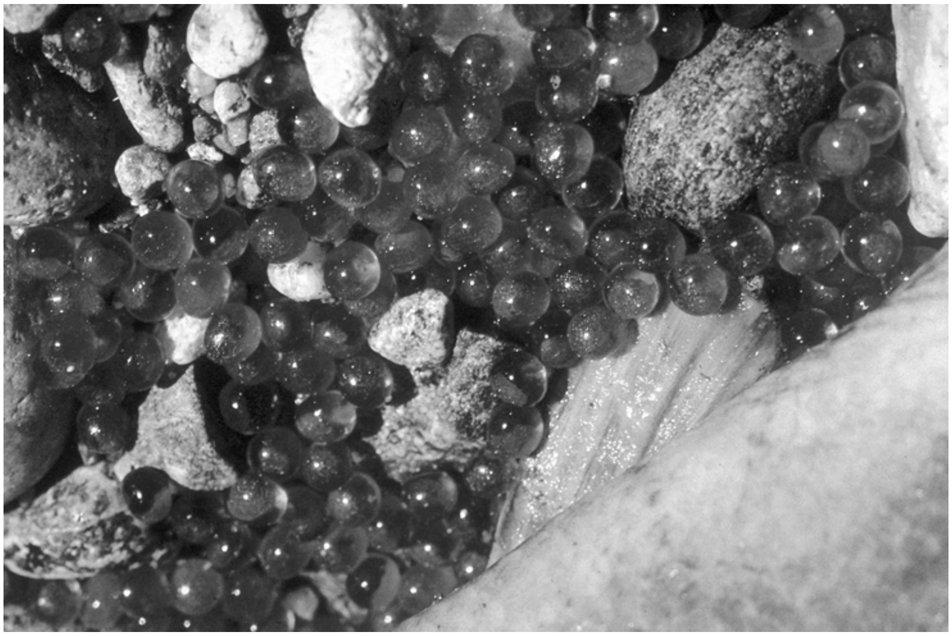

Photo courtesy of Bonneville Power Administration.

The City will provide $600,000 for the term of the HCP and will coordinate its monitoring efforts with ODFW. If ODFW can complete Bull Run River population surveys early in the term of the City's HCP, the City will postpone its surveys to a later date and thereby leverage the available funding to greater effect. Overall, the City will fund 20 years of adult Chinook salmon surveys over the 50-year term of the HCP. A more detailed description of the protocol is provided in Appendix F, Monitoring and Research Protocols.

9.3.2 Research in the Sandy River Basin

The population research done by the City will be part of a coordinated basin-wide effort. ODFW, U.S. Forest Service (USFS, Mt. Hood National Forest), BLM, ODEQ, and the City are currently coordinating efforts to monitor population trends for adult Chinook, coho, and steelhead; juvenile salmonids; and freshwater habitat conditions in the Basin. Currently, ODFW is monitoring adult fall and spring Chinook, coho, and steelhead. The fall and spring Chinook counts are index surveys which account for most of the known spawning areas for the species. For coho and steelhead, the adult spawner population estimates are expected to have a precision of ± 35 percent. ODFW is also starting probabilistic snorkel surveys for juvenile coho, Age-1+ steelhead, and Age-1+ cutthroat. The surveys are designed to provide status and trend information at the Lower Columbia Evolutionarily Significant Unit (ESU) scale. The program includes approximately 50 sites in the ESU and 7 sites in the Sandy River Basin. The surveys began in August 2006. ODFW also started habitat surveys in the Sandy Basin in July 2006; the information will provide habitat status and trend information over time.

Juvenile Salmonid Outmigrant Research

The City understands the importance of tracking the status of the ESA-listed fish populations in the Sandy River Basin. The City has discussed the need for Juvenile Outmigrant (JOM) data in the Sandy River Basin with other agencies (Phil Roni, NMFS, pers. comm., October 2006) and will participate in funding JOM research. Although this HCP is habitat-based and not focused on the specific population responses of the species, information about juvenile outmigrants is needed to obtain a complete picture of the condition and change in freshwater productivity through time, which is important for determining the overall status of the fish populations. The results of the City's research will be evaluated with monitoring results to determine the City's adaptive management response over time.

The City will provide $100,000 per year for the term of the HCP for collecting juvenile salmonid information for the Sandy River Basin. This money will be used in cooperation with the Sandy River Basin Partners (Partners) to leverage additional funds and to create a coordinated JOM monitoring program for the Basin. The City's share amounts to 43 percent of the JOM monitoring effort.

The City will conduct its research on juvenile outmigrants using seven rotary smolt traps. The Sandy River Monitoring Group has identified 12 sites in the Sandy River Basin where operating a smolt trap is feasible. Those sites are Beaver, Gordon, Cedar, Still, Camp, Clear, and Lost creeks, and the Bull Run, Little Sandy, Salmon, Clear Fork Sandy, and Zigzag rivers. These streams will collectively serve as an index for the entire Sandy River Basin.

Use of the juvenile salmonid outmigrant research budget will be reviewed by NMFS and the City as needed and can be reallocated, if necessary, to address other higher priority population research needs in the Sandy River Basin. The City's will commit no more than $100,000 per year for the term of the HCP.

More detail about the protocol is provided in Appendix F, Monitoring and Research Protocols.

9.4 Adaptive Management Program

Adaptive management is an important aspect of successfully implementing a habitat conservation program over a 50-year period. The City anticipates that scientific understanding will improve during the term of the HCP, and that conditions will change to the degree that some reconsideration and adaptation will be appropriate.

The City's approach to adaptive management incorporates the following components:

1. Sandy River Basin Restoration Strategy
2. HCP Implementation Committee
3. Adaptive Management Response Framework

9.4.1 Sandy River Basin Restoration Strategy

As described in Chapter 2, the City's HCP was developed in the context of a partnership effort to restore aquatic and riparian habitat throughout the Sandy River Basin. The Partners have developed a Sandy River Basin Restoration Strategy (Sandy River Basin Partners 2006) and have committed to work together to implement the strategy over time. The Partners recognize the key role the HCP plays in complementing and leveraging restoration work throughout the Basin. Contributing to a coordinated basin-wide restoration effort is fundamental to the rationale for the offsite conservation measures and Habitat Fund included in the HCP.

The Partner's Restoration Strategy is built on geographic and project-type priorities. The geographic prioritization is based on anchor habitats, defined as those reaches currently most productive for fall and spring Chinook salmon, steelhead, and coho salmon. Habitat improvement project priorities are based on a hierarchical framework developed from the most recent literature and consistent with the Oregon Plan for Salmon and Watersheds (Oregon Watershed Enhancement Board 2005).

The City will continue to actively participate in the Partner's ongoing work. While the City's legal obligation is to meet the requirements of federal law, the City's intent is to do so in manner consistent with the Sandy River Basin Partner's Restoration Strategy as that strategy matures and evolves into the future.

9.4.2 HCP Implementation Committee

For both the HCP and the Sandy River Basin Restoration Strategy to be successful in the long term, the City will need to continue to work in collaboration with the partner organizations. The City recognizes the value of the effort that the Partners have already dedicated to assisting in the definition of measures for the HCP. Similar communication and coordination will be needed during the term of the HCP.

To this end, the City will establish an HCP Implementation Committee. Assuming the Sandy River Basin Partners continue to exist in a similar form, the members will constitute this committee. During the 50-year term of the HCP, the Implementation Committee will assist in making adaptive management decisions. The role of the Implementation Committee will be advisory only. NMFS and the City will retain final authority to make changes to the HCP.

9.4.3 Framework for Adaptive Response

The design of the HCP creates a variety of adaptive management needs over time. The adaptive management framework includes two major components:

- Adaptive Responses for Individual Measures
- Decision Milestones for Addressing Effectiveness of HCP as a Whole

(See also Chapter 10 for a description of adaptive responses to Changed Circumstances. See Chapter 11 for the estimated costs and funding allocations.)

Adaptive Responses for Individual Measures

The City will implement adaptive management for individual measures if any of the following circumstances occurs during the term of the HCP:

1. A habitat conservation measure cannot be implemented
2. Effectiveness monitoring indicates that an instream habitat conservation measure has not met the applicable measurable objective
3. Due to factors outside the control of the City (e.g., flood, wildfire, insects and disease, landslide, permanent change in land use, or unauthorized logging), more than 20 percent of the anticipated riparian or instream habitat benefit of an offsite habitat conservation measure, within the reach it is implemented, is lost prior to the end of the 50-year HCP term[2]

If appropriate, given new information, the City and NMFS, with the input of the Implementation Committee, will also reconsider specific offsite measures that have not yet been implemented. In those cases, the merits and feasibility of substituting a new measure for an original measure will be discussed. (See also the contingency provisions in Chapter 11 for situations in which a measure is expected to cost more than the amount estimated and allocated.)

The necessary adaptive response in these situations will be discussed by the City and NMFS on a case-by-case basis. As a starting point, the City will, when appropriate, conduct site surveys (see Appendix F for protocols) and run the EDT model with updated habitat ratings to characterize baseline watershed conditions.

If implementation of an additional or substitute measure is necessary, the City and NMFS will use the following guidelines in the order of priority listed or as applicable to the circumstances:

1. Repeat the original approach in the same location
2. Define a new approach to achieve the same habitat benefit for the same primary covered species in the same reach
3. Define a different but equivalent habitat benefit (and an approach to achieve that benefit) for same primary covered species in the same reach; determine if the new habitat benefit targets a limiting factor for that species in that reach
4. Define an equivalent habitat benefit in a different reach (and an approach to achieve that benefit) that will benefit the same primary covered species; determine if the new habitat benefit targets a limiting factor for that species in that reach
5. Define an equivalent habitat benefit (and an approach to achieve that benefit) that will benefit another of the four primary covered species; determine if the new habitat benefit targets a limiting factor for that species in that reach

[2]Habitat loss, in this context, is defined as the destruction or degradation of 20 percent of the riparian zone acreages indicated for riparian zone easement and improvement measures in Table 9-2. Habitat loss is also defined as a 20 percent reduction in the aquatic habitat as defined by the measurable habitat objectives associated with the large wood/log placements and the channel redesign and reconnection projects in Table 9-3. The loss would be anticipated to last for 10 years or longer.

Once a measure—or set of alternative measures—has been selected, the City will rerun the EDT model to assist in evaluating the equivalence of the habitat benefit as compared to the benefit predicted for the original measure.

For measures that require effectiveness monitoring, the equivalent habitat benefits described above will be defined based on the specific EDT rating changes predicted to occur for the original measure (see Appendix E).

Decisions applying these guidelines will be made by the City and NMFS, working collaboratively and with input from the HCP Implementation Committee. Monitoring information and scientific literature available at the time will be used.

Costs for implementing the adaptive response, when the original measure was not implemented, will be paid with the funding allocated for the original measure. Costs for implementing additional measures, after the original measures have been implemented, will be paid from the adaptive management portion of the Habitat Fund. (See Chapter 11 for more information on the Habitat Fund.)

Decision Milestones for Addressing Effectiveness of the HCP as a Whole

The City and NMFS have established key milestones when effectiveness of the HCP, as a whole, will be evaluated and decisions will be made as to whether or not additional habitat measures are needed. These milestones will occur at Years 20, 30, and 35. Year 20 was selected as the first milestone because it would occur after the City has implemented most of the offsite conservation measures described in Chapter 7 and because it will take approximately that long to collect adequate and meaningful data about the Sandy River fish populations. Years 30 and 35 were selected to allow adequate time for implementing measures, accruing biological benefits, and assessing effectiveness before the next milestone and before the end of the HCP term.

As a first step at each of these milestones, the City will have a Progress Report meeting with NMFS and the HCP Implementation Committee. The purpose of this meeting will be to reach a common understanding of the

- population trends for the covered species
- City's compliance record to date
- effectiveness of City measures implemented to date
- need (if any) for adaptive management to meet HCP obligations
- opportunities available to improve habitat in accordance with the Sandy River Basin Restoration Strategy
- opportunities for partnership efforts (e.g., to use City funds to leverage additional resources from other sources)
- project preferences of the committee participants

Following the Progress Report meeting, the City and NMFS will have one or more additional meetings to define the adaptive management actions necessary (if any) to maintain compliance with the HCP. The focus of these meetings will be to decide whether new measures should be selected and implemented, and if so to determine the specific measures.

The City and NMFS will also consider changes in the science underlying the offsite conservation measures. The focus will be on whether or not the preponderance of the available scientific literature indicates that the original hypotheses (for one or more of the offsite conservation measures) have become faulty enough to warrant an adaptive response.

Final decisions will be made by NMFS and will be determined based on what is required to maintain compliance with the HCP. The magnitude of the effort will be constrained by the funding allocated to adaptive management (see Chapter 11).

Decisions at each milestone are described in Table 9-4, and shown in Figure 9-2. The Habitat Fund and Insurance Fund mentioned in Table 9-4 and Figure 9-2 are described in the next section.

Table 9-4. Milestones and Related Decisions

Decision at Year 20	Are Habitat Fund dollars allocated to Years 21–30 needed for adaptive management actions to achieve HCP compliance?	
	If yes, the City and NMFS will select the necessary projects and define implementation schedules during the Year 21–30 time window. Final decision is by NMFS.	If no, the City will dedicate those funds to projects identified with input from the Partners (based on the Sandy River Basin Restoration Strategy). Preference will be given to projects with characteristics necessary to leverage additional funds through partnerships.
Decisions at Year 30	Are Habitat Fund dollars allocated to Years 31–35 needed for adaptive management actions to achieve HCP compliance?	
	If yes, the City and NMFS will select the necessary projects and define implementation schedules during the Year 31–35 time window. Final decision is by NMFS.	If no, the City will dedicate those funds to projects identified with input from the Partners (based on the Sandy River Basin Restoration Strategy). Preference will be given to projects with characteristics necessary to leverage additional funds through partnerships.
	Is the Insurance Fund allocation for Years 31–35 needed, in addition to the Habitat Fund dollars, for adaptive management actions to achieve HCP compliance?	
	If yes, the City and NMFS will select the necessary projects and define implementation schedules during the Years 31–35 time window. Final decision is by NMFS.	If no, the funding allocation for Years 31-35 will revert to the City and will not be retained until the Year 35 milestone.

Table continued on next page.

Table 9-4. Milestones and Related Decisions, continued

Decision at Year 35	Are the Insurance Fund allocations for Years 36–40 and Years 41–45 needed for adaptive management actions to achieve HCP compliance?	
	If yes, the City and NMFS will select the necessary projects and define implementation schedules during the Year 36–45 time window. Final decision is by NMFS.	If no, the funding allocation for Years 36–45 will revert to the City and will no longer be available for adaptive management.

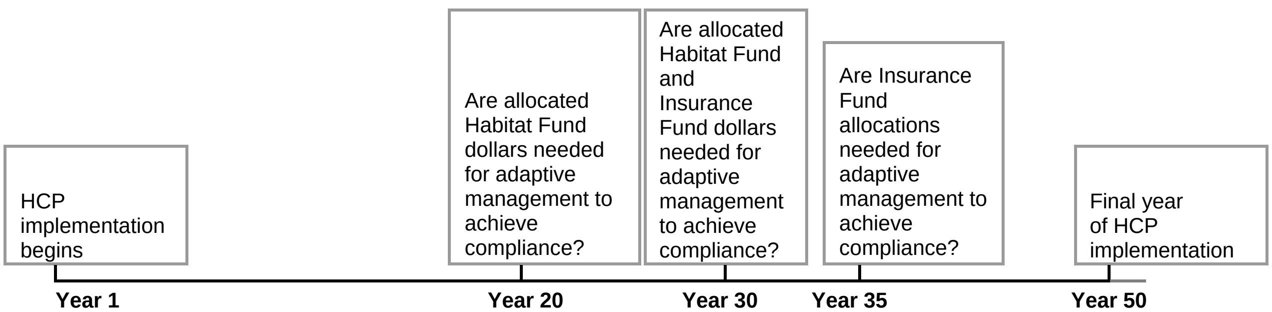

Figure 9-2. Milestones for Adaptive Management Decisions

Resources for Addressing Effectiveness of the HCP as a Whole

The City has designated two funds to be used to implement decisions at the milestones described above: a $4-million portion of the Habitat Fund and a $ 3-million Insurance Fund.

Habitat Fund

As described in Chapter 7, the $9-million Habitat Fund has two functions. One function is to provide funds to implement additional projects to address impacts not fully addressed by the other specific projects described in Chapter 7, especially for contributing to larger scale partnership projects. The habitat benefits that will accrue from the City's portion of these projects will add to total benefit provided by the City's HCP. A $5-million portion of the fund is designated solely for that first function. The second function is to provide resources to implement additional habitat projects, in the form of adaptive management, as necessary to ensure effectiveness of the HCP as a whole (per decisions at designated milestones described in Table 9-4). The remaining $4-million portion of the $9-million fund will be used for this second function to the extent it is needed. The $4-million is allocated in three increments: $2 million for Years 21-25, $1 million for Years 26-30, and $ 1 million for Years 31-35. If these increments are not needed for adaptive management, they will be reallocated to partnership projects as described in Table 9-4. (Note: Appendix I shows approximately $2 million of the $ 4 million total as being available prior to Year 20 if monitoring of projects implemented early in the term of the HCP shows those projects are not achieving the habitat objectives defined in this chapter and additional projects are required. Although this funding will be available earlier if needed, the City's intent is to follow the schedule shown in Table 9-4, Figure 9-2 and Figure 11-1 to the greatest extent possible. Decisions on how and when the adaptive management funding will be spent will be made by NMFS in consultation with the City and consistent with constraints defined in Chapter 11.)

Insurance Fund

The City will provide an Insurance Fund to provide resources late in the 50-year term of the HCP. The purpose of the $3-million Insurance Fund is to fund additional habitat projects, if necessary, based on decisions at the relevant milestones in Table 9-4 and shown in Figure 9-2. The fund is divided into three increments: $1 million for Years 31-35, $1.5 million for Years 36-40, and $0.5 million for Years 41-45 (see also Figure 11-1 in Chapter 11). If decided at the defined milestone that the Insurance Fund amount is not needed to ensure effectiveness of the HCP as a whole, the funding will be retained by the City and will no longer be available for the HCP. (See also Chapter 11, Costs and Funding, for additional information.)

Chapter 10. Changed Circumstances

10. Changed Circumstances

10.1 Introduction

The City of Portland (City) and NMFS foresee that certain circumstances could substantially change during the term of the Habitat Conservation Plan (HCP). Those changes, some due to natural events or factors outside the control of the City or NMFS, could merit changes in the approach as defined in the HCP. Because the Incidental Take Permit (ITP) will authorize the incidental take of covered species under ordinary circumstances as well as changed circumstances (as long as the City is operating in compliance with the relevant requirements), the changed circumstances are specifically identified in this chapter along with the planned responses. If mitigation measures or costs beyond those provided for in the HCP become necessary in response to these circumstances, the City understands that NMFS will not require additional measures or expenditures without the City's prior consent unless NMFS has concluded that a species is in jeopardy of extinction.

10.2 Climate Change

The City has designed its HCP to take into account reasonably predicted climate changes. The City believes that under climate patterns that might prevail over the next 50 years, it should be able to meet its commitments under the HCP. It is possible, however, that climate changes will occur more quickly or in directions that are not now anticipated. Such changes might affect the ability of the City to meet its commitments or the viability of the species protected by the HCP. These kinds of changes are addressed in this part of the HCP.

The City has kept climate-related records for the past 66 years and continues to assess climate patterns and their effect in the Bull Run watershed. The City also monitors current global and regional climate change research and related legal and policy developments. For example, the City hired University of Washington staff to study climate change as it might affect the Bull Run watershed. The study (Palmer and Hahn 2002) showed that winter precipitation may likely increase on average, but that snowmelt may likely provide less flow in spring. Although the length of the longest drawdown period was not predicted to increase, the average length of drawdown for all years was expected to increase. The study also indicated that the reservoirs in the Bull Run system would likely continue to fill each year, because overall winter flows in the watershed are still much greater than the available storage capacity.

Bull Run is primarily a rain-driven system, with peak flows occurring in late spring and early summer, tapering off as the summer progresses. The current research from University of Washington suggests that the shape and timing of the Bull Run hydrograph will probably not change much over the next several decades as a result of climate change. Flow monitoring will enable confirmation or alteration of those predictions.

Although global climate change models vary in predictions of precipitation amounts and patterns—particularly for the summer—predictions of increased temperatures in the future show a more consistent trend. The University of Washington Climate Impacts Group's (CIG) review of newer global climate models for the 2007 Intergovernmental Panel on Climate Change reports show that, for the Pacific Northwest, the precipitation changes in the summer are still fairly unpredictable, and that predicted temperature increases might be 10-20 years further into the future than estimated in the studies conducted in 2002.

The City is preparing for climate change through research and monitoring. Hydrology and water temperature data for the Bull Run River will continue to be monitored as part of the HCP.

10.2.1 Long-term Changes in Hydrology of the Bull Run River

The lower Bull Run River instream flow measures of the HCP are based on the needs of the covered fish species, the anticipated water supply demands of the City, and a 60-plus-year record of flows in the Bull Run River. The measures represent a balance among conflicting water uses, with provisions for the full range of hydrologic conditions that are likely to exist over the term of the HCP. The HCP addresses extreme seasonal low flows (critical spring and/or critical fall seasons) as determined from the hydrologic record. The definition of a critical flow season, a description of the triggers for recognizing the critical flow condition, and the City's measure for responding to the low season flows are described in detail in Chapter 7 (Measure F-2).

Seasonal low flows are not expected to be lower or to occur with greater frequency than those observed in the historical record. If they do occur more frequently in the future, that circumstance will be addressed as described below under Long-Term Change in Hydrology of the Bull Run River. The focus of implementation will be on defining and responding to the actual low-flow conditions.

Currently available data show a reduction in the Bull Run reservoir inflows over the last 60 years (see Chapter 2, Figure 2-4). The amount of stream inflow into the Bull Run reservoirs has decreased during the traditional reservoir drawdown period. The City used this data when developing the HCP and will continue to monitor river hydrology to determine whether the HCP conservation measures can be met during the term of the HCP.

Definition: A significant reduction of inflow to both Bull Run reservoirs evaluated in 2025 (and every 5 years after) and determined by statistical testing will be considered a changed circumstance. The City will apply three statistical tests to the Bull Run reservoir inflow data to determine whether there had been a significant change:

- Trend analysis
- Comparisons of means and/or median flow values
- Frequency of critical flow year occurrence

The reference condition will be Bull Run Reservoir inflow data from 1946–2004. If two of the three tests indicate that there has been a statistical reduction in the Bull Run reservoir inflows, this will be considered a changed circumstance. Appendix H, Impact of the Long-Term Climate Changes on Bull Run Stream Flow, describes the approach to testing whether there has been a significant reduction in flow.

Response: If a long-term change in Bull Run reservoir inflows occurs, the City will consider three options:

- Continued implementation of flow measures with no modification of the HCP
- Revised instream flow measures with minor modification of the HCP
- A proposed major amendment to the HCP

Under the first option, the City will consider its current water supply situation, the water supply demands, and the original HCP fish flow commitments. If the City determines that the fish flow commitments can still be met feasibly even with a reduction in Bull Run reservoir inflows, implementation of the flow measures will continue. If the City determines that it cannot meet the HCP flow measure commitments due to the changed circumstance, it will enter into good-faith discussions with NMFS to review the HCP flow measures and identify modifications that would comply with ESA requirements. The City will also determine the potential changes to Weighted Usable Area (WUA) values associated with the long-term change in hydrology and will make the data available to NMFS.

The City's incidental take coverage will continue while response options are being discussed and any necessary amendments to the HCP are made. During those discussions, the water supply system will continue to be operated to provide favorable flows for salmonids to the maximum extent practical.

10.2.2 Changes in Water Temperature of the Bull Run River

Water temperature is a key management concern in the lower Bull Run River. The covered fish species are sensitive to water temperature and can experience metabolic stress if temperatures exceed certain levels. The Oregon statewide water quality standards include two tests for compliance. The biologically based (numeric) criteria for maximum water temperature are 16 °C for salmonid rearing and 13 °C for salmonid spawning. However, if those numeric criteria cannot be met due to natural, nonanthropogenic conditions, then natural conditions are the standard to be met.

Detailed modeling analysis has demonstrated that even under natural pre-water-system conditions, temperatures in the lower Bull Run River would often exceed the state numeric criteria for salmonid rearing and spawning. The natural temperatures are elevated in the summer months because of the river's east-west orientation, bedrock morphology, and low summer flows. Consequently, during those periods, the water quality temperature standard in the Bull Run River is the "natural temperature." Given these natural conditions and given the constraints imposed by the limited storage of cold water in the City's reservoirs, the flow measures were designed to manage temperatures in the lower Bull Run River to meet the state standard and to favor native salmonids to the maximum extent practicable.

Under the terms of the Oregon Department of Environmental Quality (ODEQ) Total Maximum Daily Load (TMDL) for the Sandy River Basin, ODEQ uses temperatures in the Little Sandy River, as a surrogate to represent natural temperatures in the lower Bull Run River. The City's analysis indicates that it can and will meet the ODEQ standard. During the term of the HCP, however, it is possible that climatic conditions will change and Bull Run reservoir inflow (i.e., upper Bull Run River) temperatures will increase to the extent that the City cannot meet the Little Sandy River reference standard. If that occurs, the City will enter into good-faith discussions with NMFS and ODEQ to review the HCP flow and temperature measures. Possible outcomes of the discussions include the following:

- Continued implementation of flow and temperature measures, with no modification of the HCP
- Revised flow and/or temperature measures, with minor modification of the HCP
- A proposed major amendment to the HCP

The City's incidental take coverage will continue while response options are being discussed and any necessary amendments to the HCP are made. During those discussions, the water supply system will continue to be operated to provide favorable temperatures for salmonids to the maximum extent practical without additional structural modifications to the infrastructure.

10.3 Significant Change in the Status of Habitat within the Sandy River Basin

The HCP conservation measures were designed to ensure that incidental take associated with the Bull Run water supply system will not reduce the likelihood of the survival and recovery of species covered by the ITP in the wild. A major consideration in the development of the measures was the current status of the covered species and their habitats in the Sandy River Basin. A significant decrease in the quantity or quality of fish habitat within the Basin could alter the overall status of one or more covered species, as well as the relative impact of incidental take associated with the water supply system. In the event of such a change, it will be necessary to review all ongoing fish habitat conservation efforts in the Basin, including the HCP. The process for review and modification of the HCP following a significant change in habitat is described below.

Definition: A significant change in the status of habitat in the Sandy River Basin is defined for the purposes of this HCP as: the loss through destruction or degradation of more than 50 percent of the ability of a sixth-field or larger stream within the Basin to support covered fish species, expected to last for 10 years or longer. For example, such a loss could occur from a catastrophic flood, an eruption of Mount Hood, or an unexpected outcome of the removal of the Marmot or Little Sandy dam. This definition is intentionally kept broad to cover all possible circumstances that could affect the overall ability of the Sandy River Basin to support sustainable populations of the covered species. The City and NMFS will review any and all potentially significant changes in the status of habitat and mutually agree on which changes are significant for purposes of this provision of the HCP.

Response: In the event of a significant change in the status of habitat within the Sandy River Basin, the City and NMFS will enter into good-faith discussions to explore available response options. Potential responses by the City could include the following: helping to rehabilitate/restore function in the affected stream, improving habitat in other reaches/tributaries of the Sandy River, altering Bull Run flow releases, and/or using habitat in the upper Bull Run River for covered anadromous species. The type and magnitude of response could vary, depending on the time of the event (i.e., early or late in the HCP term). Joint funding with the Sandy River Basin Partners will be explored if feasible and appropriate. The City’s incidental take coverage will continue while response options are being discussed and any necessary amendments to the HCP are made.

10.4 Change in the Status of a Species

From time to time, NMFS might list additional species under the federal Endangered Species Act (ESA) as threatened or endangered, delist species that are currently listed, or declare a listed species extinct. In the event of a change in the federal status of one or more species, the following steps will be taken.

10.4.1 New Listings of Species Not Covered by the ITP

If a species that is present or potentially present in the Sandy River Basin becomes a candidate for listing, is proposed for listing, is petitioned for listing, or is the subject of an emergency listing under the federal ESA, the City will survey the area affected by the Bull Run water supply system (after coordinating with NMFS) to determine whether the species and/or its habitat(s) are present. If the survey results indicate the species or its habitat(s) are present, the City will report the survey results to NMFS. If NMFS determines there is a potential for incidental take of the species as a result of continued operation of the Bull Run water supply system, the City will exercise one of several options (e.g., choose to avoid the incidental take of the species, or request NMFS to add the newly listed species to the HCP and ITP in accordance with the provisions in the Implementing Agreement and HCP, and in compliance with the provisions of Section 10 of the ESA).

If avoidance of take of a newly listed species isn't possible or interferes with the City's ability to meet its obligations under the HCP, the City recognizes that new or revised mitigation measures may be necessary to satisfy ESA requirements for the newly listed species and will consult with NMFS. If the City chooses to pursue incidental take coverage for the species by amending the HCP or by preparing a separate HCP, the City and NMFS will enter into good-faith discussions to develop necessary and appropriate mitigation measures. All parties will endeavor to secure incidental take coverage prior to final listing of the species. The City's expectation is that NMFS will consider the habitat benefits resulting from the City's ongoing actions at the time of the species evaluations associated with listing. The City's incidental take coverage will continue while response options are being discussed and any necessary amendments to the HCP are made.

10.4.2 Delistings of Species Covered by the HCP

If a species covered by the HCP is delisted, NMFS and the City will review the mitigation measures being implemented for that species to determine whether they are still necessary to protect the species from being relisted. If continued mitigation by the City is necessary to avoid relisting the species, mitigation will continue as specified in the HCP. If cessation or modification of the mitigation for that species will not lead to the relisting of the species, NMFS and the City will revise the HCP to eliminate or otherwise modify the mitigation measures in question. However, if elimination or modification of mitigation measures initially implemented for the species being delisted will materially reduce the mitigation for another covered species, the mitigation measures will not be eliminated.

10.4.3 Extinction of Species Covered by the HCP

In the event that a species covered by the HCP becomes extinct in the relevant Evolutionarily Significant Unit, NMFS and the City will review the mitigation measures implemented for that species to determine whether they are still necessary to meet ESA requirements for the remaining covered species. If the City and NMFS mutually agree that elimination or modification of mitigation measures initially implemented for the extinct species will not materially reduce the protection and mitigation for another covered species, the mitigation measures will be eliminated or modified.

Chapter 11. Costs and Funding

11. Costs and Funding

11.1 Financial Summary

The City of Portland's (City's) Habitat Conservation Plan (HCP) involves four programs to be funded by the City: the habitat conservation program, the monitoring program, the research program, and the adaptive management program. The habitat conservation program described in Chapter 7 includes individual measures in Bull Run, individual offsite measures in the Sandy River Basin, and a Habitat Fund for measures not yet specifically defined. Chapter 9 describes the compliance and effectiveness monitoring and research programs. The adaptive management program, also described in Chapter 9, includes provisions to select, fund, and implement additional measures if the measures in Chapter 7 do not achieve the expected biological results. The total 50-year estimated cost of the HCP is $93,208,477 in 2008 dollars. Appendix I provides a table showing how the forecasted HCP costs are spread over the 50-year term. The total cost for each of the four programs is provided in Table 11-1. Additional detail is provided in this chapter.

Table 11-1. Habitat Conservation Plan Financial Summary

Program		Estimated Cost (2008 dollars)[a]
Habitat Conservation (see Table 11-2) *Bull Run Measures* *Offsite Measures* *Habitat Fund* *Staff Time* [b]		$70,666,277
Monitoring (see Table 11-5) *Compliance* *Effectiveness* *Staff Time* [b]		$5,175,200
Research (see Table 11-6) *Habitat Research* *Population Research* *Staff Time* [b]		$7,013,400
Adaptive Management (see Table 11-7) *Habitat Fund* [a] *Insurance Fund* *Staff Time* [b]		$10,353,600
	TOTAL	$93,208,477

[a]All HCP estimated costs will be adjusted for inflation during the term of the HCP. See Section 11.4 for more information.

[b] Staff time estimates are based on a total of approximately $17 million (approximately three FTE) over 50 years, allocated by percentage to habitat conservation, monitoring, research, and adaptive management. See Tables 11-3, 11-4, 11-5, 11-6 and 11-7 for detail. Two of these FTEs are for fish biologists.

[c] A $4-million subset portion of the Habitat Fund has dual purposes. To avoid double-counting in the table, this amount is shown above in the Adaptive Management Program subtotal and not in the Habitat Conservation Program subtotal.

11.2 Program Costs

11.2.1 Habitat Conservation Program Costs

The estimated habitat conservation program costs are allocated to three categories: Bull Run measures, offsite habitat conservation measures, and the Habitat Fund. Totals for these categories are provided in Table 11-2. Detail is provided in Tables 11-3 and 11-4. Unless otherwise noted, the operation and maintenance (O&M) costs are 50-year totals for measures implemented continuously or annually (as applicable).

Table 11-2. Habitat Conservation Program Estimated Costs

Habitat Conservation Measure Category		Estimated Cost in 2008 Dollars (50-year total)
Bull Run Measures (including staff time)[a]		$44,037,787
Offsite Measures (including staff time)		$21,628,490
Habitat Fund[b]		$5,000,000
	TOTAL	**$70,666,277**

[a]Includes funding for maintenance of land and maintenance of habitat improvements.

[b]A $4-million subset portion of the $9-million Habitat Fund has dual purposes. To avoid double-counting, this amount is not included in this table and is instead shown in Table 11-1 and in Table 11-7 as Adaptive Management.

Bull Run Habitat Conservation Measures

Bull Run habitat conservation measure costs are shown in Table 11-3. Estimated costs for the Bull Run measures include costs of operating the City's well field to provide water when needed to meet the needs of both people and fish, a pro-rated portion of well field maintenance costs, as well as the costs of habitat conservation measures located in either the lower Bull Run River or the Bull Run reservoirs. Well field maintenance helps ensure that the City's groundwater source functions properly when needed. Based on current supply assumptions and availabilities, groundwater is a crucial component of maintaining flows and temperatures that will benefit the covered species. Planning and permitting for the capital costs are included in the project-specific estimates. Planning, permitting, and project management for the O&M costs are included in the Water Bureau staff time subtotal. The staff time estimates comprise 30 percent of the three full-time equivalents (FTE) mentioned in Table 11-1.

Table 11-3. Bull Run Habitat Conservation Measure Estimated Costs[a]

Measure	Type[b]	Estimated Cost in 2008 Dollars (50-year total)
Flow Measures[c]		
Flow releases to meet minimum instream flows (costs of groundwater operation, prorated to amount needed to meet flow release commitments)	O&M	$16,082,750
Well field maintenance (costs attributable to more frequent use of well field due to flow release commitments)	Capital	$10,905,993
Temperature Measures		
Multi-level intakes at Dam 2 (temperature)	Capital	$9,613,132
Stilling pool bypass pipe (temperature)	Capital	$208,000
Lower Bull Run River Measures		
Spawning gravel placement	O&M	$928,288
Walker Creek fish passage	Capital	$989,000
Bull Run Reservoir Measures		
Cutthroat trout rescue	O&M and Capital	$280,225
Water Bureau Staff Time to Implement Bull Run Measures		
Staff time (30% of total allocated to staff time)	O&M	$5,030,400
	TOTAL	**$44,037,787**

[a] The following measures will be implemented with in-house staff and are included in the staff time dollar amount: F-4 Little Sandy Flow Agreement, R-1 Reservoir Operations, R-3 Reed Canarygrass Removal, O&M-1 Infrastructure O&M, O&M-2 Spill Prevention, H-2 Riparian Land Protection, W-1 Spotted Owls, W-2 Bald Eagles, W-3 Fisher.

[b] O&M is an acronym for operation and maintenance.

[c] Includes costs associated with flow downramping (F-3) and the flow aspects of temperature management (T-1 and T-2) .

Offsite Sandy River Basin Habitat Conservation Measures

The offsite Sandy River Basin measure costs are shown in Table 11-4. These costs were derived from the Sandy River Watershed Draft Restoration Actions matrix (Sandy River Basin Partners 2002). Estimates from the 2002 matrix were inflated 16.6 percent to 2008 dollars, based on the Consumer Price Index (CPI) for Portland. These measure costs were also increased by 15 percent as a contingency in case actual costs are higher than estimated costs. For more information on the funding, see Section 11.3.1, Habitat Conservation Program Funding. Most of the planning, permitting, and project management for the offsite measures will be done by Water Bureau staff, and related costs are included in the staff time subtotal shown in Table 11-4. Some of the permitting costs for offsite capital projects may be contracted and are shown in a separate line item in Table 11-4.

If measures are not implemented as planned and substitute measures are implemented (per the Adaptive Management Program described in Chapter 9), the funding will come from the amounts allocated for the original measure (with inflation if implemented at a later date).

If measures require minor maintenance, such as replanting or invasive plant removal, costs will be paid from the allocation of $3,012,956 for Land and Habitat Improvement Maintenance included in the funding for the habitat conservation program and shown in Table 11-4.

Table 11-4. Estimated Offsite Habitat Measure Costs Plus 15% Contingency Allowance

Measure number	Measure	Capital or O&M[a]	Cost in 2008 Dollars[b] + 15% Contingency Allowance
HCP Years 1-5			
H-5	Gordon 1A/1B LW Placement	O&M	$214,531
H-6	Trout 1A LW Placement	O&M	$53,633
H-7	Trout 2A LW Placement	O&M	$15,017
H-11	Sandy 1 Riparian Easement and Improvement	Capital	$103,243
H-12	Sandy 2 Riparian Easement and Improvement	Capital	$633,537
H-13	Gordon 1A/1B Riparian Easement and Improvement	Capital	$732,087
H-16	Alder 1A/2 Riparian Easement and Improvement	O&M	$403,587
H-22	Boulder 1 Riparian Easement and Improvement	Capital	$136,093
H-26	Boulder 0/1 LW Placement	O&M	$48,270
P-2	Alder 1 Fish Passage	O&M	$402,246
P-3	Alder 1A Fish Passage	O&M	$80,449
P-4	Cedar 1 Fish Passage	O&M	$3,700,000
	Subtotal		$6,522,691

Table continued on next page

Table 11-4. Estimated Offsite Habitat Measure Costs Plus 15% Contingency Allowance, continued

Measure number	Measure	Capital or O&M[a]	Cost in 2008 Dollars + 15% Contingency Allowance
HCP Years 6-10			
H-3	Little Sandy 1 and 2 LW Placement	O&M	$96,539
H-4	Sandy 1 and 2 Log Jams	O&M	$670,409
H-8	Sandy 1 Reestablishment of River Mouth	O&M	$1,186,624
H-9	Sandy 1 Channel Reconstruction	O&M	$402,246
H-15	Cedar 2 and 3 Riparian Easement and Improvement	Capital	$460,705
H-17	Cedar 2 and 3 LW Placement	O&M	$429,062
H-19	Salmon 1 Riparian Easement and Improvement	Capital	$211,179
H-23	Salmon 2 Miller Quarry Acquisition	Capital	$335,205
H-25	Salmon 2 Carcass Placement	O&M	$4,157
F-5	Cedar Creek Purchase Water Rights	Capital	$1,005,614
	Subtotal		$4,801,739
HCP Years 11-15			
H-14	Sandy 3 Riparian Easement and Improvement	Capital	$61,007
H-18	Sandy 8 Riparian Easement and Improvement	Capital	$234,643
H-20	Salmon 2 Riparian Easement and Improvement	Capital	$337,886
H-21	Salmon 3 Riparian Easement and Improvement	Capital	$112,628
H-24	Salmon 2 Miller Quarry Restoration	Capital	$475,991
H-27	Zigzag 1A Channel Design	O&M	$268,164
H-28	Zigzag 1A/1B Riparian Easement and Improvement	Capital	$113,118
H-29	Zigzag 1A/1B/1C Carcass Placement	O&M	$26,816
	Subtotal		$1,630,254
	Subtotal for all three time periods		**$12,954,684**

Table 11-4. Estimated Offsite Habitat Measure Costs Plus 15% Contingency Allowance, continued

Measure number	Measure	Capital or O&M[a]	Cost in 2008 Dollars + 15% Contingency Allowance
	Purchase portion of LW needed for multiple measures [c]	O&M	$530,450
	Design and Permitting	Capital	$100,000
	Land and Habitat Improvement Maintenance	O&M	$3,012,956
	Staff Time[d] (30% of total allocated to staff time)		$5,030,400
		TOTAL	**$21,628,490**

[a]O&M is an acronym for "operation and maintenance".

[b] Will be inflation-adjusted. See Section 11.4

[c] The offsite measures involving LW will require the City to obtain approximately 1,500 large logs and rootwads. Some of this material will be available for only the cost necessary to transport the wood. In other cases, the City might need to purchase logs commercially. The $500,000 included here is a very rough estimate of the funding that might be required.

[d] Measure H-10, Turtle Survey and Relocation, will also be performed with in-house staff and is included in the staff time estimate.

Habitat Fund

As described in Chapter 7, the City has also allocated $9 million to a Habitat Fund for future partnership projects. Selection of projects will be guided by the Sandy River Basin Restoration Strategy. Decision-making for the fund is described in Chapters 7 and 9. Specific projects have not yet been selected, so specific project costs associated with the Habitat Fund are not yet known. Five-year funding increments for the Habitat Fund are described further in the Funding section below. Table 11-2 includes a $5-million portion of the Habitat Fund (to avoid double-counting in Table 11-7). The remaining $4 million shown in Table 11-7 is dedicated to adaptive management needs, but will be used for additional partnership projects if not needed for adaptive management (see Measure H-30).

11.2.2 Monitoring Program Estimated Costs

Costs for the monitoring program are shown in Table 11-5. The monitoring activities included are described in Chapter 9. The methodologies are described in Appendix F.

Table 11-5. Monitoring Program Estimated Costs

Monitoring Measure Category		Estimated Cost in 2008 Dollars[a] (50-year total)
Flow and Water Temperature Monitoring [b,c]		$910,000
Effectiveness Monitoring for Instream Projects		$1,750,000
Staff Time (15% of total allocated to staff time)		$2,515,200
	TOTAL	**$5,175,200**

[a] Will be inflation-adjusted. See Section 11.4.

[b]Monitoring measures not specifically listed will be completed with in-house staff and are included in the staff time estimate. See Chapter 9 for a complete list of monitoring measures.

[c]USGS flow monitoring is included.

11.2.3 Research Program Estimated Costs

The costs to implement the research measures described in Chapter 9 are shown in Table 11-6. Some of these amounts are parts of larger partnership programs (see details in Chapter 9). The methodologies are described in Appendix F.

Table 11-6. Research Program Estimated Costs

Research Measure		Estimated Cost in 2008 Dollars (50-year total)
Habitat Research		
Gravel Monitoring		$500,000
Scour Monitoring		$75,000
Population Research		
Adult Chinook Population Data		$600,000
Juvenile Outmigrant Data (Smolt Trapping)		$5,000,000
	Subtotal	$6,175,000
Staff Time (5% of total allocated to staff time) [a]		$838,400
	TOTAL	**$7,013,400**

[a]All estimated costs for TDG research are allocated to Staff Time

11.2.4 Adaptive Management Program Estimated Costs

Costs involved in the adaptive management program include responses to monitoring of new measures if effectiveness monitoring indicates original measures have not met their measurable objectives, as well as responses to assessments of the overall effectiveness of the HCP. Elements of the adaptive management program are described in Chapter 9. Actual future costs associated with adaptive management are dependent on information not yet available. (See Program Funding section below for the total dollars allocated.)

11.3 Program Funding

The City will pay the costs of the HCP with revenues from the sale of water. Each spring, the City Council adopts an annual budget for the Water Bureau based on anticipated costs and revenues. The annual budget is a public document and is available on the City's web site. Commitments made in the HCP will be included in the annual budget requests to the Council. Although the City Council will not automatically fund these expenses, the City understands that the Incidental Take Permit (ITP) coverage would be at risk, and federal enforcement measures would be possible, if adequate budgets are not approved and measures are not implemented as planned.

City Constraints Associated with Funding

The City recognizes that changes in the allocation of funds from one project or action to another might be necessary during the 50-year term of the HCP. Reallocation decisions will be made by the signatories of the ITP, but will take into account advice given by the HCP Implementation Committee (see Framework for Adaptive Response in Chapter 9). To allow flexibility, the City will accommodate reallocation of funds within the following constraints:

- The ratio of operating expenses to capital costs must remain constant.
- The increments of funding must adhere to the schedule in Figure 11-1.
- Funds can be reallocated within programs and categories, but not between programs and categories; some category totals are capped.

Details of these constraints are described in the sections below.

Ratio of Operating Expenses to Capital Costs

Accounting regulations of the Government Accounting Standards Board require that some of the HCP cost types be paid as operating expenses, while others can be paid as capital costs. Bonds sold to fund capital costs are paid back over time (from water sales revenue) and have less impact on annual water rates than do operating expenses, which are paid as they are incurred. To manage the annual and total costs to ratepayers of implementing the HCP, the City must maintain a constant overall ratio of operating expenses to capital costs for all of the HCP commitments. The City's expectation is that 50 percent (+/- 10 percent) of the total Habitat Fund project costs will be projects that can be financed as capital costs.

Scheduled Funding Increments

The City has carefully spread HCP investments over time to achieve habitat conservation benefits, to accommodate adaptive management contingencies, and to manage the impact on water ratepayers. The increments of investment are shown in Figure 11-1. The City's analysis has shown that shifting funds forward or backward in time from the defined increments will have unacceptable effects on water rates. For this reason, the funding allocations are confined to the time periods shown. Shifts in the allocation of project costs can occur only within, not between, the allocated time periods. (See Section 9.3 about use of Habitat Fund for adaptive management prior to Year 20).

Limits on City's Financial Commitments

The City's total financial commitments to offsite habitat conservation measures, monitoring measures, adaptive management measures, the Habitat Fund, and the Insurance Fund are capped at the totals shown in Table 11-1. These capped amounts will be inflation-adjusted (see Section 11.4). There is no similar limit on the City's financial commitment to accomplish the Bull Run habitat conservation measures. Details are provided in Section 11.3.1.

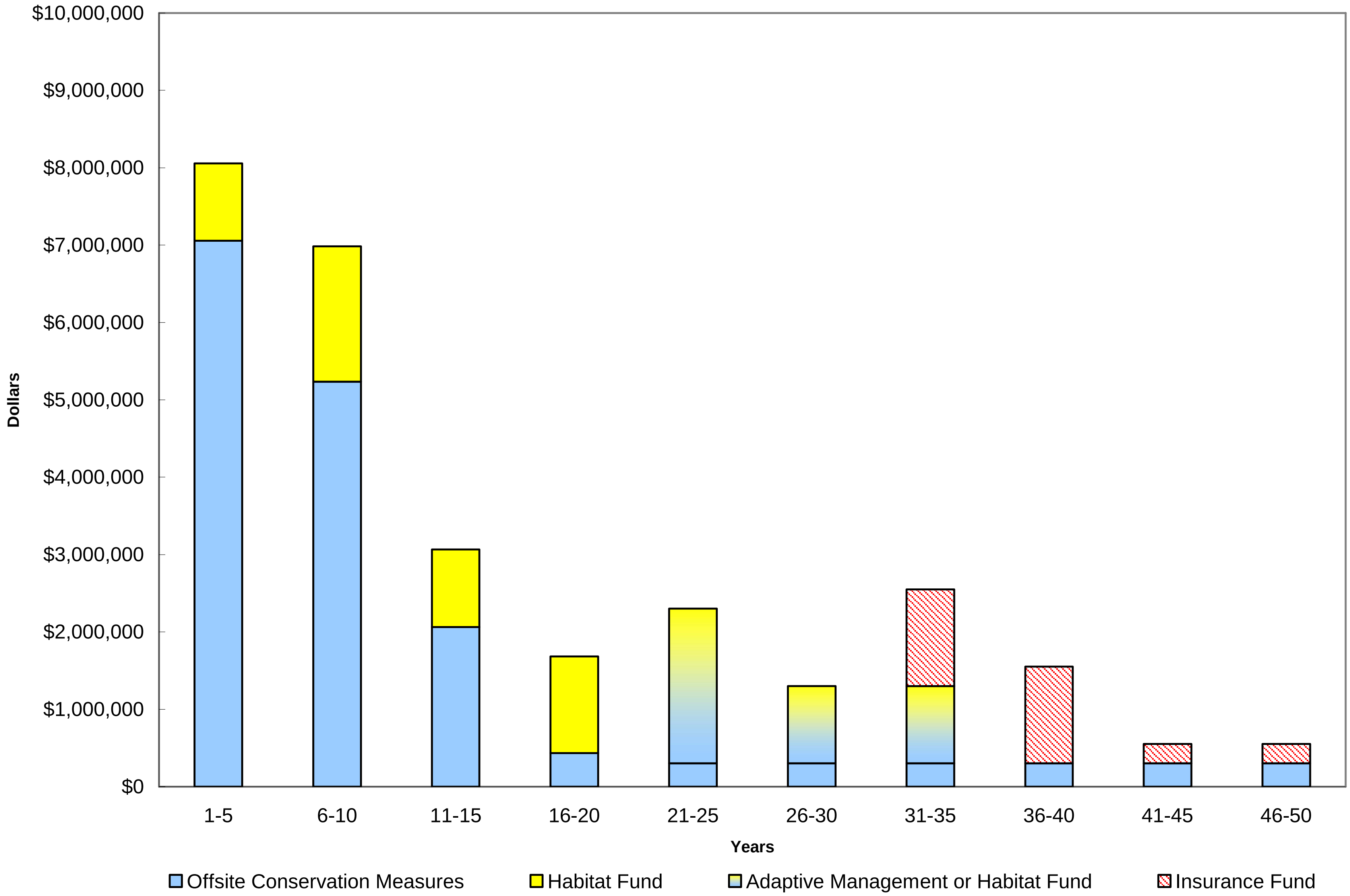

Figure 11-1. Funding Committed to Offsite Conservation Measures, Habitat Fund/Adaptive Management, and Insurance Fund in 2008 Dollars[a]

[a]Offsite conservation measures include money for purchasing large wood, land maintenance, design and permitting, and providing fish passage in Cedar Creek (Measure P-4). See Appendix I for detail.

11.3.1 Habitat Conservation Program Funding

Bull Run Habitat Conservation Measures

The Bull Run measure costs shown in Table 11-3 are estimated. The City has not placed a financial limit on funding for the Bull Run habitat conservation measures. For example, if costs to pump groundwater to meet flow and temperature requirements of the HCP are higher than estimated in Table 11-3, the City will pay the additional costs without a cap. Additional costs to fund the Bull Run measures (beyond those estimated in Table 11-3) will not be deducted from the capped funding provided in the HCP for offsite measures, the Habitat Fund, or the Insurance Fund, Funding for the Bull Run measures is, however, subject to the provisions of Chapter 10, Changed Circumstances.

Offsite Habitat Conservation Measures

The amounts shown in Table 11-4 are the estimated cost of each habitat conservation measure, including a 15 percent contingency allowance. The City will pay up to the amount shown in Table 11-4 for each measure plus an addition for CPI inflation up to the date of implementation. For example, the funding for a measure implemented in 2010 would be inflated from the 2008 estimate to 2010 based on the CPI for Portland, Oregon. The CPI inflated amount represents the financial limit of the City's commitments for each project.

The City is confident that the dollar amounts allocated will be adequate to meet the measurable objectives described in Chapter 9. If, however, after detailed project planning, the measure is shown to cost more than the amount shown in Table 11-4 (inflated to the implementation date), the City will consult with NMFS and with the HCP Implementation Committee about how to proceed. A variety of options are possible, including the following:

- The extra cost, above the amount shown in Table 11-4 plus CPI inflation, could be paid with savings from offsite measures that cost less than expected.
- The extra cost, above the amount shown in Table 11-4 plus CPI inflation, could be deducted from remaining unallocated dollars in the Habitat Fund.
- An alternative funding source could be found to supplement City funding for the project.
- A lower-cost measure with similar habitat benefits could be identified and implemented.
- The scope of the project could be modified.

The City will not pay for expenses that exceed the per-project totals shown in Table 11-4 (as inflated to implementation date), except as provided in the Adaptive Management Program or in Chapter 10, Changed and Unforeseen Circumstances. The scheduling of the offsite measures is also constrained by the availability of the funding increments shown in Table 11-4.

Habitat Fund

The City has allocated $9 million to a Habitat Fund. The Habitat Fund will be available in the scheduled increments as shown in Figure 11-1. If needed, monitoring for Habitat Fund projects will be paid from the total allocated to the Habitat Fund.

A $4 million subset of this Fund has been specifically set aside for adaptive management activities as described in Chapter 9. If the $4 million is not needed for adaptive management, it will remain available to fund additional habitat conservation measures as described in Chapter 7. The blue-to-yellow shading in Figure 11-1 highlights the multipurpose function of the Habitat Fund.

11.3.2 Monitoring Program Funding

The City will fund the monitoring program as shown in Table 11-5. The amounts defined in Table 11-5 are capped totals. The City will accommodate reallocation of funds within the categories shown in the table, but will not pay more than the totals shown for each category, as adjusted for inflation (see Section 11.4).

11.3.3 Research Program Funding

The City will fund the research program as shown in Table 11-6. The amounts defined in Table 11-6 are capped totals. The City will accommodate reallocation of funds within the categories shown in the table, but will not pay more than the totals shown for each category. Use of the funding allocated for juvenile salmonid outmigrant research may be reviewed by NMFS and the City and adjusted as needed to address population research needs in the Sandy River Basin. The City's commitment is limited to $100,000 per year for the term of the HCP, as adjusted for inflation (see Section 11.4).

11.3.4 Adaptive Management Program Funding

As mentioned above, up to $4 million of the Habitat Fund is available for adaptive management, according to the framework described in Chapter 9 and according to the schedule shown in Figure 11-1. If needed for measures implemented from the Habitat Fund (for adaptive management purposes), related monitoring will also be funded from this $4 million.

A $3-million Insurance Fund is also available in four five-year increments as shown in Figure 11-1. Related monitoring will also be funded from this $3 million if it is needed for measures implemented with the Insurance Fund. If the Insurance Fund is not needed for adaptive management at the milestones described in Chapter 9, it will revert to the City and not be available for other HCP costs.

The adaptive management funding allocations are shown in Table 11-7. These amounts are capped totals (with inflation adjustment, see Section 11.4), except as affected by provisions of Chapter 10, Changed and Unforeseen Circumstances.

Table 11-7. Adaptive Management Funding Allocations

Adaptive Management Funding Category		**Allocation in 2008 Dollars[a]** (50-year total)
Habitat Fund		$4,000,000
Insurance Fund		$3,000,000
Staff Time (20% of total allocated to staff time)		$3,353,600
	TOTAL	**$10,353,600**

[a] Will be inflation-adjusted. See Section 11.4.

11.4 Adjustments for Inflation or Deflation

All cost estimates and commitments in the HCP are shown in 2008 dollars. These dollar commitments will be adjusted annually for inflation or deflation, based on the CPI for Portland, Oregon.

The original cost estimates for the offsite habitat conservation measures were developed in 2002. Those estimates were updated to 2008 dollars, as described above in Section 11.2.1.

Chapter 12. Alternatives to the Proposed Incidental Take

12. Alternatives to the Proposed Incidental Take

The HCP represents the City's approach for minimizing and mitigating the impacts of operating the water supply system on the covered species. Section 10 of the ESA requires an applicant for an incidental take permit to identify "what alternative actions to such taking the applicant considered and the reasons why such alternatives are not being utilized." This chapter describes those alternatives. The environmental impacts of the alternatives and the HCP actions are described in the accompanying environmental impact statement (EIS).

12.1 No Action/No HCP

In this alternative, the City would continue to release water from the reservoirs into the Bull Run River to improve water temperature conditions and comply with Clean Water Act requirements. Flow to achieve the necessary temperatures would average 35 cfs (varying from 20 cfs to 40 cfs, depending on daily weather) in the summer and would be a minimum of 70 cfs in October in normal years and 30 cfs in critical years. Temperatures at Larson's Bridge would be kept below 21 °C to prevent salmonid mortality until modifications were completed on the intake towers at Dam 2. When the intake tower modifications are complete (as well as modifications to the Dam 2 stilling pool and rock weir), temperatures would be managed to comply with the requirements specified in the Temperature Management Plan (see Appendix G) and described in Chapter 7. A rock weir below Dam 2 would also be modified to allow for quicker routing of cool water. No other actions would be taken. This alternative was not selected because it would offer less benefit to the covered species than the HCP measures with none of the regulatory assurances.

12.2 Passage above Bull Run Dams/No Offsite Measures

In this alternative, the City would install facilities to collect returning adult fish near the rock weir below Dam 2, truck them upstream past the dams, and release them into the two reservoirs. Facilities would also be installed to collect juvenile fish above the dams, truck them downstream, and release them below the rock weir below Dam 2. All other Bull Run River and Bull Run reservoir measures in the HCP would also be implemented. None of the offsite measures in the HCP would be implemented. This alternative was not selected because it also would provide less overall benefit to covered species than the HCP measures but at a greater cost to the City and its water customers than the HCP.

Glossary

Term or phrase	Definition
Adaptive management	An approach that allows actions to be taken in the face of some uncertainty or lack of data, but provides for monitoring and the ability to change operations in response to new information to meet a particular objective
Adfluvial	A life history type in which fish live in lakes but migrate into streams to spawn
Alevin	A recently hatched juvenile salmonid that still has its yolk sac and has not emerged from the gravel
Ammocoete	A protracted larval stage of lamprey
Anadromous	A life history type in which fish mature in marine waters but migrate into fresh water to spawn
Anchor habitat	Distinct stream reaches that currently harbor specific life history stages of salmon and steelhead to a greater extent than the stream system at large
Bankfull discharge	The maximum discharge that can be accommodated by a stream channel without overtopping the banks and spreading onto the floodplain. Bankfull discharge is generally associated with a 1.5- to 2-year streamflow event.
Basin	The topographic region from which a stream receives runoff, throughflow, and groundwater flow. Drainage basins are divided from each other by topographic barriers. In this HCP, "basin" is used to refer to the collection of all watersheds that flow into the same river system.
Cobble	Particles in the stream substrate between 64 and 128 millimeters (mm) in size
Critical abundance threshold	Threshold below which populations of a species, an Evolutionarily Significant Unit, or a Distinct Population Segment are at relatively high risk of extinction over a short period of time
Diameter at breast height (dbh)	The diameter of a tree measured 4.5 feet above the ground on the uphill side of the tree

Term or phrase	Definition
Distinct Population Segment	A subgroup of a vertebrate species that is treated as a species for purposes of listing under the Endangered Species Act. It is required that the subgroup be separable from the remainder of and significant to the species to which it belongs (61 Fed. Reg. 4722, Feb. 7, 1996).
Downramping	Reductions in instream flows as a result of changes in water supply or hydroelectric facility operations—often expressed as a rate of drop of river water elevation in inches per hour
Drawdown	The point in time each year when the water supply diversion consistently exceeds reservoir inflows and precipitation is not anticipated
Easement	A right-of-way giving specified individuals other than the owner permission to use a property for a specific purpose
Environmental impact statement	A report that documents the information required to evaluate the environmental impact of a project under the National Environmental Policy Act (NEPA)
Escapement	The number of fish that avoid or escape all harvest and return to spawn at their home stream
Evolutionarily Significant Unit (ESU)	A sub-portion of a species that is defined by substantial reproductive isolation from other units and represents an important component of the evolutionary legacy of the species
Exceedance	The amount that a river exceeds flow projections at a named location. In this HCP, exceedance is expressed as a probability that the flow at certain locations will be more than the median flow.
Fluvial	A life history type in which fish mature in rivers but migrate into smaller tributaries to spawn
Fry	A free-swimming, juvenile salmonid that has recently emerged from the gravel and fully absorbed its yolk sac
Glide	A stream habitat type that is relatively shallow and slow, characterized by a relatively uniform depth and a smooth water surface

Term or phrase	Definition
Habitat	The environmental conditions of a specific place occupied by a plant or animal species, or a population of a species. An individual may require or use more than one type of habitat to complete its life cycle.
Hydroacoustic survey	A method for underwater assessment of fish locations and number using echoes resulting from emitted sound pulses
Hydrologic	Pertaining to the cycling, movement, distribution, and properties of water on the surface of the land, in the soil, and underlying rocks and in the atmosphere
Hydrologic Unit Code (HUC)	Codes identifying hydrologic units in a nation-wide classification system; hydrologic units are arranged by size from the largest to the smallest.
Incidental Take Permit	A permit issued by the National Marine Fisheries Service or the U.S. Fish and Wildlife Service that allows take of a listed species incidental to otherwise lawful activities in accordance with an approved Habitat Conservation Plan.
Introgression	The entry or introduction of a gene from one gene complex into another through hybridization
Iteroparous	A life history type in which individuals breed more than once and may live to spawn in several years
Juveniles	Salmonid life stage after emergence from gravel and and prior to maturation or residence in marine waters; includes fry, parr, and smolts
Large wood	Large pieces of wood in, or partially in, stream channels, including logs, pieces of logs, and root wads. Large wood provides streambed and bank stability and habitat complexity.
Median flow	For this HCP, median flows are the month-specific daily flows that are exceeded on 50% of all dates for that month for the period from 1940-2006.
Metamorphs	Characterized by metamorphosis or change in physical form
Mitigation	Methods of reducing adverse impacts of a project or compensating for the impact by providing substitutes

Term or phrase	Definition
Monitoring	Periodic assessment to determine whether the HCP measures implemented have resulted in anticipated changes in habitat conditions
Off-channel habitat	A habitat type that is located in a stream's floodplain, can be either perennially or seasonally wetted, but is only connected to the main channel at its upstream end when the stream floods
Outmigration	Process by which smolts leave freshwater habitat and enter salt water habitat
Parr	Juvenile salmonid fish rearing in fresh water that have developed parr marks before reaching the smolt, or sub-adult, stage
Parr marks	Oval or circular dark marks on the sides of pre-smolt juvenile salmonids
Peak flow	The highest flow recorded at a gauging stations during a calendar or water year
PIG	Habitat standards used by USFS, based on the Columbia River Basin Anadromous Fish Policy Implementation Guide (PIG) objectives. These include habitat standards to aid selection on habitat enhancement projects for streams used by anadromous fish (USFS, 1991).
Pool	A stream habitat type that is relatively slow and deep, characterized by a gradient less than 1%
Pool tail-out	The downstream portion of a pool habitat type, where the water usually becomes shallow and velocity increases
Range of Natural Variation (RNV)	RNV modeling is an approach to maintaining sustainable populations of plant and animal communities by emulating the types and amount of habitat that existed across a regional landscape under natural disturbance regimes. The underlying concept behind RNV is that, over relatively recent history prior to European settlement, the native communities of plants and animals adapted to particular ranges in the amounts of forest types and ages created by the dominant forest-regenerating disturbances of the pre-settlement forest.

Term or phrase	Definition
Reach	A lineal section of a river
Rearing	Life stage during which juvenile fish find shelter and food prior to outmigration
Redd	A salmonid fish nest, created by excavating a shallow pit in gravel where eggs are buried for incubation
Riffle	A stream habitat type that is relatively shallow and swift, characterized by a gradient between 1% and 8% and an agitated water surface
Riparian	Relating to, living, or located on the bank of a natural watercourse, such as a river, a lake, or a tidewater
River mile (RM)	Statute miles as measured along the center line of a river; the distance expressed by river miles is the distance upstream from the mouth of the river.
Salmonids	Fish species belonging to the family Salmonidae, which includes trout and salmon, among others
Scour	The erosion of a stream bed and/or banks, caused by flowing water in a river or stream
Semelparous	Life history type in which individual fish breed only once then die after spawning
Side channel	A secondary channel containing a portion of the stream flow from the main channel and separated from the main channel at bankfull discharge
Smolt	The life stage of a juvenile salmon during which it migrates to salt water and changes physiologically to adapt to this new environment
Spawning	The act of reproduction of fish, which includes egg laying and fertilization, and sometimes nest building (e.g, salmon)

Term or phrase	Definition
Species	A unit of the biological classification system below the level of genus; a group of individual plants or animals that have common attributes and are capable of interbreeding. The federal Endangered Species Act defines species to include subspecies and any Distinct Population Segment or Evolutionarily Significant Unit of any species.
Take	To harass, harm, pursue, hunt, wound, kill, trap, capture, or collect a federally listed endangered species of fish or wildlife. Includes disturbance of species, nests, or habitat when disturbance is extensive enough to disrupt normal behavioral patterns and result in injury or death (Endangered Species Act of 1973, Section 3[10])
Total Maximum Daily Load (TMDL)	A written plan with an analysis that determines the total amount of a pollutant that can be present in a specific waterbody and still meet water quality standards according to Section 303(d) of the federal Clean Water Act
Viability abundance threshold	Threshold above which populations have negligible risk of extinction due to local factors over a long time frame (e.g, 100 years)
Viable salmonid population (VSP)	An independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame
Water Quality Limited	A receiving stream that does not meet narrative or numeric water quality criteria during the entire year or defined season even after the implementation of standard technology—for more information see Water Quality Standards: Beneficial Uses, Policies, and Criteria For Oregon Department Of Environmental Quality Water Pollution Division 41 340-041-0002, Definitions, Part 70 a-c.
Watershed	The land area from which surface runoff drains into a stream, river, lake, reservoir, or other body of water

Term or phrase	Definition
Weighted Usable Area (WUA)	An integrated measure of fish habitat quantity and quality as a function of river flow, weighted for differences among sampling locations with respect to depth, velocity, substrate, and cover. In this HCP, WUA was calculated for spawning and rearing life stages.
Wood recruitment	The accumulation of wood from trees that have fallen from riparian or upstream areas into a stream channel

Appendices

Appendix A. Implementing Agreement

IMPLEMENTING AGREEMENT

by and between

CITY OF PORTLAND, OREGON, WATER BUREAU

and

NATIONAL MARINE FISHERIES SERVICE

TO ESTABLISH A MITIGATION PROGRAM FOR ENDANGERED AND THREATENED SPECIES AT THE CITY OF PORTLAND'S BULL RUN WATER SUPPLY FACILITIES, MULTNOMAH AND CLACKAMAS COUNTIES, OREGON

This Implementing Agreement ("Agreement"), made and entered into as of the _____ day of ____________, 2008, by and among the City of Portland, Oregon, Water Bureau (hereinafter Portland) and the National Marine Fisheries Service (NMFS) (the Service), hereinafter collectively called the "Parties," defines the Parties' roles and responsibilities and provides a common understanding of action that will be undertaken to minimize and mitigate the effects on the subject listed and unlisted species and their habitats of the City of Portland's water supply operations in the Bull Run Watershed and the Sandy River Basin.

1.0 RECITALS AND PURPOSES

1.1 RECITALS: This Agreement is entered into with regard to the following facts:

WHEREAS, The Bull Run Watershed, including those portions that are owned by the City, has been determined to provide, or potentially provide, habitat for a variety of species of fish and wildlife that pursuant to the Endangered Species Act, are listed as threatened, or are candidates for such listing, or are otherwise considered species of concern. These species are identified in Table 3.1 of the Habitat Conservation Plan that is the subject of this agreement, attached hereto as Exhibit 1; and,

WHEREAS, Portland, with technical assistance from the Sandy River Basin Partners (which includes the Service, the U.S. Fish and Wildlife Service, the United States Forest Service, and the Oregon Department of Fish and Wildlife) , has developed a series of measures, described in the Habitat Conservation Plan, to minimize and mitigate the effects of the covered activities associated with the Bull Run water supply operations upon the subject listed and unlisted species and their associated habitats.

1.2 PURPOSES: The purposes of this Agreement are:

1.2.1 To ensure implementation of each of the terms of the HCP;

1.2.2 To describe remedies and recourse should any Party fail to perform its obligations, responsibilities, and tasks as set forth in this Agreement; and,

1.2.3 To provide assurances to Portland that as long as the terms of the HCP and the Permit issued pursuant to the HCP and this Agreement are fully and faithfully performed, no additional mitigation will be required except as provided for in this Agreement or required by law.

2.0 DEFINITIONS: The following terms as used in this Agreement shall have the meanings set forth below:

2.1 "Permit" or ITP shall mean the incidental take permit issued by the Service to Portland pursuant to Section 10(a)(1)(B) of the Endangered Species Act (ESA).

2.2 "Conservation Plan" or "HCP" shall mean the Habitat Conservation Plan prepared for the Bull Run Watershed water supply operations.

2.3 "Covered lands" shall mean those lands listed as "covered lands" in the HCP, that is, including lands and facilities associated with and/or potentially affected by covered activities located within the hydrologic boundary of the Sandy River Basin in Clackamas and Multnomah Counties, Oregon, as depicted in Figure 2-1 of the HCP.

2.4 "Permittee" shall mean the City of Portland Water Bureau, hereinafter referred to either as Portland or the Permittee.

2.5 "Covered species" shall mean species adequately covered in the HCP and identified in Table 3.1 of the HCP and Exhibit 1 of this Agreement.

2.6 "Covered activities" shall mean those activities described as covered activities in the HCP, that is, City activities associated with covered lands and facilities to the extent they affect covered species, including operation, maintenance and repair of the water system; implementation of habitat conservation, research, and monitoring; and incidental land management related to the water system and HCP implementation.

2.7 "Covered facilities" shall mean those facilities listed as "covered facilities" in the HCP, that is, facilities owned, operated, and/or used by the City as part of the Bull Run water supply system within the hydrologic boundary of the Sandy River Basin to the extent these facilities are affected by the covered activities.

2.8 "Changed circumstances" means only those circumstances described in Chapter 10 of the HCP which fall into three general categories: climate change, change in status of habitat, and change in status of a species.

2.9 "Unforeseen circumstances" means any significant, unanticipated adverse change in the status of species addressed under the HCP or in their habitats; or any significant unanticipated adverse change in impacts of the project or in other factors upon which the HCP is based. The term "unforeseen circumstances" as defined in this Agreement is intended to have the same meaning as in the Service's No Surprises policy.

2.10 "Force Majeure" means events that are beyond the reasonable control of, and that did not occur through the fault or negligence of, Portland or any entity controlled by Portland, including its contractors and subcontractors to the extent they are carrying out authorized activities, that wholly or partially prevent the City from performing obligations under the HCP and this Agreement. Force Majeure events include but are not limited to acts of God, sudden actions of the elements, or actions of local, state, or federal agencies or courts. Force Majeure does not include circumstances described as "changed circumstances" in the HCP.

2.11 Terms defined in Endangered Species Act. Terms used in this agreement that are specifically defined in the ESA, in regulations adopted by the Service under the ESA, or the "no surprises policy," shall have the same meaning as in the ESA, those implementing regulations, and that policy, unless this agreement expressly provides otherwise.

3.0 INCORPORATION OF HCP

The HCP and each of its provisions are intended to be, and by this reference are, incorporated herein. In the event of any direct contradiction between the terms of this Agreement and the HCP, the terms of this Agreement shall control. In all other cases, the terms of this Agreement and the terms of the HCP shall be interpreted to be supplementary to each other.

4.0 LEGAL REQUIREMENTS

In order to fulfill the requirements that will allow the Service to issue the Permit, the HCP sets forth measures that are intended to ensure that any take associated with covered activities on covered lands or at covered facilities will be incidental; that the impacts of the take will, to the maximum extent practicable, be minimized and mitigated; that procedures to deal with changed circumstances will be provided; that adequate funding for the HCP will be provided; and that the take will not appreciably reduce the likelihood of the survival and recovery of the covered species in the wild. It also includes measures that have been suggested by the Service as being necessary or appropriate for purposes of the HCP.

5.0 TERM

This Agreement shall become effective on the date that the Service issues the Permit requested in the HCP and shall remain in full force and effect for a period of 50 years or until termination of the Permit, whichever occurs sooner.

6.0 FUNDING

Portland will provide such funds as may be necessary to carry out its obligations under the HCP. Portland should notify the Service if the Permittee's funding resources have materially changed, including a discussion of the nature of the change, from the information provided in Chapter 11 of the HCP.

7.0 RESPONSIBILITIES OF THE PARTIES IN MITIGATION PROGRAM IMPLEMENTATION AND MONITORING RESPONSIBILITIES OF THE PERMITTEE

7.1 PORTLAND'S RESPONSIBILITIES

7.1.1 The HCP will be properly functioning if the terms of the Agreement have been or are being fully implemented.

7.1.2 Portland shall undertake all activities set forth in the HCP in order to meet the terms of the HCP and comply with the Permit, including adaptive management procedures described in Chapter 9 of the HCP.

7.1.3 Portland shall submit an annual report, or a report at a frequency mutually agreeable to the parties, describing its activities during the relevant year, including implementation of HCP measures, documentation of progress toward meeting the HCP's measurable habitat objectives, cumulative effects and analysis of whether the terms of the HCP were met for the reporting period. The report shall rely upon and reference all reasonably available data regarding HCP-related activities and Portland shall make the underlying data available to the Service upon request. Anticipated components include planning and implementation of measures, expenditures, compliance and effectiveness monitoring, fish population research as required by the HCP, and any plans or actions related to changed circumstances and/or adaptive management. The report shall also include the following certification from a responsible City official who supervised or directed the preparation of the report:

> Under penalty of law, I certify that, to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted is true, accurate, and complete.

7.2 RESPONSIBILITIES OF THE SERVICE

7.2.1 The Service shall cooperate and provide, to the extent funding is available, technical assistance to implement the Framework for Adaptive Response as detailed in Section 9.4.3 and Table 9-4 of the HCP. Nothing in this Agreement shall require the Service to act in a manner contrary to the requirements of the Anti-Deficiency Act.

7.2.2 After issuance of the Permit, the Service shall monitor the implementation thereof, including each of the terms of this Agreement and the HCP in order to ensure compliance with the Permit, the HCP and this Agreement.

8.0 DISPUTE RESOLUTION

Any Party to this agreement claiming a dispute shall notify the other Party of the dispute within 20 days of such Party's actual knowledge of the act, event, or omission that gives rise to the dispute. The Parties shall convene at least one meeting within 20 days after such notice, to attempt to resolve the dispute. If the dispute is not resolved within 15 days of the meeting, the Parties may agree to attempt to resolve the dispute using a neutral mediator unanimously selected by the Parties. The mediator shall mediate the dispute in accordance with the instructions and schedule provided to it by the Parties. Any of these time periods may be reasonably extended or shortened by agreement of the Parties, or as necessary to conform to the procedure of an agency or court with jurisdiction over the dispute. Unless otherwise agreed among the Parties, each Party shall bear its costs for its own participation in the dispute resolution. In all cases, the Parties shall proceed expeditiously to allow either Party to meet any regulatory, statutory or judicial deadlines regarding the subject matter of the dispute.

9.0 REMEDIES AND ENFORCEMENT

9.1 REMEDIES IN GENERAL

Except as set forth below, each Party shall have all remedies otherwise available to enforce the terms of this Agreement, the Permit, and the HCP, and to seek remedies for any breach hereof, subject to the following:

9.1.1 NO MONETARY DAMAGES: No Party shall be liable in damages to the any other Party or other person for any breach of this Agreement, any performance or failure to perform a mandatory or discretionary obligation imposed by this Agreement or any other cause of action arising from this Agreement. Notwithstanding the foregoing:

9.1.1.1 <u>Retain Liability:</u> All Parties shall retain whatever liability they would possess for their present and future acts or failure to act without existence of this Agreement.

9.1.1.2 Land Owner Liability: All Parties shall retain whatever liability they possess as an owner of interests in land.

9.1.1.3 Responsibility of the United States: Nothing contained in this Agreement is intended to limit the authority of the United States government to seek civil or criminal penalties or otherwise fulfill its enforcement responsibilities under the ESA.

9.1.2 INJUNCTIVE AND TEMPORARY RELIEF

The Parties acknowledge that the covered species are unique and that their loss as species would result in irreparable damage to the environment and that therefore injunctive and temporary relief may be appropriate to ensure compliance with the terms of this Agreement.

9.2 PERMIT SUSPENSION OR REVOCATION

Except as otherwise provided for under the terms of the Agreement, the Permit shall be suspended or revoked only in conformance with the provisions of 50 CFR 13.27 through 13.29 (1994), as the same exists as of the date hereof.

9.3 LIMITATIONS AND EXTENT OF ENFORCEABILITY

9.3.1 NO SURPRISES POLICY

Subject to the availability of appropriated funds as provided in Paragraph 14.6 hereof, and except as otherwise required by law, no further mitigation for the effects of the covered activities on covered lands or at covered facilities upon the covered species may be required from a Permittee who has otherwise abided by the terms of the HCP, except in the event of unforeseen circumstances; provided that any such additional mitigation may not require additional land or water use restrictions or financial compensation from the Permittee without its written consent.

9.3.2 PRIVATE PROPERTY RIGHTS AND LEGAL AUTHORITIES UNAFFECTED

Except as otherwise specifically provided herein, nothing in this Agreement shall be deemed to restrict the rights of Portland to the use or development of those lands, or interests in lands, constituting covered lands, to the use or development of covered facilities, or to the use or development of water rights or claims to water rights held by the City; provided, that nothing in this Agreement shall absolve Portland from such other limitations as may apply to such lands, interests in lands, facilities, water rights, or claims to water rights under other laws of the United States and the State of Oregon. Nothing in this agreement shall be construed to give the Service the authority to impose or seek to impose measures additional to those specified in the HCP or this agreement that would degrade drinking water quality, trigger a need for additional water treatment, or require commitment of additional water to purposes other than municipal water supply.

9.3.3 FORCE MAJEURE

9.3.3.1 Force Majeure procedures. In the event that Portland is wholly or partially prevented from performing obligations under this agreement because of a Force Majeure event, the City will be excused from whatever performance is affected by such Force Majeure event to the extent so affected, and such failure to perform will not be considered a material breach provided that nothing in this section will be deemed to authorize the City to violate the ESA or render the goals of the HCP unobtainable, and provided further that:

(a) The suspension of performance is of no greater scope and no longer duration than is reasonably required by the Force Majeure;

(b) The City notifies the Service orally within a reasonable time (normally not to exceed 72 hours) after becoming aware of any event that the City contends constitutes a Force Majeure, and in writing within seven (7) calendar days after the event. Such notice will: identify the event causing the delay or anticipated delay; estimate the anticipated length of delay; state the measures taken or to be taken to minimize the delay; and estimate the timetable for implementation of the measures;

(c) The City uses its best efforts to avoid and mitigate the effects of any delay upon its ability to perform. A Force Majeure event may require use of the adaptive management provisions of this agreement and the HCP in remedying the effects of the Force Majeure event; and

(d) When the City is able to resume performance of its obligations, it provides the Service written notice to that effect.

9.3.3.2 Termination through Force Majeure. Any party may terminate the HCP if a Force Majeure event renders the goals of the HCP unobtainable.

10.0 AMENDMENTS

Except as otherwise set forth herein, this Agreement may be amended consistent with the ESA and with the written consent of each of the Parties hereto.

11.0 MINOR MODIFICATIONS

11.1 The HCP, including its appendices, is a very lengthy and complex document, and the parties recognize that various minor and non-controversial corrections and adjustments may from time to time be required. Any party may propose minor modifications to the HCP or this agreement by providing written notice to all other parties. Such notice shall include a statement of the reason for the proposed modification and an analysis of its environmental effects, including its effects on operations under the HCP and on covered species. The parties will use best efforts to respond to proposed modifications within 60 days of receipt of such notice. Proposed modifications will become effective upon all other parties' written approval. If, for any reason, a receiving party objects to a proposed modification, it must be processed as an amendment of the permit in accordance with section 13 of this agreement. The Service will not propose or approve minor modifications to the HCP or this agreement if the Service determines that such modifications would result in operations under the HCP that are significantly different from those analyzed in connection with the original HCP, or would result in adverse effects on the environment that are new or significantly different from those analyzed in connection with the original HCP, or additional take not analyzed in connection with the original HCP.

11.2 Minor modifications to the HCP and IA processed pursuant to this subsection may include but are not limited to the following:

11.2.1 Corrections of typographic, grammatical, and similar editing errors that do not change the intended meaning;

11.2.2 Corrections of any maps or exhibits to correct errors in mapping or to reflect previously approved changes in the permit or HCP;

11.2.3 Minor changes to survey, monitoring or reporting protocols;

11.2.4 Minor corrections and adjustments to the HCP, including changes in implementation schedules of up to two years.

11.3 Decisions on specific design details for facilities, studies, projects, or adaptive management strategies identified in the HCP are not modifications or amendments and may proceed without processing as amendments or modifications.

12.0 RELATIONSHIP TO FERC LICENSE, PROJECT NO. 2821

The City operates hydroelectric generators at its Bull Run Dams No. 1 and 2 under license from the Federal Energy Regulatory Commission. Generation of electricity at the dams is subordinate to water supply operations. The City's hydroelectric license is effective until March 1, 2029. If the City wishes to continue generation of electricity at the project after that date, it will seek a new license before license expiration. The parties agree that the HCP will be used as part of the required Exhibit E. Unless one of the changed circumstances described in the HCP has arisen, the Service shall endorse the HCP as the appropriate fish and wildlife terms and conditions for covered species for a new license with a term coincident with the remaining term of the HCP. Should FERC impose, as part of a new license, conditions that are inconsistent with or make impossible the implementation of any provision of the HCP, the City may decline to accept the new license and cease production of electricity at the projects or the City may ask the Service to enter into good-faith discussions. The purpose of those discussions will be to review the HCP, seeking ways to make the license and HCP consistent and to establish mechanisms to allow implementation of or change to HCP measures affected by license conditions. If the parties are not able to reach an agreement and the City accepts a FERC license that makes impossible the implementation of any provision of the HCP, the new license may be treated by any party as a Force Majeure event under the terms of this Implementing Agreement.

13.0 NEW LISTINGS

The ITP for federally listed species will be issued contemporaneously with the signing of this Agreement. In the future during the term of the Agreement, should any other covered species become listed, the Service shall add to the ITP, within sixty (60) days of receipt by the appropriate Service of a written request by the City, each such species at the level of take requested by the City and supported by the HCP without requiring additional mitigation, unless, within the specified sixty-day period, the Service demonstrates that unforeseen circumstances exist. If such unforeseen circumstances are found to exist, the Service may request or provide additional mitigation as provided in this agreement.

14.0 MISCELLANEOUS PROVISIONS

14.1 NO PARTNERSHIP

Except as otherwise expressly set forth herein, neither this Agreement nor the HCP shall make or be deemed to make any Party to this Agreement the agent for or the partner of any other Party.

14.2 SUCCESSORS AND ASSIGNS

This Agreement and each of its covenants and conditions shall be binding on and shall inure to the benefit of the Parties hereto and their respective successors and assigns.

14.3 NOTICE

Any notice permitted or required by this Agreement shall be delivered personally to the persons set forth below or shall be deemed given five (5) days after deposit in the United States mail, certified and postage prepaid, return receipt requested and addressed as follows or at such other address as any Party may from time to time specify to the other Parties in writing:

Assistant Regional Director
National Marine Fisheries Service
1201 NE Lloyd Blvd, Suite 1100
Portland, OR 97232

Administrator
Portland Water Bureau
1120 SW 5th Avenue
Portland, OR 97204

14.4 ENTIRE AGREEMENT

This Agreement, together with the HCP and the Permit, constitutes the entire Agreement between the Parties. It supersedes any and all other Agreements, either oral or in writing among the Parties with respect to the subject matter hereof and contains all of the covenants and Agreements among them with respect to said matters, and each Party acknowledges that no representation, inducement, promise or Agreement, oral or otherwise, has been made by any other Party or anyone acting on behalf of any other Party that is not embodied herein.

14.5 ELECTED OFFICIALS NOT TO BENEFIT

No member of or delegate to Congress shall be entitled to any share or part of this Agreement, or to any benefit that may arise from it.

14.6 AVAILABILITY OF FUNDS

Implementation of this Agreement and the HCP by the Service is subject to the requirements of the Anti-Deficiency Act and the availability of appropriated funds. Nothing in this Agreement will be construed by the parties to require the obligation, appropriation, or expenditure of any money from the U.S. treasury. The parties acknowledge that the Service will not be required under this Agreement to expend any Federal agency's appropriated funds unless and until an authorized official of that agency affirmatively acts to commit to such expenditures as evidenced in writing.

14.7 DUPLICATE ORIGINALS

This Agreement may be executed in any number of duplicate originals. A complete original of this Agreement shall be maintained in the official records of each of the Parties hereto.

14.8 THIRD PARTY BENEFICIARIES

Without limiting the applicability of the rights granted to the public pursuant to the provisions of 16 U.S.C. § 1540(g), this Agreement shall not create any right or interest in the public, or any member thereof, as a third party beneficiary hereof, nor shall it authorize anyone not a Party to this Agreement to maintain a suit for personal injuries or property damages pursuant to the provisions of this Agreement. The duties, obligations, and responsibilities of the Parties to this Agreement with respect to third parties shall remain as imposed under existing Federal or State law.

14.9 RELATIONSHIP TO THE ESA AND OTHER AUTHORITIES

The terms of this Agreement shall be governed by and construed in accordance with the ESA and other applicable laws. In particular, nothing in this Agreement is intended to limit the authority of the Service to seek penalties or otherwise fulfill its responsibilities under the ESA. Moreover, nothing in this Agreement is intended to limit or diminish the legal obligations and responsibilities of the Service as an agency of the Federal government.

14.10 REFERENCES TO REGULATIONS

Any reference in this Agreement, the HCP, or the Permit to any regulation or rule of the Service shall be deemed to be a reference to such regulation or rule in existence at the time an action is taken.

14.11 APPLICABLE LAWS

All activities undertaken pursuant to this Agreement, the HCP, or the Permit must be in compliance with all applicable State and Federal laws and regulations.

IN WITNESS WHEREOF, THE PARTIES HERETO have executed this Implementing Agreement to be in effect as of the date last signed below.

BY ____ Date _________

Bob Lohn
National Marine Fisheries Service
Seattle, Washington

BY ____ Date _________

Randy Leonard
Commissioner in Charge, Portland Water Bureau
Portland, Oregon

Appendix B. River Reach Lengths by Watershed

Table B-1 of this appendix defines the stream reach names in the Sandy River Basin, as used in the Habitat Conservation Plan (HCP) and the Sandy River Basin Characterization Report (Sandy River Basin Partners 2005). The reach lengths that appear in this appendix are from a geographic information systems (GIS) database and were first published in the Sandy River Basin (SRB) Characterization Report. The reach lengths from the SRB Characterization Report were used for general planning and discussion of the HCP measures. In some cases, the reach lengths in the SRB Characterization Report differ from the reach lengths used in Chapters 5 and 8 of this HCP. Where the difference occurs, the reach lengths in Chapters 5 and 8 are based on specific stream surveys.

The reach lengths in Chapters 5 and 8 were developed by the Sandy River Basin Agreement Technical Team (SRBTT). The SRBTT reviewed all existing stream survey reports for the Sandy River Basin and defined these reaches based on stretches of relatively homogeneous habitat conditions (USFS 1999). The reach breaks were established based on a variety of factors, such as transitions in geomorphic characteristics, stream gradient, channel form, condition of the riparian zone, locations of confluences with major tributaries, presence of artificial structures such as Marmot Dam, and other similar features.[1]

The reach lengths and river miles presented in this appendix are from a GIS database.

Table B-1. River Reach Lengths by Watershed

Reach	Reach length (miles)	River miles
Bull Run Watershed		
Blazed Alder 1	2.5	0.0–2.5
Bull Run Bear 1	0.3	0.0–0.3
Bull Run Camp 1	0.1	0.0–0.1
Bull Run Camp 2	0.5	0.1–0.6
Bull Run Cedar 1	8.1	0.0–8.1
Bull Run 1	1.7	0.0–1.7
Bull Run 2	1.7	1.7–3.4
Bull Run 3	0.8	3.4–4.2
Bull Run 4	2.3	4.2–6.5
Bull Run 5 (Dam 2 diversion pool)	0.0	6.5–6.5
Bull Run 6 (Reservoir 2)	4.6	6.5–11.1
Bull Run 6A (Reservoir 1)	3.7	11.1–14.8
Bull Run 7	1.7	14.8–16.5
Bull Run 8	0.8	16.5–17.3
Bull Run 9	3.2	17.3–20.5
Bull Run 10	0.8	20.5–21.2

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[1] Since the first Services Review Draft of the HCP was published in November 2006, the Marmot Dam has been decommissioned and removed (July 2007) and the Little Sandy Dam is slated to be decommissioned and removed in 2008.

Table B-1. River Reach Lengths by Watershed, continued

Reach	Reach length (miles)	River miles
Bull Run Watershed (continued)		
Cougar 1	0.2	0.0–0.2
Cougar 2	0.4	0.2–0.6
Deer 1	0.2	0.0–0.2
Deer 2	0.2	0.2–0.4
Falls Creek 1	1.1	0.0–1.1
Fir 1	0.5	0.0–0.5
Little Sandy 1	1.8	0.0–1.8
Little Sandy 2	5.9	1.8–7.7
N.F. Bull Run 1	0.2	0.0–0.2
N.F. Bull Run 2	0.6	0.2–0.8
S.F. Bull Run 1	0.5	0.0–0.5
S.F. Bull Run 2	2.2	0.5–2.7
Lower Sandy Watershed		
Beaver 1A	1.9	0.0–1.9
Beaver 1B	0.3	1.9–2.2
Beaver 1C	1.9	2.2–1.9
Beaver 1D	3.1	1.9–5.0
Big 1	4.0	0.0–4.0
Buck 1	0.4	0.0–0.4
Burlingame 1	0.5	0.0–0.5
Gordon 1A	1.6	0.0–1.6
Gordon 1B	2.4	1.6–4.0
Gordon 2A	3.2	0.0–3.2
Gordon 2B	0.2	3.2–3.4
Kelly 1	1.8	0.0–1.8
Sandy 1	5.4	0.0–5.4
Sandy 2	12.4	5.4–17.8
Smith 1	2.9	0.0–2.9
Trout 1A	0.5	0.0–0.5
Trout 2A	0.3	0.5–0.8
Trout 3A	0.5	0.8–1.3
Walker 1	0.1	0.0–0.1
Middle Sandy Watershed		
Alder 1	0.9	0.0–0.9
Alder 1A	1.1	0.9–2.0
Alder 2	0.7	2.0–2.7
Alder 3	2.8	2.7–5.5
Cedar 1	1.5	0.0–1.5
Cedar 2	3.4	1.5–4.9

Table continued on next page

Table B-1. River Reach Lengths by Watershed, continued

Reach	Reach length (miles)	River miles
Middle Sandy Watershed (continued)		
Cedar 3	5.3	4.9–10.2
Cedar 4	4.5	10.2–14.7
Sandy 3	5.8	17.8–23.6
Sandy 4	4.2	23.6–27.8
Sandy 5	1.4	27.8–29.2
Marmot Dam	0.0	29.2–29.2
Sandy 6	1.8	29.2–31.0
Sandy 7	5.9	31.0–36.9
Wildcat 1	0.4	0.0–0.4
Wildcat 2	1.2	0.4–1.6
Wildcat 3	0.2	1.6–1.8
Upper Sandy Watershed		
Bear 1	1.3	0.0–1.3
Cast 1	1.0	0.0–1.0
Clear 1A	3.1	0.0–3.1
Clear 1B	1.2	3.1–4.3
Clear Fork 1A	0.3	0.0–0.3
Clear Fork 1B	0.3	0.3–0.5
Clear Fork 1C	1.5	0.5–2.0
Clear Fork 1D	2.8	2.0–4.8
Hackett 1	3.1	0.0–3.1
Horseshoe 1	1.4	0.0–1.4
Little Clear 1	0.8	0.0–0.8
Lost 1A	3.5	0.0–3.5
Lost 1B	1.0	3.5–4.5
Lost Tributary 1	1.3	0.0–1.3
Muddy Fork 1	2.5	0.0–2.5
Muddy Fork 2	1.0	2.5–3.5
N. Boulder 1	1.2	0.0–1.2
N. Boulder 2	1.2	1.2–2.4
Rushing Water 1	1.2	0.0–1.2
Sandy 8	5.6	36.9–42.6
Sandy 9	6.8	42.6–49.4
Sandy 10	3.1	49.4–52.5
Sandy 11	0.9	52.5–53.4
Sandy 12	0.8	53.4–54.2
Salmon River Watershed		
Boulder 0	0.3	0.0–0.3
Boulder 1	0.6	0.3–0.9

Table continued on next page

Table B-1. River Reach Lengths by Watershed, continued

Reach	Reach length (miles)	River miles
Salmon Watershed (continued)		
Boulder 2	3.7	0.9–4.6
Cheeney 1	1.0	0.0–1.0
Cheeney 1A	2.0	1.0–3.0
Mack Hall 1	2.9	0.0–2.9
S. Fork Salmon 1	1.4	0.0–1.4
S. Fork Salmon 2	3.8	1.4–5.2
Salmon 1	0.9	0.0–0.9
Salmon 2	6.2	0.9–7.1
Salmon 3	6.2	7.1–13.3
Sixes Creek 2	1.6	0.0–2.3
Wee Burn 1	1.0	0.0–1.0
Zigzag Watershed		
Camp Creek 1A	0.4	0.0–0.4
Camp Creek 1B	3.6	0.4–4.0
Camp Creek 1C	1.3	4.0–5.3
Cool 1	0.5	0.0–0.5
Devils Canyon 1A	0.8	0.0–0.8
Henry 1	1.4	0.0–1.4
Lady 1	1.2	0.0–1.2
Little Zigzag 1	1.4	0.0–1.4
Still 1	1.0	0.0–1.0
Still 1A	2.2	1.0–3.2
Still 2	4.1	3.2–7.3
Still 3	2.1	7.3–9.4
Still 4	3.4	9.4–12.8
Still 5	1.6	12.8–14.4
Wind 1	0.3	0.0–0.3
Zigzag 1A	2.2	0.0–2.2
Zigzag 1B	5.1	2.2–7.3
Zigzag 1C	2.1	7.3–9.4

Source: Sandy River Basin Characterization Report 2005

Appendix C. Current and Historical Distribution of the Covered Species in the Sandy River Basin Watershed

The current and historical distribution of the four primary covered species, fall Chinook salmon, spring Chinook salmon, winter steelhead trout, and coho, are shown in the maps in Chapter 5. Table C-1 in this appendix describes the current and historical distribution by reach within each subwatershed in the Sandy River Basin.

The data for this distribution were collected through the combined efforts of several organizations that collaborated as the Sandy River Basin Agreement Technical Team (SRBTT). Representatives from eight organizations, including fish biologists and other scientists with field experience, participated in the data-gathering effort. These entities are listed below:

- U.S Bureau of Land Management
- City of Portland Water Bureau
- Clackamas County
- National Marine Fisheries Service
- Oregon Department of Environmental Quality
- Oregon Department of Fish and Wildlife
- U.S. Fish and Wildlife Service
- U.S. Forest Service

Between August and December of 2000, the SRBTT compiled all of the available data for streams in the Sandy River Basin, including stream surveys and reach habitat ratings. The data were cross-checked and verified against the SRBTT's observations and experience, then entered into the Ecosystem Diagnosis and Treatment (EDT) model to determine the current and historical distribution of the four species. The results of the modeling were used to create the maps that appear in Chapter 5.

The current and historical distributions of the covered species in the Sandy River Basin were used by the City to help describe the current condition of the species and to help select appropriate reaches that could be improved by the conservation measures. References in the HCP to the information in this appendix are found primarily in Chapters 5 and 8.

The information presented in this appendix is the EDT model results shown in tabular form, rather than in maps, to facilitate finding the distribution of each species in a particular reach. Under each species name, the cells and marks indicate whether the species is currently present (a solid bullet •); historically present (an open circle ∘); neither currently nor historically present (empty cell); or historically present but access has been blocked by a barrier (open circle in a cell that is shaded gray ∘).

Several areas of the Sandy River Basin are currently not accessible to anadromous salmonids. Fall Chinook no longer use the upper Sandy (above the Marmot Dam site), Zigzag, or Salmon watersheds. The SRBTT agreed that the representation of current fall Chinook salmon distribution in the EDT database should end at the Marmot Dam site, although the dam did not obstruct spring Chinook, coho, or winter steelhead.[1] The reason fall Chinook are restricted to below the Marmot Dam site is unknown. Anadromous fish do not currently use the upper Bull

[1] Marmot Dam was decommissioned and removed in July 2007.

Run River because the dams do not have fish passage facilities. Access to the upper Little Sandy River is currently blocked by Portland General Electric's (PGE's) dam but that structure is scheduled to be removed in 2008. Fish access is partially blocked in several reaches of Beaver and Kelly creeks in the lower Sandy River Basin because of culverts and a pond on the Mt. Hood Community College campus. Buck Creek has a large culvert at its mouth that is probably a partial barrier to steelhead and coho salmon. ODFW maintains a weir that blocks fish access on Cedar Creek in the middle Sandy Basin; ODFW is currently discussing providing fish passage at this barrier. A bedrock waterfall and a water diversion structure in Alder Creek have restricted fish access for steelhead and coho; both facilities are probably partial barriers to fish passage.

Table C-1. Current and Historical Distribution of the Covered Species in the Sandy River Basin Watershed

		Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
Watershed	**Reach**	Current	Historical	Current	Historical	Current	Historical	Current	Historical
Bull Run	Bull Run 1	●	○	●	○	●	○	●	○
	Bull Run 2	●	○	●	○	●	○	●	○
	Bull Run 3	●	○	●	○	●	○	●	○
	Bull Run 4	●	○	●	○	●	○	●	○
	Bull Run 5		○		○		○		○
	Bull Run 6		○		○		○		○
	Bull Run 6A		○		○		○		○
	Bull Run 7		○		○		○		○
	Bull Run 8						○		
	Bull Run 9						○		
	Bull Run 10						○		
	Bear 1						○		○
	Camp 1						○		○
	Camp 2						○		
	Cedar 1				○		○		○
	Cougar 1				○		○		○
	Cougar 2						○		
	Deer 1						○		○
	Deer 2						○		○
	Falls Creek						○		
	Fir 1						○		○
	Fir 2						○		○

● species currently present in reach ○ species was present in reach historically ○ (shaded) historical presence cut off by dam

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Table C-1. Current and Historical Distribution of the Covered Species, continued

		Fall Chinook		**Spring Chinook**		**Winter Steelhead**		**Coho**	
Watershed	**Reach**	Current	Historical	Current	Historical	Current	Historical	Current	Historical
Bull Run (continued)	N. Fork Bull Run 1				○		○		○
	N. Fork Bull Run 2						○		○
	S. Fork Bull Run 1		○		○		○		○
	S. Fork Bull Run 2				○		○		○
	Little Sandy 1	●	○	●	○	●	○	●	○
	Little Sandy 2		○		○		○		○
Lower Sandy	Beaver 1A	●	○			●	○	●	○
	Beaver 1B						○		○
	Beaver 1C						○		○
	Beaver 1D						○		○
	Big 1						○		
	Buck 1						○		○
	Burlingame 1					●	○	●	○
	Gordon 1A	●	○	●	○	●	○	●	○
	Gordon 1B					●	○	●	○
	Gordon 2A					●	○	●	○
	Gordon 2B					●	○		
	Kelly 1						○		○
	Sandy 1	●	○	●	○	●	○	●	○
	Sandy 2	●	○			●	○	●	○
	Smith1					●	○		

● species currently present in reach ○ species was present in reach historically ○ (shaded) historical presence cut off by dam

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Table C-1. Current and Historical Distribution of the Covered Species, continued

		Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
Watershed	**Reach**	Current	Historical	Current	Historical	Current	Historical	Current	Historical
Lower Sandy (continued)	Trout 1A	●	○	●	○	●	○	●	○
	Trout 2A					●	○	●	○
	Trout 3A					●	○		
Middle Sandy	Alder 1					●	○	●	○
	Alder 1A					●	○	●	○
	Alder 2					●	○	●	○
	Cedar 1	●	○	●	○	●	○	●	○
	Cedar 2						○		○
	Cedar 3						○		○
	Cedar 4						○		○
	Sandy 3	●	○	●	○	●	○	●	○
	Sandy 4	●	○	●	○	●	○	●	○
	Sandy 5	●	○	●	○	●	○	●	○
	Sandy 6		○	●	○	●	○	●	○
	Sandy 7		○	●	○	●	○	●	○
	Wildcat 1					●	○	●	○
	Wildcat 2					●	○	●	○
	Wildcat 3					●	○		
Upper Sandy	Bear 1					●	○		
	Cast 1		○	●	○	●	○		
	Clear 1A		○	●	○	●	○	●	○
	Clear 1B			●	○	●	○	●	○
	Clear Fork 1A		○	●	○	●	○	●	○

● species currently present in reach ○ species was present in reach historically ○ (shaded) historical presence cut off by dam

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Table C-1. Current and Historical Distribution of the Covered Species, continued

		Fall Chinook		**Spring Chinook**		**Winter Steelhead**		**Coho**	
Watershed	**Reach**	Current	Historical	Current	Historical	Current	Historical	Current	Historical
Upper Sandy (continued)	Clear Fork 1B		○ (shaded)	●	○	●	○	●	○
	Clear Fork 1C			●	○	●	○	●	○
	Clear Fork 1D					●	○	●	○
	Hackett 1					●	○	●	○
	Horseshoe 1					●	○		
	Lost 1A			●	○	●	○	●	○
	Lost 1B					●	○	●	○
	Muddy Fork 1					●	○		
	Muddy Fork 2					●	○		
	N. Boulder 1					●	○		
	Rushing Water 1					●	○		
	Sandy 8		○ (shaded)	●	○	●	○	●	○
	Sandy 9		○ (shaded)	●	○	●	○	●	○
	Sandy 10		○ (shaded)	●	○	●	○		
	Sandy 11		○ (shaded)	●	○	●	○		
	Sandy 12		○ (shaded)	●	○	●	○		
Salmon	Boulder 0		○ (shaded)	●	○	●	○	●	○
	Boulder 1		○ (shaded)	●	○	●	○	●	○
	Boulder 2		○ (shaded)	●	○	●	○	●	○
	Cheeney 1					●	○	●	○
	Cheeney 1A					●	○	●	○
	S. Fork Salmon 1		○ (shaded)	●	○	●	○	●	○
	S. Fork Salmon 2			●	○	●	○	●	○

● species currently present in reach ○ species was present in reach historically ○ (shaded) historical presence cut off by dam

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Table C-1. Current and Historical Distribution of the Covered Species, continued

		Fall Chinook		**Spring Chinook**		**Winter Steelhead**		**Coho**	
Watershed	**Reach**	Current	Historical	Current	Historical	Current	Historical	Current	Historical
Salmon (continued)	Salmon 1		○	●	○	●	○	●	○
	Salmon 2		○	●	○	●	○	●	○
	Salmon 3		○	●	○	●	○	●	○
	Sixes Creek 1					●	○	●	○
	Sixes Creek 2					●	○		
	Wee Burn 1					●	○	●	○
Zigzag	Camp Creek 1A		○	●	○	●	○	●	○
	Camp Creek 1B		○	●	○	●	○	●	○
	Camp Creek 1C					●	○	●	○
	Cool 1					●	○		
	Devils Canyon 1A					●	○		
	Henry 1					●	○	●	○
	Lady 1					●	○	●	○
	Little Zigzag 1					●	○		
	Still 1		○	●	○	●	○	●	○
	Still 1A		○	●	○	●	○	●	○
	Still 2		○	●	○	●	○	●	○
	Still 3			●	○	●	○		
	Wind 1			●	○	●	○	●	○
	Zigzag 1A		○	●	○	●	○		
	Zigzag 1B		○	●	○	●	○		
	Zigzag 1C			●	○	●	○		

● species currently present in reach ○ species was present in reach historically ○ (shaded) historical presence cut off by dam

Source: GIS layer in EDT data model, August 8, 2006.

Appendix D. EDT Information Structure

Introduction

The Ecosystem Diagnosis and Treatment (EDT) model, developed by Mobrand Biometrics, Inc., is a tool for evaluating the productivity and carrying capacity of a basin's fisheries (Lestelle et al. 1996). Productivity is defined as a population's change in numbers over time in the absence of competition between individuals of the population. The carrying capacity of a population is defined in EDT as the maximum number of individuals that a population's habitat can support.

In the presence of competition, a population's actual change in numbers is determined by its productivity and how close it is to its carrying capacity. The EDT model draws on a database of habitat attributes and a set of mathematical algorithms to predict both the survival (determining, in part, potential productivity) and carrying capacity within a watershed for specific fish species. The model produces estimates of a population's productivity, carrying capacity, equilibrium population size, and life-history diversity on the scale of the Sandy River, and generates limiting-factors analyses on the scale of individual reaches (reaches size is defined by the user). EDT is a deterministic model that produces estimates that do not have confidence intervals.

For the purposes of this Habitat Conservation Plan (HCP), EDT provides estimates of fish productivity, diversity, and abundance in the Sandy River Basin based on 46 habitat attributes related to hydrology, water temperature, channel and streambed morphology, the richness of the biological community, riparian conditions, physical habitat conditions (e.g., relative quantity of pool, riffle, or glide habitat), water quality, and some additional factors, such as the presence of pathogens or competition with hatchery fish. EDT estimates are primarily used in two chapters of this HCP. In Chapter 5, they are used for the limiting factors analysis. They are also used in Chapter 8 for the Population Effects and VSP Parameters, and the Population Effects and Benchmark Comparison of Fish Abundance sections of the effects analysis. All model estimates are for Sandy River fish populations.

Information in the EDT model is organized on three levels:

> Level 1—fundamental stream characteristics, relatively beyond the influence of individual restoration activities
>
> Level 2—environmental attributes, mutable by individual restoration activities
>
> Level 3—survival factors

Level 1 characteristics are used to create a broad-brush profile of a watershed. They consist of a wide range of data types such as general geomorphic characterizations, descriptions of flow regime, sediment load, temperature, land use, and ownership.

Level 2 environmental attributes provide a more refined depiction of the aquatic environment. They are the measurable physical and biological characteristics of the environment that are relevant to salmonids at the reach level and that can vary within the context of a given set of Level 1 stream characteristics.

Level 3 survival factors are umbrella groups that organize the Level 2 environmental attributes into broader concepts of habitat conditions for each species under study. The Level 3 survival factors describe the biological performance of a species in relation to the state of the environment as described in the Level 2 environmental attributes.[1]

The Level 3 factors are determined from rule sets derived from scientific literature (see Lestelle et al. 2004) and have been compiled using the expert judgment of the following scientists:

- Larry Lestelle
- Lars Mobrand
- Kevin Malone
- Greg Blair
- Bruce Watson

The relationship of the Levels 2 environmental attributes in EDT for the sediment load survival factor is illustrated in Figure D-1. Figure D-1 does not represent the entire EDT model, but rather illustrates how rule sets are used, with Level 2 environmental attributes as inputs, to determine Level 3 survival factors.

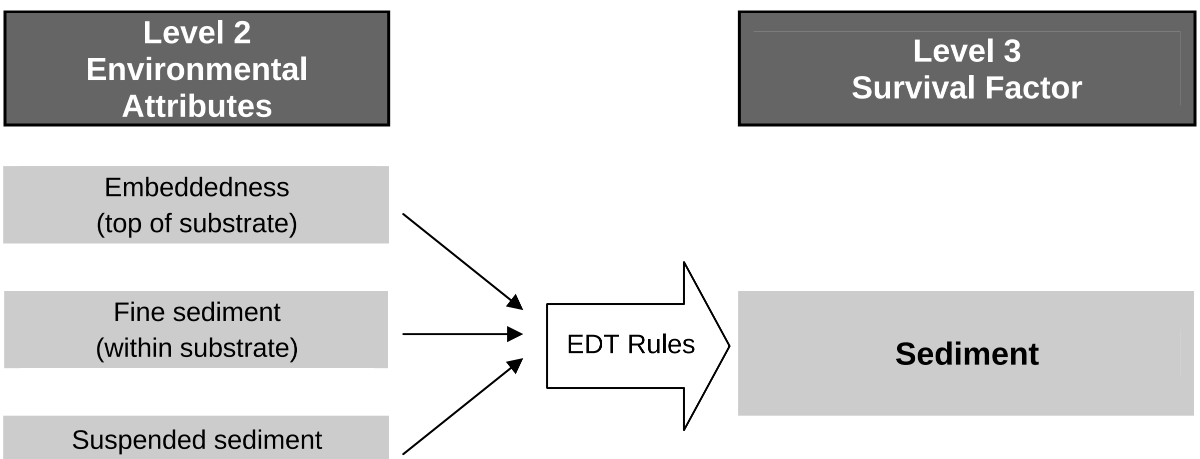

Figure D-1. Relationship of Level 2 Environmental Attributes to Level 3 Survival Factors in EDT

Table D-1, on the following pages, shows the 46 Level 2 attributes used in the analysis of the Sandy River Basin stream reaches. The table lists the variable name as it appears in the EDT database and model output, the full name of the attribute, and the definition of the attribute.

Table D-2 lists the 16 Level 3 survival factors and provides a description for each survival factor.

[1] These survival factors correspond to the types of factors typically referred to by biologists as limiting factors.

Table D-3 shows the relationship of Level 3 survival factors and Level 2 environmental attributes at different life stages for Chinook, coho, and steelhead in the Sandy River Basin.

For more information on the EDT model, see Lestelle et al. 2004; City of Portland Bureau of Water Works 2004; and Lestelle et al. 1996.

Strengths and Weaknesses of the EDT model

The Independent Scientific Advisory Board (ISAB) of the Northwest Power and Conservation Council concluded that the major strength of EDT is as follows:

"EDT accounts for cumulative effects of factors such as spatial temporal interactions, all attributes, competition, and predation effects. Density dependent factors are included. It translates combinations of actions at any scale into biological performance responses (population productivity, abundance, and life history diversity." (2001)

The ISAB also noted that EDT is a flexible model that links habitat conditions to ecological function and eventually to the biological performance of the species of interest (ISAB 2001).

EDT is best used for developing working hypothesis for how changes to stream habitat result in a change in species performance. These hypotheses are then tested over time through the use of well designed monitoring programs. This is the approach taken by the City of Portland (City) in this HCP.

The ISAB (2001) also noted that EDT weaknesses are the *"…lack of ground truthing of input data and peer review to ensure that rules are consistent with current information and knowledge."*

The SRBTT used the following methods to ensure the validity of the data:

- The input data for the Sandy River stream reaches predominantly came from recent stream surveys.
- The biologists on the Sandy River Basin Agreement Technical Team (SRBTT) checked all data before creating EDT reach ratings for the habitat attributes.

About half (52 percent) of input data for both historical and present habitat conditions in Sandy River Basin stream reaches were based on empirical measurements or extrapolations from empirical measurements in neighboring reaches. Local biologists with expert knowledge contributed information that was used to derive an additional 27 percent of the EDT input data. The remaining 21 percent of input data, mostly concerning historical conditions, were based on a review of similar Cascade streams. After the initial EDT model runs were done, biologists then reviewed the results and made corrections to the reach ratings as appropriate.

The EDT model and its biological rules have been offered to many agencies for peer review. The ISAB reviewed the model for the Northwest Power and Conservation Council and found the biological rules to be adequate for prioritizing habitat actions in a basin. Since the ISAB review was completed in 2001, the EDT model has been used by biologists throughout the region for developing subbasin plans for the Northwest Power and Conservation Council. Through this process, many of the rules in EDT have been updated and refined.

These updates are included in the version of the model the City used for modeling fish populations in the Sandy River Basin for the HCP.

The National Marine Fisheries Service (NMFS), through its Science Center, is currently doing a sensitivity analysis on the EDT model. NMFS has not found much criticism of the model's biological rules, but was concerned about the large number of model inputs and resulting output variability. NMFS has determined that there can be high variability around the model outputs resulting from high variability around the inputs, specifically the reach habitat ratings and the out-of-basin survival factors such as ocean conditions.

The Washington Department of Fish and Wildlife (WDFW) also conducted a sensitivity analysis on EDT model runs for Puget Sound basins using Monte Carlo statistical techniques (WDFW 2006). WDFW found the EDT model output variability was generally low, although higher levels were observed occasionally. The simulations yielded variations of approximately 4 percent to 11 percent for EDT estimates of productivity, capacity, and abundance. In addition, WDFW found that EDT rankings of a river reach's relative restoration and protection value for Chinook salmon were quite stable for the highest ranked reaches.

As noted above, EDT is a deterministic model, not a statistical model, so does not provide a measure of confidence to accompany its estimates.

Table D-1. EDT Level 2 Environmental Attributes

Variable Name	Attribute	Definition
Alka	Alkalinity	Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/L of either HCO3 or CaCO3.
BdScour	Bed scour	Average depth of bed scour in salmonid spawning areas (i.e., in pool tail-outs and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
BenComRch	Benthos diversity and production	Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of Oregon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).
ChLngth	Channel length	Length of the primary channel contained with the stream reach. Note: this attribute will not be given by categories but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.
WidthMx	Channel width – month maximum width (ft)	Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.
WidthMn	Channel width – month minimum width (ft)	Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

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Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
ConfineHdro	Confinement – Hydromodifications	The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cutoff due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees—consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.
Confine	Confinement – natural	The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankfull channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.
DisOxy	Dissolved oxygen	Average dissolved oxygen within the water column for the specified time interval.
Emb	Embeddedness	The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tail-out habitat units and only where cobble or gravel substrates occur.
FnSedi	Fine sediment	Percentage of fine sediment within salmonid spawning substrates, located in pool tail-outs, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1 mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.
FshComRch	Fish community richness	Measure of the richness of the fish community (number of fish taxa, i.e., species).
FshPath	Fish pathogens	The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

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Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
FSpIntro	Fish species introductions	Extent of introductions of exotic fish species in the vicinity of the stream reaches under consideration.
FlwHigh	Flow – change in average annual peak flow	The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).
FlwLow	Flow – change in average annual low flow	The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.
FlwDielVar	Flow – Intra daily (diel) variation	Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.
FlwIntraAnn	Flow – intra-annual flow pattern	The average extent of intra-annual flow variation during the wet season—a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.
Grad	Gradient	Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.
HbBckPls	Habitat type – backwater pools	Percentage of the wetted channel surface area comprising backwater pools.
HbBvrPnds	Habitat type – beaver ponds	Percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat.

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Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
HbGlide	Habitat type – glide	Percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.
HbLrgCbl	Habitat type – large cobble/boulder riffles	Percentage of the wetted channel surface area comprising large cobble/boulder riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
HbOfChFctr	Habitat type – off-channel habitat factor	A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.
HbPlTails	Habitat type – pool tailouts.	Percentage of the wetted channel surface area comprising pool tailouts.
HbPls	Habitat type – primary pools	Percentage of the wetted channel surface area comprising pools, excluding beaver ponds.
HbSmlCbl	Habitat type – small cobble/gravel riffles	Percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).
Harass	Harassment	The relative extent of poaching and/or harassment of fish within the stream reach.
HatFOutp	Hatchery fish outplants	The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.
HydroRegimeNatural	Hydrologic regime – natural	The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.
HydroRegimeReg	Hydrologic regime – regulated	The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (see Flow-Intra-daily variation attribute).

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Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
Icing	Icing	Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.
MetWatCol	Metals – in water column	The extent of dissolved heavy metals within the water column.
MetSedSls	Metals/Pollutants – in sediments/soils	The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.
MscToxWat	Miscellaneous toxic pollutants – water column	The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.
NutEnrch	Nutrient enrichment	The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.
Obstr	Obstructions to fish migration	Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).
PredRisk	Predation risk	Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish-eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude, and frequency of exposure to potential predators (assuming other habitat factors are constant). Note: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).
RipFunc	Riparian function	A measure of riparian function that has been altered within the reach.
SalmCarcass	Salmon Carcasses	Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.
TmpMonMx	Temperature – daily maximum (by month)	Maximum water temperatures within the stream reach during a month.
TmpMonMn	Temperature – daily minimum (by month)	Minimum water temperatures within the stream reach during a month.

Table continued on next page

Table D-1. EDT Level 2 Environmental Attributes, continued

Variable Name	Attribute	Definition
TmpSptVar	Temperature – spatial variation	The extent of water temperature variation (cool or warm water depending upon season) within the reach as influenced by inputs of groundwater or tributary streams, or the presence of thermally stratified deep pools.
Turb	Turbidity	The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids; hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended solids, including very fine particles such as clays and colloids and some dissolved materials, cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/L. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.
Wdrwl	Water withdrawals	The number and relative size of water withdrawals in the stream reach.
WdDeb	Wood	The amount of wood (large woody or LW) within the reach. Dimensions of what constitutes LW are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LW corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LW pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Source: Lestelle et al. 2004s

Table D-2. EDT Level 3 Survival Factors

Factor	Description
Channel stability	Stability of the reach with respect to its stream bed, banks, and its channel shape and location. The more unstable the channel, the lower the survival of eggs and juvenile fish.
Stream Flow	The amount, pattern, or extent of stream flow fluctuations. Both too much and too little flow in the stream channel can reduce salmon performance. High flows may cause juveniles to leave a stream, low flows may eliminate all production from the stream.
Habitat diversity	The extent of habitat complexity within a stream reach. Complexity is the opposite of uniformity; greater complexity increases survival. Streams with large amounts of wood, boulders, undercut banks, and pools provide better habitat than those that do not.
Sediment Load	The amount of sediment present in or passing through the stream reach. Fine sediment can smother incubating eggs and reduce the quality of juvenile rearing habitat.
Stream Temperature	Water that is too cold or hot can reduce salmon survival at all life stages. In general, fish sensitivity to temperature decreases as fish move from egg to smolt to adult.
Predation	The relative abundance of predators that feed upon fish. Predators can be fish, mammals, or birds.
Chemicals	Concentrations of toxic chemicals and conditions (such as pH) from point and non-point sources.
Competition With Other Species	The relative abundance of other species that compete with salmon for food and space in the same stream reach.
Competition with Hatchery Fish	The relative abundance of hatchery fish that compete with salmon for food and space in the same stream reach.
Obstructions	Physical structures, such as dams, weirs, or waterfalls, that impede the use of a stream reach by fish.
Water Withdrawals	Water removed from stream channels for irrigation, city water supply, or other uses. Water removal can affect fish by entraining juveniles on pump intakes or lowering water levels. Low water levels can impede fish passage, reduce available habitat, and result in high water temperatures.
Food	The amount, diversity, and availability of food available to the fish community. Food sources include macroinvertebrates, salmon carcasses, and terrestrial insects.
Oxygen	Mean concentration of dissolved oxygen in the stream reach. Low oxygen levels reduce fish survival at all life stages.
Pathogens	The abundance, concentration, or effects of pathogens on fish in the stream reach. For example, the presence of a fish hatchery or large numbers of livestock along the reach could cause unusually high concentrations of pathogens.
Key Habitat	The amount of the key habitat present in the stream for each life stage. An example of key habitat would be riffles in which salmonids spawn. If key habitats are limited, fewer salmon can be supported by the stream.
Harassment/Poaching	Humans may reduce the survival of salmonids though such activities as swimming, boating, and poaching, i.e., catching fish illegally. The effects of legal harvest on salmonids are not considered in this factor.

Source: Lestelle et al. 2004

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Table D-3. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
Spawning	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Small cobble/gravel riffles	Pool tailouts	Glides				
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						
Incubation	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals/Pollutants - in sediments/soils	Metals - in water column				

Source: Mobrand Biometrics, Inc., 2004

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon. Source: Mobrand Biometrics, Inc., 2004

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Habitat diversity	No effect						
	Harassment	Harassment						
	Key Habitat	Small cobble/gravel riffles	Pool tailouts	Glides				
	Obstructions	No effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	No effect						
	Sediment load	Fine sediment						
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	No effects						
Fry colonization	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effects						
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	no effects						
	Key Habitat	Backwater pools	Beaver ponds	Primary pools	Pool tailouts	Glides	Small cobble/gravel riffles	Large cobble riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Embeddedness					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	Off-channel habitat (just coho)
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age transient rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	no effects						
	Key Habitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age Inactive	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment						
	Key Habitat	Primary pools	Backwater pools	Beaver ponds	Glides	Large cobble riffles just chinook		
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily minimum (by	Hatchery fish outplants		

Source: Mobrand Biometrics, Inc., 2004

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
					month)			
	Sediment load	Embeddedness	Turbidity (susp. sed.)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	no effects						
	Key Habitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Prespawning migrant	Channel stability	no effects						

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - changes in interannual variability in low flows						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration2						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						
Prespawning holding	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						

Source: Mobrand Biometrics, Inc., 2004

Table D-3 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for chinook salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with other species)	no effects						
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Glides	Large cobble riffles				
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						

Table D-4. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
Spawning	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Small cobble/gravel riffles	Pool tailouts	Glides				
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						
Incubation	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals/Pollutants - in sediments/soils	Metals - in water column				

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Harassment	Harassment						
	Key Habitat	Small cobble/gravel riffles	Pool tailouts	Glides				
	Obstructions	No effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Sediment load	Fine sediment						
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	No effects						
Fry colonization	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effects						
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Harassment	no effects						
	Key Habitat	Backwater pools	Beaver ponds	Primary pools	Pool tailouts	Glides	Small cobble/gravel riffles	Large cobble riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Embeddedness					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	Off-channel habitat

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Key Habitat (continued)		Small cobble/gravel riffles					
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	no effects						
	Key Habitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age Inactive	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment						
	Key Habitat	Primary pools	Backwater pools	Beaver ponds	Glides	Off-channel habitat		
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily minimum (by	Hatchery fish outplants		

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
					month)			
	Sediment load	Embeddedness	Turbidity (susp. sed.)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - change in intra-annual variability (flow flashiness)	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity and production	Riparian function			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Backwater pools	Glides	Pool tailouts	Beaver ponds	Large cobble riffles	Small cobble/gravel riffles
	Key Habitat (continued)		Off-channel habitat					
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by					

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
			month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	no effects						
	Key Habitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
Prespawning migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - changes in interannual variability in low flows						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						
Prespawning holding	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				

Table D-4 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for coho salmon.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (continued)		Riparian function	Wood				
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	Key Habitat	Primary pools	Glides	Large cobble riffles				
	Obstructions	no effects						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	no effects						

Table D-5. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
Spawning	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	Habitat type- small cobble/gravel riffles	Habitat type- pool tailouts	Habitat type-glides				
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Incubation	Channel stability	Bed scour	Icing	Riparian function	Wood	Confinement - Hydromodifications	Flow - change in interannual variability in high flows	Flow - intra-annual flow pattern
	Chemicals	Miscellaneous toxic pollutants - water	Metals/Pollutants - in sediments/soils	Metals - in water column				

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
		column						
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow - Intra daily (diel) variation	Flow - change in interannual variability in low flows					
	Food	no effects						
	Habitat diversity	No effect						
	Harassment	Harassment						
	KeyHabitat	Habitat type- small cobble/gravel riffles	Habitat type- glides	Habitat types- pool tailouts				
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	No effect						
	Sediment load	Fine sediment						
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Fry colonization	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		

Source: Mobrand Biometrics, Inc., 2004

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow - intra-annual flow pattern	Riparian function	Wood
	Food	Alkalinity	Benthos diversity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	no effects						
	KeyHabitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- large cobble/boulder riffles	Habitat type- primary pools	Habitat type- small cobble/gravel riffle	Habitat type- glides	Habitat type- pool tailouts
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Embeddedness					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Riparian function	Wood	Confinement - Hydromodifications	Confinement - natural	Confinement - Hydromodifications

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Food	Alkalinity	Benthos Diversity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	No effect						
	Food	no effects						
	Habitat diversity	Riparian function	Confinement - natural	Confinement - Hydromodifications	Wood			
	Harassment	No effect						

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead tro

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
	Key Habitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- glides	Habitat type-large cobble/boulder riffles	Habitat type- pool tailouts	Habitat type- primary pools	Habitat type- small cobble/gravel riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temper1ature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age Inactive	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow-intra-annual flow pattern	Riparian function	Wood
	Food	Benthos diversity and production	Alkalinity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	Harassment						
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily minimum (by month)	Hatchery fish outplants		
	Sediment load	Embeddedness	Turbidity (susp. sed.)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydromodifications	Gradient	Flow- intra-annual flow pattern	Riparian function	Wood
	Food	Alkalinity	Benthos diversity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	no effects						
	Competition (with other species)	no effects						
	Flow	no effects						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood	Icing	
	Harassment	Harassment						
	KeyHabitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- glides	Habitat type- large cobble/boulder riffles	Habitat type-pool tailouts	Habitat type- primary pools	Habitat type- small cobble/gravel riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Hatchery fish outplants		
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age inactive	Channel stability	Bed Scour	Icing	Riparian Function	Wood			
	Chemicals	Misc toxic pollutants- water column	Metals/Pollutants- in sediments/soils	Metals- in water column				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow- change in interannual variability in high flows	Confinement- Hydromodifications	Confinement- natural	Gradient	Flow- intra-annual flow pattern	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity	Riparian function			
	Habitat diversity	Gradient	Confinement- Hydromodifications	Confinement- natural	Riparian Function	Wood		
	Harassment	No effect						
	KeyHabitat							
	Obstructions							
	Oxygen	Dissolved Oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature- daily Max (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature- daily Min (by month)	Hatchery fish outplants		
	Sediment load	Embeddedness	Turbidity					
	Temperature	Temperature- daily Min (by month)	Temperature- spatial variation					
	Withdrawals	Water withdrawals						

Source: Mobrand Biometrics, Inc., 2004

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
2+ age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Misc toxic pollutants- water column	Metals/Pollutants- in sediments/soils	Metals- in water column				
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity	Riparian function	Salmon Carcasses		
	Flow	Flow- change in interannual variability in high flows	Confinement- Hydromodifications	Confinement- natural	Gradient	Flow- intra-annual flow pattern	Riparian function	Wood
	Food	Alkalinity	Salmon Carcasses	Benthos diversity	Riparian function			
	Habitat diversity	Gradient	Confinement- Hydromodifications	Confinement- natural	Riparian function	Wood		
	Harassment	Harassment	Habitat type- primary pools	Riparian function	Turbidity	Wood		
	KeyHabitat							
	Obstructions							
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature- daily Max (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature- daily Max (by month)			
	Sediment load	Turbidity	Temperature- daily Max (by month)					
	Temperature	Temperature- daily Max (by month)	Temperature- daily Min (by month)	Temperature- spatial variation				
	Withdrawals	Water withdrawals						
2+ age migrant	Channel stability	No effect						
	Chemicals	Misc toxic pollutants- water column	Metals/Pollutants- in sediments/soils	Metals- in water column				

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	No effect						
	Food	No effect						
	Habitat diversity	Riparian function	Confinement- Hydromodifications	Confinement- natural	Wood			
	Harassment	No effect						
	Key Habitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- glides	Habitat type- large cobble/boulder riffles	Habitat type- pool tailouts	Habitat type- primary pools	Habitat type- small cobble/gravel riffles
	Obstructions							
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature- daily Max (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature- daily Max (by month)	Hatchery fish outplants		
	Sediment load	Turbidity	Temperature- daily Max (by month)					
	Temperature	Temperature- daily Max (by month)	Temperature- spatial variation					
	Withdrawals	Water withdrawals						
2+ age inactive	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Misc toxic pollutants- water column	Metals/Pollutants- in sediments/soils	Metals- in water column				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow- change in interannual variability in high	Confinement- Hydromodifications	Confinement- natural	Gradient	Flow- intra-annual flow pattern	Riparian function	Wood

Source: Mobrand Biometrics, Inc., 2004

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trou

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
		flows						
	Food	Alkalinity	Salmon Carcasses	Benthos diversity	Riparian function			
	Habitat diversity	Gradient	Confinement-Hydromodifications	Confinement-natural	Riparian function	Wood		
	Harassment	No effect						
	KeyHabitat							
	Obstructions							
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature- daily Max (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature- daily Min (by month)	Hatchery fish outplants		
	Sediment load	Embeddedness	Turbidity					
	Temperature	Temperature- daily Min (by month)	Temperature-spatial variation					
	Withdrawals	Water withdrawals						
Prespawning migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effect						
	Competition (with other species)	No effect						
	Flow	Flow - changes in interannual variability in low flows						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydromodifications	Riparian function	Wood		

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**	**Modifying**
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	Habitat type- backwater pools	Habitat type- beaver ponds	Habitat type- glides	Habitat type- large cobble/boulder riffles	Habitat type- pool tailouts	Habitat type- primary pools	Habitat type-small cobble/gravel riffles
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	No effects						
Prespawning holding	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/Pollutants - in sediments/soils				
	Competition (with hatchery fish)	No effects						
	Competition (with other species)	No effects						
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydromodifications
	Flow (cont)		Riparian function	Wood				
	Food	no effects						
	Habitat diversity	Gradient	Confinement - Hydromodifications	Riparian function	Wood			

Table D-5 continued. Associations used in translating Level 2 Environmental Attribute values to Level 3 Survival Factor values through rule sets for steelhead trout.

Life stage	Level 3 Survival Factor	Level 2 Environmental Attribute						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Harassment	Harassment	Habitat type - primary pools	Riparian function	Turbidity (susp. sed.)	Wood		
	KeyHabitat	Habitat type- primary pools	Habitat type- glides	Habitat type- large cobble/boulder riffles				
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk						
	Sediment load	Turbidity (susp. sed.)	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	No effect						

Source: Mobrand Biometrics, Inc., 2004

Appendix E. Offsite Habitat Effects Tables

Introduction

In the Chapter 8 subsection "Habitat Effects in the Sandy River Basin from the HCP Offsite Measures," habitat benefits tables show the projected trends in the reference conditions (e.g., improvement, increase, decrease, etc.) for each of the four primary covered fish species. To supplement the trend information, the tables in this appendix show the expected numeric habitat benefits for each of the primary covered fish species.

Habitat benefits derived from instream projects are expected to accrue within five years. The instream projects will be implemented over the first 11 years of the Habitat Conservation Plan (HCP). Instream projects that involve placing large wood will be designed to have an estimated life span of 15 years. Benefits from these projects will, therefore, begin decreasing after 15 years, but are expected to be completely offset by increasing benefits derived from riparian easements.

Habitat benefits derived from riparian easements and improvements are expected to begin accruing after 15 years and take up to 30 years to be fully realized. Riparian easements will be implemented over the first 15 years of the HCP. The cumulative benefits summarized in the tables in this appendix, therefore, are expected to be accomplished at staggered intervals throughout the life of the HCP and fully attained by 30 years after the last riparian easement is implemented.

Habitat Benefits Effects Tables

The habitat benefit tables in this appendix, Tables E-6 through E-20, show the current condition, habitat benefits as a percentage improvement, and the expected post-implementation condition for each of the four primary covered species. Definitions for all of the habitat benefits are provided in Table D-1 of Appendix D in this HCP.

The current condition for each stream reach was input into the Ecosystem Diagnosis and Treatment (EDT) model from data gathered during stream surveys conducted in the 1990s. The current and post-implementation conditions are expressed as percentages, units per measure of habitat (e.g., number of pieces of large wood (LW) per channel width), or EDT scores. The EDT scores are ratings from 0 to 4 in which 0 represents optimal conditions (zero negative impact), and 4 represents extremely poor, or lethal, conditions for fish. The EDT scores are based on index values that are provided below.

EDT Score Index Values

In the habitat benefits tables for each species, five habitat conditions are expressed as EDT scores: maximum water temperature, minimum water temperature, temperature moderation by groundwater, fish pathogens, and harassment. The following tables show the index values that are the numeric basis for the EDT scores shown in the habitat benefits tables. The EDT maximum water temperature scores are based on the index values shown in Table E-1.

Table E-1. Index Values for EDT Maximum Water Temperature Scores

EDT Score	Index Values
0	warmest day with a maximum temperature <10°C
1	warmest day with temperatures >10°C and < 16°C
2	• more than 1 day with temperatures of 22–25°C *or* • 1–12 days with temperatures >16°C
3	• more than 1 day with temperatures of 25–27.5°C *or* • more than 4 non-consecutive days with temperatures during the warmest day of 22–25°C *or* • more than 12 days with temperatures >16°C
4	• more than 1 day with temperatures of >27.5°C *or* • 3 consecutive days with temperatures of >25°C *or* • more than 24 days with maximum temperatures >21°C

Source: Lestelle et al. 2004

The EDT minimum water temperature scores are based on the index values shown in Table E-2.

Table E-2. Index Values for EDT Minimum Water Temperature Scores

EDT Score	Index Values
0	Coldest day with a minimum temperature >4°C
1	Fewer than 7 days with temperatures < 4°C and >1°C
2	Between 1 and 7 days with minimum temperatures of < 1°C
3	Between 8 and 15 days with minimum temperatures of < 1°C
4	More than 15 winter days with minimum temperatures of < 1°C

Source: Lestelle et al. 2004

The EDT temperature moderation by groundwater scores are based on the index values shown in Table E-3.

Table E-3. Index Values for EDT Temperature Moderation by Groundwater Scores

EDT Score	Index Values
0	Super-abundant sites of groundwater discharge into surface waters (primary source of streamflow), tributaries entering reach, or deep pools that provide abundant temperature variation in reach
1	Abundant sites of groundwater discharge into surface waters, tributaries entering reach, or deep pools that provide abundant temperature variation in reach
2	Occasional sites of groundwater discharge into surface waters, tributaries entering reach, or deep pools that provide intermittent temperature variation in reach
3	Infrequent sites of groundwater discharge into surface waters, tributaries entering reach, or deep pools that provide intermittent temperature variation in reach
4	No evidence of temperature variation in reach

Source: Lestelle et al. 2004

The EDT fish pathogen scores are based on the index values shown in Table E-4.

Table E-4. Index Values for EDT Fish Pathogen Scores

EDT Score	Index Values
0	No historic or recent fish stocking in drainage and no known incidence of whirling disease, Ceratomyxa shasta (C. shasta), infectious hematopoietic necrosis Virus (IHN), or infectious pancreatic necrosis (IPN)
1	Historic fish stocking, but no fish stocking records within the past decade, or sockeye population currently existing in drainage, or known incidence of viruses among kokanee populations within the watershed
2	Ongoing periodic, frequent, or annual fish stocking in drainage or known viral incidence within sockeye, Chinook, or steelhead populations in the watershed
3	Operating hatchery within the reach or in the reach immediately downstream or upstream
4	Known presence of whirling disease or C. shasta within the watershed

Source: Lestelle et al. 2004

The EDT harassment scores are based on the index values shown in Table E-5.

Table E-5. Index Values for EDT Harassment Scores

EDT Score	Index Values
0	Reach is distant from human population centers, no road access or no local concentration of human activity
1	Reach is distant from human population centers, but with partial road access or little local concentration of human activity
2	Reach is near human population center, but has limited public access (through roads or boat launching sites)
3	Extensive road and/or boat access to the reach with localized concentrations of human activity
4	Reach is near human population center or has extensive recreational activities, and has extensive road access and/or opportunities for boat access

Source: Lestelle et al. 2004

Habitat Benefits for Fall Chinook

Table E-6. Habitat Benefits for Fall Chinook in the Lower Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Beaver 1A	63% of full riparian function	3% improvement	65% of full riparian function
	0.7 pieces LW per channel width	21% increase	0.8 pieces LW per channel width
Gordon 1A	24% surface area of gravel patches is fine sediment	25% decrease	18% surface area of gravel patches is fine sediment
	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	30% of total habitat is large-cobble riffles	17% decrease	25% of total habitat is large-cobble riffles
	14% of total habitat is pool habitat	115% increase	30% of total is pool habitat
	3% of total habitat is pool-tail habitat	46% increase	5% of total habitat is pool-tail habitat
	52% of total habitat is small-cobble riffles	33% decrease	35% of total habitat is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Sandy 1	25% artificial confinement	20% reduction	20% artificial confinement
	63% of full riparian function	19% improvement	75% of full riparian function
	6.5 pieces LW per channel width	35% increase	8.8 pieces LW per channel width
Sandy 2	38% of full riparian function	69% improvement	64% of full riparian function
	EDT maximum water temperature score of 3	3% decrease in the score	EDT maximum water temperature score of 2.9
	6.5 pieces LW per channel width	121% increase	14.4 pieces LW per channel width
Trout 1A	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b]When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Beaver 1A riparian function, the current condition of 63% will be improved by 3% to give 0.63+(0.63*0.03)=0.65.

Table E-7. Habitat Benefits for Fall Chinook in the Middle Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Cedar 1	7 mg/l of dissolved oxygen	14% increase	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement	EDT fish pathogen score of 1.6
	EDT minimum water temperature score of 1	20% decrease in the score	EDT minimum water temperature score of 0.8
	EDT score of 2 in the maximum water temperature score	20% decrease in the score	EDT score of 1.6 in the maximum water temperature score
	EDT temperature moderation by groundwater score of 3	33% improvement in the score	EDT temperature moderation by groundwater score of 2
Sandy 3	83% of full riparian function	5% improvement	87% of full riparian function
	EDT score of 3 in the maximum water temperature score	1% decrease in the score	EDT score of 2.97 in the maximum water temperature score
	2.0 pieces LW per channel width	31% increase	2.6 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 3 riparian function, the current condition of 83% will be improved by 5% to give 0.83+(0.83*0.05)=0.87.

Habitat Benefits for Spring Chinook

Table E-8. Habitat Benefits for Spring Chinook in the Lower Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Gordon 1A	24% surface area of gravel patches is fine sediment	25% decrease	18% surface area of gravel patches is fine sediment
	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	30% of total habitat is large-cobble riffles	17% decrease	25% of total habitat is large-cobble riffles
	14% of total habitat is pool habitat	115% increase	30% of total is pool habitat
	3% of total habitat is pool-tail habitat	46% increase	5% of total habitat is pool habitat
	52% of total habitat is small-cobble riffles	33% decrease	35% of total habitat is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Gordon 1B	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	6% of total is pool habitat	212% increase	20% of total is pool habitat
	1% of total is pool-tail habitat	326% increase	5% of total is pool-tail habitat
	58% of total is small-cobble riffles	40% decrease	35% of total is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Sandy 1	25% artificial confinement	20% reduction	20% artificial confinement
	63% of full riparian function	19% improvement	75% of full riparian function
	6.5 pieces LW per channel width	35% increase	8.8 pieces LW per channel width
Sandy 2	38% of full riparian function	69% improvement	64% of full riparian function
	EDT maximum water temperature score of 3	3% decrease in the score	EDT maximum water temperature score of 2.9
	6.5 pieces LW per channel width	121% increase	14.4 pieces LW per channel width
Trout 1A	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Trout 2A	1.5 pieces LW per channel width	13% increase	1.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Gordon 1A fine sediment, the current condition of 24% will be decreased by 25% to give 0.24-(0.24*0.25)=0.18.

Table E-9. Habitat Benefits for Spring Chinook in the Middle Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Cedar 1	7 mg/l of dissolved oxygen	14% increase	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement	EDT fish pathogen score of 1.6
	EDT minimum water temperature score of 1	20% decrease in the score	EDT minimum water temperature score of 0.8
	EDT score of 2 in the maximum water temperature score	20% decrease in the score	EDT score of 1.6 in the maximum water temperature score
	EDT temperature moderation by groundwater score of 3	33% improvement in the score	EDT temperature moderation by groundwater score of 2
Sandy 3	83% of full riparian function	5% improvement	87% of full riparian function
	EDT score of 3 in the maximum water temperature score	1% decrease in the score	EDT score of 2.97 in the maximum water temperature score
	2.0 pieces LW per channel width	31% increase	2.6 pieces LW per channel width
Sandy 7	25.0 carcasses per stream mile	70% increase [c,d]	42.5 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	2% decrease in the score	EDT score of 1.97 in the maximum water temperature score

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 3 riparian function, the current condition of 83% will be improved by 5% to give 0.83+(0.83*0.05)=0.87.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-10. Habitat Benefits for Spring Chinook in the Upper Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 8	63% of full riparian function	14% improvement	72% of full riparian function
	113 carcasses per stream mile	31% increase[c,d]	148 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	3% decrease in the score	EDT score of 1.95 in the maximum water temperature score
	2.0 pieces LW per channel width	34% increase	2.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 8 riparian function, the current condition of 63% will be improved by 14% to give 0.63+(0.63*0.14)=0.72.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-11. Habitat Benefits for Spring Chinook in the Salmon River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Boulder 0	24% fine sediments by surface area	5% decrease	22.8% fine sediments by surface area
	EDT maximum water temperature score of 1.5	27% decrease in the score	EDT maximum water temperature score of 1.1
	0.7 pieces LW per channel width	315% increase	2.8 pieces LW per channel width
Boulder 1	83% of full riparian function	20% improvement	100% of full riparian function
	EDT maximum water temperature score of 1.5	13% decrease in the score	EDT maximum water temperature score of 1.3
	1.5 pieces LW per channel width	133% increase	3.5 pieces LW per channel width
Salmon 1	3% of total is off-channel habitat	66% increase	4% of total is off-channel habitat
	3% of total is small-cobble riffles	54% decrease	5% of total is small-cobble riffles
	75% of full riparian function	8% improvement	81% of full riparian function
	200 carcasses per stream mile	50% increase[c,d]	300 carcasses per stream mile
	EDT maximum water temperature score of 3	21% decrease in the score	EDT maximum water temperature score of 2.36
	2.0 pieces LW per channel width	62% increase	3.2 pieces LW per channel width
Salmon 2	14.0 cm is average depth of bed scour	3% reduction	13.6 cm is average depth of bed scour
	25% artificial confinement	12% reduction	22% artificial confinement
	3% of total is off-channel habitat	90% increase	5% of total is off-channel habitat
	50% of full riparian function	33% improvement	67% of full riparian function
	EDT maximum water temperature score of 2	2% decrease in the score	EDT maximum water temperature score of 1.97
	2.0 pieces LW per channel width	67% increase	3.3 pieces LW per channel width
Salmon 3	2 pieces LW per channel width	90% increase in the amount of LW	3.8 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Boulder 0 fine sediments, the current condition of 24% will be decreased by 5% to give 0.24-(0.24*0.05)=0.228.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-12. Habitat Benefits for Spring Chinook in the Zigzag River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Zigzag 1A	40% artificial confinement	38% reduction	25% artificial confinement
	EDT harassment score of 1.5	14% improvement in the score	EDT harassment score of 1.29
	20% of total habitat is large-cobble riffles	20% decrease	15% of total habitat is large-cobble riffles
	55% of total habitat is small-cobble riffles	4% increase	57% of total habitat is small-cobble riffles
	15% of total habitat is pools	15% increase	17% of total habitat is pools
	3% of total habitat is pool-tails	27% increase	4% of total habitat is pool-tails
	63% of full riparian function	7% improvement	68% of full riparian function
	113 carcasses per stream mile	167% increase[c]	300 carcasses per stream mile
	0.7 pieces LW per channel width	323% increase	2.8 pieces LW per channel width
Zigzag 1B	113 carcasses per stream mile	167% increase [c]	300 carcasses per stream mile
Zigzag 1C	13 carcasses per stream mile	100% increase [c]	25 carcasses per stream mile

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Zigzag 1A artificial confinement, the current condition of 40% will be reduced by 38% to give 0.40-(0.40*0.38)=0.25.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

Habitat Benefits for Winter Steelhead

Table E-13. Habitat Benefits for Winter Steelhead in the Lower Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Beaver 1A	63% of full riparian function	3% improvement	65% of full riparian function
	0.7 pieces LW per channel width	21% increase	0.8 pieces LW per channel width
Gordon 1A	24% surface area of gravel patches is fine sediment	25% decrease	18% surface area of gravel patches is fine sediment
	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	30% of total habitat is large-cobble riffles	17% decrease	25% of total habitat is large-cobble riffles
	14% of total is pool habitat	115% increase	30% of total is pool habitat
	3% of total habitat is pool-tail habitat	46% increase	5% of total habitat is pool-tail habitat
	52% of total habitat is small-cobble riffles	33% decrease	35% of total habitat is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Gordon 1B	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	6% of total is pool habitat	212% increase	20% of total is pool habitat
	1% of total is pool-tail habitat	326% increase	5% of total is pool-tail habitat
	58% of total is small-cobble riffles	40% decrease	35% of total is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Sandy 1	25% artificial confinement	20% reduction	20% artificial confinement
	63% of full riparian function	19% improvement	75% of full riparian function
	6.5 pieces LW per channel width	35% increase	8.8 pieces LW per channel width
Sandy 2	38% of full riparian function	69% improvement	64% of full riparian function
	EDT maximum water temperature score of 3	3% decrease in the score	EDT maximum water temperature score of 2.9
	6.5 pieces LW per channel width	121% increase	14.4 pieces LW per channel width
Trout 1A	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Trout 2A	1.5 pieces LW per channel width	13% increase	1.7 pieces LW per channel width

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Beaver 1A riparian function, the current condition of 63% will be improved by 3% to give 0.63+(0.63*0.03)=0.65.

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

Table E-14. Habitat Benefits for Winter Steelhead in the Middle Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Alder 1	Partial barrier at RM 0.1		Access to 1.6 river miles
	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Alder 1A	Partial barrier at RM 1.7		Access to 3.8 river miles
	63% of full riparian function	59% improvement	100% of full riparian function
	1.5 pieces LW per channel width	100% increase	3 pieces LW per channel width
Alder 2	63% of full riparian function	59% improvement	100% of full riparian function
	1.5 pieces LW per channel width	100% increase	3 pieces LW per channel width
Cedar 1	Partial barrier at ~ RM 0.5		Access to ~ 11.5 river miles
	7 mg/l of dissolved oxygen	14% increase	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement	EDT fish pathogen score of 1.6
	EDT minimum water temperature score of 1	20% decrease in the score	EDT minimum water temperature score of 0.8
	EDT score of 2 in the maximum water temperature score	20% decrease in the score	EDT score of 1.6 in the maximum water temperature score
	EDT temperature moderation by groundwater score of 3	33% improvement in the score	EDT temperature moderation by groundwater score of 2
Cedar 2	7 mg/l of dissolved oxygen	14% increase[c]	8 mg/l of dissolved oxygen
	EDT score of 2 in fish pathogen score	20% improvement in the score[c]	EDT score of 1.6 in fish pathogen score
	15% of total is off-channel habitat	75% increase[b]	26% of total is off-channel habitat
	63% of full riparian function	19% improvement[b]	75% of full riparian function
	EDT minimum water temperature score of 1	20% decrease in the score[c]	EDT minimum water temperature score of 0.8
	EDT maximum water temperature score of 2	20% decrease in the score[c]	EDT maximum water temperature score of 1.6
	EDT temperature moderation by groundwater score of 3	33% improvement in the score[b]	EDT temperature moderation by groundwater score of 2
	1.5 pieces LW per channel width	167% increase[c]	4 pieces LW per channel width
Cedar 3	7 mg/l of dissolved oxygen	14% increase[c]	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement[c]	EDT fish pathogen score of 1.6
	6% of total is beaver pond habitat	39% increase[c]	8% of total is beaver pond habitat
	15% of total is off-channel habitat	45% increase[c]	22% of total is off-channel habitat
	21% of total is pool habitat	25% increase[c]	26% of total is pool habitat
	63% of full riparian function	19% improvement [c]	75% of full riparian function
	EDT minimum water temperature score of 1	20% decrease in the score[c]	EDT minimum water temperature score of 0.8
	EDT maximum water temperature score of 2	20% decrease in the score[c]	EDT maximum water temperature score of 1.6
	EDT temperature moderation by groundwater score of 3	33% improvement in the score[c]	EDT temperature moderation by groundwater score of 2
	1.5 pieces LW per channel width	100% increase[c]	3 pieces LW per channel width

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Table E-14. Habitat Benefits for Winter Steelhead in the Middle Sandy River Watershed by Reach, continued

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 3	83% of full riparian function	5% improvement	87% of full riparian function
	EDT score of 3 in the maximum water temperature score	1% decrease in the score	EDT score of 2.97 in the maximum water temperature score
	2.0 pieces LW per channel width	31% increase	2.6 pieces LW per channel width
Sandy 7	25.0 carcasses per stream mile	70% increase[c, d]	42.5 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	2% decrease in the score	EDT score of 1.97 in the maximum water temperature score

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Alder 1A riparian function, the current condition of 63% will be improved by 59% to give 0.63+(0.63*0.59)=1.0.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-15. Habitat Benefits for Winter Steelhead in the Upper Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 8	63% of full riparian function	14% improvement	72% of full riparian function
	113 carcasses per stream mile	31% increase[c,d]	148 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	3% decrease in the score	EDT score of 1.95 in the maximum water temperature score
	2.0 pieces LW per channel width	34% increase	2.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 8 riparian function, the current condition of 63% will be improved by 14% to give 0.63+(0.63*0.14)=0.72.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-16. Habitat Benefits for Winter Steelhead in the Salmon River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Boulder 0	24% fine sediments by surface area	5% decrease	22.8% fine sediments by surface area
	EDT maximum water temperature score of 1.5	27% decrease in the score	EDT maximum water temperature score of 1.1
	0.7 pieces LW per channel width	315% increase	2.8 pieces LW per channel width
Boulder 1	83% of full riparian function	20% improvement	100% of full riparian function
	EDT maximum water temperature score of 1.5	13% decrease in the score	EDT maximum water temperature score of 1.3
	1.5 pieces LW per channel width	133% increase	3.5 pieces LW per channel width
Salmon 1	3% of total is off-channel habitat	66% increase	4% of total is off-channel habitat
	3% of total is small-cobble riffles	54% decrease	5% of total is small-cobble riffles
	75% of full riparian function	8% improvement	81% of full riparian function
	200 carcasses per stream mile	50% increase[c,d]	300 carcasses per stream mile
	EDT maximum water temperature score of 3	21% decrease in the score	EDT maximum water temperature score of 2.36
	2.0 pieces LW per channel width	62% increase	3.2 pieces LW per channel width
Salmon 2	14.0 cm is average depth of bed scour	3% reduction	13.6 cm is average depth of bed scour
	25% artificial confinement	12% reduction	22% artificial confinement
	3% of total is off-channel habitat	90% increase	5% of total is off-channel habitat
	50% of full riparian function	33% improvement	67% of full riparian function
	EDT maximum water temperature score of 2	2% decrease in the score	EDT maximum water temperature score of 1.97
	2.0 pieces LW per channel width	67% increase	3.3 pieces LW per channel width
Salmon 3	2 pieces LW per channel width	90% increase in the amount of LW	3.8 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Boulder 0 fine sediment, the current condition of 24% will be reduced by 5% to give 0.24-(0.24*0.05)=0.228

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-17. Habitat Benefits for Winter Steelhead in the Zigzag River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Zigzag 1A	40% artificial confinement	38% reduction	25% artificial confinement
	EDT harassment score of 1.5	14% improvement in the score	EDT harassment score of 1.29
	20% of total habitat is large-cobble riffles	20% decrease	15% of total habitat is large-cobble riffles
	55% of total habitat is small-cobble riffles	4% increase	57% of total habitat is small-cobble riffles
	15% of total habitat is pools	15% increase	17% of total habitat is pools
	3% of total habitat is pool-tails	27% increase	4% of total habitat is pool-tails
	63% of full riparian function	7% improvement	68% of full riparian function
	113 carcasses per stream mile	167% increase[c,d]	300 carcasses per stream mile
	0.7 pieces LW per channel width	323% increase	2.8 pieces LW per channel width
Zigzag 1B	113 carcasses per stream mile	167% increase[c]	300 carcasses per stream mile
Zigzag 1C	13 carcasses per stream mile	100% increase[c,d]	25 carcasses per stream mile

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Zigzag 1A artificial confinement, the current condition of 40% will be reduced by 38% to give 0.40-(0.40*0.38)=0.25.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Habitat Benefits for Coho

Table E-18. Habitat Benefits for Coho in the Lower Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Beaver 1A	63% of full riparian function	3% improvement	65% of full riparian function
	0.7 pieces LW per channel width	21% increase	0.8 pieces LW per channel width
Gordon 1A	24% surface area of gravel patches is fine sediment	25% decrease	18% surface area of gravel patches is fine sediment
	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	30% of total habitat is large-cobble riffles	17% decrease	25% of total habitat is large-cobble riffles
	14% of total is pool habitat	115% increase	30% of total is pool habitat
	3% of total habitat is pool-tail habitat	46% increase	5% of total habitat is pool-tail habitat
	52% of total habitat is small-cobble riffles	33% decrease	35% of total habitat is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Gordon 1B	0% of total habitat is backwater pools	increase from 0% to 5%	5% of total habitat is backwater pools
	6% of total is pool habitat	212% increase	20% of total is pool habitat
	1% of total is pool-tail habitat	326% increase	5% of total is pool-tail habitat
	58% of total is small-cobble riffles	40% decrease	35% of total is small-cobble riffles
	38% of full riparian function	118% improvement	83% of full riparian function
	1.5 pieces LW per channel width	567% increase	10 pieces LW per channel width
Sandy 1	25% artificial confinement	20% reduction	20% artificial confinement
	63% of full riparian function	19% improvement	75% of full riparian function
	6.5 pieces LW per channel width	35% increase	8.8 pieces LW per channel width
Sandy 2	38% of full riparian function	69% improvement	64% of full riparian function
	EDT maximum water temperature score of 3	3% decrease in the score	EDT maximum water temperature score of 2.9
	6.5 pieces LW per channel width	121% increase	14.4 pieces LW per channel width
Trout 1A	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Trout 2A	1.5 pieces LW per channel width	13% increase	1.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Beaver 1A riparian function, the current condition of 63% will be improved by 3% to give 0.63+(0.63*0.03)=0.65.

Table E-19. Habitat Benefits for Coho in the Middle Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Alder 1	Partial barrier at RM 0.1		Access to 1.6 river miles
	1.5 pieces LW per channel width	7% increase	1.6 pieces LW per channel width
Alder 1A	Partial barrier at RM 1.7		Access to 3.8 river miles
	63% of full riparian function	59% improvement	100% of full riparian function
	1.5 pieces LW per channel width	100% increase	3 pieces LW per channel width
Alder 2	63% of full riparian function	59% improvement	100% of full riparian function
	1.5 pieces LW per channel width	100% increase	3 pieces LW per channel width
Cedar 1	Partial barrier at ~ RM 0.5		Access to ~ 11.5 river miles
	7 mg/l of dissolved oxygen	14% increase	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement	EDT fish pathogen score of 1.6
	EDT minimum water temperature score of 1	20% decrease in the score	EDT minimum water temperature score of 0.8
	EDT score of 2 in the maximum water temperature score	20% decrease in the score	EDT score of 1.6 in the maximum water temperature score
	EDT temperature moderation by groundwater score of 3	33% improvement in the score	EDT temperature moderation by groundwater score of 2
Cedar 2	7 mg/l of dissolved oxygen	14% increase[c]	8 mg/l of dissolved oxygen
	EDT score of 2 in fish pathogen score	20% improvement in the score[c]	EDT score of 1.6 in fish pathogen score
	15% of total is off-channel habitat	75% increase[c]	26% of total is off-channel habitat
	63% of full riparian function	19% improvement[c]	75% of full riparian function
	EDT minimum water temperature score of 1	20% decrease in the score[c]	EDT minimum water temperature score of 0.8
	EDT maximum water temperature score of 2	20% decrease in the score[c]	EDT maximum water temperature score of 1.6
	EDT temperature moderation by groundwater score of 3	33% improvement in the score[c]	EDT temperature moderation by groundwater score of 2
	1.5 pieces LW per channel width	167% increase[c]	4 pieces LW per channel width
Cedar 3	7 mg/l of dissolved oxygen	14% increase[c]	8 mg/l of dissolved oxygen
	EDT fish pathogen score of 2	20% improvement[c]	EDT fish pathogen score of 1.6
	6% of total is beaver pond habitat	39% increase[c]	8% of total is beaver pond habitat
	15% of total is off-channel habitat	45% increase[c]	22% of total is off-channel habitat
	21% of total is pool habitat	25% increase[c]	26% of total is pool habitat
	63% of full riparian function	19% improvement[c]	75% of full riparian function
	EDT minimum water temperature score of 1	20% decrease in the score[c]	EDT minimum water temperature score of 0.8
	EDT maximum water temperature score of 2	20% decrease in the score[c]	EDT maximum water temperature score of 1.6
	EDT temperature moderation by groundwater score of 3	33% improvement in the score[c]	EDT temperature moderation by groundwater score of 2
	1.5 pieces LW per channel width	100% increase[c]	3 pieces LW per channel width

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Table E-19. Habitat Benefits for Coho in the Middle Sandy River Watershed by Reach, continued

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 3	83% of full riparian function	5% improvement	87% of full riparian function
	EDT score of 3 in the maximum water temperature score	1% decrease in the score	EDT score of 2.97 in the maximum water temperature score
	2.0 pieces LW per channel width	31% increase	2.6 pieces LW per channel width
Sandy 7	25.0 carcasses per stream mile	70% increase[c,d]	42.5 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	2% decrease in the score	EDT score of 1.97 in the maximum water temperature score

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Alder 1A riparian function, the current condition of 63% will be improved by 59% to give 0.63+(0.63*0.59)=1.0.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-20. Habitat Benefits for Coho in the Upper Sandy River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Sandy 8	63% of full riparian function	14% improvement	72% of full riparian function
	113 carcasses per stream mile	31% increase[c,d]	148 carcasses per stream mile
	EDT score of 2 in the maximum water temperature score	3% decrease in the score	EDT score of 1.95 in the maximum water temperature score
	2.0 pieces LW per channel width	34% increase	2.7 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Sandy 8 riparian function, the current condition of 63% will be improved by 14% to give 0.63+(0.63*0.14)=0.72.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Table E-21. Habitat Benefits for Coho in the Salmon River Watershed by Reach

Reach	Current Condition	Habitat Benefit	Post-Implementation Condition[a,b]
Boulder 0	24% fine sediments by surface area	5% decrease	22.8% fine sediments by surface area
	EDT maximum water temperature score of 1.5	27% decrease in the score	EDT maximum water temperature score of 1.1
	0.7 pieces LW per channel width	315% increase	2.8 pieces LW per channel width
Boulder 1	83% of full riparian function	20% improvement	100% of full riparian function
	EDT maximum water temperature score of 1.5	13% decrease in the score	EDT maximum water temperature score of 1.3
	1.5 pieces LW per channel width	133% increase	3.5 pieces LW per channel width
Salmon 1	3% of total is off-channel habitat	66% increase	4% of total is off-channel habitat
	3% of total is small-cobble riffles	54% decrease	5% of total is small-cobble riffles
	75% of full riparian function	8% improvement	81% of full riparian function
	200 carcasses per stream mile	50% increase[c,d]	300 carcasses per stream mile
	EDT maximum water temperature score of 3	21% decrease in the score	EDT maximum water temperature score of 2.36
	2.0 pieces LW per channel width	62% increase	3.2 pieces LW per channel width
Salmon 2	14.0 cm is average depth of bed scour	3% reduction	13.6 cm is average depth of bed scour
	25% artificial confinement	12% reduction	22% artificial confinement
	3% of total is off-channel habitat	90% increase	5% of total is off-channel habitat
	50% of full riparian function	33% improvement	67% of full riparian function
	EDT maximum water temperature score of 2	2% decrease in the score	EDT maximum water temperature score of 1.97
	2.0 pieces LW per channel width	67% increase	3.3 pieces LW per channel width
Salmon 3	2 pieces LW per channel width	90% increase in the amount of LW	3.8 pieces LW per channel width

Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures. Post-implementation values are cumulative benefits expected from individual restoration projects that affect the same attributes in the same reach.

[a]Some post-implementation conditions are expressed as units per measure of habitat, e.g., LW pieces per channel width. Other attributes are expressed as EDT ratings from 0 to 4, in which 0 represents optimal conditions (zero negative impact) and 4 represents extremely poor or lethal conditions.

[b] When the current and post-implementation conditions are expressed as a percentage, the habitat benefit is expressed as a percentage change of the current condition percentage. Using the example of Boulder 0 fine sediments, the current condition of 24% will be reduced by 5% to give 0.24-(0.24*0.05)=0.228.

[c]This habitat benefit was not included in the EDT model run used to determine the effects of the HCP measures on adult salmon and steelhead abundance.

[d]Salmon carcass placement is a one-time treatment.

Literature Cited

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, Inc.

Appendix F. Monitoring and Research Protocols

Introduction

Chapter 9 of the Habitat Conservation Plan (HCP) introduces the City of Portland's (City's) monitoring and research programs designed to document compliance and verify progress toward meeting the measurable objectives defined in that chapter. Protocols for effectiveness monitoring are provided in this appendix. Protocols for compliance monitoring are provided in Tables 9-1 and 9-2 in Chapter 9.

The City will also conduct a series of research measures. Protocols for these measures are also included in this appendix. Research in the Bull Run watershed will include spawning gravel availability, the degree of Chinook spawning gravel bed scour, adult Chinook counts, and concentrations of total dissolved gases (TDG). The City will also conduct research on juvenile salmonid outmigrants (JOMs) in conjunction with the Oregon Department of Fish and Wildlife (ODFW), U.S. Forest Service (USFS, Mt. Hood National Forest), Bureau of Land Management (BLM), and the Oregon Department of Environmental Quality (ODEQ) in the Sandy River Basin. The City's research is in addition to the compliance and effectiveness monitoring efforts of the HCP and it plays an important role in the City's adaptive management approach described Chapter 9.

Effectiveness Monitoring

Effectiveness monitoring protocols are described below for the in-channel measures that will be conducted in the Sandy River Basin. These measures include large wood (LW) placement/log jam creation, side-channel development, river mouth reestablishment, and floodplain reconnection.

Effectiveness Monitoring for Offsite In-channel Conservation Measures

This protocol describes sampling methods and assessment procedures for monitoring the effectiveness of the offsite, in-channel conservation measures in Chapter 7 of this HCP. Offsite measures occur outside of the Bull Run River but within the anadromous reaches of the Sandy River watershed or in the tributary basin of the Little Sandy River.[1] In-channel measures occur actively within the normal high-flow channel of the stream. In-channel measures do not include efforts to improve the riparian zone.

[1] The Little Sandy River is a tributary of the Bull Run River, but enters below Dam 2. Although the Little Sandy is within the Bull Run watershed, its in-channel measure functions as an offsite measure.

Measurable Habitat Objectives and Working Hypothesis

The offsite in-channel measures discussed in Chapter 7 are summarized by reach and general restoration category in Table F-1. The measures and their predicted effects on habitat attributes have been evaluated using the Ecosystem Diagnostic and Treatment (EDT) model (City of Portland and Mobrand Biometrics 2004). The anticipated benefits of these measures are summarized by reach and ranked by predicted net change in the attributes' respective metrics in Table F-2 on the next page. The net attribute changes in Table F-2 include only benefits expected to be derived from in-channel restoration projects.

Table F-1. Treated Reaches in Watersheds by Treatment Category

Watershed	Treated Reaches	Project Treatment Types
Lower Sandy River	Gordon 1A and 1B, Trout 1A, Sandy 1 and 2	LW placement/log jam creation
	Sandy 1	Side-channel development
	Sandy 1	River mouth reestablishment
Middle Sandy River	Cedar 2 and 3	LW placement/log jam creation
Bull Run River	Little Sandy 1	LW placement/log jam creation
Salmon River	Salmon 2, Boulder 0 and 1	LW placement/log jam creation
	Salmon 2	Floodplain reconnection/side channel development
Zigzag River	Zigzag 1A	LW placement/log jam creation, Floodplain reconnection/ side-channel development

The net changes predicted in Table F-2 represent measurable habitat objectives created for each individual reach. The monitoring objective is to document the effectiveness of the offsite in-channel measures at accomplishing the measurable habitat objectives. The City's working hypothesis for effectiveness monitoring of the offsite in-channel conservation measures is that at least 80 percent of the projected changes in the key habitat attributes (pre-project versus post-project conditions) will occur in each affected stream reach.   The "80 percent of the projected changes" is not an EDT output, but it is a performance level that the City is committing to for this HCP. The City chose the 80 percent level, instead of a 100 percent level, because there will be a high degree of natural variation, year to year and site to site. The natural variation will be further compounded by the error associated with measuring habitat variables in the field. Given this high level of variation, it would not be possible to   statistically detect a difference between a 100 percent change in a habitat variable and a much smaller change. The City chose 80 percent as a minimum performance standard. If that level of habitat response is not met, additional actions will occur, and the City will follow the adaptive management program described in Chapter 9.

Table F-2. Attributes and Measurable Habitat Objectives in Reaches Affected by In-channel Measures

	Measurable Habitat Objective (80% of Net Change in Metric)		
Attribute	**Metric**	**Net Change**	**Reach**
Large wood	Number of pieces per channel width	26%	Sandy 1
Artificial confinement	% length of bank artificially confined	-20%	
Large wood	Number of pieces per channel width	70%	Sandy 2
Large wood	Number of pieces per channel width	19%	Sandy 8
Large wood	Number of pieces per channel width	567%	Gordon 1A
Backwater pools	Percentage of reach (by surface area) that comprises backwater pools	Increase from 0% to 5%	
Pool habitat	Percentage of reach (by surface area) that comprises pool habitat	115%	
Pool-tail habitat	Percentage of reach (by surface area) that comprises pool tail-outs	46%	
Small-cobble riffles	Percentage of reach (by surface area) that comprises small cobble riffles	-33%	
Fine sediment	Percentage of gravel patches (by surface area) that is fine sediment	-25%	
Large-cobble riffle	Percentage of reach (by surface area) that comprises large cobble riffles	-17%	
Large wood	Number of pieces per channel width	567%	Gordon 1B
Pool habitat	Percentage of reach (by surface area) that comprises pool habitat	212%	
Pool-tail habitat	Percentage of reach (by surface area) that comprises pool tail-outs	326%	
Backwater pools	Percentage of reach (by surface area) that comprises backwater pools	Increase from 0% to 5%	
Small-cobble riffles	Percentage of reach (by surface area) that comprises small cobble riffles	-40%	
Large wood	Number of pieces per channel width	7%	Trout 1A
Large wood	Number of pieces per channel width	13%	Trout 2a
Large wood	Number of pieces per channel width	34%	Little Sandy 1
Large wood	Number of pieces per channel width	100%	Cedar 2
Large wood	Number of pieces per channel width	67%	Cedar 3
Beaver ponds	Percentage of reach (by surface area) that comprises beaver ponds	39%	
Pool habitat	Percentage of reach (by surface area) that comprises pool habitat	25%	

Table continued on next page.

Table F-2. Attributes and Measurable Habitat Objectives in Reaches Affected by In-channel Measures, continued

	Measurable Habitat Objective (80% of Net Change in Metric)		
Attribute	**Metric**	**Net Change**	**Reach**
Large wood	Number of pieces per channel width	10%	Salmon 2
Artificial confinement	% length of bank artificially confined	-12%	
Large wood	Number of pieces per channel width	90%	Salmon 3
Large wood	Number of pieces per channel width	231%	Boulder 0
Large wood	Number of pieces per channel width	100%	Boulder 1
Large wood	Number of pieces per channel width	291%	Zigzag 1A
Artificial confinement	% length of bank artificially confined	-38%	
Large-cobble riffle	Percentage of reach (by surface area) that comprises large cobble riffles	-25%	
Small-cobble riffle	Percentage of reach (by surface area) that comprises small cobble riffles	4%	
Pools	Percentage of reach (by surface area) that comprises pools	27%	
Pool-tails	Percentage of reach (by surface area) that comprises pool-tails	15%	

Key Questions/Hypotheses. One key question will be answered by the offsite monitoring protocol:

Did the implementation of the restoration projects result in the changes to the monitored habitat attributes that were predicted by the EDT assessment?

- H_o: The mean of post-treatment values in treatment reaches will not be significantly less than the change from baseline values predicted by the EDT assessment.

In order to make this comparison, the baseline values in EDT will be updated by collecting two years of pre-treatment data on all the habitat attributes that are predicted to significantly change (summarized in Table F-2). If the baseline habitat conditions are the same or worse than those used to develop the measurable habitat objectives summarized in Table F-2, the City will proceed with the in-channel conservation measures as described in the HCP. If the current reach habitat conditions are found to be better than those originally rated in 2003, the City will follow the framework for adaptive response described in Section 9.4.3 of the HCP.

The comparison of the observed changes in monitored habitat attributes to measurable habitat objectives will be analyzed both numerically and statistically (using a 95 percent level of confidence). The numeric test will simply determine if the mean of post-treatment values is at least 80 percent of the target values. The measurable habitat objective for each offsite in-channel measure response variable was set at 80 percent of the projected change for the numeric comparison to account for the fact that each variable is expected to show a large degree of natural variation, year to year and site to site. This natural variation will be compounded by the error associated with measuring habitat attributes in the field. The statistical test will assign a level of confidence to each of the pre-treatment and post-treatment values and determine the power of the statistical test to detect significant shortfalls. Having a level of confidence associated with each EDT value will be helpful during the adaptive management process, if any post-treatment value should fall short of the measurable habitat objective. The numeric comparison will provide a back-up criterion, in case the statistical comparison does not have adequate power to detect significant shortfalls in the measurable habitat objectives.

Monitoring Design

The City has the following options to monitor the effects of its instream restoration efforts:

1. Compare each reach's post-treatment condition to its pre-treatment condition. This option requires collecting data over many pre-treatment and post-treatment years.
2. Compare the both the pre-treatment and post-treatment condition of each reach with those of a similar control reach. This also requires the collection of data over multiple years, but because a control reach will account for much of the variation in measurable habitat attributes caused by factors such as storms or other disturbances, a smaller number of years will be sufficient.

The City has selected the second monitoring option because the time and resources necessary to collect data over a large number of pre-treatment and post-treatment years would be prohibitive. The City will use a Before-After with Control-Impact (BACI) study design to monitor the effects of the HCP offsite, instream mitigation projects (Roni et al. 2005). Control reaches upstream of the treated reaches will be surveyed, in addition to the treated reaches (Table F-3). Control reaches will be entire upstream reaches delineated for EDT or one mile in length, whichever is less, to minimize survey effort, yet provide a representative length of stream. In cases in which a treated reach is very long (over five miles) and the treatment is restricted to the lower portion of the reach, the upstream portion of the same reach will serve as a control. This approach is used because the further upstream that a control reach is, the less representative it probably is of the habitat where treatment occurred. Given the hierarchical nature of stream networks, many treatment and control reaches are downstream of other reaches where the City will implement restoration projects. These upstream treatment reaches could influence downstream reaches by, for example, exporting large wood. Control reaches could be influenced in this way more than the respective treatment reach because they are, in every case, located upstream. This potential bias cannot be avoided but is likely to make the comparison more conservative. The City will remain cognizant of it when analyzing monitoring data. The City will use attribute values for the entire EDT reach (including control-reach segment) as the treatment reach values and just attribute values from the control-reach segment as the respective control-reach values.

Table F-3. Paired Treated and Control Reaches

HCP Years Implemented	Watershed	Treated Reaches	Control Reaches
1–5	Lower Sandy River	Trout 1A	Trout 3A
		Trout 2A	Trout 3A
		Gordon 1A	Gordon 2A
		Gordon 1B	Gordon 2A
	Bull Run River	Little Sandy 1	Little Sandy 2
	Salmon River	Boulder 0	Boulder 2
		Boulder 1	Boulder 2
6–10	Lower Sandy River	Sandy 1	Sandy 1
		Sandy 2	Sandy 2
	Middle Sandy River	Cedar 2	Cedar 4
		Cedar 3	Cedar 4
11–15	Salmon River	Salmon 2	Salmon 2
	Zigzag River	Zigzag 1A	Zigzag 1B

Sampling Scheme. Habitat attributes in both treatment and control reaches will be monitored using the ODFW Aquatic Inventories Project (AIP) stream habitat survey protocol (Moore et al. 2002). The AIP survey protocol is an extensive inventory of stream channel, riparian vegetation, and aquatic habitat conditions following a stratified-systematic sampling design

The standard AIP protocol involves two main sources of error. The City will adjust the protocol to reduce these sources of error. The first source of error stems from the strategy of estimating habitat dimensions throughout a reach and then using a subset of measurements to correct the estimates. These corrections are associated with a range of variability, which decreases confidence in the final result. To maximize the statistical power of the monitoring data analysis, given the small sample size of pre-treatment data, all habitat unit dimensions will be measured. The second source of error is measurement error, which can accumulate over the length of a reach. The City will monument survey reaches at specific intervals to allow for standardization of lengths between years.

In addition to the standard AIP in-channel data, surveys will include a measurement of the length of each bank that is artificially constrained. Other riparian information will not be collected, except for recording observations that directly pertain to interpreting instream conditions. Collecting extensive riparian data would dramatically increase survey effort without contributing to the evaluation of the in-channel restoration efforts. The AIP protocols will also be modified by the addition of a habitat-unit-scale visual estimate of off-channel habitat, other than side channels, for each unit. Off-channel habitat will be defined as the estimated surface area of individual alcove habitats, the portion of certain tributaries that flow over the main channel's floodplain and provide access to fish from the main channel, or ponds adjacent to the channel but connected to it only during high-water events. The surface area of these habitats will not be included in the total surface area of adjacent habitat units. During analysis, these data will be combined with data on side channels to estimate the percentage of each reach's total habitat that consists of off-channel habitat.

Scale. The measurable habitat objectives (Table F-2) are reach-scale objectives. The AIP protocols collect data at both the habitat-unit and reach scales, but they all are used to derive reach-scale assessments of habitat condition. Reaches vary in length, so all attribute values will be normalized by either channel length or surface area.

Data that will be collected. The habitat attributes used by EDT to evaluate restoration alternatives are derived from the data-types summarized below. All are information collected during stream surveys. However, not all attributes will be used to evaluate the effectiveness of the offsite in-channel measures.

- Reach-scale data
    - Active channel (Bankfull)[2] width (feet)
    - Gradient (%)
    - Total surface area of off-channel habitat (estimated visually in square feet)
- Habitat unit-scale data
    - Habitat type (pool, backwater pool, beaver pond, glide, small cobble riffle, large cobble riffle)
    - Average length (feet)
    - Average width (feet)
    - Amount of pool tail-out habitat (Data collected in pools only, percentage of total surface area that is at the down-stream end of the pool and flowing with velocities comparable to those of neighboring glides and riffles)
    - Confinement – Natural (categorical: confined, moderately confined, unconfined)
    - Confinement – Hydrological modifications (% of both banks)
    - In-channel wood (# pieces greater than 1 foot diameter and greater than 7 feet long in active channel of habitat unit)
    - Fine sediment in spawning habitat types (% surface area of gravel patches in small cobble riffles; pool tail-outs, glides)
    - Embeddedness in spawning habitat types (% of the vertical dimension of surface cobbles and large gravel that is buried in fine sediment in gravel patches in small cobble riffles; pool tail-outs, glides)

These data will allow the City to evaluate how well it has met most of the measurable habitat objectives summarized in Table F-2. The percentage of fine sediment in spawning gravels may show too much within-reach variability to allow the detection of the anticipated change.

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[2] The active channel, or bankfull channel, is the portion of the channel where flows occur often enough to prevent the establishment of vegetation, generally corresponding to a break in the slope of the bank.

Replication/Duration. Most habitat attributes are naturally variable from year to year. For example, there may not be formation of pools expected to result from the addition of wood during the first winter if high flows do not occur. In other years, high flows might fill in some pools and create new ones elsewhere. For this reason, Before (pre-treatment) and After (post-treatment) data will be replicated across time. Pre-treatment data for each reach will be collected for two years (n_{before}=2). This replication provides a minimum estimate of annual variation in habitat features when comparing pre-treatment and post-treatment data in treatment and control streams. Monitoring will continue once every three years *after* treatment for the first 15 years for a total of 5 post-treatment sampling surveys (n_{after}=5).

The monitoring schedule is tied implicitly to the HCP implementation schedule, as shown in Table F-4. In-channel restoration projects are anticipated to provide rapid changes in stream habitat conditions and, hence, relatively immediate benefits to fish productivity. The City has assumed the life of each in-channel project to be approximately 15 years. Monitoring results will be summarized and discussed at the first monitoring check-in meeting with NMFS following 15 years of data collection. A monitoring program for assessment in subsequent years will be reviewed and approved during the Year 15 check-in meeting.

Table F-4. Schedule for Offsite Mitigation Effectiveness Monitoring

				HCP Plan Year																						
Years	**Reach**	**Total Length**	**Treated Length**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
	Trout 1A	0.5	0.2	B	B	A			A			A			A			A								
	Trout 2a	0.3	0.3	B	B	A			A			A			A			A								
	Trout 3a	0.5	-	C	C	C			C			C			C			C								
	Gordon 1A	1.6	1.8	B	B	A			A			A			A			A								
1–5	Gordon 1B	2.4	2.2	B	B	A			A			A			A			A								
	Gordon 2a	3.2	-	C	C	C			C			C			C			C								
	Boulder 0	0.3	0.3	B	B	A			A			A			A			A								
	Boulder 1	0.6	0.6	B	B	A			A			A			A			A								
	Boulder 2	3.7	-	C	C	C			C			C			C			C								
Subtotal																										
	Sandy 1	5.4	1.0				B	B	A			A			A			A			A					
	Sandy 1	5.4	1.0				C	C	C			C			C			C			C					
	Sandy 2	12.4	1.0				B	B	A			A			A			A			A					
	Sandy 2	12.4	1.0				C	C	C			C			C			C			C					
6–10	Little Sandy 1	1.8	1.8				B	B	A			A			A			A			A					
	Little Sandy 2	1.0	-				C	C	C			C			C			C			C					
	Cedar 2	3.4	3.5				B	B	A			A			A			A			A					
	Cedar 3	5.3	5.3				B	B	A			A			A			A			A					
	Cedar 4	4.5	-				C	C	C			C			C			C			C					
Subtotal																										
	Salmon 2	6.2	0.3									B	B	A			A			A			A			A
	Salmon 2	6.2	0.3									C	C	C			C			C			C			C
	Sandy 8[b]	5.6	-									B	B	A			A			A			A			A
	Sandy 9	-	-									C	C	C			C			C			C			C
11–15	Zigzag 1A	2.2	1.1									B	B	A			A			A			A			A
	Zigzag 1A	2.2	1.1									C	C	C			C			C			C			C
	Zigzag 1B	5.1	2.4									B	B	A			A			A			A			A
	Zigzag 1B	5.1	2.4									C	C	C			C			C			C			C
Subtotal																										
Total																										
Evaluation																							M/R			

[a]B= Before (Pre-Treatment) surveys, A=After (Post-Treatment) Surveys, C=Control surveys (survey reaches are shaded in the table), M/R=Meeting of the Basin Partners/Report
[b]Sandy 8 is expected to receive significant benefits from restoration work done in Zigzag 1A and 1.

Analysis

Data Storage. Monitoring data collected during the HCP will be maintained by the City in a Microsoft® Access database. Summary data will be added to the Sandy River EDT database. It will be made available to NMFS for review at any time and will be extensively discussed during the HCP Year 20 check-in meeting of the City with NMFS. Following quality assurance/quality control procedures, and review and approval by the City and NMFS, the data will be made available to the StreamNet Library (through the Columbia River Inter-Tribal Fish Commission [CRITFC] technical reports), ODFW AIP (http://oregonstate.edu/Dept/ODFW/freshwater/inventory/index.htm), and the USFS Natural Resource Information System (NRIS) Water module databases. Each of these databases was consulted extensively in the Sandy River Basin EDT analysis. Appropriate treatment- and control-reach data that are already in these databases will be used to bolster the sample size of the pre-treatment habitat attributes. Pre-existing data will not be used if the habitat in the respective streams has since been modified by restoration activities other than the planned HCP offsite in-channel measures.

Hypothesis Testing. Both the numeric and statistical evaluation of the hypotheses for the monitoring plan key question suggest a fundamental comparison between pre-treatment and post-treatment data on a reach-by-reach, attribute-by-attribute basis. Control reaches will be employed to subtract out variation due to large-scale effects outside of the City’s control. An example of how this would occur is given below (T=Treatment reach value, C=Control reach value):

$$\left.\begin{matrix} T_{before1}-C_{before1} \\ T_{before2}-C_{before2} \end{matrix}\right\} \textbf{mean} \quad \text{vs.} \quad \textbf{mean} \left\{\begin{matrix} T_{after1}-C_{after1} \\ T_{after2}-C_{after2} \\ T_{after3}-C_{after3} \\ T_{after4}-C_{after4} \\ T_{after5}-C_{after5} \end{matrix}\right.$$

The numeric comparison of the means of pre-treatment and post-treatment data will determine whether or not the post-treatment mean is equal to or greater than 80 percent of the measurable habitat objective. For statistical comparisons, t-tests will be performed on the differences between treatment reach and control reach habitat attribute values, with a 95 percent level of confidence.

Adaptive Management. If data indicate that the effectiveness monitoring protocol hypotheses should be rejected and the new EDT results do not indicate that the predicted changes to freshwater productivity would be at least as much as originally described for the City’s offsite in-channel conservation measures, the City will follow the adaptive management process described in Chapter 9 of the HCP.

Research Program

The City will conduct research on several factors in the Bull Run watershed: spawning gravel placement, the degree of Chinook spawning gravel bed scour, and concentrations of TDG. In addition, the City will work with ODFW, USFS (Mt. Hood National Forest), BLM, and ODEQ to measure JOMs in the Sandy River Basin. The results of the City's research will be evaluated with monitoring results to determine the City's adaptive management response over time.

Research in the Bull Run Watershed

Lower Bull Run River Spawning Gravel Research Protocol

The availability of appropriate gravel patches can limit the productivity of salmonid populations within a given stream. The dams on the Bull Run River block the downstream movement of stream-bed substrates. These obstructions have contributed over time to a net loss of spawning gravel patches in the lower Bull Run River, as gravel is washed away and then not replaced.

The availability of spawning gravel in the lower Bull Run River was estimated in 1997, 1999, and 2001 (R2 Resource Consultants 1998, Beak and CH2M Hill 2001). The most recent survey estimated that there are approximately 1,082 square feet of spawning gravel available to steelhead and 1,352 square feet available to Chinook salmon.

The City's HCP proposes adding adequately sized gravel annually to the lower Bull Run River to benefit spawning salmonids. This appendix describes the methods and protocols for monitoring the effectiveness of this effort to increase the surface area of spawning gravel in the lower Bull Run River.

Measurable Habitat Objectives

The City identified a measurable habitat objective for the spawning gravel placement conservation measure (see HCP Chapters 7 and 9). The City will supply spawning gravel in amounts equivalent to or exceeding natural supply rates. The City will augment spawning gravel in the lower Bull Run River with a total of 1,200 cubic yards of gravel annually for the first 5 years of the HCP implementation. This roughly doubles the estimated natural recruitment rate of gravel, in the absence of reservoirs (calculations and estimates summarized in CH2M Hill 2003) and is intended to accelerate the accumulation of gravel in the lower Bull Run River. After five years, the rate of gravel supplementation by the City would be decreased to 600 cubic yards annually for the remainder of the HCP, the estimated natural recruitment rate in the absence of upstream reservoirs. The City, however, cannot predict how the gravel will be distributed or how quickly it will be moved downstream. There is no information on the areal extent of spawning gravel in the lower Bull Run prior to the construction of the Bull Run dams, beginning in 1929.

Research Objective

The objective of the Bull Run River spawning gravel research is to measure the surface area of patches of gravel suitable for spawning steelhead and Chinook salmon in an index reach of the lower Bull Run River. Separate estimates will be generated for steelhead and Chinook salmon. The City will quantify both the surface area of all patches with suitable substrate size ranges and the surface area of the subset of the patches that would be effective for spawning. Effective spawning gravel patches are patches that experience adequate depth and flow throughout the egg and alevin incubation period.

Key Questions/Hypotheses

The key questions (and related hypotheses) to be answered by the Bull Run River spawning gravel research are the following:

Question 1: What is the summed surface area of gravel patches suitable for steelhead and Chinook spawning in the lower Bull Run River and has it significantly increased from pre-supplementation values?

- H_o: The summed surface area of spawning gravel patches in each post-supplementation year will not be significantly greater than the mean of pre-supplementation years (one-sample t-test, α=0.05).

The pre-supplementation years that will be used for the analysis are 1997, 1999, and 2001. The City may also do additional spawning gravel surveys prior to the start of the HCP. If those surveys are completed, the data from those surveys will also be used as pre-supplementation years for the analysis.

Question 2: What is the effective spawning area of each reach (see below under *Research Design* for a definition of effective spawning area) at various combinations of flows and at the flows actually observed during steelhead incubation in the lower Bull Run River?

- H_o: The summed effective spawning area at various flow combinations in each post-supplementation year will not be significantly greater than the mean of pre-supplementation years (one-sample t-test, α =0.05).

The pre-supplementation years that will be used for the analysis are 1997, 1999, and 2001. The City may also do additional spawning gravel surveys prior to the start of the HCP. If those surveys are completed, the data from those surveys will also be used as pre-supplementation years for the analysis.

Question 3: What is the trend in the summed surface area of spawning gravel patches and the effective spawning area for each reach?

- H_o: The summed surface area of spawning gravel patches in post-supplementation years will not show a significant increase over time (α=0.05).
- H_o: The summed surface area of effective spawning gravel patches at various flow combinations in post-supplementation years will not show a significant increase over time (α=0.05).

Research Design

The design of the lower Bull Run spawning gravel research will involve the use of surveys of spawning gravel surface area to create a snapshot of the distribution of spawning gravel at a particular point in time. Previously developed relationships between stage and discharge in each reach will then be used to estimate the amount of spawning gravel that will have suitable depth and velocities for spawning and egg and alevin incubation at various flows for steelhead and spring and fall Chinook salmon.

The amount of steelhead spawning gravel will be estimated for the following flows:

- **1,405 cubic feet per second (cfs):** 10 percent average exceedence flow for March, April, and May (peak steelhead spawning months)
- **614 cfs:** 50 percent average exceedence flow for March, April, and May
- **120 cfs:** The lowest allowed flow during March, April, and May under the HCP measure for minimum flows (actual flows may be higher)

The amount of spring Chinook spawning gravel will be estimated for the following flows:

- **358 cfs:** 10 percent average exceedence flow for September and October (the peak spring Chinook spawning months)
- **77 cfs :** 50 percent average exceedence flow for September and October
- **30 cfs**: The lowest allowed flow during September and October under the HCP measure for minimum flows (actual flows may be higher)

The amount of fall Chinook spawning gravel will be estimated for the following flows:

- **1,480 cfs:** 10 percent average exceedence flow for October and November (the peak fall Chinook spawning months)
- **77 cfs :** 50 percent average exceedence flow for October and November
- **30 cfs**: The lowest allowed flow during October and November under the HCP measure for minimum flows (actual flows may be higher)

Calculating the amount of spawning gravel at the 10 percent and 50 percent exceedence flows, as well as the minimum allowable flow for each species' peak spawning period, allows for comparisons in the amount of spawning gravel across flows and across years. The amount of gravel wetted at the minimum allowable flow represents the minimum amount of gravel that would be available to each species. The amount of gravel wetted at the 10 percent and 50 percent exceedence flows indicates how far up the margins of the channel gravel accumulates and how much gravel remains available for spawning. This combined information will be used to evaluate the effectiveness of the HCP spawning gravel placement at increasing the amount of spawning gravel for steelhead and spring and fall Chinook.

The suitability of gravel patches in the lower Bull Run River for both spawning and incubation will be determined for each combination of flows above and for the actual flow regime experienced during steelhead and Chinook spawning and incubation in the year of the survey[3]. The area of gravel that meets depth and water velocity criteria for both spawning and incubation (Table F-5) during the respective period will be summed to determine the "effective spawning area" of each reach (R2 Resource Consultants 1998).

Table F-5. Minimum Gravel Depth and Water Velocity for Spawning and Incubation Periods for Steelhead and Chinook

	Steelhead	Chinook	Minimum Depth	Minimum Water Velocity
Spawning	March–May	September–November	0.6 feet	0.7 ft/sec
Incubation	March–July	September–April	0.1 feet	0.1 ft/sec

Source: R2 Resource Consultants 1998

Spatial Scale. Surveys will be used to determine the amount and quality of spawning gravel at various flows within the lower Bull Run River from the mouth to the Reservoir 2 spillway plunge pool. Results will be applicable only to the lower Bull Run River and have a reach-scale resolution.

Replication/Duration. Surveys will be conducted once per year in the late spring/early summer or early fall in conjunction with adult Chinook surveys. The surveys will occur after high flows associated with winter and spring storms have ceased, and spawning gravel patches have stabilized representing the amount available to steelhead and later to Chinook spawners for that year. There will be no spatial replication; the entire channel will be surveyed.

One survey will be conducted each year, from HCP Years 2 through 6, while increased gravel supplementation occurs. This represents the period of time when gravel is expected to accumulate most rapidly in the lower Bull Run River.

After gravel supplementation is reduced in Year 6 of the HCP, gravel surveys will continue once per year for an additional five years, from HCP Years 7 through 11. During this phase, gravel supplementation is primarily intended to maintain gravel deposits in the lower Bull Run River and surveys are designed to allow for an analysis powerful enough to detect negative trends in the surface area of spawning gravel.

Provided that gravel supplementation at maintenance levels does not result in a rapid negative trend during HCP Years 7 through 11, the frequency of gravel surveys will be reduced to once every five years for the duration of the HCP.

Variables. The following variables will be measured for each gravel patch:

- Longitudinal Location. Location relative to the beginning of the reach, measured with a hand-held global positioning system (GPS) device

[3] The high flows that recruit and redistribute gravel are expected to occur mostly after the Chinook and before the steelhead peak spawning months. Gravel surveys conducted during the late spring to early fall will therefore be most representative of the levels steelhead encountered the previous spring and what Chinook will encounter the following fall.

- Lateral Location. Location within the channel. Either in the center of the channel, in the channel margin, and above the channel margin (outside the wetted area but within the active channel[4])
- Retention Feature. Feature that acts on current to allow gravel deposition: pool-tail, boulder, bedrock, large wood, and/or slow margins
- Patch size. Surface area of patch (ft^2), calculated as total length multiplied by average width
- Depth or Elevation. For submerged patches, depth of the center of the patch below the water surface. For gravel patches above the water surface, elevation of the center of the patch above the water surface
- Velocity. The average velocity (ft/sec) at six-tenths depth from the surface over the upstream end of the gravel patch
- Embeddedness. The visually estimated percentage of the vertical dimension of surface substrates between 1.8 inches and 4 inches intermediate axis (roughly golf-ball size to softball size) that is surrounded by silt and sand. Average of 10 particles per patch of varying sizes. The percentage of total embeddedness will be calculated as

  $$\%\text{Total Embedded}=([(\%\text{Embedded}_{\text{large particles}}/100)*(100-\%\text{ fines})]+[\%\text{ fines}])/100.$$

  (Embeddedness procedures are reviewed in Sylte and Fischenich 2002).
- Percentage of Fines. Estimated surface area of patch covered by silt and sand (not a thin film over other obvious surface substrates)
- Dominant and Subdominant Substrate Size. Substrate size categories were chosen to correspond to various size thresholds used in previous surveys and gravel scour studies in the Bull Run River.
  - Silt and Sand: >0.1 inch
  - Small Gravel: 0.1 to 0.4 inch
  - Medium Gravel: 0.4 to 1.8 inches
  - Large Gravel: 1.8 to 4.0 inches
  - Small Cobble[5]: 4.0-6.0 inches

Sampling Scheme. Methods and protocols used to survey spawning gravel patches will closely follow those used in previous years (Beak and CH2M Hill 2001).

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[4] The active channel, or bankfull channel, is the portion of the channel where flows occur often enough to prevent the establishment of vegetation, generally corresponding to a break in the slope of the bank.

[5] The size range of small cobble used here differs slightly from that used to define small cobble riffles for EDT, which considers small cobble to be from 2.9 to 5.0 inches. The range used here corresponds to the size of substrate that can be used by spawning Chinook salmon, but not by steelhead.

The lower Bull Run River will be divided into the following survey reaches:

- Reach 1: The confluence of the Bull Run River with the Sandy River to the bottom of the large pool above the Bull Run Portland General Electric (PGE) Powerhouse at RM 1.5
- Reach 2: The bottom of the large pool above the Bull Run PGE Powerhouse to Bowman's Bridge (RM 2.3)
- Reach 3: Bowman's Bridge (RM 2.3) to the confluence of the Little Sandy River (RM 2.8)
- Reach 4: The Little Sandy River Confluence (RM 2.8) to the top of the pool at Larson's Bridge (RM 3.7)
- Reach 5: Larson's Bridge (RM 3.7) to the Road 14 bridge (RM 4.8)
- Reach 6: The Road 14 bridge (RM 4.8) to the Reservoir 2 spillway plunge pool (RM 5.8)

These reach breaks were chosen to be compatible with the reaches used in 1997 and 2001 (R2 Resource Consultants 1997, Beak and CH2M Hill 2001) as well as those used in 1999 (Beak 2000a). They will be surveyed in an upstream direction.

The timing of surveys will be coordinated with operations at the City's Headworks facility and the PGE powerhouse. Flows will be reduced in the lower Bull Run River to less than 150 cfs for the duration of the survey, to allow for safe navigation by field crews and maximize the comparability of the resulting data to that of previous surveys.

Patches of gravel suitable for spawning steelhead and/or Chinook will be identified along the length of each reach. Patches of spawning gravel will be defined as being equal to or greater than 9 square feet, lying within the active channel and composed of substrates between 0.1 and 6.0 inches in diameter along their intermediate axis for Chinook, and between 0.1 and 4.0 inches in diameter for steelhead.

The depth and water velocity at each gravel patch at various flow levels will be determined as described in R2 Resource Consultants (1998), using stage-discharge relationships established for each reach. The amount of effective spawning gravel for each combination of flows will be calculated as described above. The amount of effective spawning gravel under the actual observed flow regime will be determined using flow data from the U.S. Geological Survey (USGS) Gauge No. 14140000.

Analysis

Data Storage. Data will be stored in a Microsoft® Access database managed by the City of Portland Water Bureau.

Hypothesis Testing. The hypotheses relating each year's measured surface area of gravel to the mean of pre-gravel supplementation years will be evaluated using one-tailed, one-sample t-tests (α=0.05). The power of each test will also be calculated.

The significance and direction of the trend in each category of gravel surface area over time will be evaluated using linear regression (α=0.05). The power of each regression will also be calculated.

Adaptive Management

In HCP Years 6 and 12, the City will summarize the effectiveness of the Bull Run spawning gravel placements. If spawning gravel placements are not successful, as defined through hypothesis testing, the City will meet with NMFS to determine options.

Chinook Spawning Gravel Scour Research

The lower Bull Run River experiences high flows during the late fall and winter months, when the Bull Run reservoirs are full and natural high flows exceed the withdrawals of water by the City's facilities. These flows can reach levels that are capable of mobilizing streambed substrates and therefore are a potential cause of mortality to salmonid eggs and alevins residing in the streambed. Flows of 600 cfs and greater—high enough to mobilize gravels of the size used by spawning Chinook salmon—are estimated to occur in the lower Bull Run River every one to one-and-a-half years (Carlson 2003). The Services identified the scouring of Chinook redds to be of particular concern in the lower Bull Run River.

This HCP defines measures to benefit spawning salmon, such as the maintenance of minimum flows in the lower river and the addition of gravel adequately sized for use by spawning salmon. These efforts can both affect and be affected by the scouring of spawning gravels. This appendix describes sampling methods and protocols for monitoring the effects of high flows on the stability of Chinook salmon redd gravels in the lower Bull Run River.

Research Objectives

The objective of this research effort is to measure the effects of high flows on bed elevation and scour depth for a number of sites used by spawning Chinook salmon.

Key Questions/Hypotheses

The key questions (and related hypotheses) to be answered by this monitoring protocol are:

Question 1: What is the mean change in bed elevation each year and its associated variance at the locations of Chinook salmon redds in the lower Bull Run River?

- H_o: There will be no significant change in bed elevation at the locations of a sample of Chinook salmon redds.

Question 2: What is the mean depth of scour and its associated variance at the locations of Chinook salmon redds in the lower Bull Run River?

- H_o: The mean depth of scour will not exceed the assumed upper limit of Chinook egg deposition of 8 inches (Schuett-Hames et al. 1996).

Question 3: What is the percentage of monitored Chinook redds that have significant scour?

- H_o: The percentage of scoured Chinook redds will not be more than 40 percent (Harvey and Lisle 1999).

Forty percent is the level of scour observed by Harvey and Lisle (1999) among Chinook redds in natural gravel patches (compared to 80 percent in fresh dredge tailings).

Research Design

Gravel scour will be measured using sliding-bead type monitors and protocols described in Nawa and Frissell (1993). These devices consist of a thin cable attached at one end to a sediment anchor and equipped with some sort of stop at the other end. Neutrally or positively buoyant beads are strung on the cable between the anchor and the stop. The anchor and cable are inserted vertically into the gravel immediately adjacent to a redd, using a pipe or tube wide enough to accommodate the beads. The insertion pipe or tube is carefully removed so that the beads are buried next to the anchor in the sediment. An excess of cable is left to protrude from the gravel with a marker attached to facilitate its relocation. As gravel is disturbed by high flows, beads are dislodged and slide to the end of the end of the cable at the stop. Periodically, the scour monitoring devices can be relocated and the beads at the end of the cable counted to determine how deep the gravel has been scoured.

Bed elevation at each redd site will be measured using a laser level and a survey rod with a 5-inch base (DeVries and Goold 1999).

Spatial Scale. Chinook redds will be monitored in the lower Bull Run River from river mile (RM) 1.5 –3.7. The City has surveyed this section of the Bull Run River previously for spring and fall Chinook spawning.

Replication Duration. Ten Chinook redds will be selected per year for monitoring. Based on total redd counts from previous surveys, this amount represents between 15 and 100 percent of the estimated population of Chinook redds.

Monitoring will start after HCP Year 5 to allow for 5 years of gravel placements. Monitoring will occur during three years in which high stream flows (>600 cfs) occur. The three years might not be consecutive as some years might pass without high-flow events. Scour monitoring results will be summarized after the three years of data collection are completed.

Parameters. The parameters that will be measured are

- bed elevation (inches below the elevation of a benchmark, which will be established nearby at the time of initial measurement) before and after the incubation season (i.e., as soon as scour monitoring devices are placed and then as soon as possible after the end of March),
- maximum scour depth for the season (inches below the initial bed elevation), and
- maximum flow since the last survey (in cfs, taken from USGS Gauge No. 14140000, 1.8 miles below Reservoir 2).

Sampling Scheme. Chinook redds will be identified during Chinook spawning surveys. The lower Bull Run River, from RM 1.5 to 3.7, will be stratified into reaches based on geomorphic characteristics. These reaches correspond to those used during Chinook spawning surveys. A total of 10 redds will be selected each year for monitoring, with their allocation between reaches corresponding to relative reach length. Within each reach, redds will be chosen as evenly as possible from each of two general categories: redds created in pool tail-outs, riffle crests, and mid-riffle locations; and redds created in gravel associated with obstructions in the channel (e.g., boulders or bedrock outcrops). These two categories of redd locations are expected to differ in the degree of scour they experience, with obstructions contributing to more complex flow patterns.

The re-identification of redds will require a high degree of precision, given the variable nature of streambed topography. Each redd will be re-identified using two pieces of monofilament line of specific length attached at divergent locations on the bank and left in place between surveys. Two scour monitors will be inserted into the sediment adjacent to each active redd, to avoid egg mortality associated with monitor placement. The results of the two monitors will be averaged. Scour monitor placement will occur at least 15 days after redd creation to avoid shock to the embryos during what is an especially sensitive stage.

Bed elevation will be measured when the sliding-bead scour monitors are placed and again as soon as possible after Chinook have completed their gravel-rearing life stages (early to mid-May). Scour monitors will be visited weekly, if possible, during spawning season, to capture the effects of redd superimposition. After spawning season has concluded, scour monitors will be visited as soon as possible after each peak-flow event that exceeds the previous peak-flow event. Peak-flow events will be defined as the highest flow on a given day that exceeds 600 cfs and larger than the highest flow for the previous and following days. Six hundred cfs is the smallest flow calculated to mobilize fine gravel (0.5 inch, intermediate axis). This means that monitors would be visited after flows exceeded 600 cfs, but then would not be revisited until a flow occurred that was higher than the initial flow. At the very least, in the absence of peak flows, scour monitors will be visited twice during the post-spawning period.

Analysis

Data Storage. Data will be stored in a Microsoft® Access database by the City of Portland Water Bureau.

Hypothesis Testing. Bed elevation at the conclusion of the Chinook gravel-rearing season will be compared with the initial bed elevation at each site using a paired t-test ($n=10$, $\alpha=0.05$, $\beta=0.20$). Scour depth for each flow will be compared with the estimated 8-inch upper limit for Chinook egg pockets (Schuett-Hames et al. 1996) using standard t-tests. An estimate for the total impact of scouring on Chinook redds in the lower Bull Run River will be derived for each year that the study occurs by weighting the observed scouring in each of the two categories of redd location according to the relative use of each by Chinook spawners.

Adaptive Management

If spawning gravel placements are not successful, which is defined as the percentage of Chinook redd scour exceeding 40 percent, the City will meet with NMFS to determine options.

Research Protocol for Total Dissolved Gases in the Bull Run River

The level of TDG is the sum of the partial pressures of all gases, including water vapor, dissolved in a volume of water. Elevated levels of TDG in water can have various negative impacts on fish, including the formation of gas bubbles in tissues and the vascular system (gas bubble disease), and over-inflation of the air bladder. Extremely high levels of TDG or long exposure times can lead to immediate or delayed mortality.

Oregon's Water Quality Standards, as enforced by ODEQ, state that the concentration of TDG relative to local barometric pressure should not exceed 110 percent of saturation [OAR 340-041-0031]. An exception will be made when stream flows at a given sampling site exceed the 10-year, 7-day average flood (7Q10), defined as the 7-day rolling average annual high flow that has an average recurrence interval of 10 years.

In 2005, the City initiated a monitoring plan to check TDG levels associated with the water facilities in the Bull Run River. The plan, developed in consultation with ODEQ, identified sites at risk of elevated TDG levels and established a sampling regime specific to each sampling site. The City proposes to monitor TDG levels until enough data are collected to determine whether elevated TDG levels are a concern in the lower Bull Run watershed. This appendix describes sampling sites and protocols for monitoring TDG levels in the lower Bull Run River.

Total Dissolved Gases Research Objective

The TDG research results will be used to determine whether there are locations in the lower Bull Run watershed with elevated concentrations of TDG. The sites will be monitored across a range of flows.

Key Questions/Hypotheses

There are two key questions to be answered by this TDG Monitoring Plan. One of the questions has a hypothesis that will be tested with the monitoring protocol and the other will be addressed by field observation. The questions are:

Question 1: Do any of the monitoring sites exceed the ODEQ standard of 110 percent saturation of TDG?

- H_o: At each monitoring site, the observed TDG concentration will not exceed 110 percent of saturation within any range of flow (as defined in Table F-7) unless flow exceeds the 7Q10 for the lower Bull Run River.

Question 2: How quickly do elevated levels of TDG dissipate downstream when they are observed?

This key question does not have an associated null hypothesis. It involves the collection of information to assist in the adaptive management process.

Monitoring Design

Sites. The City, in conjunction with ODEQ staff, identified all structures within the watershed associated with City operations that could cause elevated levels of TDG. These structures include the spillways, valves, or turbines in which air bubbles could be brought under sufficient pressure to cause their dissolution in water beyond the level of saturation. Monitoring locations were established to monitor the effects of each specific structure on TDG levels, or to provide information on the persistence of TDG downstream. Monitoring sites, the associated structure that increases the risk of elevated TDG concentrations, and the purpose of measuring each site are summarized in Table F-6. The locations of monitoring sites are shown in Figures F-1 and F-2.

Table F-6. TDG Monitoring Sites, Associated Structure, and Purpose of Measuring

Monitoring Site	Associated Structure	Purpose
TDG-1	Dam 2 Spillway	Structure Effects
TDG-1a	Dam 2 Spillway	Downstream Effects
TDG-2	Dam 2 Spillway	Downstream Effects
TDG-3	South Howell-Bunger (HB) Valve	Structure Effects
TDG-4	North HB Valve	Structure Effects
TDG-5	Powerhouse 2	Structure Effects
TDG-6	Diversion Dam	Structure Effects (Upstream Value)
	Powerhouse 2	Downstream Effects
TDG-7	Diversion Dam	Structure Effects (Downstream Value)
TDG-8	Lamprey Weir	Structure Effects (Upstream Value)
	Diversion Dam	Downstream Effects
TDG-9	Lamprey Weir	Structure Effects (Downstream Value)
TDG-10	Dam 1 Spillway	Downstream Effects
	Powerhouse 1	Downstream Effects
TDG-11	Dam 1 Spillway	Structure Effects
TDG-12	Powerhouse 1	Structure Effects

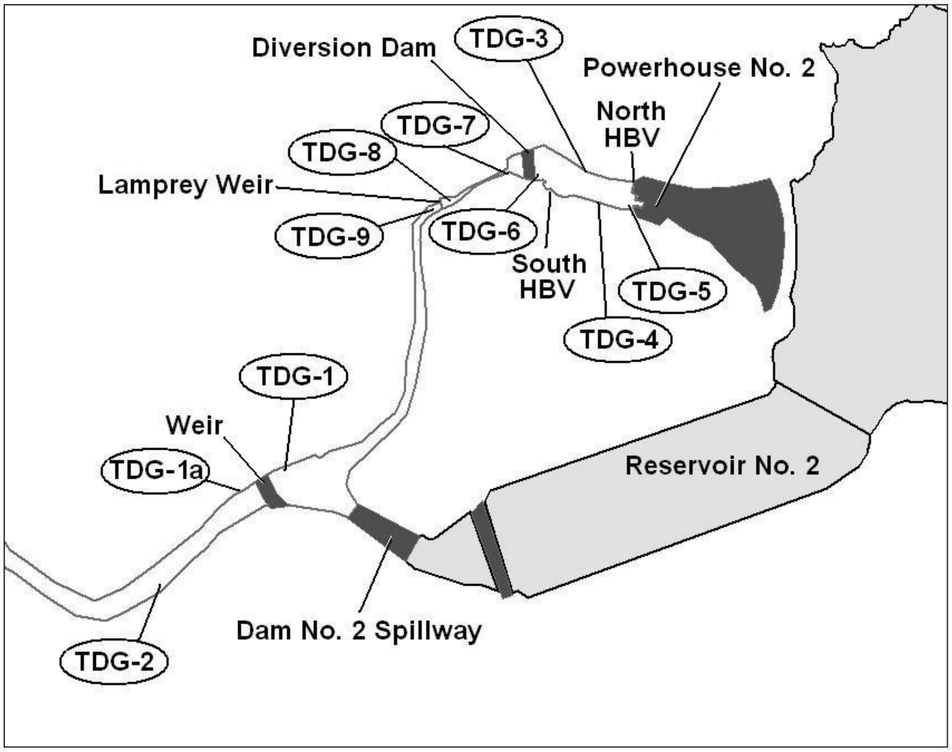

Figure F-1. Locations of TDG Monitoring Sites Associated with Dam 2

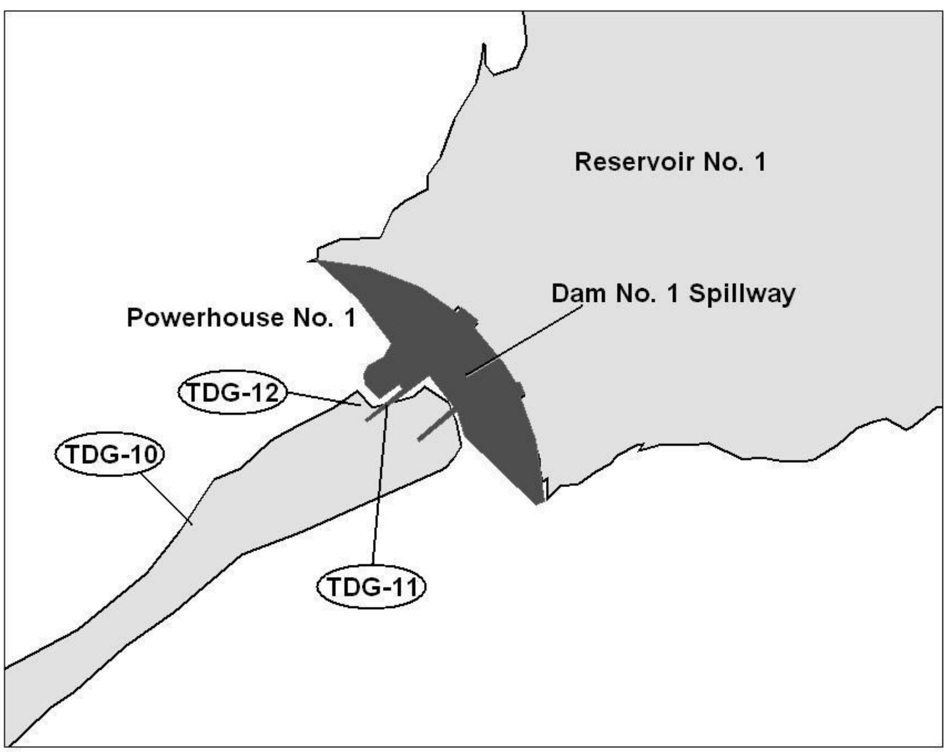

Figure F-2. Locations of TDG Monitoring Sites Associated with Dam 1

Each site has a unique span of possible flows, associated with its longitudinal position along the Bull Run River and its function as a part of the City's water and hydroelectric facilities. Flows passing through each of the two powerhouses are determined by flow sensors in the penstocks and are constrained by the minimum flows required to run the turbines and the maximum flows that the turbines can accommodate. Flows passing over each dam's spillway are estimated by subtracting the powerhouse flows from the instream flows measured at gauging stations upstream of each reservoir. The flows are constrained only by the range of natural variability in the Bull Run River as modified by the water diversions and withdrawals by the City.

For most of the structures, the historical span of flows was divided into three equal parts or flow ranges. Each flow range will be sampled with replication. The ranges of flows for each structure and the number of replicates for sampling are defined in Table F-7. Sites located downstream of structures are for the purpose of monitoring the persistence of TDG concentrations and will be sampled on the same day as the associated upstream sites.

Two Howell-Bunger (HB) valves at Reservoir 2 provide a route for releasing water that bypasses the hydroelectric turbines and the spillway. The HB valves dissipate energy associated with the head pressure behind the dam. Monitoring sites have been located at the outlet of each HB valve. No range of flows has been established for the HB valves. Each site will be sampled several times when the respective valve is in operation.

Table F-7. Flow Ranges and Number of Replicates per Flow Range for Sampling TDG

Structure	Flow Ranges (cfs)	Number of Replicates
Dam 2 Spillway	1,700–6,900	5
	6,900–12,000	5
	12,000–17,200	5
Powerhouse 2	210–700	5
	700–1,200	5
	1,200–1,700	5
South HB Valve	While operating	5
North HB Valve	While operating	5
Diversion Dam	Whenever Powerhouse 2 or HB valve readings are taken	15 to 20
Lamprey Weir	Whenever Powerhouse 2 or HB valve readings are taken	15 to 20
Dam 1 Spillway	2,000–5,500	5
	5,500–8,900	5
	8,900–12,400	5

Table continued on next page

Table F-7. Flow Ranges and Number of Replicates per Flow Range for Sampling TDG, continued

Structure	Flow Ranges (cfs)	Number of Replicates
Powerhouse 1	800–1,200	5
	1,200–1,600	5
	1,600–2,000	5

The 7Q10 for the lower Bull Run was calculated from historical records from October 1, 1959, to September 30, 2003, and is currently estimated to be 5,743 cfs. When flows of this magnitude occur or are exceeded, sampling will continue; however, the ODEQ standard of 110 percent saturation for TDG will not apply. The City will annually update the 7Q10 flow amount for future monitoring purposes.

Scale. All data collected on TDG are site specific. Downstream sites have been included to determine the spatial extent of elevated TDG exposure.

Replication/Duration. Each site will be sampled five times within each flow range; some sampling has already been conducted. The sites associated with the diversion pool dam next to the Water Bureau Headworks facility and the lamprey weir will be sampled whenever the Powerhouse 2 sites are sampled. Downstream sites will be sampled whenever the associated upstream sites are sampled. The HB valve sites will be sampled five times each during valve operation.

Each site will be monitored until the full set of ranges, as defined in Table F-7, has been adequately sampled. Once the relationship of TDG concentrations for each site and set of variables has been established, further monitoring will rely on tracking the environmental variables rather than sampling TDG.

Parameters. On each sampling occasion, the following information will be recorded:

- TDG concentration
- Water temperature
- Date and time of day
- Flow at the respective structure (e.g., spillway or powerhouse)

Sampling. TDG concentrations will be measured using a Common Sensing TBO-DL6 dissolved gas and oxygen meter. Water temperature will be measured with a digital traceable thermometer. Flow at the time of measurement will be obtained from data gathered at the City's water facilities by staff.

Analysis

Linear and non-linear multiple regression will be used to explore the relationship between TDG levels, flow, and temperature at each of the dam spillways and the lamprey weir, and, if possible, to create a model that predicts under what conditions TDG concentrations might exceed 110 percent at each site.

The dissipation of elevated TDG concentrations downstream of their source will be characterized and evaluated across levels of flow using Analysis of Covariance (ANCOVA) of log-transformed data.

If the TDG research hypotheses are rejected, it would indicate there are TDG levels that consistently exceed 110 percent, and/or those levels affect a significant portion of the lower Bull Run River. If that occurs, the City will enter into good-faith discussions with NMFS and ODEQ to review the situation. (See Chapter 9, Monitoring, Research, and Adaptive Management Programs, for details about discussions with NMFS and ODEQ.)

Fish Population Research

Sandy River Basin Juvenile Salmonid Outmigrant Research

This section describes the rationale, objectives, and procedures for conducting research on the emigration of salmonid smolts from portions of the Sandy River Basin. Monitoring salmonid juvenile outmigrants (JOMs) has been recommended by the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) as a key component of assessing an anadromous population’s viability. JOM monitoring provides a gauge of freshwater productivity and is particularly important in basins such as in the Sandy River Basin in which freshwater habitat improvements are an important management goal (WLCTRT 2003).

This research approach focuses on determining the number of steelhead and coho salmon smolts from different subwatersheds of the Sandy River Basin. Information will also be collected for spring Chinook smolts (1+ and larger), but the data may not be useful for trend analysis due to the complexities of their life history pattern. The JOMs research is designed to provide biologists with meaningful data to evaluate the long-term trend in smolt abundance for the Sandy River subwatersheds.

JOM Life-Stages to be Studied

The term “salmonid juvenile outmigrant” includes all life stages of salmonids, other than adults, that are leaving a given watershed, at any time of year. The term is not restricted to smolts, but can include emigrating fry and parr. The City, however, will only study the spring emigration of smolts in the Sandy River Basin.

Although the City acknowledges that understanding the magnitude of the emigration of non-smolt juveniles is valuable, especially if significant numbers might be expected to successfully rear in downstream reaches, a thorough study of non-smolt juveniles is beyond the scope of this effort. Quantifying the emigration of non-smolt JOMs is difficult because emigration can occur throughout the year and because monitoring certain life stages, particularly fry, can pose a high risk of mortality to the fish. In order to be meaningful, an estimate of non-smolt JOMs should also be accompanied by an estimate of freshwater survival after emigration from a given subwatershed, further adding to the difficulty and expense. Without an estimate of freshwater survival after emigration, non-smolt JOMs lose effectiveness as a gauge of freshwater productivity. The mortality of smolts after they leave a given subwatershed but before they leave the Sandy River Basin, on the other hand, is considered negligible, based on studies from other basins (e.g., Smith et al. 1999). EDT, for instance, assumes that survival rates through the emigration phase for age 1 Chinook smolts, coho smolts, and steelhead smolts, derived from reviewing the scientific literature, are 98 percent, 98 percent, and 99 percent, respectively.

The City considers the emigration of smolts to be an adequate measure of freshwater productivity in the Sandy River Basin for coho and steelhead. It is unlikely that the mainstem of the Sandy River would provide suitable rearing habitat for non-smolt juveniles that emigrate from clear-water tributaries. The mainstems of the Sandy and the Zigzag rivers are both glacial streams with high levels of suspended solids. Fish productivity has been shown to have an inverse relationship to levels of suspended solids (Bash et al. 2001, Ptolemy 1993). Newcombe and Jensen's (1996) scale of severity index for the effects of suspended solids predicts that the levels of suspended solids observed in the Sandy River during the summer months, from 6 to 40 mg/L, (City of Portland, unpublished data) would lead to sublethal effects on juvenile salmonids ranging from moderate physiological stress to long-term reduction in feeding success. A significant portion of the fall and spring Chinook JOMs in the Sandy River Basin emigrate as fry. The study of outmigrating fry, however, would require different methods.

Smolt emigration is mostly confined to the spring. Data from the North Fork Dam on the Clackamas River suggest that a small portion of the emigration of steelhead, coho, and Chinook smolts in the region can occur during the fall (James Bartlett, pers. comm., 2006). The fall is a difficult time to monitor smolts, however, due to high-flow events and debris in the water. Only salmonid smolts and juveniles that emigrate during the spring will be monitored as a part of this plan.

Geographic Scope of Smolt Studies

Many portions of the Sandy River Basin are neither feasible for nor accessible to smolt monitoring efforts. The mainstem of the Sandy River, for instance, is too large to feasibly monitor and produce meaningful population estimates without risking mass fish mortality. Other smolt-monitoring programs in large river systems have required measures such as checking traps constantly while in operation and subsampling through time (e.g., the Stillaguamish River smolt trap is fished for six hours at a time and checked at least every one to two hours (Griffith et al. 2006). Some streams are inaccessible due to the land ownership patterns or impassable terrain in the surrounding areas.

The City has decided, in consultation with its partners in the Basin and experts in the field, to contribute to a basin-wide, smolt-monitoring effort. This effort proposes to coordinate the limited resources of the various partners in order to collect smolt information for as much of the Sandy River Basin as possible. A portion of those resources will be dedicated to a sampling design that rotates smolt traps between subwatersheds from year to year. The rotation will be designed to provide answers to the key questions identified below.

The City identified a number of streams where monitoring could feasibly take place (Table F-8 on page F-31). The streams make up 50 percent of the available anadromous habitat and represent what is referred to as the "Monitoring Frame." The Monitoring Frame is the area to which monitoring results are directly applicable. The City believes that the Monitoring Frame can also serve as a representative index for the Basin as a whole. The streams listed in Table F-8 span the full range of stream elevations, gradients, temperatures and flow regimes in the Sandy River Basin. The listed streams include reaches with a variety of ownership and management arrangements, and range from relatively pristine streams on federal land near the headwaters of the Sandy River to highly impacted urban streams near the mouth.

Other Smolt Monitoring Designs Considered

Alternative sampling designs that were considered include operating a trap on the mainstem of the Sandy River near the mouth and selecting seven streams to monitor every year for the duration of the HCP.

Trap Operation on the Mainstem Sandy River. Maintaining a trap on the mainstem of the Sandy River near the mouth would have the advantage of potentially providing a Basin-scale estimate of trend. It would require a large amount of effort, however, precluding the monitoring of individual streams. Risk to the trap from vandalism and floating debris and the risk of mass mortality to fish from throughout the Basin would be high. The collected information would also lack the subwatershed-scale resolution that could be used to guide adaptive management.

Trap Operations in Seven Fixed Locations. Operating seven traps in seven fixed locations would have the advantage of providing better estimates of the trend in each trapped stream. It would also have many of the advantages of the rotating design, including greater spatial resolution than trapping near the mouth of the Sandy River. Trapping seven fixed locations, however, would provide information for only 31 percent of the anadromous habitat in the Basin, compared with 50 percent for the rotating design. It is likely that four of the streams selected for fixed-site monitoring would be streams with the largest fish populations, in more pristine condition, and nearer their carrying capacity for juvenile fish. They would not represent the portions of the Basin with the greatest potential for growth in fish populations.

Rotating Trap Operations. The City believes that the rotating design has the greatest potential for providing managers with useful information about the status and trend of JOMs in the Sandy River Basin. The Monitoring Frame overlaps with 72 percent of the habitat for which coho adult spawner numbers are estimated[6]. This compares with an 82 percent overlap if a trap were operated near the mouth of the Sandy River[7]. The Monitoring Frame also overlaps with approximately 52 percent of the habitat for which steelhead adult spawner numbers are estimated and 64 percent of the habitat for which spring Chinook counts are made. The rotating design monitors streams spanning the range of variation in the Sandy River, including streams which are marginal in quality.

If unforeseen difficulties arise, which would prevent the proposed rotating design from answering the key questions identified below, the City and its partners maintain the option of monitoring seven fixed sites, which would be jointly selected from those listed in Table F-8.

Monitoring Objectives

The City is contributing $100,000 per year for the duration of the HCP to the study of JOMs in the Sandy River Basin in order to collect information to aid in the management of anadromous fish populations. The objective of the Sandy River Basin JOM research is to contribute to the viability assessment of salmonid stocks in the Sandy River Basin and support adaptive management by

- collecting information to assess the long-term trend in salmonid smolt populations for as much of the Sandy River Basin as possible.

[6] A portion (24 percent) of potential coho spawning habitat in the Sandy River Basin is not included in the effort to count adult coho spawners. This is because the stream reaches are turbid with glacial till, preventing reliable visual counts.

[7] All potential smolt trap sites on the Sandy River mainstem are above Beaver Creek. Smolt estimates for the entire Sandy River would also include coho rearing in portions of the river for which there is no estimate of adult coho spawners.

- collecting information to assess the long-term trend in salmonid smolt populations at the subwatershed scale.
- evaluating salmonid smolt production of subwatersheds relative to one another.
- evaluating salmonid smolt physical quality in subwatersheds relative to one another.
- determining the values of various life-history characteristics at a subwatershed scale.

Key Questions

The key questions to be answered by the Sandy River Basin juvenile outmigrant research are the following:

- What is the long-term (20-year) trend in smolt populations for as much of the Sandy River Basin as possible?
    - H_o: The slope of the 20-year trend in the combined population estimate for the Monitoring Frame will be insignificant or significant and positive (α=0.05, β=0.20).
- What is the long-term (20-year) trend in smolt populations at the subwatershed scale for as many Sandy River subwatersheds as possible?
    - H_o: The slope of the 20-year trend in the population estimates for the individual streams within the Monitoring Frame will be insignificant or significant and positive (α=0.05, β=0.20).
- What is the average relative contribution of each subwatershed to the total smolt production for the Monitoring Frame compared with the other subwatersheds?
- When during the year does emigration occur (mean, median, range, variation) for each species in each subwatershed?
- How does smolt quality compare among subwatersheds?
    - Average fork lengths
    - Physical condition
    - Presence or absence of pathogens

Research Design

Number of Traps and Trap Sites. Research on smolt production in the Sandy River Basin will be a joint effort with the Sandy River Basin Partners (Partners). The City and the Partners anticipate operating a total of seven traps each year in the Basin. The City's financial commitment of $100,000 per year, over the term of the HCP, will provide support for maintaining three smolts traps with a City crew. The City also anticipates that three traps will be maintained by the USFS, and one will be maintained by ODFW on Cedar Creek.

Twelve streams have been identified as being feasible and accessible for operating a smolt trap. These sites are summarized in Table F-8.

Table F-8. Streams Accessible for Smolt Trapping and Monitoring

Stream	Miles Used by Anadromous Fish	Land Ownership[a]
Clear Fork Sandy River	4	USFS
Lost Creek	4	USFS
Clear Creek	6	USFS, private
Still Creek	9	USFS
Camp Creek	6	USFS
Zigzag River	7	USFS, private
Salmon River	18	USFS, BLM, private
Cedar Creek	13	Private, state, USFS
Lower Bull Run River (without the Little Sandy River)	8	USFS, City, private
Little Sandy River	6	USFS, BLM, PGE, private
Gordon Creek	7	Metro, BLM, private
Beaver Creek	7	Private
	95 miles total	

[a]Land ownership of the riparian areas is distributed under the U.S. Forest Service (USFS), Bureau of Land Management (BLM), Portland General Electric (PGE), Metro regional government (Metro), the City of Portland (City), the state of Oregon (state), and private owners.

Source: Metro tax lot information 2004

These streams make up 50 percent of the anadromous habitat in the Sandy River Basin. Seven traps will provide monitoring for as little as 26 percent and as much as 37 percent of the anadromous habitat in the Basin in a given year.

Trap Rotation. The allocation of trapping effort in the 12 streams will differ from year to year with the following constraints:

- Seven traps will be operated per year.
- The Bull Run River, Little Sandy River, and Cedar Creek sites will be trapped every year.
- Each rotated site will be trapped four of every nine years.
- As many rotated sites as possible will be sampled once in the first two years, once in the middle two years, and once in the last two years of a 20-year time period. For each of these two-year periods, there will be one site that cannot be trapped. The site that cannot be trapped in Years 1 or 2 will be trapped in both Years 3 and 4. The site that cannot be trapped in Years 10 or 11 will be trapped in both Years 9 and 12. The site that cannot be trapped in Years 19 and 20 will be trapped in both Years 17 and 18.
- Within the above constraints, rotated sites will be trapped according to a schedule that maximizes the number of pair-wise comparisons between them.

These conditions were established to maximize the ability of the City to use the rotation to detect trends and provide pair-wise comparisons between individual subwatersheds.

The City will operate three smolt traps in the Sandy River Basin. Two traps will be in the Bull Run Watershed and an additional site will be trapped as dictated by the rotation design. The Little Sandy River is a special case; the City anticipates operating a trap each year at the Little Sandy Dam site. With the anticipated removal of the Little Sandy Dam in 2008, anadromous fish are expected to recolonize the upper Little Sandy River. Recolonization is expected to result in a positive trend in smolt numbers unrelated to the overall trend of the Monitoring Frame. The Bull Run River trap site, located downstream of the Little Sandy River, will be affected by this recolonization. The Little Sandy estimate will be subtracted from the Bull Run River estimate when calculating trends.

Cedar Creek is another stream in which obstacles to anadromous fish passage will be removed. The recolonization of upper Cedar Creek will be studied in detail by ODFW. In addition to smolt estimates, ODFW plans to collect data on the number of adult and pre-smolt salmon and steelhead in upper Cedar Creek.

The USFS has been running smolt traps for more than 15 years in the upper Sandy River Basin, and the City anticipates that involvement will continue. For this monitoring protocol, the City assumed that the USFS would be able to continue the monitoring of three smolt trap locations.

The trend for the Monitoring Frame will be calculated by using the sum of estimates for all trap sites in a given year and estimating values for sites that were not trapped. Each site will have several years for which an estimate must be calculated. A multiple regression model will be developed for each site to predict the missing years' values. The variables that will be available for the analysis and are likely to have value as predictors of smolt numbers include

- the estimated number of adults in the parental generation in the Sandy River Basin.
- levels of flow at various USGS gauges throughout the Sandy River Basin.
- water temperatures during the summer.

If multiple regression fails to yield a model with predictive value ($R^2 \geq 0.75$), the missing years for each trap will be filled using imputation. Pair-wise comparisons of smolt estimates between any two trap sites will be used to calculate an average ratio between the sites. For every year that a trap site is not monitored, there will be five independent approximations for what its estimate should be, using the site's calculated ratios to the sites that were trapped that year. It is assumed that populations in neighboring streams will have a higher correlation to each other than populations in streams that are widely separated. For this reason, each approximation will be weighted according to the proximity of the contributing trap site to the site for which the imputation is being made. Streams with low smolt estimates, whether because they contain little habitat or because the habitat is marginal, are expected to show high levels of variability, including zero values. For this reason, each approximation will also be weighted according to its average population size or quantity of habitat. The most appropriate method for weighting and dealing with zero values will be determined once the data have been collected.

Duration. The trap rotation is designed to provide useful trend information for both the Monitoring Frame and individual streams within 20 years. Smolt monitoring, however, will continue for the duration of the HCP (50 years).

Fish Capture and Population Estimation. Salmonid smolts will be captured using floating rotary-screw traps. Traps will be fished from mid-March until mid-June each year and will be emptied once per day, while in operation. Species, life stage, fork length, and weight data will be recorded for each fish. Scale samples will also be collected from juvenile and smolt salmonids in order to provide a catalogue for future age analysis. The age of an individual fish can be determined by observing the pattern of widths in the circuli that are created as a scale grows. Knowing the age of individual fish can be useful in determining the average age at smoltification and average fork length-at-age for a given stream.

In addition to fish information, the following environmental data will be collected:

- Daily air temperature
- Continuous water temperature (using temperature dataloggers)
- Relative stage height (from a seasonal gauge)
- Amount of time it takes for five full rotations of the trap screw (measure of current velocity)

Variables. The values of the following variables will be determined for each site each year that the stream is trapped:

- Smolt population (for every species possible)
- Average fork length (by species and life stage)
- Average condition factor ((weight/(length^3))×100,000)
- Average date of emigration (by species)
- Indications of pathogens

Ancillary environmental information on geomorphic, geographic, land-use, and stream-survey data will be gathered to characterize the watershed above each trap site. These data will be available for future attempts to model the relationship between salmonid smolt population characteristics and environmental variables.

Analysis

Data Storage. Smolt trap data will be maintained by the City using a Microsoft Access® database. Data collected by USFS and ODFW will also be shared with the City, which will be responsible for its analysis and dissemination.

Population Estimates. Population estimates will be calculated using mark-recapture protocols described in Thedinga et al. (1994). Calculations will be made using a modified Lincoln-Peterson estimator that combines smolt data by two-week periods. Variances for the estimates will be calculated using the bootstrap technique suggested in Thedinga et al. (1994). If smolt captures are very small, Darroch Analysis with Rank-Reduction (DARR) will be used to calculate estimates (Bjorkstedt 2000). Procedures for calculating smolt estimates are summarized in the above literature.

The 20-year trend for the Monitoring Frame will be calculated using the four-year running average, as recommended by the WLC-TRT. Individual site 20-year trends will be calculated using the estimates, rather than running averages of the estimates. Emigration timing will be determined using captures corrected by using trap efficiencies. If 10 fish are captured on a given day, for example, and the trap is estimated to have an efficiency of 25 percent (i.e., one in four fish passing the trap site is captured) then the daily number of emigrants is estimated to be 40 (10/0.25). Differences in fork length and average emigration date between sites will be statistically evaluated using Analysis of Variance (ANOVA) coupled with the Tukey multiple-comparisons test.

Adaptive Management

The City will use the data from the JOM research as part of the framework for addressing effectiveness of the HCP as a whole, as described in Chapter 9.

Lower Bull Run River Chinook Population Research

This section describes the sampling methods and protocols for conducting surveys of spawning Chinook adults and redds in the lower Bull Run River. Both spring and fall runs of Chinook salmon may spawn in the lower Bull Run River.

ODFW has conducted surveys of spring Chinook adults and redds in the Sandy River Basin by boat and on foot from 1996 to the present, and surveys on foot of fall Chinook adults and redds in index reaches in the lower Sandy River Basin from 1984 to 2004. These surveys, however, have not included the lower Bull Run River. Weekly surveys of spawning spring and fall Chinook salmon and redds in the lower Bull Run River (RM 0-5.8) were conducted by ODFW in 1997. The City continued weekly surveys from RM 1.5 to RM 5.8 in 1998 and 1999. An index reach of the lower Bull Run River (RM 1.5–RM 3.7) was surveyed by the City in 2005 and 2006.

For HCP Years 1-20, the City will conduct an annual count of spawning Chinook salmon and redds. The lower Bull Run River Chinook population research is designed to provide biologists with meaningful data within a 20-year time frame to evaluate the long-term trend in adult abundance for the Bull Run. The Bull Run data could then be used with information gathered by other agencies to determine the status of listed Sandy River Chinook populations.

Research Objectives

For HCP Years 1-20, the City will conduct annual counts of spawning Chinook salmon and redds in the lower Bull Run River from RM 0—RM 5.8.

The objectives of the lower Bull Run River Chinook population research are to

- document use of the lower Bull Run River by spring and fall Chinook salmon.
- contribute to ODFW's annual assessment of spring Chinook in the Sandy River Basin.

Key Questions/Hypotheses

The key questions to be answered by the research are the following:

- How many Chinook salmon adults enter the Bull Run River to spawn each year? This key question does not have an associated null hypothesis.
- What is the long-term trend (20 years) in spawning Chinook salmon abundance?
  - H_o: The abundance of spawning Chinook salmon will not change significantly over the long term (20 years, α=0.05, β=0.20).
- What is the timing (range of dates and peak date) of adult Chinook presence and redd creation in the lower Bull Run River? This key question does not have an associated null hypothesis.
- What proportion of the spawning Chinook salmon are of hatchery origin?[8] This key question does not have an associated null hypothesis.

The City will also collect otolith[8], tissue, and scale samples from adult carcasses found in the lower Bull Run River. The City will send the samples to ODFW to assist in ODFW's assessment of spring Chinook in the Sandy River Basin. In return, the City will receive information from ODFW about the proportion of unclipped Chinook salmon that are of hatchery origin, the relative number of spring and fall Chinook salmon in the lower Bull Run River, and proportion of Chinook adults showing various life history types (i.e., number of years spent in rivers and number of years spent in the ocean). The compilation of this information, however, depends on analyses conducted by ODFW and is therefore not reflected in the key questions.

Research Design

The study design for the lower Bull Run River Chinook population research will use weekly surveys to count live Chinook adults, Chinook salmon carcasses, and newly created redds. Surveys will be coordinated with the operators at Headworks and the PGE powerhouses to

[8] The protocols followed by the City will provide the proportion of carcasses found with clipped adipose fins. The proportion of unclipped carcasses that are of hatchery origin will be provided by the analysis of otoliths by ODFW. Otoliths are tiny bones that form a portion of a fish's inner ear. A fish lays down new bone material on the ototlith's edge as it grows, forming bands that record a fish growth rate through time. ODFW thermally "marks" otoliths in hatchery Chinook by exposing juvenile fish to varying water temperatures over time. As fish growth increases in warm water or decreases in cold water, characteristic banding patterns are created, which provide an indication of the fish origin (Schroeder et al. 2005)

maintain flows of 150 cfs or less above the Little Sandy confluence for the duration of each survey. This is the level of flow necessary for safety and for accurate counts.

Scale. The lower Bull Run River will be divided into the following reaches to provide greater spatial resolution and to reflect the reaches used in previous surveys for comparison:

- Reach 1: The confluence of the Bull Run River with the Sandy River to the bottom of the large pool above the Bull Run PGE Powerhouse (RM 0–RM 1.5)
- Reach 2: The bottom of the large pool adjacent to the Bull Run PGE Powerhouse to Bowman's Bridge (RM 1.5–RM 2.3)
- Reach 3: Bowman's Bridge to the confluence of the Little Sandy River (RM 2.3–RM 2.8)
- Reach 4: The Little Sandy River confluence to the top of the pool at Larson's Bridge (RM 2.8–RM 3.7)
- Reach 5: Larson's Bridge to the Road 14 bridge (RM 3.7–RM 4.8)
- Reach 6: The Road 14 bridge to the Reservoir 2 spillway plunge pool (RM 4.8–RM 5.8)

These reaches correspond to those used for the HCP Chinook spawning gravel research. Reaches 2, 3, and 4 are also the reaches used in previous Chinook spawning surveys conducted by ODFW and the City. Reach 4 also corresponds to one of ODFW's probabilistic, randomly selected reaches for the Sandy River Basin steelhead and coho spawning surveys and snorkel surveys. Reaches 5 and 6 are not believed to be used by spawning Chinook salmon. If the results from the first three years indicate that Chinook do not use these reaches, then they will not be surveyed in subsequent years.

Adult and redd abundance and timing information will be summarized at the reach scale. The proportion of hatchery fish will be summarized at the scale of the entire lower Bull Run River.

Replication/Duration. The City is contributing $600,000 over the term of the HCP to the annual survey of spawning Chinook salmon and redds. This amount will fund Chinook population research in the lower Bull Run River for the first 20 years of the HCP. Weekly surveys will be conducted from mid-August through the end of November. There will be no spatial replication, because the entire channel will be surveyed.

Parameters. The following information and samples will be collected during each survey.

- Live Adults
  - Number of adults and number of jacks
  - Species
  - Reach
  - Additional behavioral information (e.g., spawning, defending a redd, etc.)

- Carcasses
    - Species
    - Reach
    - Length (both total length from the snout-tip to the fork of the tail and the middle of the eye to posterior scale—or MEPS —length, in millimeters)
    - Sex
        - If a female, did it die before spawning?
    - Presence of adipose fin
        - If it doesn't have an adipose fin, check for coded-wire tags (CWT). Collect the snout, if it has a CWT.
        - If it has an adipose fin collect
            - An otolith sample (for ODFW determination of hatchery origin)
            - A tissue sample (for NMFS distinction of spring from fall Chinook)
            - A scale sample (for ODFW determination of age and life history)
    - Additional information (e.g., eaten by scavengers, found in the riparian zone)
- Redds
    - Reach
    - Species (assume Chinook unless another species is seen creating or defending it)
    - Size (length x width, ft^2)
    - Substrate size range (visual estimate of the range from approximately the 10^{th} to the 90^{th} percentile of substrate sizes, inches)
    - Channel feature retaining the gravel patch (e.g., behind boulder or bedrock, pool tail, riffle margin, etc.)
    - Evidence of superimposition over a previous redd
- Environmental data
    - Weather (description)
    - Water clarity/visibility
    - Flow (determined from USGS Gauge No. 14140000)

Sampling Scheme. Surveys will be conducted by two observers walking downstream on each side of the channel, when flows can be maintained at or below 150 cfs. All surveys of Reaches 4, 5, and 6 can be conducted by walking. Flows in Reaches 1, 2, and 3 may be too high for walking surveys in October and November due to uncontrolled flow inputs from the Little Sandy River after the Little Sandy Dam has been removed. When flows are in excess of 150 cfs but only up to 500 cfs, in Reaches 1, 2, and 3, these reaches will be surveyed by floating them with kayaks.

Live adults will be counted and their location recorded.

Any carcasses that are found and have a tail will be counted. All carcasses that can be retrieved will be measured and their sex will be recorded. Females will be opened to determine whether they died before spawning. All carcasses will be checked for the presence of an adipose fin. Carcasses with adipose fins will be sampled for otoliths, tissue, and scales. Carcasses without adipose fins will be checked for a CWT using an ODFW detector. The snouts of carcasses with a CWT will be removed and retained. The tail of each carcass will then be removed to prevent it from being recounted during future surveys.

Redds will be counted and their location recorded. The approximate area of each redd and the size of its substrate will be visually estimated. Once these and other data have been collected, each redd will marked with a painted rock comparable in size to those comprising the redd. A flag with the date will also be attached to the bank adjacent to the redd. The painted rock will help distinguish new redds from old ones. Painted rocks from previous surveys that have been dislodged or buried indicate that further spawning activity has occurred at that location. The flag on the bank will aid in confirming the presence of an old redd if the painted rock is missing.

Analysis

Data storage. Monitoring data collected during the HCP will be maintained by the City in a Microsoft® Access database.

Hypothesis Testing. The number and timing of Chinook salmon in the lower Bull Run in a given year will be compared to the number and timing of Chinook salmon in other years. Individual years will not be compared statistically, however, because of the lack of replication.

The long-term (20-year) trend will be calculated using linear regression (α=0.05, β=0.20).

The proportion of hatchery fish in the lower Bull Run in a given year will be compared to the proportion of hatchery fish in other years. Individual years will not be compared statistically, however, because of the lack of replication.

Reporting

All results from the lower Bull Run River Chinook population research will be summarized in the City's HCP compliance reports.

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Appendix G.

Temperature Management Plan for the Lower Bull Run River

Portland Water Bureau
City of Portland, Oregon

Approved by Oregon Department of Environmental Quality
May 2008

Introduction and Background

By authorities delegated from the U.S. Environmental Protection Agency (EPA) under the federal Clean Water Act (CWA), as well as related state statutes, the Oregon Department of Environmental Quality (ODEQ) manages the quality of Oregon's streams, lakes, estuaries, and groundwater.

In 2005, ODEQ completed a Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP) for the Sandy River Basin (ODEQ 2005). This document was required because ODEQ had previously identified that a number of stream segments of the Sandy River did not meet the applicable water quality standards. These stream segments were included on the state's CWA 303(d) list and are referred to as "water quality limited."

One of the identified stream segments was the lower Bull Run River (RM 0–RM 5.8). This section of the lower Bull Run River is located downstream of the Portland Water Bureau's water-supply infrastructure, which includes two dams and related reservoirs as well as the Headworks facility where river flow is diverted into pipes for water supply. Municipal supply operations have an influence on water temperatures in this reach of the lower river due to warming that occurs in the reservoirs and due to reduced river flows below the diversion. The Water Bureau was identified as a designated management agency (DMA) in the TMDL/WQMP and is required to develop an implementation plan, known as a temperature management plan, describing actions that will be taken to comply with the water quality standards.

This temperature management plan (TMP) has been developed in parallel to a Habitat Conservation Plan (HCP) prepared according to Section 10 of the federal Endangered Species Act (ESA). The primary purpose of the HCP is to describe actions the City will take to minimize and mitigate impacts of the Bull Run water supply system on ESA-listed anadromous fish (i.e., salmonids). Salmonid species are native to the Bull Run River. Salmonid spawning and rearing were first blocked in 1921 by the Headworks diversion dam at RM 6.0, and are now limited to the lower Bull Run River because of the rock weir at the base of the Dam 2 stilling pool at RM 5.8.

A key element of the HCP involves improving water temperature conditions for spawning and rearing salmonids. Because this ESA objective substantially overlaps with the objectives of the applicable CWA water temperature standard and because action is specifically required by the load allocation for temperature in the Lower Bull Run River established in the Sandy River Basin TMDL, a single integrated strategy has been developed to address both federal requirements. The HCP describes the integrated strategy in detail. This temperature management plan provides a summary (and cross references to the HCP) to describe the actions to be taken to comply with the CWA requirements.

Water Quality Criteria and Beneficial Uses of the Bull Run

In 2004, EPA approved Oregon's revised water quality standards for temperature and cold water fish. According to the new water quality standards, the designated beneficial use for the lower Bull Run River is "core cold-water habitat." Core cold-water habitat is defined as "waters that are expected to maintain temperatures within the range generally considered optimal for salmon and steelhead rearing…during the summer" [OAR 340-041-0002(13)].

The water quality standard includes three applicable components [OAR 340-041-0028]:

- Numeric temperature criteria
- Natural condition temperature criteria
- Air temperature exclusion

Numeric Temperature Criteria

The numeric criteria are described in Table 1.

Table 1. Numeric Water Quality Criteria for Lower Bull Run River

River Reach	Time Period	Habitat Use	Numeric Criterion (7-Day Average Maximum)
River Mile 0 to 5.3	June 16 to August 14	Salmonid rearing	16°C
	August 15 to June 15	Salmonid spawning	13°C
River Mile 5.3 to 5.8	June 16 to October 14	Salmonid rearing	16°C
	October 15 to June 15	Salmonid spawning	13°C

Source: ODEQ 2005

Natural Condition Temperature Criteria

If the natural conditions in a stream exceed the numeric criteria, ODEQ's temperature standard states that the natural condition temperatures become the applicable temperature criteria for the water body [OAR 340-041-0028].

Temperature data for the Bull Run River were not recorded prior to the construction of the Bull Run water supply system. ODEQ and the Water Bureau used two methods to estimate the natural condition temperatures for the lower Bull Run River: modeling and a surrogate stream.

- **Models.** ODEQ and the Water Bureau used models to estimate the natural condition temperatures that likely occurred in the lower Bull Run River prior to construction and operation of the City's water supply system which began in the 1890s (City of Portland 2004). The models used physical characteristics from field studies and meteorological data to provide estimated daily average temperatures for the Bull Run River.

- **Surrogate Stream.** Modeling results were verified through comparisons with temperatures in the Little Sandy River. The Little Sandy River is a tributary of the Bull Run River and is geomorphically similar enough to create similar water temperature conditions during most seasons (ODEQ 2005). ODEQ identified the Little Sandy River as an appropriate surrogate stream for estimating natural condition temperatures in the lower Bull Run River on a daily, or real-time, basis.

In the Sandy River Basin TMDL (ODEQ 2005), ODEQ defined the natural condition temperature criteria for the Bull Run River as follows:

> Meet the measured 7-day moving average of the daily maximum temperature for the Little Sandy River with the following specific exceptions:
>
> - Between August 16 and October 15, the lower Bull Run River temperature may be up to 1 °C higher than the Little Sandy River temperatures measured at RM 3.8.
> - If the 7-day moving average of the daily maximum ambient air temperature (as measured at U.S. Geological (USGS) Gauge No. 1414000 in the lower Bull Run) is above 27 °C, then the lower Bull Run River temperature may be up to 1.0 °C higher than the Little Sandy River temperatures measured at RM 3.8.
> - If the 7-day moving average of the daily maximum ambient air temperature (as measured at U.S. Geological (USGS) Gauge No. 1414000 in the lower Bull Run) is above 28 °C, then the lower Bull Run River temperature may be up to 1.5 °C higher than the Little Sandy River temperatures measured at RM 3.8.

The Little Sandy River has a smaller drainage area, shorter water transit times, and lower natural flows than the Bull Run River. Analysis of these differences resulted in ODEQ's definition of these exceptions.

Air Temperature Exclusion

The ODEQ temperature standard also includes the following exception:

> Air temperature exceeds the 90th percentile of the 7-day average of the daily maximum air temperature calculated in a yearly series over the historical record [OAR 340-041-0028(12)(D)(c)]

If this situation occurs in the lower Bull Run River, neither the numeric or natural condition criteria would apply.

Summary of ODEQ Requirements for the Lower Bull Run River

ODEQ's requirements for the lower Bull Run River apply both the numeric criteria and the natural condition temperature components of the standard, as follows:

- **Numeric criteria.** When the estimated natural condition temperatures of the Bull Run River (determined using measured temperatures in the Little Sandy River) are at or below the numeric criteria in Table 1, the numeric criteria apply.
- **Natural condition temperatures.** When the estimated natural conditions of the Bull Run River (determined using measured temperatures in the Little Sandy River) are above the

numeric criteria in Table 1, the natural condition temperature criteria (with exceptions) and 90th percentile air temperature exclusion apply.

Figure G- 1 shows modeled natural temperatures for the lower Bull Run River compared with measured Little Sandy River temperatures (2000–2001) and with ODEQ's numeric criteria.

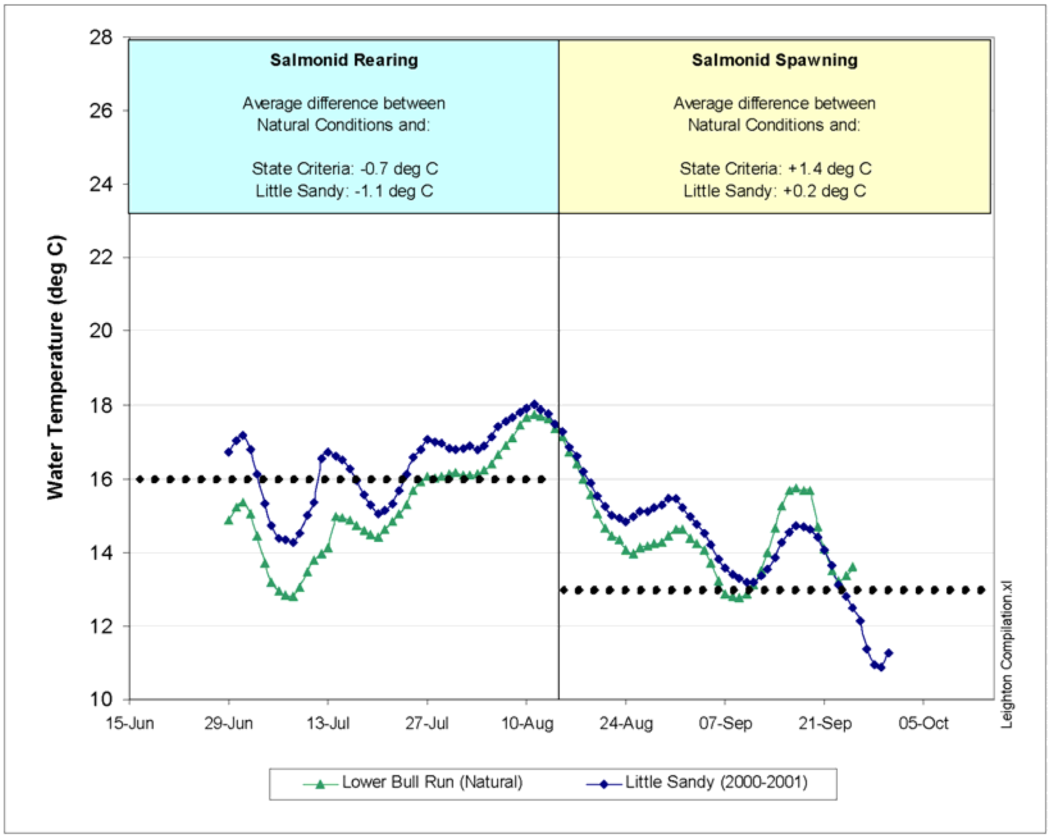

Figure 1. Comparison of Bull Run River Natural Temperatures, Measured Sandy River Temperatures, and ODEQ Numeric Criteria

Source: Leighton 2001

Management Strategies

To comply with ODEQ's water temperature requirements for the Bull Run River, the Water Bureau has defined three management strategies. The strategies include riparian forest protection, reservoir flow releases, and modification of intake tower structures. These strategies are part of the overall strategy to protect listed salmonids as described in the HCP.

Strategy #1 — Riparian Forest Protection

The Water Bureau owns land along 5.3 miles of the lower Bull Run River (1,650 acres) in a patchwork pattern from RM 0—RM 6.0. The Water Bureau-owned lands have been subjected to minimal human or natural disturbance during the past 90 years. Shade conditions on Water Bureau land were evaluated as part of the analyses leading to this TMP, including solar pathfinder estimates of incident radiation and gray card estimates of shading. Vegetation conditions were also assessed (Beak 1998, Leighton 2001, 2002). Canopy coverage is generally good and provides riparian habitat comparable to unmanaged late-seral forest. The east-west orientation of the river does, however, limit the effective shading of the channel.

Action: The Water Bureau will continue managing these lands to protect riparian shade conditions so that their value to protecting instream water temperatures will be maintained. The Water Bureau will not cut trees within 200 feet of the river's average high water level on Water Bureau-owned lands for the 50-year term of the HCP. Exceptions will include selective tree cutting to construct, maintain, and operate water supply and treatment facilities, water monitoring facilities, power lines, roads, and bridges, or to protect infrastructure or human safety from hazards. If trees are removed, the Water Bureau will plant replacement trees. (See full description in **Measure H-2** [Riparian Land Protection] in Chapter 7 of the HCP and the Appendix of this document.)

Monitoring: The Water Bureau will survey and measure shading along the lower Bull Run River with a solar pathfinder once every five years. Results will be reported in an annual report. (See Monitoring and Evaluation section below, as well as description of compliance monitoring for Measure H-2 in Chapter 9 of the HCP.)

Strategy #2 — Reservoir Flow Releases

The Water Bureau will release water into the lower Bull Run River to manage water temperature.

Action: Flow releases will be managed to meet temperature management objectives (see Temperature Management Objectives section below). The amount of water released will vary within a range (20–40 cfs) as needed to meet the target temperatures, depending on the weather. Amounts at the higher end of the range will be released in warmer weather. In cooler weather, amounts at the lower end of the range will be released so that cool water in the reservoir can be conserved for later in the season.

Existing multiple-level intakes at Reservoir 1 will also be used to selectively withdraw water at different depths during the summer season to conserve and strategically use cooler water. Early releases will come from upper strata of the reservoir while the temperatures are still cool. As the reservoir warms, releases will be taken from deeper, colder strata.

(See full descriptions in **Measures F-1** [Minimum Instream Flows, Normal Water Years], **F-2** [Minimum Instream Flows, Water Years with Critical Seasons], and **T-1** [Pre-infrastructure Temperature Management] in Chapter 7 of the HCP and the Appendix of this document.)

Monitoring: The Water Bureau will check hourly USGS flow and water temperature records for the lower Bull Run River. (See Monitoring and Evaluation section below, as well as compliance monitoring measures for Measures F-1, F-2 and T-1 in Chapter 9 of the HCP.)

Strategy #3 — Multiple Intakes at Dam 2 and Stilling Pool Bypass Pipe

To improve the Water Bureau's ability to manage water temperature, the Water Bureau will modify the intake structures at Dam 2 and modify the stilling pool basin below Dam 2. The planned multiple-level intake towers will create two important capabilities:

- selective withdrawal of water from Reservoir 2 at depths with desired temperatures
- separation of flow going to the water system from flow going to the lower river

Unlike the towers at Dam 1, the Dam 2 towers do not currently have multiple-level intakes. The existing Dam 2 intakes draw from the deeper strata in the reservoir which makes it difficult, if not impossible, to conserve cooler water for later in the season. Planned modification of the stilling pool will allow cool water to flow quickly through the stilling pool to the lower river, preventing unnecessary warming. These infrastructure modifications will enable the Water Bureau to meet ODEQ's temperature requirements.

Action: The Water Bureau will design, construct, and operate modified intake structures at Dam 2 to enable selective withdrawal of cool water at different depths and to conserve cool water for late in the season. The Water Bureau will also modify the stilling pool basin to route cool water more quickly to the lower river. (See the full description in **Measure T-2** [Post-infrastructure Temperature Management] in Chapter 7 of the HCP and the Appendix of this document.)

Monitoring: The Water Bureau will document progress toward completion of Dam 2 tower and spillway rock weir improvements in annual reports. When the modified intakes are operational, the Water Bureau will check and record hourly temperature records for the Little Sandy River, as well as for the lower Bull Run River. (See Monitoring and Evaluation section below, as well as compliance monitoring for Measure T-2 in Chapter 9 of the HCP.)

Temperature Management Objectives and Predicted Results

The Water Bureau acknowledges that successful temperature management is constrained by the current infrastructure. The Water Bureau is unlikely to consistently meet the ODEQ water temperature standard in very warm and very dry weather conditions without new infrastructure.

Until the new infrastructure can be designed and constructed (see Strategy #3), the Water Bureau will manage the reservoir releases to achieve temperatures at Larson's Bridge (RM 3.8) that do not exceed 21 °C. This 21 °C maximum will allow continued growth for the cold water fish. The Water Bureau has analyzed the expected results of implementing this strategy using the model described above and data for 2005 summer season weather conditions (June through October). The results are shown in Figure 8-3 in Chapter 8 of the HCP. The results indicate that the lower Bull Run River is likely to exceed both Little Sandy

River temperatures and the ODEQ numeric criteria, but will be less than 21 °C. Temperatures during the summer and early fall will usually be substantially less than 21 °C, particularly during the majority of the spawning season for spring and fall Chinook. During the remainder of the year (not shown in Figure 8-3 of the HCP), temperatures in the river will also be substantially below 21°C (City of Portland 2004).

When the new infrastructure is in place, the Water Bureau will manage the reservoir releases to achieve temperatures at Larson's Bridge that meet the criteria described above in the Water Quality Criteria section. Temperature results expected with the new infrastructure have been analyzed and are shown in Figure 8-4 in Chapter 8 of the HCP. The analysis, based on 2005 weather data, indicates that lower Bull Run River temperatures will be near to or less than Little Sandy temperatures for much of the summer season. At times, lower Bull Run River temperatures will exceed Little Sandy temperatures in September and October, but will be less than ODEQ's 13 °C criterion for spawning.

In addition to the exception criteria evaluated by ODEQ in the TMDL, the Water Bureau developed an additional exception for the HCP to account for situations when the Water Bureau has limited or no ability to manage water temperature. These situations can include unexpected power grid interruptions, downed power lines, equipment failures, loss of computer contact with the Dam 2 intake towers, emergency responses at Headworks as required to assure compliance with federal Safe Drinking Water Act standards, mandatory annual testing of the protection devices at the powerhouse, and other circumstances that preclude the use of the intake towers or diversion pool at the Water Bureau's water supply Headworks. This exception will also apply for the Water Bureau's compliance with ODEQ temperature requirements. Since disruptions of the kinds mentioned above have the potential to also affect our ability to meet water supply objectives, the Water Bureau will have incentives to make rapid assessments and repairs. The Water Bureau also maintains an active asset management program emphasizing proactive maintenance and risk analysis based repair and replacement, which will help avoid failures of water system equipment and infrastructure. If this exception is triggered and results in disruptions in our ability to meet temperature requirements in the lower Bull Run River, the Water Bureau will take action to limit the duration to as short a time as possible and will be in communication with ODEQ as needed during the episode.

Time Frame

Implementation of the Bull Run temperature management strategies will occur as part of implementing the HCP. The Water Bureau is already implementing HCP Measures F-1, F-2, and T-1. Performance data are available from the Water Bureau. Annual reporting will begin after Year 1 of the HCP (first report expected in 2009).

The Water Bureau has completed conceptual design for Measure T-2. The preliminary and final design process began in late 2007. Construction of the intake tower and spillway improvements will be complete in 2012.

Costs and Funding

Implementing the Bull Run temperature management strategies will involve both capital and operating costs. The costs are shown in Table 2, and additional detail is provided in Chapter 11 and Appendix I of the HCP.

The Water Bureau will pay these costs with revenues from the sale of water to customers. Capital costs will be paid from bonds sold to fund the Capital Improvement Program. Operating funds will be paid from annual operating budgets.

Table 2. Costs to Implement the Three Management Strategies

	Operating Costs	Capital Costs
Strategy #1 Riparian Forest Protection	N/A [a]	N/A [a]
Strategy #2 Reservoir Flow Releases	$14,992,955 [b]	$10,279,944 [b]
Strategy #3 Multiple Intakes at Dam 2 and Stilling Pool Bypass Pipe	N/A [a]	$7,203,000

[a] Costs are limited to staff time and have not been calculated separately.

[b] Only a portion of the reservoir release costs are attributable to temperature management. The releases are also to achieve river flow objectives. The dollar portion for temperature has not, however, been calculated separately. Total costs are shown. Reservoir releases will also be monitored. The total estimated cost for flow and temperature monitoring is $18,200 per year, or $910,000 (in 2006 dollars) over the 50-year term of the HCP.

Monitoring and Evaluation

Oregon law requires that DMAs monitor and evaluate progress toward achieving TMDL allocations and water quality standards [OAR 340-042-0080(3)(a)(C) and OAR 340-042-0040(4)(1)(M)].

Methodology for Collecting and Analyzing the Data

The Water Bureau will check hourly and daily maximum Bull Run River water temperatures and hourly flow records collected by the USGS. The Water Bureau will use established USGS sites on the lower Bull Run and Little Sandy rivers as flow and water temperature compliance locations. The Water Bureau has already installed real-time temperature monitoring equipment at Larson's Bridge and at the USGS gauge on the Little Sandy River.

Daily water temperatures will be recorded at the Larson's Bridge site on the lower Bull Run (USGS Gauge No. 14140020, Bull Run River at Larson's Bridge, RM 3.8), and also from USGS Gauge No. 14141500 (Little Sandy River at RM 1.95). Daily flows will be recorded at USGS

Gauge No. 14140000 (Bull Run River at RM 4.7 near Bull Run, Oregon). Monitoring locations are shown in Figure 2.

Daily maximum air temperatures will be recorded at the Water Bureau's Headworks facility below Dam 2 (approx. RM 6).

The Water Bureau will also monitor riparian conditions in the lower Bull Run River. Shade conditions along the lower Bull Run River will be recorded once every five years. Any tree cutting and/or replanting will be recorded annually and included in the annual report.

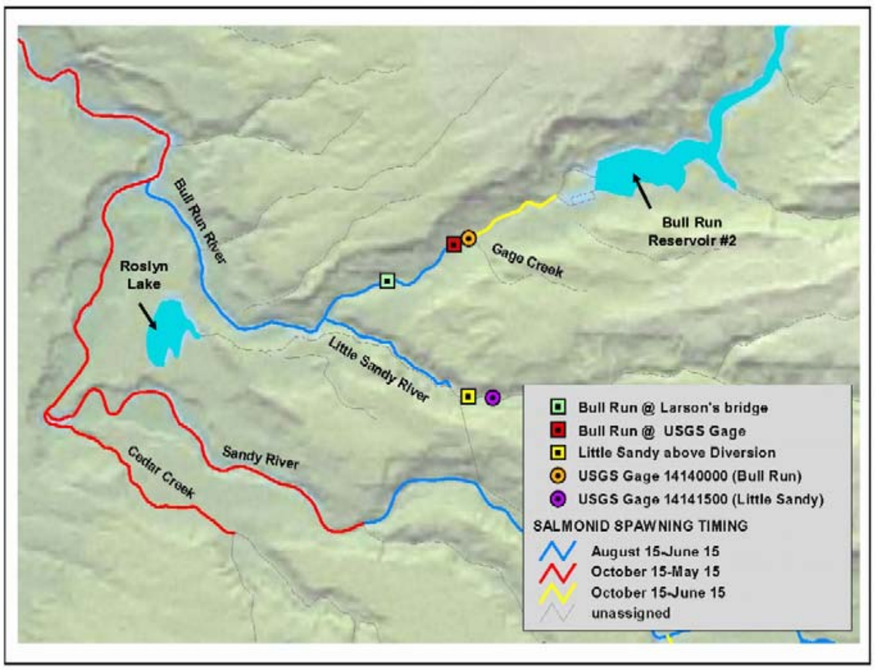

Figure 2. Monitoring Locations in the Bull Run and Little Sandy Rivers

Party Responsible for Collecting, Analyzing, and Reporting Information

The Water Bureau will collect, analyze, and report water temperature information to ODEQ on an annual basis. The annual report for the TMP is anticipated to be prepared on the same schedule as the longer annual report for the HCP because the temperature data reported will be the same. Timing for the first annual report will be determined in consultation with ODEQ and is expected to occur in 2009.

The Water Bureau's Resource Protection and Planning Group Director or designee will be responsible for ensuring that annual reports are produced and delivered to ODEQ. The Resource Protection and Planning Group Director is on the Water Bureau's management team and reports directly to the Water Bureau Administrator.

Staff involved in collecting, analyzing, and reporting data will include personnel responsible for operating the reservoirs to meet flow and temperature criteria, as well as scientists and engineers with monitoring and regulatory compliance duties. The Water Bureau will continue to contract with the USGS to monitor and maintain the flow gauges, as well as to analyze and conduct quality control of the flow data.

Adaptive Management

The Water Bureau has incorporated adaptive management approaches into both the HCP and this TMP. Acknowledgement of the infrastructure limitations on water temperature management resulted in a two-phased approach to comply with ODEQ's water temperature standard. If the infrastructure changes are effective and the Water Bureau is able to meet ODEQ's temperature requirements, the Water Bureau will then be in compliance and additional incremental improvements in strategy will not be necessary. The HCP will be in place as an enforceable contract for a period of 50 years.

Ongoing adjustments will be made in reservoir operations (e.g., to vary flow releases according to the weather during the summer season); the resulting water temperatures will be reported in an annual report. ODEQ's comments on the annual reports, especially about any compliance problems, will be used by the Water Bureau to plan improvements for subsequent operating seasons.

The Water Bureau has also acknowledged the potential effects of climate change on Bull Run watershed hydrology and has developed a statistical approach to identify changes that might affect the feasibility of continuing to release flows into the lower Bull Run River, as described in the HCP (see Chapter 10 of the HCP). These analyses will be provided to ODEQ if the results indicate a need to change temperature management strategies during the term of the HCP.

Chapter 9 in the HCP describes an adaptive management framework that will be used if the actions described above do not result in compliance with ODEQ's temperature requirements. Specifically, the Water Bureau and ODEQ will meet to discuss monitoring results that indicate the Water Bureau is not implementing the strategies as planned, or the three strategies are not successful in meeting the requirements. The TMP and HCP will be amended if necessary to incorporate new approaches. The HCP anticipates formal progress meetings approximately every five years and major decision milestones at Years 20, 30, and 35.

Evidence of Compliance with Land Use Requirements

The Water Bureau owns 4,782.8 acres of land in the Bull Run watershed, most of which is located around Reservoir 2 and downstream along the Bull Run River. This Water Bureau-owned land is located in Clackamas County. Approximately 95 percent of the physical drainage is federally owned land administered by the Mt. Hood National Forest. The Water Bureau holds multiple special use permits and easements to allow operation of water-system-related facilities on federal land.

Clackamas County established a River and Stream Conservation Area in 1997. Section 704 of the Clackamas County zoning and development ordinance (Title 12) defines requirements for all streams, which vary by stream size and designation. Fish-bearing streams are addressed and policies are defined for the Sandy, Salmon, and Zigzag rivers. Provisions include setbacks and native vegetation protection requirements. Section 1002 also includes provisions dealing with erosion control and habitat protection.

All three of the strategies outlined in this temperature management plan are consistent with current county land use regulations and policies. Land use, zoning, and building permits will be obtained for any new or modified structures that may require them. No changes in zoning are anticipated.

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Appendix

Note: The Temperature Management Plan approved by DEQ included an appendix excerpting text from the draft HCP for measures H-2, F-1 and F-2, and T-1 and T-2. See chapter 7 of the final HCP for the text of these measures.

Appendix H. Methodology to Assess Impact of the Long-term Climate Changes on Bull Run River Streamflow

The City of Portland (City) will track and analyze the impact of long-term climate changes on Bull Run River reservoir inflows as part of the Habitat Conservation Plan (HCP) (see Chapter 10, Changed Circumstances). Three statistical approaches will be applied to the Bull Run reservoir inflow data to determine whether there has been a significant decline in flow: linear regression, comparison of means/medians, and the number of critical flow years.

Two of the three tests, the comparison of means/medians and the number of critical flow years, require a sample size with enough power to enable comparisons. For this reason, the City will use a 20-year data set (from 2005–2025) to calculate the mean/median and the proportion of critical flow years. The tests will be implemented in 2025 and once every five years thereafter with cumulative year totals.

Specific statistical software packages are identified in this appendix. If better statistical software options are available in the future, those options will be discussed with NMFS and selected if appropriate.

Data Set

Streamflow for the Bull Run River and some of its tributaries has been measured by the U.S. Geologic Survey (USGS) since 1907. Historical streamflow measures for Little Sandy River extend as far back as 1911. However, the most reliable data without interruption starts in 1920.

The City evaluated the available data to select a data set that would be stationary and would include enough years to be able to detect a statistically significant trend. A data set of Bull Run reservoir inflows from 1946 to 2004 (59 years) was selected. The 1946–2004 data are stationary. Between 23 and 37 years of data are needed in order to detect a trend of magnitude 0.5 – 0.1 percent per year when the data are stationary (Weatherhead 1998). The 1946-2004 data set is also expected to be large enough to detect a decline in average flow as a possible impact of long-term climate change on Bull Run streamflow.

Test Procedures

The following statistical tests will be implemented in 2025 and every five years after that through 2050 to detect changes in Bull Run reservoir inflow due to long-term climate changes: linear regression, comparison of means or medians, and number of critical flow years. Future analyses will contrast the 1946-2004 data set first with the data for 2005–2025 and then with additional data gathered during the five-year increments (i.e., 2005–2030, 2005–2035, etc.). If two out of three tests indicate a decline in flow, the conclusion will be in favor of the two tests.

Linear Regression

The City will detect and measure the trend in the flow using a linear regression model. The slope of the fitted trend line to the natural log of the data shows the average percentage growth (positive or negative), for the time period over the entire range of data. The semi-log regression model is of the form:

$$\ln(Flow) = \alpha + \beta t + u$$

in which *t* is time (in this case, 1946–2004), α and β are the intercept and the slope of the trend line, and *u* is the error term of the regression.

The trend detection test procedure is as follows.

- Compute the natural log of the flow data for the entire 1946–2025 period.
- Fit a regression trend line to the data in which the independent variable *t* takes the value 1946–2025.
- Check the level of significance of the coefficients.
- If the coefficient of *t* is equal to or less than -0.007, then that indicates a downward trend in flow.

When detecting a change in the rate of decline, the investigator should perform a test procedure for point of inflection or deflection. A Chow test can determine whether there is a statistically significant change in the coefficient of the trend at any specified point in time. Most regression software packages are capable of performing the Chow test. The test is usually found under the Coefficient Stability Test category. The Chow test can determine whether there is a change in magnitude or direction of the trend during the 2005–2025 period.

Comparison of the Means and/or Medians

For this test, the means or medians of flow data can be compared and statistically tested to see whether they are significantly different. Unlike the median, the sample mean is affected by outliers that are unusually large or small compared with the rest of the data. Moreover, the mean is a computed number that might not actually occur. Therefore, in cases where outliers exist, comparison of medians is a more reliable test. Tests of both the mean and the median are suggested here.

Test of Means

In order to detect a downward trend in streamflow, the mean of historical flow data, 1945–2004, will be statistically tested against the mean of flow during the 2005–2025 period.

Let μ_0 and μ_1 be the 1946–2004 and 2005–2025 mean flows respectively. The null hypothesis is

$$H_n: \mu_0 = \mu_1.$$

This is tested against the alternative hypothesis,

$$H_a: \mu_0 > \mu_1.$$

A t-test with 0.05 level of significance can determine whether there is a statistically significant decline in the mean flow. The test procedure is as follows.

- Determine the critical value $t_{0.05}$ with $(n+m-2)$ degrees of freedom, where n and m are number of flow observation in 1946–2004 and 2005–2025 periods respectively.
- Compute means $\overline{x}_0$ and $\overline{x}_1$, and standard deviations, s_0 and s_1, of the 1945–2004 and 2005–2025 flows respectively.
- Compute the test statistic,

$$t = \frac{\overline{x}_0 - \overline{x}_1}{\sqrt{\frac{(n-1)s_0^2 + (m-1)s_1^2}{n+m-2}}\sqrt{\frac{1}{n}+\frac{1}{m}}}.$$

- If $t > t_{0.05}$, then reject the null hypothesis and conclude that there is a decline of statistical significance in mean flow. If $t < t_{0.05}$, then do not reject the null hypothesis.

Microsoft® Excel or other statistical software can be used to implement the above test statistics.

Test of Medians

A similar test of hypotheses can be done using medians instead. The null and alternative hypotheses are:

$$H_n: M_0 = M_1$$
$$H_a: M_0 > M_1$$

The Mann-Whitney-Wilcoxon (MWW) test procedure with 0.05 level of significance is as follows:

- Determine the critical value, $z_{0.05}$.
- Combine $N = n + m$ observations from 1946–2004 and 2005–2025 flows, but keep track of which sample the observation was drawn from.
- Order and rank the N observations from smallest, rank 1, to the largest, rank N. For observations of equal magnitude, assign each the average of their ranks.
- Compute the sum of ranks, T_0, for the observations in the 1946–2004 sample.
- Compute the test statistics,

$$z = \frac{T_0 - \frac{m(N+1)}{2}}{\sqrt{\frac{mn(N+1)}{12}}}$$

- If $|z| > z_{0.05}$, then reject the null hypothesis and conclude there is a decline of statistical significance in the median flow. If $|z| < z_{0.05}$, then do not reject the null hypothesis.

There are no specific modules that perform the MWW test in Microsoft® Excel. However, the test can be set up manually according to the explained procedure and performed in Excel. Also, most statistical software packages perform MWW or other versions of test of equality of medians.

Number of Critical Flow Years

The third approach to detecting the long-term climate impact is to observe the increase in the frequency of occurrence of critical flow years. The 1946–2004 Bull Run inflow data were used to determine the cutoff for the critical flow. The proprietary statistical software Crystal Ball was used to fit an empirical distribution to the flow data. The best-fitted distribution was a gamma distribution with scale 41 and shape 8 parameters. The goodness-of-fit tests show a Kolmogrov value of 0.05 with a p-value 0.99 and an Anderson-Darling value of 0.14 with a p-value of 0.99.

Crystal Ball was used to simulate ten thousand flow numbers according to the fitted gamma distribution. Figure H- 1 shows the empirical simulated gamma distribution and the 10th percentile cutoff flow.

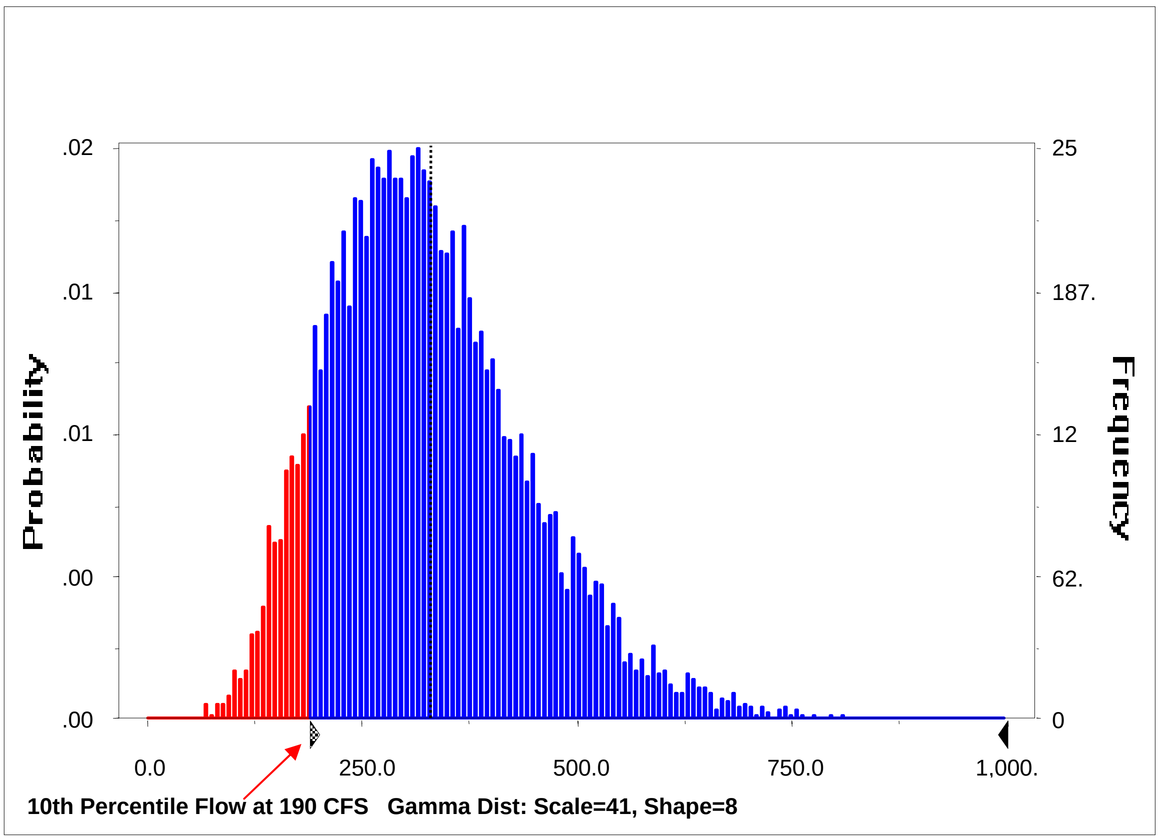

Figure H-1. Bull Run Flow Empirical Frequency Distribution, 1946–2004

The lowest 10th percentile flow cutoff, 190 cubic feet per second (cfs), was determined from the simulated flow numbers. Critical flow years are defined as years in which the June–October average flow is equal to or less than 190 cfs. According to this criterion, the five years between 1946 and 2004 are considered critical flow years (see Table H-1). The proportion of critical flow years during the 1946–2004 period is 5 out of 59 or 0.085.

Table H-1. Critical Flow Years for 1946–2004

Years	Flow (cfs)
1965	130
1987	133
1991	188
1992	162
2003	158

Sources: USGS Gauges No. 14138850, Bull Run River at RM 14.8; No. 14138870, Fir Creek at RM 0.6; No. 14138900, North Fork Bull Run River at approximately RM 0.2; and No. 14139800, South Fork Bull Run River at RM 0.6.

Given the determined cutoff flow and the proportion of critical flow years, let p_0 and p_1 be the 1946–2004 and 2005–2025 proportion of critical flow years respectively. The null and alternative hypotheses are:

$$H_n: \; p_0 = p_1$$
$$H_a: \; p_0 < p_1$$

A z test with 0.05 level of significance can determine whether there has been a statistically significant increase in the proportion of the critical flow years. The test procedure is as follows:

- Use the critical flow year cutoff flow of 190 cfs to determine the number of critical flow years for 2005–2025 and compute the proportion $\hat{p}_1$. The proportion $\hat{p}_0$ is already computed as 0.085.
- Compute the test statistic

$$z = \frac{\hat{p}_1 - \hat{p}_0}{\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{m} + \frac{\hat{p}_0(1-\hat{p}_0)}{n}}}$$

- If $z > z_{0.05}$, then reject the null hypothesis and conclude that there is an increase of statistical significance in the frequency of the critical flow years. If $z < z_{0.05}$, then do not reject the null hypothesis.

This test can be set up manually and performed in Microsoft® Excel.

The City will use simulation software in the future to determine the shift in the frequency of occurrence of critical flow years.

Literature Cited

E.C. Weatherhead, G.C. Reinsel, G.C. Tiao, X.-L. Meng, D.-S. Choi, W.-K. Cheang, T. Keller, J. DeLuisi, D.J. Wuebbles, J.B. Kerr, A.J. Miller, S.J. Oltmans, J.E. Frederick. 1988. Factors affecting the detection of trend: Statistical considerations and application to environmental data. *J Geophysical Research,* 103: 17,149–17,161.

Appendix I. Timeline of Bull Run Water Supply Habitat Conservation Plan Projected Costs in 2008 Dollars[a]

			HCP Year										
			2006-2008	2008-2013	2013-2018	2018-2023	2023-2028	2028-2033	2033-2038	2038-2043	2043-2048	2048-2053	2053-2058
	Type of cost	50-year total		(1-5)	(6-10)	(11-15)	(16-20)	(21-25)	(26-30)	(31-35)	(36-40)	(41-45)	(46-50)
Habitat Conservation		**$70,666,277**											
Bull Run Measures	**TOTAL**	**$39,007,387**	**$905,000**	**$11,160,496**	**$1,926,726**	**$1,465,924**	**$5,856,275**	**$2,742,199**	**$2,337,390**	**$3,123,121**	**$3,376,338**	**$2,900,594**	**$3,213,323**
Flow Measures													
Measures F-1 and F-2 (Minimum Instream Flows)	O&M	$16,082,750	$0	$393,803	$660,255	$926,709	$1,193,161	$1,460,840	$1,736,275	$2,012,936	$2,289,596	$2,566,257	$2,842,918
Measures F-1 and F-2 (Capital Maintenance of Well Field)	Capital	$10,905,993	$0	$607,859	$1,160,381	$433,125	$4,557,024	$1,175,269	$495,025	$1,004,095	$980,652	$228,247	$264,315
Measure F-3 (Flow Downramping)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure F-4 (Little Sandy Flow Agreement)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Temperature Measures													
Measure T-1 (Pre-infrastructure Temperature Management)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure T-2 (Post-infrastructure Temperature Management)	Capital	$9,613,132	$642,000	$8,971,132	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure T-2 (Modification of Spillway Rock Weir)	Capital	$208,000	$94,000	$114,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lower Bull Run Measures													
Measure H-1 (Spawning Gravel Placement)	O&M	$928,288	$0	$212,180	$79,568	$79,568	$79,568	$79,568	$79,568	$79,568	$79,568	$79,568	$79,568
Measure P-1 (Walker Creek Fish Passage)	Capital	$989,000	$169,000	$820,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-2 (Riparian Land Protection)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Bull Run Reservoir Measures													
Measure R-1 (Reservoir Operations)		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure R-2 (Cutthroat Trout Rescue Equipment Purchase)	Capital	$15,000	$0	$15,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure R-2 (Cutthroat Trout Rescue Staff Time)	O&M	$265,225	$0	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523	$26,523
Measure R-3 (Reed Canarygrass Removal)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure O&M-1 (Bull Run Infrastructure Operation and Maintenance)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure O&M-2 (Bull Run Spill Prevention)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Offsite Measures	**TOTAL**	**$16,598,090**	**$0**	**$7,056,599**	**$5,235,648**	**$2,064,162**	**$433,908**	**$301,296**	**$301,296**	**$301,296**	**$301,296**	**$301,296**	**$301,296**
HCP Years 1-5	***$6,522,691***												
Measure H-5 (Gordon 1A & 1B LW Placement)	O&M	$214,531	$0	$214,531	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-6 (Trout 1A LW Placement)	O&M	$53,633	$0	$53,633	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-7 (Trout 2A LW Placement)	O&M	$15,017	$0	$15,017	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-11 (Sandy 1 Riparian Easement and Improvement)	Capital	$103,243	$0	$103,243	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-12 (Sandy 2 Riparian Easement and Improvement)	Capital	$633,537	$0	$633,537	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-13 (Gordon 1A & 1B Riparian Easement and Improvement)	Capital	$732,087	$0	$732,087	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-16 (Alder 1A & 2 Riparian Easement and Improvement)	O&M	$403,587	$0	$403,587	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-22 (Boulder 1 Riparian Easement and Improvement)	Capital	$136,093	$0	$136,093	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-26 (Boulder 0 & 1 LW Placement)	O&M	$48,270	$0	$48,270	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure P-2 (Alder 1 Fish Passage)	O&M	$402,246	$0	$402,246	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure P-3 (Alder 1A Fish Passage)	O&M	$80,449	$0	$80,449	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure P-4 (Cedar 1 Fish Passage)	Capital	$3,700,000	$0	$3,700,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
HCP Years 6-10	***$4,801,739***												
Measure H-3 (Little Sandy 1 & 2 LW Placement)	O&M	$96,539	$0	$0	$96,539	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-4 (Sandy 1 & 2 Log Jams)	O&M	$670,409	$0	$0	$670,409	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-8 (Sandy 1 Reestablishment of River Mouth)	O&M	$1,186,624	$0	$0	$1,186,624	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-9 (Sandy 1 Channel Reconstruction)	O&M	$402,246	$0	$0	$402,246	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-10 (Turtle Survey and Relocation)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-15 (Cedar 2 & 3 Riparian Easement and Improvement)	Capital	$460,705	$0	$0	$460,705	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-17 (Cedar 2 & 3 LW Placement)	O&M	$429,062	$0	$0	$429,062	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-19 (Salmon 1 Riparian Easement and Improvement)	Capital	$211,179	$0	$0	$211,179	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-23 (Salmon 2 Miller Quarry Acquisition)	Capital	$335,205	$0	$0	$335,205	$0	$0	$0	$0	$0	$0	$0	$0
Measure H-25 (Salmon 2 Carcass Placement)	O&M	$4,157	$0	$0	$4,157	$0	$0	$0	$0	$0	$0	$0	$0
Measure F-5 (Cedar Creek Purchase Water Rights)	Capital	$1,005,614	$0	$0	$1,005,614	$0	$0	$0	$0	$0	$0	$0	$0
HCP Years 11-15	***$1,630,254***												
Measure H-14 (Sandy 3 Riparian Easement and Improvement)	Capital	$61,007	$0	$0	$0	$61,007	$0	$0	$0	$0	$0	$0	$0
Measure H-18 (Sandy 8 Riparian Easement and Improvement)	Capital	$234,643	$0	$0	$0	$234,643	$0	$0	$0	$0	$0	$0	$0
Measure H-20 (Salmon 2 Riparian Easement and Improvement)	Capital	$337,886	$0	$0	$0	$337,886	$0	$0	$0	$0	$0	$0	$0
Measure H-21 (Salmon 3 Riparian Easement and Improvement)	Capital	$112,628	$0	$0	$0	$112,628	$0	$0	$0	$0	$0	$0	$0
Measure H-24 (Salmon 2 Miller Quarry Restoration)	Capital	$475,991	$0	$0	$0	$475,991	$0	$0	$0	$0	$0	$0	$0
Measure H-27 (Zigzag 1A Channel Design)	O&M	$268,164	$0	$0	$0	$268,164	$0	$0	$0	$0	$0	$0	$0
Measure H-28 (Zigzag 1A & 1B Riparian Easement and Improvement)	Capital	$113,118	$0	$0	$0	$113,118	$0	$0	$0	$0	$0	$0	$0
Measure H-29 (Zigzag 1A, 1B, & 1C Carcass Placement)	O&M	$26,816	$0	$0	$0	$26,816	$0	$0	$0	$0	$0	$0	$0
Purchase LW	O&M	$530,450	$0	$132,613	$132,613	$132,613	$132,613	$0	$0	$0	$0	$0	$0
Land Maintenance	O&M	$3,012,956	$0	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296	$301,296
Design and Permitting	Capital	$100,000	$0	$100,000	$0	$0	$0	$0	$0	$0	$0	$0	$0

	Type of cost	50-year total	2006-2008	2008-2013 (1-5)	2013-2018 (6-10)	2018-2023 (11-15)	2023-2028 (16-20)	2028-2033 (21-25)	2033-2038 (26-30)	2038-2043 (31-35)	2043-2048 (36-40)	2048-2053 (41-45)	2053-2058 (46-50)
			HCP Year										
Habitat Fund	**TOTAL**	**$5,000,000**	**$0**	**$1,000,000**	**$1,750,000**	**$1,000,000**	**$1,250,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Measure H-30	O&M	$2,500,000	$0	$500,000	$875,000	$500,000	$625,000	$0	$0	$0	$0	$0	$0
Measure H-30	Capital	$2,500,000	$0	$500,000	$875,000	$500,000	$625,000	$0	$0	$0	$0	$0	$0
Staff Time	**TOTAL**	**$10,060,800**	**$0**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**	**$1,006,080**
60% of Total	O&M	$10,060,800	$0	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080	$1,006,080
Monitoring		**$5,175,200**											
Compliance	**TOTAL**	**$910,000**	**$0**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**	**$91,000**
Flow and Water Temperature Monitoring (USGS)	O&M	$910,000	$0	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000	$91,000
Effectiveness	**TOTAL**	**$1,750,000**	**$0**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**	**$175,000**
Effectiveness Monitoring for Instream Projects	O&M	$1,750,000	$0	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000
Staff Time	**TOTAL**	**$2,515,200**	**$0**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**	**$251,520**
15% of Total	O&M	$2,515,200	$0	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520	$251,520
Research		**$7,013,400**											
Habitat Research	**TOTAL**	**$575,000**	**$0**	**$50,000**	**$125,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**	**$50,000**
Gravel Monitoring	O&M	$500,000	$0	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Scour Monitoring	O&M	$75,000	$0	$0	$75,000	$0	$0	$0	$0	$0	$0	$0	$0
Population Research	**TOTAL**	**$5,600,000**	**$0**	**$650,000**	**$650,000**	**$650,000**	**$650,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**	**$500,000**
Adult Chinook Population Data	O&M	$600,000	$0	$150,000	$150,000	$150,000	$150,000	$0	$0	$0	$0	$0	$0
Juvenile Outmigrant Data (Smolt Trapping)	O&M	$5,000,000	$0	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
Staff Time	**TOTAL**	**$838,400**	**$0**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**	**$83,840**
5% of Total	O&M	$838,400	$0	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840	$83,840
Adaptive Management		**$10,353,600**											
Habitat Fund	**TOTAL**	**$4,000,000**	**$0**	**$388,889**	**$388,889**	**$444,444**	**$1,000,000**	**$666,667**	**$666,667**	**$222,222**	**$222,222**	**$0**	**$0**
Measure H-30	O&M	$2,000,000	$0	$194,444	$194,444	$222,222	$500,000	$333,333	$333,333	$111,111	$111,111	$0	$0
Measure H-30	Capital	$2,000,000	$0	$194,444	$194,444	$222,222	$500,000	$333,333	$333,333	$111,111	$111,111	$0	$0
Insurance Fund	**TOTAL**	**$3,000,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$1,250,000**	**$1,250,000**	**$250,000**	**$250,000**
Insurance Fund Requirements at Years 31, 36, and 41	O&M	$3,000,000	$0	$0	$0	$0	$0	$0	$0	$1,250,000	$1,250,000	$250,000	$250,000
Staff Time	**TOTAL**	**$3,353,600**	**$0**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**	**$335,360**
20% of Total	O&M	$3,353,600	$0	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360	$335,360
Terrestrial Wildlife Conservation													
Wildlife Measures													
Measure W-1 (Minimize Impacts to Spotted Owls)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure W-2 (Minimize Impacts to Bald Eagles)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Measure W-3 (Minimize Impacts to Fishers)	–[b]	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Capital Requirements		**$34,984,061**	$905,000	$16,627,394	$4,242,528	$2,490,621	$5,682,024	$1,508,603	$828,359	$1,115,206	$1,091,764	$228,247	$264,315
Total O&M Requirements		**$58,224,416**	$0	$5,621,390	$7,776,534	$5,126,709	$5,500,959	$4,694,359	$4,969,794	$6,274,233	$6,550,893	$5,716,443	$5,993,104
CAPITAL AND O&M GRAND TOTAL		**$93,208,477**	$905,000	$22,248,784	$12,019,062	$7,617,331	$11,182,983	$6,202,962	$5,798,153	$7,389,439	$7,642,656	$5,944,690	$6,257,418

[a]This cost estimate is the City's best estimate for the timing of measure funding but implementation of measures may vary from this timeline.
[b]No estimated costs are included in the relevant staff time line item for this measure.

Appendix J. The Life Cycle of Salmonids

The material in this appendix has been adapted from Section 3.2.3 of Seattle Public Utility's Cedar River Habitat Conservation Plan*.*

Introduction

Salmon and steelhead trout are members of several species in the biological family Salmonidae (also referred to as "salmonids"). This appendix provides background on the basic life cycle of salmonids with some information on the variations that occur among species.

The Redd

Most members of the family Salmonidae begin life in streams, or sometimes lakes, when eggs and sperm are released into clean gravel (Wydoski and Whitney 1979). Female salmon or trout typically dig several egg pockets in the gravel in a stream bed. Shortly after digging each egg pocket, the female will release a portion of her eggs as the male releases sperm. The eggs settle onto the gravel and, after a short interval, the female will move upstream to repeat the process. As she digs the next egg pocket, the excavated gravel from the new pocket covers the previously deposited eggs. The spawning fish will create several egg pockets over the course of several days. The combined group of egg pockets is called a redd.

Eggs, Alevins, and Fry

The eggs develop for variable lengths of time, depending on species, subspecies, individual variability, water temperature, and general incubation conditions. After 1-3 months, the eggs hatch into larval fish called alevins. Newly hatched alevins burrow downward into the gravel to avoid light within 48 hours of hatching (Fast 1987). The alevins remain in the gravel and gradually continue to develop, using the energy stored in their attached yolk sacs. Figure J-1 shows an alevin with an attached yolk sac. After 1-3 months—depending primarily on the species and water temperature—absorption of the the yolk sacs is almost complete. At this point, the alevins move up through the gravel, swimming towards the light and the current. The alevins emerge from the gravel as free-swimming fry. Most salmonids fry have several dark oval or circular markings on their sides called parr marks (see Figure J-1).

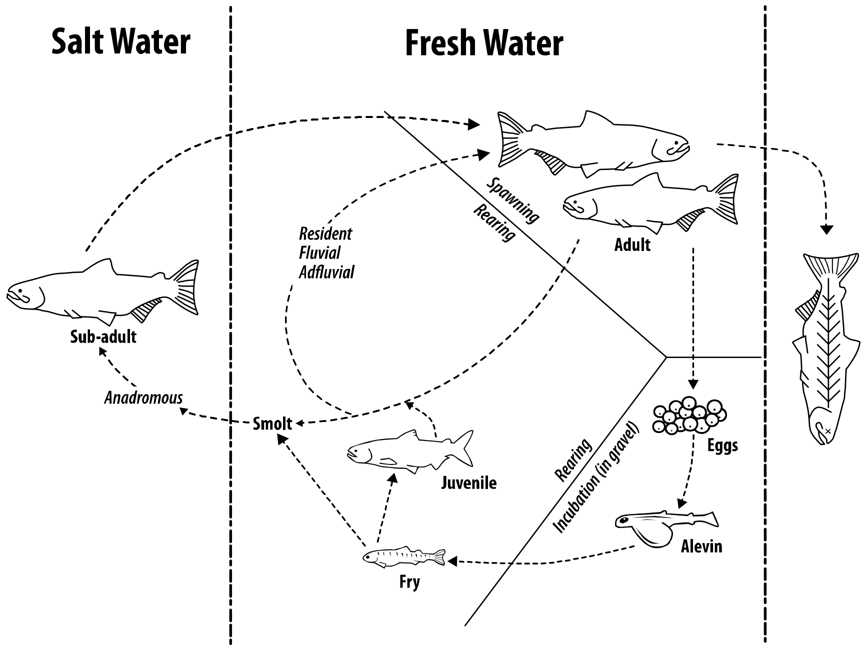

Figure J-1. Salmonid Life Cycle

Juvenile Salmonids

There is considerable variation in life history strategies among species and populations of salmonids during the juvenile stage (Groot and Margolis 1991). Species vary with respect to the amount of time spent in fresh water and where the young fish grow, or rear, to maturity. Juvenile Chinook, winter steelhead, and coho typically remain in their natal streams for extended periods and produce relatively smaller runs of adults, compared with other salmon species.

Spawning

As salmon and trout approach sexual maturity, they begin a spawning migration, returning to their natal stream, although a small percentage strays to other streams (Hasler 1966; Groot and Margolis 1991). The maturing adults exhibit changes in body form and color; individuals of some species return to their natal streams with highly developed coloring on their sides, dark spots, and/or a hooked snout for which the genus is named (*Oncorhynchus* is derived from the Greek for "hooked nose").

Females choose the site of the redd and defend it from other females. Males fight over the females, aggressively chasing off other males after acceptance by a female. In some species, a few males (and occasionally females) in a population will return to spawn a full year earlier than the majority of the population. These precocious males (called jacks) can successfully fertilize some of the eggs during the act of spawning by a full-size, adult pair.

Chinook, coho, and chum salmon are semelparous, meaning that individuals breed only once and die after spawning. Winter steelhead are iteroparous, which means that individuals breed more than once and may live to spawn in several years (Groot and Margolis 1991). One important consequence of the return of anadromous fish is that nutrients from the ocean are carried into the fish's natal stream once the individual dies and its body decomposes. This source of nutrients has been shown to contribute to aquatic and riparian productivity (Bilby et al. 1996).

Life Histories

Salmonids that spend their entire lives within a fairly limited stream range are said to exhibit a *resident* life history. Fish with *fluvial* life histories spawn and perhaps rear for a period in a small tributary but move into larger streams and rivers later in life. Fish with *adfluvial* life histories spawn and sometimes rear in streams, then move into lakes after maturity.

Fish that leave fresh water to grow and mature in the ocean before returning to spawn are *anadromous*. Juvenile anadromous fish with parr marks lose the marks as their physiologies change in preparation for leaving fresh water and entering salt water. At this stage, the fish are called smolts.

Salmon and winter steelhead spend from one to several years in the ocean, depending on species, sub-species, and individual variability.

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Appendix K. Data Source Information for Maps

Table K-1. Data Source Information for Maps

Theme	Source(s)	Date	Scale
Figure 2-1. Location of the Bull Run Watershed in the Sandy River Basin			
1:100k Sandy Basin streams with EDT reach delineation[a]	Portland Water Bureau & Ecotrust modification of OGDC file[b]	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish and Wildlife	2004	—
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Bull Run watershed hydrologic unit boundary	Ecotrust	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
Major and principal highways	City of Portland GIS data	2003	—
Hillshade from 30m DEMs[c]	Ecotrust	1999	n/a
30m DEMs	Ecotrust	1999	n/a
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Urban growth boundary	Metro Regional Government	2002	—
Mt. Hood National Forest boundary	U.S. Forest Service	1997	—
Figure 2-2. City of Portland Water System and Service Area			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Bull Run watershed hydrologic unit boundary	Ecotrust	2003	—
Major rivers	U. S. Geological Survey	1996	1:100K
Lakes	Mount Hood National Forest		1:24K
Portland Water Bureau retail and wholesale service area boundaries	Metro Regional Government Data Resource Center	1999	—
Columbia South Shore Well Field and Former Powell Valley Road Water District Drinking Water Protection Zone boundaries	Portland Water Bureau GIS data	2004	1:1200
Figure 4-1. Watersheds of the Sandy River Basin			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish and Wildlife	2004	—
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
Major and principal highways	City of Portland GIS data	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a

Table K-1. Data Source Information for Maps, continued

Theme	Source(s)	Date	Scale
Figure 4-1. Watersheds of the Sandy River Basin, continued			
30m DEMs	Ecotrust	1999	n/a
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Urban growth boundary	Metro Regional Government	2002	—
Mt. Hood National Forest boundary	U.S. Forest Service	1997	—
Figure 4-4. Relative Water Temperatures in Sandy River Basin Streams and Tributaries			
Forward Looking Infrared Radar (FLIR) thermography monitoring data	Oregon Department of Environmental Quality	2001	—
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish & Wildlife	2004	—
Columbia River	U. S. Geological Survey	1996	1:100K
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Urban growth boundary	Metro Regional Government	2002	—
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Major and principal highways	Metro Regional Government	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
Figure 4-6. Sandy River Basin Vegetation Cover Types			
1998 GAP vegetation[d]	Natural Heritage	1998	n/a
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	
Columbia River	U. S. Geological Survey	1996	1:100K
Major and principal highways	Metro Regional Government	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Urban growth boundary	Metro Regional Government	2002	—
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish & Wildlife	2004	—
Figure 4-7. Land Cover and Existing Uses in the Sandy River Basin			
Landsat satellite imagery	U. S. Geological Survey	2000	—
Major and principal highways	Metro Regional Government	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k

Table K-1. Data Source Information for Maps, continued

Theme	Source(s)	Date	Scale
Figure 4-7. Land Cover and Existing Uses in the Sandy River Basin, continued			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Oregon dams	Oregon Department of Fish & Wildlife	2004	—
Lakes	Mount Hood National Forest	—	1:24K
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Urban growth boundary	Metro Regional Government	2002	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
Mt. Hood National Forest boundary	U.S. Forest Service	1997	—
Figures 4-8 through 4-13. Watersheds in the Sandy River Basin (Lower, Middle, Upper Sandy River; the Salmon River; the Zigzag River; and the Bull Run River)			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish and Wildlife	2004	—
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
Highways and freeways	City of Portland GIS data	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
30m DEMs	Ecotrust	1999	n/a
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Urban growth boundary	Metro Regional Government	2002	—
Mt. Hood National Forest boundary	U.S. Forest Service	1997	—
Figures 5-5, 5-6, 5-14, 5-15, 5-23, 5-24, 5-32, and 5-33. Current and Historical Distribution (Fall Chinook, Spring Chinook, Winter Steelhead, Coho)			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Oregon dams	Oregon Department of Fish & Wildlife	2004	—
Sandy Basin hydrologic unit boundary	Ecotrust	Varies	Varies
Watershed hydrologic unit boundaries	Ecotrust	2003	—
Major streets and highways	Metro Regional Government	2003	—
Hillshade from 30m DEMs	Ecotrust	1999	n/a
Urban growth boundary	Metro Regional Government	2002	—
County boundaries	Metro Regional Government	2003	—
City limits	SCSGIS	1997	1:24k
Columbia River	U. S. Geological Survey	1996	1:100K

Table K-1. Data Source Information for Maps, continued

Theme	Source(s)	Date	Scale
Figures 7-2 through 7-7. Offsite Habitat Conservation Measure Locations (Little Sandy River; Lower, Middle, and Upper Sandy River; Salmon River, Zigzag River)			
1:100k Sandy Basin streams with EDT reach delineation	Portland Water Bureau & Ecotrust modification of OGDC file	2003	1:100k
Lakes	Mount Hood National Forest	—	1:24K
Sandy Basin hydrologic unit	Ecotrust	Varies	Varies
Sandy sub-basin hydrologic unit	Ecotrust	2003	—
Columbia River	U. S. Geological Survey	1996	1:100K
Hillshade from 30m DEMs	Ecotrust	1999	n/a

— indicates metadata that are unavailable or unknown
[a]EDT–Ecosystem Diagnosis and Treatment; see Appendix D for more information
[b]OGDC–Oregon Geospatial Data Clearinghouse, available at http://www.gis.state.or.us/data/alphalist.html
[c]DEM–digital elevation map
[d]GAP–GAP Analysis Program, a project conducted by the U.S. Geological Survey, available at http://gapanalysis.nbii.gov/portal/server.pt

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Appendix M. Changes or Additions to HCP After Fall 2007 Public Review Draft

Chapter or Appendix	Document		Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	Page	Section			
Ch 2	2-7	2.2.1	Clarification that none of the covered species is found in Bull Run Lake	No	No
	2-13	2.4	Clarification that City funding of ODFW hatchery operations is not covered	No	No
Ch 3	3-1	3.1	Addition of eulachon (*Thaleichthys pacificus*) as a covered species because of the National Marine Fisheries Services decision in March 2008 to initiate a status review of the species (a decision on the listing determination is expected by November 8, 2008)	No	No
	3-3	3.3	Clarification that federal ESA coverage can be provided for Bull Run Lake and federal roads under Section 7	No	No
Ch 4	4-14	4.1.5	Addition of a brief overview of the conclusions from the University of Washington study on climate change in the Bull Run watershed	No	No
	4-32 and 4-33	4.3	Explanation of the data source for the watershed stream miles in Table 4.8 and correction of watershed mileages to conform to mileages in the Sandy River Basin Characterization Report	No	No
Ch 5	5-2	5.1	Explanation that eulachon sometimes spawn in the lower Sandy River in the vicinity of the area that will be affected by some of the City's HCP measures.	No	No

Chapter or Appendix	Document		Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	Page	Section			
Ch 5			Correction of GIS-generated historical stream mileages for fish distribution to mileages based on stream surveys:	No	Yes
	5-56 and	Table 5-3	Winter steelhead		
	5-73	Table 5-6	Coho		
	5-78	5.4.2	Addition of information on eulachon including species status, life history and diversity, distribution, abundance and productivity, harvest in the Sandy River Basin, reasons for decline, and threats to survival.	No	No
Ch 7	7-17	Measure T-2	Inclusion of Table 7-6. Appropriate Numeric Temperature Criteria Clarification of conditions under which Bull Run water temperature target will be adjusted or an exception to the temperature targets would occur per the ODEQ Total Maximum Daily Load (TMDL) document.	No	No

Chapter or Appendix	Document		Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	Page	Section			
Ch 7			For offsite riparian easement and improvement measures: • Clarification that the City will consider obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide • Clarification that easement management will include control of invasive plant species	No	No
	7-39	Measure H-11	Reach Sandy 1		
	7-40	Measure H-12	Reach Sandy 2		
	7-40	Measure H-13	Reaches Gordon 1A and 1B		
	7-45	Measure H-14	Reach Sandy 3		
	7-45	Measure H-15	Reaches Cedar 2 and 3		
	7-45	Measure H-16	Reach Alder 1A and 2		
	7-51	Measure H-18	Reach Sandy 8		
	7-54	Measure H-19	Reach Salmon 1		
	7-55	Measure H-20	Reach Salmon 2		
	7-55	Measure H-21	Reach Salmon 3		
	7-55	Measure H-22	Reach Boulder 1		
	7-61	Measure H-28	Reaches Zigzag 1A and 1B		
Ch 8	8-156	8.3.2	Addition of effects on eulachon habitat in the lower Bull Run River, the Columbia River, effects on eulachon habitat from the HCP offsite measures, population effects and VSP parameters, and conclusions about the habitat effects of HCP measure implementation on eulachon.	Minor addition specific to eulachon	No

Chapter or Appendix	Document		Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	Page	Section			
	8-4	8.1.2	Clarification that the estimated production that would result from the HCP conservation measures does not include fish passage in Walker and Alder creeks	No	No
Ch 8			Under Effects of the Bull Run Measures on Lower Bull Run River Habitat, clarification of blocked stream miles in the Bull Run watershed in the Reference Condition and total number of miles provided by HCP measures under Habitat Effects of Conservation Measures for the four primary species:	No	No
	8-9	Table 8-2	Fall Chinook		
	8-43	Table 8-12	Spring Chinook		
	8-82	Table 8-26	Winter steelhead		
	8-120	Table 8-39	Coho		
		8.2.1	Clarification that the benefit level excludes the benefits of large wood additions for each primary covered species:	No	No
	8-39		Fall Chinook		
	8-78		Spring Chinook		
	8-116		Winter steelhead		
	8-153		Coho		
		Access	Correction of mileages blocked in the upper Bull Run River for three of the primary covered species:	No	Yes
	8-57		Spring Chinook		
	8-93		Winter steelhead		
	8-133		Coho		

Chapter or Appendix	Document Page	Document Section	Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
			Correction of Zigzag stream reaches affected by Zigzag measures:	No[c]	No
	8-72 and	Table 8-22	Spring Chinook		
	8-109	Table 8-35	Winter steelhead		
Ch 8		Summaries	Correction of mileages that will become accessible to winter steelhead and coho with the passage improvements in Alder and Cedar creeks:	No	No
	8-100		Winter steelhead		
	8-139		Coho		
	8-148		Corrections to percentages for diversity and abundance for Coho	No	Yes
	8-149	Table 8-50	Corrections to percentages for productivity and diversity for Coho	No	Yes
	8-150	Table 8-51	Corrections to adult abundance numbers for Coho	No	Yes
			Clarification of the flow requirements for exceedence of total dissolved gas (TDG) as well as the locations where elevated TDG levels have been observed in the Bull Run River for the four primary species:	No	No
	8-23		Fall Chinook		
	8-59		Spring Chinook		
	8-94 — 8-95		Winter steelhead		
	8-136		Coho		
			Clarification of additional stream miles available after the removal of Little Sandy Dam:	No	No
	8-22		Fall Chinook		

Chapter or Appendix	Document		Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	Page	Section			
	8-57 8-93 8-133		Spring Chinook Winter steelhead Coho		
Ch 8	8-156 – 8-157	Table 8-52	Addition of table showing historical distribution of rainbow trout in the Bull Run River (based on historical distribution of winter steelhead)	No	No
Ch 9	9-21	Total Dissolved Gas Research	Addition of exception to Oregon Administrative Rule 340-041-0031 on TDG and clarification of TDG locations within the Bull Run water system infrastructure	No	No
	9-28 and 9-29	Habitat Fund	Clarification of one of the functions of the Habitat Fund and explanation of how the Habitat Fund costs in Appendix I relate to the Habitat Fund discussions in chapters 9 and 11	No	No
Ch 10	10-1 – 10-3	10.2	Discussion of the City's monitoring of and preparation for climate change. Discussion includes a description of findings from the 2002 study on climate change in the Bull Run prepared by University of Washington staff.	No	No
Ch 11	All		All costs have been updated from 2006 dollars to 2008 dollars.	No	No
	11-10	Figure 11-1	Updated bar chart showing the scheduled funding increments over time	No	No
	11-11	11.3.1	Clarification on the lack of capped totals for Bull Run measures	No	No
App B	B-1		Clarification of the data sources for the river reach lengths	No	No

Chapter or Appendix	Document		Description of change or addition	Changes Chapter 8 Conclusions[a]	Included in Errata[b]
	Page	Section			
App E			Correction to rounding error of percentage change for artificial confinement on reach Sandy 1 for all four primary covered species:	No	Yes
	E-5	Table E-6	Fall Chinook		
	E-7	Table E-8	Spring Chinook		
	E-12	Table E-13	Winter steelhead		
	E-17	Table E-18	Coho		
			Correction of Zigzag stream reaches affected by Zigzag measures for two species:	No[c]	No
	E-11	Table E-12	Spring Chinook		
	E-16	Table E-17	Winter steelhead		
App F	F-2	Table F-1	Correction of Zigzag treated reaches by treatment category	No	Yes
	F-4	Table F-2	Correction of attributes and measurable habitat objectives in Zigzag reaches affected by HCP measures and deletion of Zigzag 1B.		
	F-7	Table F-3	Correction to the Zigzag paired treated and control reaches		
App G	All		Temperature Management Plan as approved by Oregon Department of Environmental Quality in May 2008 (update from Public Review Draft)	No	No
App I	All		All costs have been updated from 2006 dollars to 2008 dollars.	No	No

[a]Changes population effects, VSP parameters, or conclusions about HCP effectiveness in Chapter 8.

[b]Change was included in Technical Errata memo to National Marine Fisheries Service, dated February 12, 2008.

[c]The habitat benefits tables in Chapter 8 (tables 8-22 and 8-35) and Appendix E (tables E-12 and E-17) were incorrect for Measure H-27 (Zigzag 1A Channel Design). Although the EDT model run used in the Public Review Draft of the HCP correctly incorporated the habitat benefits for reach Zigzag 1A (and excluded the benefits in Zigzag 1B), the tables in Chapter 8 and Appendix E incorrectly included benefits from an earlier analysis and had not been updated. These tables in Chapter 8 and Appendix E have been corrected.