Oregon Department of Fish and Wildlife

Fish Passage WAIVER Application

- *Use this form if providing fish passage at the artificial obstruction for which a Waiver is being requested would benefit native migratory fish.*
- *Use the "Fish Passage EXEMPTION Application" if a waiver has already been granted for the artificial obstruction, fish passage mitigation has already been provided for the artificial obstruction , or if there would be no appreciable benefit for native migratory fish if passage were provided at the artificial obstruction.*
- *If you unlock and re-lock this Form, information already entered may be lost in certain versions of MS Word.*

APPLICANT INFORMATION

The Applicant must be the owner or operator of the artificial obstruction for which a Waiver is sought.

ORGANIZATION/APPLICANT: Portland Water Bureau
CONTACT: Steve Kucas
TITLE: Senior Environmental Program Manager
ADDRESS: 1120 SW 5th Ave., Room 600
CITY: Portland **STATE:** OR **ZIP:** 97204
PHONE: 503-823-6976
FAX: 503-823-4500
E-MAIL ADDRESS: skucas@water.ci.portland.or.us

SIGNATURE: ______________________ **DATE:** __________

OWNER (*if different than Applicant*)**:**
CONTACT: **TITLE:**
ADDRESS:
CITY: **STATE:** **ZIP:**
PHONE:
FAX:
E-MAIL ADDRESS:

SIGNATURE: ______________________ **DATE:** __________
Signature indicates that you understand and do not dispute this request.

APPLICATION COMPLETED BY (*if different than Applicant*)**:**
TITLE:
ORGANIZATION:
ADDRESS:
CITY: **STATE:** **ZIP:**
PHONE:
FAX:
E-MAIL ADDRESS:

SIGNATURE: ______________________ **DATE:** __________

To Be Completed by ODFW Fish Passage Coordinator

APPLICATION #: W-03-0001 **DATE RECEIVED:** 11-02-2009

FILE NAME: City of Portland's Bull Run Watershed Fish Passage Waiver Application

APPROVED ☐ **SIGNATURE:** ________________________________ **DATE:** __________

DENIED ☐ **TITLE:**

1. Type of Artificial Obstruction:

☒ Dam
☐ Culvert/Bridge
☐ Tidegate
☐ Other (describe):

New ☐
Existing ☒

2. Please Provide a Background and Description of the Proposed Action Triggering the Need to Address Fish Passage:

The City of Portland (the City) has developed a Habitat Conservation Plan (HCP) (Portland Water Bureau 2008), in consultation with the National Marine Fisheries Service (NMFS), and in collaboration with the Oregon Dept. Fish and Wildlife (ODFW), the U.S. Forest Service (USFS), the Bureau of Land Management (BLM), and a number of other partners, in order to address its obligations under the Endangered Species Act (ESA) for the impacts of its municipal water supply operations on ESA-listed species. The HCP mitigation package outlines 49 measures designed to improve habitat for anadromous and resident fish in the Bull Run subbasin and the larger Sandy River basin. The term of the HCP is 50 years. The HCP was approved by NMFS in April 2009.

The adoption of the HCP constitutes a fundamental change in permit status for the City's Bull Run operations, triggering the need for a review of the blockage of fish passage by three Bull Run River dams and a rock weir. The proposed aquatic measures in the HCP support a fish passage waiver application for three Bull Run dams and rock weir.

The City is applying for a passage waiver for Bull Run Dam 1, Bull Run Dam 2, the Headworks diversion dam, and a rock weir. Bull Run Dam 1 (at river mile (RM) 11.1) is a concrete gravity-arch dam, impounding a reservoir 4 miles long and up to 190 feet deep. Bull Run Dam Number 2 (RM 6.5) is an earthfill dam, creating a reservoir 4.5 miles long and as much as 130 feet deep. It was completed in 1964. Both Dam 2 and Dam 1 have hydroelectric power generation facilities as a secondary product of water storage and transmission. The Headworks diversion dam (RM 6), built in 1921, is 37 feet high and diverts water from the diversion pool into the City’s water conduits. The diversion pool behind the Headworks diversion dam is approximately 620 feet in length. A 15-foot-high concrete/boulder rock weir (RM 5.8) is the hydraulic control for Reservoir 2 spillway plunge pool.

The rock weir has been the downstream barrier to anadromous fish runs since its construction in 1962. The weir was washed away during the 1964 flood and rebuilt. The City is considering modifying the rock weir to allow rapid flow movement past the site, which is needed to meet the HCP water temperature commitments, and would also allow for the passage of native migratory fish. The City will complete its designs for the rock weir in the next few months. Part or all of the weir may be removed.

None of the dams or obstructions has ever provided passage for native migratory fish.

The City has a license from the Federal Energy Regulatory Commission (FERC) (license #2821) to operate hydroelectric facilities on its Bull Run dams. The license was approved in 1979 and expires in 2029. ODFW was an intervenor in the FERC licensing process. In 1984, the City and

ODFW signed a comprehensive mitigation agreement to address the impacts of the construction and operation of the City's hydroelectric project and to resolve all fish mitigation disputes concerning the project. The agreement was approved by FERC in satisfaction of the City's fish and wildlife obligations under its license. The City maintains that ODFW/City agreement precludes the need for a fish passage waiver. Although the City does not intend to waive its rights under the 1984 agreement, it is filing this fish passage waiver application as long as filing this application and issuance of a waiver do not prejudice the City's rights under the FERC agreement.

3. Passage will Not be Provided for the Following Reason(s):

The City is not providing fish passage at its dams in the Bull Run watershed because the HCP mitigation package, as a whole, provides a net benefit to fish that is greater than the benefit that would be derived from provision of any reasonable fish passage alternatives at the structures.

The Benefits and Costs of Providing Fish Passage:

Benefits

The alternative for providing fish access to the upper Bull Run watershed is described in detail in the Final Environmental Impact Statement, Bull Run Water Supply Habitat Conservation Plan (CH2M Hill 2008, Appendix B).

The City used the Ecosystem Diagnosis and Treatment (EDT) model to estimate the number of adult anadromous fish that would return from the ocean to the Sandy River basin if passage was constructed around the Bull Run dams and rock weir. There would be an additional 173 fall-run adult Chinook, 358 spring-run adult Chinook, 36 adult coho, and 647 adult winter-run steelhead to the respective Sandy River Basin populations (CH2M Hill 2008). However, these estimates are very liberal (high) since the model assumption was that fish passage would be 100% effective (both upstream and downstream migrations) around the current dams.

Providing fish passage around the Bull Run dams could also benefit other native migratory fish, including rainbow trout, cutthroat trout, sucker species, mountain whitefish, western brook lamprey, Pacific lamprey, and possibly river lamprey. Self-sustaining populations of all but Pacific lamprey and river lamprey, however, are believed to already inhabit the portions of the upper Bull Run River basin where they might naturally occur if fish could pass around the dams. The only benefit that these populations might derive from providing fish passage would be enhanced genetic diversity. Pacific lamprey would accrue both numeric and genetic benefits from access to up to 25 additional miles of stream habitat. Nothing is known about the historical presence of river lamprey in the Bull Run River, but this species might benefit from up to 25 additional miles of stream habitat, similar to Pacific lamprey.

Costs

The cost of the fish passage measures alone would be approximately $64 million and the total cost of the fish passage alternative is approximately $139 million (see CH2M Hill 2008). For this cost, the City estimates that an additional 12.1 miles, 1.3 miles, 25 miles, and 12.1 miles of stream habitat would become available for spring Chinook, fall Chinook, winter steelhead, and coho, respectively.

The Benefits and Costs of the City's Proposed HCP Mitigation Measures

The alternative is the City's HCP mitigation package which provides habitat benefits in all of the subbasins in the Sandy River basin (see City of Portland 2008).

Benefits
For all fall and spring Chinook, coho salmon, and steelhead added together, the City's HCP would produce more adult fish than from providing complete fish passage in the Bull Run watershed (2,383 versus 1,214). The City estimates that an additional 645 adult fall-run Chinook, 793 adult spring-run Chinook, 575 adult coho, and 370 adult winter-run steelhead would be added to the respective greater Sandy River Basin populations from the City's HCP mitigation package (CH2M Hill 2008). A portion of this increase is attributable to the HCP package providing 18 more stream miles of habitat for coho, steelhead, and lamprey in Alder and Cedar creeks.

The HCP actions would also improve habitat throughout the Sandy River basin for all other native migratory fish that reside or historically occurred in the Bull Run River basin, including rainbow trout, cutthroat trout, sucker species, mountain whitefish, western brook lamprey, Pacific lamprey, and river lamprey. Although specific modeling results do not exist for these species, they are all expected to benefit both numerically and genetically from the City's HCP Mitigation Measures.

Costs
The City's HCP, approved in April 2009, has a projected cost of $93 million over 50 years. The City estimates that, for this cost, it can boost habitat capacity and population productivity in the Bull Run basin and the Sandy River basin for salmon, steelhead, and other native fish. The HCP mitigation package will result in higher abundances and other parameters that affect population viability than can be accomplished by providing fish passage past all artificial obstructions on the Bull Run River

4. Date the Trigger Action is Scheduled to Begin *(a minimum of two months should be planned for the waiver process after ODFW receives your application; requests that must go before the Commission will take longer)*: The City received an Incidental Take Permit for its HCP in April 2009. That constitutes a major change in permitting status and a trigger action for the fish passage regulations. Specific HCP improvements are scheduled to begin in the summer of 2010.

5. Location

COUNTY: Multnomah and Clackamas
ROAD CROSSING (if applicable)**:**
RIVER/STREAM: Bull Run River
TRIBUTARY OF: Sandy River
BASIN: Sandy
COORDINATES[a]**:** Longitude: 122.1578°W Latitude: 45.4453°N

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

6. Stream Description

6.1. Artificial Obstructions

TABLE 1. INFORMATION ON THE ARTIFICIAL OBSTRUCTION AND OTHER OBSTRUCTIONS UPSTREAM AND DOWNSTREAM.

	DOWNSTREAM	FIRST OBSTRUCTION	UPSTREAM			
Locations	3	Rock Weir	Diversion Dam	Dam No. 2	Dam No. 1	E
Type	None	O	D	D	D	
Length	NA	120 ft	50 ft	170 ft	100 ft	
River Mile	NA	5.8	6.4	6.5	11.1	16.3
Miles Blocked	NA	10.5 miles (mainstem), 33 miles (including tributaries)	9.9 miles (mainstem), 32.4 miles (including tributaries)	9.8 miles (mainstem), 32.3 miles (including tributaries)	5.2 miles (mainstem), 11 miles (including tributaries)	
Level	NA	5	5	5	5	

Type = C (culvert/bridge), D (dam), T (tide gate), N (natural; *describe below*), O (other; *describe below*)
Length = length of the barrier in the stream (e.g., culvert's length, dam's width/footprint)
Distance = distance from the Artificial Obstruction (to closest point of other barriers)
Level = amount of passage at the barrier using the following codes:
5 - barrier to all native migratory fish
4 - barrier to some native migratory fish adults and/or species
3 - barrier to some native migratory fish adults and/or species for only part of migration period
2 - barrier to all native migratory fish juveniles
1 - barrier to some native migratory fish juveniles and/or for only part of migration period

LOCATIONS:
AO = the existing or proposed Artificial Obstruction
1,2 = other barriers in the same stream as the Artificial Obstruction
3 = downstream barrier outside the immediate stream in which the Artificial Obstruction is located (*only needed if C/N is a confluence rather than a complete natural barrier*)
E = end of historic native migratory fish use, including all tributaries (i.e., potential range without any artificial barriers in place)
C/N = first downstream confluence or complete natural barrier, whichever comes first

NOTE: The *example* indicates that there is culvert which is 80 feet long, is located 1,200 feet from the Artificial Obstruction in question, and is a complete fish passage barrier.

Additional Descriptions for Those Barriers Included in the Barrier Table or for Other Barriers Affecting Native Migratory Fish Movement to or From the Artificial Obstruction:

The downstream-most artificial obstruction, which was used as the reference point in the barrier table is a 15-feet high rock weir. It serves as a hydraulic control, increasing the depth of the Bull Run Dam No. 2 spillway plunge-pool.

6.2. Stream and Fish Community Upstream and Downstream of the Artificial Obstruction

TABLE 2. INFORMATION ON THE STREAM AND FISH COMMUNITY UPSTREAM AND DOWNSTREAM OF THE ARTIFICIAL OBSTRUCTION (BULL RUN DAM 2 SPILLWAY ROCK WEIR).

	DOWNSTREAM	UPSTREAM
NMF Species Present Currently	Spring and fall Chinook salmon (Oncorhynchus tschawyscha), coho salmon (O. kisutch), winter steelhead/rainbow trout (O. mykiss), cutthroat trout (O. clarki), mountain whitefish (Prosopium williamsoni), Pacific lamprey (Lampetra tridentata), western brook lamprey (Lampetra richardsoni), river lamprey (Lampetra ayresi), bridgelip sucker (Catostomus columbianus), largescale sucker (C. macrocheilus), and northern pikeminnow (Ptychocheilus oregonensis).	rainbow trout, cutthroat trout, mountain whitefish, western brook lamprey, bridgelip sucker, largescale sucker
NMF Species Present Historically	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey, bridgelip sucker, largescale sucker, and northern pikeminnow.	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey, bridgelip sucker, largescale sucker, and northern pikeminnow.
Habitat Quality	Degraded from reduced instream flows and decreased gravel and large wood recruitment. The channel has a gradient of 1%-3%, is naturally confined, and dominated by bedrock and large boulder substrate. Spawning gravels are rare and subject to scouring. Summer habitat is characterized by large bedrock pools, pocket water and short riffles. Winter habitat offers little cover other than substrate for juveniles, with very few side-channels and little floodplain.	Nearly nine miles of the Bull Run River upstream of the rock weir is inundated by reservoirs. The remainder of the stream has a gradient of 1%-3%, is naturally confined, with large bedrock pools, a predominance of cobble and small boulder substrate, little floodplain and few side-channels. The watershed is in a protected, late-seral stage and large wood and spawning gravel quantities are at historic levels, though still moderately low (large wood: 20-30 pcs/mile; gravel in patches and margins).
Flows	Flows are regulated, with 20-40 cubic feet per second (cfs) minimum flows from July through September, increasing to 70 cfs or 50% of reservoir inflows through October, 150 cfs or 40% or reservoir inflows in November, and a minimum of 120 cfs from December through mid-June, when downramping begins. Bankfull flows are approximately 8,000 cfs. Winter flows, when the reservoirs are full, follow a near-natural hydrograph, modified by the removal of roughly 100 cfs for municipal water use.	Natural, unregulated flows above the reservoirs. Summer low flows in the mainstem Bull Run are typically around 70 cfs, with bankfull flows of approximately 4,000 cfs.
Water Quality	The lower Bull Run River is naturally	Water quality is high and

	warm in the summer due to its east/west orientation and bedrock substrate, exacerbated by water withdrawals for municipal water use. The lower 5 miles were listed by the Oregon Dept. Environmental Quality (ODEQ) as water quality limited for water temperatures exceeding salmonid fish-rearing standards. Minimum summer flows are currently managed to maintain 7-day average maximum water temperatures at or below 21 degrees C , as approved in the interim by ODEQ. After infrastructure improvements included in the HCP, 7-day average maximum water temperatures will be maintained at or below the appropriate ODEQ criteria, except when the natural thermal potential of the river exceeds the criteria. The natural thermal potential will be calculated using water temperatures from the tributary Little Sandy River plus a system of adjustments approved by ODEQ. Otherwise, water quality is high and dissolved nutrient content is relatively low.	oligotrophic. There are no water temperature compliance issues.
Water Right Availability	The City of Portland has been granted exclusive rights to use the waters of the Bull Run and Little Sandy Rivers.	The City of Portland has been granted exclusive rights to use the waters of the Bull Run and Little Sandy Rivers.
Land Use/Zoning	The majority of the Bull Run Watershed is federally owned and administered for the provision of high-quality water for the City of Portland's municipal water use. Portland General Electric (PGE) recently decommissioned its Bull Run Hydroproject, which diverted water from the Sandy and Little Sandy rivers into the lower 1.5 miles of the Bull Run River. Their water diversion rights in the Little Sandy River have been converted to instream use. The lower 1.5 miles are in City or private ownership. Private uses include residences, recreation, timber harvest, and a residential camp.	All of the Bull Run Watershed upstream of the rock weir is federally owned and administered for the provision of high-quality water for the City of Portland's municipal water use. There is no timber harvest.
NMF = native migratory fish		

Additional Details Regarding The Information Provided in The Stream and Fish Community Table:

Additional information on the Bull Run watershed can be found in Appendix A.

6.3. The Source for Information Contained in the Barrier and Stream Tables:

Stream channel lengths and land ownership were determined using ArcGIS. Stream habitat information was drawn from the USFS 1992 and 1999 Stream/Riparian survey reports. Fish presence, water quality, water rights, and land use information was drawn from the City of Portland's Bull Run Water Supply Habitat Conservation Plan. Additional fish presence information came from unpublished Portland Water Bureau monitoring data. Please see Appendix D for a full list of references.

7. MITIGATIONS

Mitigation Package

The City developed an HCP in support of its 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. To create the HCP, The City led a ten-year process, which included a partnership effort involving more than a dozen public and private organizations and detailed technical work. The participants, including Oregon Department of Fish and Wildlife, developed a vision and a Sandy River basin restoration plan that guided selection of the specific measures that are in the City's HCP. The partners continue to meet and to work together on recovering native fish in the Sandy River basin.

The City prepared the HCP in accordance with Section 10(a)(2)(A) of the federal 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's impacts on ESA-listed fish include 1) a reduction in the amount of available habitat through the blockage of upstream passage to the Bull Run subwatershed by the Dam 2 spillway plunge pool rock weir at RM 5.8, and 2) downstream impacts on flow quantity, timing, and temperature due to the withdrawal, storage, and regulation of water for municipal water supply purposes and the alteration of downstream habitat through the curtailment of large wood and gravel recruitment from the upper subwatershed. The HCP proposes a series of mitigation measures that were designed and agreed on through a series of technical evaluations conducted between 1999 and 2006 by the Sandy River Basin Partners (Partners), including NMFS, ODFW, USFS, BLM, and a number of other entities (summarized in Appendix B). These mitigation measures address both passage-related and downstream impacts. All measures are described in this application, but only those measures specifically designed to offset the blockage of upstream habitat are included in the evaluation of benefits. The specific offsite mitigation measures are summarized in the subsequent section by geographic groupings corresponding to subbasins of the greater Sandy River basin

Mitigation Package Benefits

The City and the Partners evaluated the benefits of the proposed mitigation package using the Ecosystem Diagnosis and Treatment (EDT) model, developed by Mobrand Biometrics, Inc., and widely used by fisheries managers in the Pacific Northwest to guide habitat restoration and preservation decisions. Benefits were evaluated relative to four primary covered species, fall Chinook, spring Chinook, coho, and winter steelhead[1]. EDT is a predictive model that draws on a database of habitat attributes for a given stream network and a set of biological rule-sets drawn from the scientific literature that relate habitat

[1] Fall and spring Chinook are the same species (O. tshawytsha), but are treated separately under the ESA because of their evolutionarily divergent life histories.

attributes to survival of various fish species at key stages of their lifecycles. The EDT model and its strengths and weaknesses are described more fully in Appendix C.

EDT facilitates the analysis of limiting factors in a stream or stream network and was used in part to design the HCP mitigation package. It also provides a means by which to evaluate the population effects of habitat restoration and preservation options relative to one another. For the purposes of the HCP, EDT provides estimates of fish productivity, diversity, and abundance for the four primary covered fish species in the Sandy River basin. Productivity in this case is the number of adults in the offspring generation per number of adults in the parent generation at very low population densities (i.e. without density-dependent effects). Diversity is the percentage of possible life-histories that could be self-sustaining in a given stream or stream network. Abundance is the equilibrium population of adults predicted for a given stream or stream network, given the habitat's capacity to support fish and the fish population's productivity.

The analysis presented below uses EDT to compare the benefits of two alternatives to the population productivity, diversity, and abundance of the four primary covered species relative to what would be expected if neither option were implemented ("no action"):

1) The HCP mitigation package. Individual mitigation measures and their anticipated cumulative benefits to instream habitat conditions are summarized in the subsequent sections of the application.

2) Providing full upstream passage for adults and downstream passage for smolts (and kelts, in the case of steelhead).

Three mitigation measures that are planned by the City, included in the HCP, and described in the subsequent section were not included in the EDT benefits analysis below: Alder 1 Fish Passage, Alder 1a Fish Passage, and Little Sandy 1 and 2 Large Wood Placement.

Alder 1 Fish Passage and Alder 1a Fish Passage will provide access to 5.5 miles of good-quality steelhead and coho habitat. The City decided to not include these two Alder Creek projects in its benefits assessment, however, because it is unclear how complete the barriers are. The Alder 1 waterfall barrier below Highway 26 has an existing, though marginal fish ladder in disrepair. Steelhead have, upon occasion, been observed above this point in Alder Creek. The City of Sandy water diversion weir on the Alder 1a reach is a complete barrier under most flow conditions, but may pass adult steelhead under certain high-flow conditions.

The Little Sandy 1 and 2 Large Wood Placement would improve habitat for all four primary covered species along 1.8 miles of stream. The City decided, however, not to include the benefits from this measure in its overall analysis below because it would be difficult to discern and evaluate the benefits of adding large wood from the benefits of removing the Little Sandy Dam.[2]

Tables 3 through 6 compare improvements in productivity, diversity, and abundance, as well as absolute abundance numbers for adults and juvenile outmigrants (JOMs)—smolts

[2] In the fall of 2008, Portland General Electric removed the dam on the Little Sandy River.

and, in the case of Chinook, ocean-type fry—for fall Chinook, spring Chinook, winter steelhead, and coho.

TABLE 3. PREDICTED BENEFITS TO FALL CHINOOK VIABLE SALMONID POPULATION (VSP) PARAMETERS FROM THE CITY'S MITIGATION PACKAGE VS. PROVIDING 100% EFFECTIVE FISH PASSAGE AROUND ALL ARTIFICIAL OBSTRUCTIONS ON THE BULL RUN RIVER, OREGON.

	INCREASE IN ABUNDANCE	INCREASE IN PRODUCTIVITY	INCREASE IN LIFE-HISTORY DIVERSITY	ADDITIONAL ADULTS	ADDITIONAL JOMS
Mitigation Package	10.3%	12.0%	10.6%	645	66,238
Passage	2.8%	0%	11.7%	173	7,914

TABLE 4. PREDICTED BENEFITS TO SPRING CHINOOK VIABLE SALMONID POPULATION (VSP) PARAMETERS FROM THE CITY'S MITIGATION PACKAGE VS. PROVIDING 100% EFFECTIVE FISH PASSAGE AROUND ALL ARTIFICIAL OBSTRUCTIONS ON THE BULL RUN RIVER, OREGON.

	INCREASE IN ABUNDANCE	INCREASE IN PRODUCTIVITY	INCREASE IN LIFE-HISTORY DIVERSITY	ADDITIONAL ADULTS	ADDITIONAL JOMS
Mitigation Package	13.2%	11.8%	6.3%	793	82,332
Passage	6.0%	0%	15.5%	358	13,092

TABLE 5. PREDICTED BENEFITS TO WINTER STEELHEAD VIABLE SALMONID POPULATION (VSP) PARAMETERS FROM THE CITY'S MITIGATION PACKAGE VS. PROVIDING 100% EFFECTIVE FISH PASSAGE AROUND ALL ARTIFICIAL OBSTRUCTIONS ON THE BULL RUN RIVER, OREGON.

	INCREASE IN ABUNDANCE	INCREASE IN PRODUCTIVITY	INCREASE IN LIFE-HISTORY DIVERSITY	ADDITIONAL ADULTS	ADDITIONAL JOMS
Mitigation Package	11.1%	6.8%	12.3%	370	5,400
Passage	19.4%	10.5%	10.8%	647	9,693

TABLE 6. PREDICTED BENEFITS TO COHO VIABLE SALMONID POPULATION (VSP) PARAMETERS FROM THE CITY'S MITIGATION PACKAGE VS. PROVIDING 100% EFFECTIVE FISH PASSAGE AROUND ALL ARTIFICIAL OBSTRUCTIONS ON THE BULL RUN RIVER, OREGON.

	INCREASE IN ABUNDANCE	INCREASE IN PRODUCTIVITY	INCREASE IN LIFE-HISTORY DIVERSITY	ADDITIONAL ADULTS	ADDITIONAL JOMS
Mitigation Package	24.9%	4.0%	21.3%	575	18,405
Passage	2.8%	0%	0.5%	36	1,036

The City's HCP mitigation package will improve habitat to produce significantly more JOMs and adults than would be produced by providing passage around all artificial barriers on the Bull Run for the four listed species. The City's HCP would produce approximately 8.4 times as many JOMs and 3.8 times as many adult fall Chinook, 6.3 times as many JOMs and 2.2 times as many adult spring Chinook, and 18 times as many JOMs and 16 times as many adult coho. The City's HCP would provide less benefit for winter steelhead because the upper Bull Run watershed would be blocked. The expected productivity or population size difference between the expected benefits from the HCP mitigation package and providing full passage (277 steelhead adults), however, should be largely offset by the benefits of providing/improving access to approximately 18 miles of quality steelhead habitat on Alder and Cedar creeks, improving habitat on the Little Sandy River by adding large wood, and the fact that it would be difficult to achieve 100% effective passage of both adults and JOMs past each of the Bull Run River obstructions.

Other native migratory fish

The short- and long-term improvements to fish habitat conditions throughout the Sandy basin from the City's HCP mitigation package would also provide a net benefit to other native migratory species that are impacted by the presence of the Bull Run dams. These species include rainbow trout, cutthroat trout, sucker species, mountain whitefish, western brook lamprey, Pacific lamprey, and possibly river lamprey.

The City estimates that the effects on habitat from the HCP measures for rainbow trout would be the same as those for steelhead, since they are the same species. Similarly, cutthroat trout, which occupy a niche that overlaps with both steelhead and coho, are expected to benefit in the same way and to the same degree as steelhead and coho would from the HCP measures. Moreover, because rainbow and cutthroat trout populations already exist above the Bull Run dams, these species would be expected to benefit only from enhanced genetic exchange with downstream populations if passage were provided at the Bull Run dams. The HCP mitigation measures, in contrast, are expected to result in increased rainbow and cutthroat trout numbers as well as genetic diversity in the Sandy River basin. Sucker species and mountain whitefish—also are believed to inhabit the upper Bull Run watershed above the dams—are likewise expected to benefit more from the HCP mitigation package than from providing passage at the Bull Run dams.

The mitigation measures in the HCP are expected to maintain the natural processes important for creating and conserving habitat for western brook, Pacific, and river lamprey in the Sandy River basin. If western brook lamprey existed historically in the upper Bull Run basin, it is likely that the species still maintains populations above the Bull Run dams. The City assumes that western brook lamprey would primarily benefit from enhanced genetic diversity if passage were provided at the Bull Run dams, whereas the HCP mitigation package would provide would provide benefit both in population size and genetic diversity for this species. Pacific lamprey and river lamprey, if they occur in the Bull Run River, are expected to benefit under both alternatives, although the degree to which these species would benefit is unknown.

7.1. HCP Mitigation Measures in the Lower Bull Run River

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 following objectives were used to identify habitat conservation measures for the lower Bull Run River:

- 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
- Protect instream flows in the Little Sandy River

Instream Flow Measures in the Lower Bull Run River

The City has estimated the natural, pre-water-system flows in the lower Bull Run River in its HCP (Portland Water Bureau 2008, 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 the HCP: normal water years and water years that have either a critical spring season or a critical fall season.[3] 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

[3] 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.

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.

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 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.

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 (expressed in mean daily flows in cubic feet per second, cfs).

Table 7. 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. 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 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 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.

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 9 and 10 (in mean daily flow in cfs). Fall flows in Table 10 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 8.

Table 8. 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 9.

Table 9. 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 9. 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.

Table 10. 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 Chinook spawning 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.

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 inches/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.

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.

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.

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 11 when the Little Sandy River temperature is below the criteria

Table 11. 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).

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.

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).

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.

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.

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, in consultation with NMFS and under advisement from the Sandy River Basin Partners, including ODFW.

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 (approximately 0.2 miles) 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: 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.

7.1.1. DISTANCE BETWEEN MITIGATION SITE(S) AND ARTIFICIAL OBSTRUCTION (LOWER BULL RUN): See Table 12 below.

7.1.2. OWNER *(if different than Applicant)* **(LOWER BULL RUN):** Same as Applicant

CONTACT: **TITLE:**
ADDRESS:
CITY: **STATE:** **ZIP:**
PHONE:
FAX:
E-MAIL ADDRESS:

7.1.3. DATE THE MITIGATION IS SCHEDULED TO BE COMPLETED (LOWER BULL RUN): See Table 12 below

7.1.4. LOCATION (LOWER BULL RUN):

COUNTY: Clackamas
ROAD CROSSING (if applicable)**:** Downstream of Rockcut Rd. crossing and Bull Run Dam No. 2 spillway
RIVER/STREAM: Bull Run River
TRIBUTARY OF: Sandy River
BASIN: Sandy
COORDINATES[a]: See Table 12 below

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

TABLE 12. HCP MITIGATION PROJECTS IN THE LOWER BULL RUN RIVER, THEIR DISTANCE FROM THE BULL RUN DAM 2 ROCK WEIR (NO PASSAGE), THEIR APPROXIMATE GEOGRAPHIC COORDINATES, AND THE TIME FRAME THEY ARE SCHEDULED TO BE IMPLEMENTED.

PROJECT	DISTANCE	LONGITUDE	LATITUDE	IMPLEMENT
Minimum Instream Flows, Normal Water Years	0.0-5.8	122.1580	45.4453	Years 2009-2059
Minimum Instream Flows, Water Years With Critical Seasons	0.0-5.8	122.1580	45.4453	Years 2009-2059
Flow Downramping	0.0-5.8	122.1580	45.4453	Years 2009-2059

Little Sandy Flow Agreement	2.3	122.2077	45.4265	Years 2009-2059
Pre-infrastructure Temperature Management	0.0-5.8	122.1580	45.4453	Years 2009-2013
Post-infrastructure Temperature Management	0.0-5.8	122.1580	45.4453	Years 2014-2059
Spawning Gravel Placement	0.4, 1.3, and 2.3	122.1642, 122.1802, and 122.1968	45.4440, 45.4375, and 45.4315, respectively	Years 2009-2059
Walker Creek Fish Passage	0.05	122.1590	45.4453	Year 2010
Riparian Land Protection	0.0-3.5	122.1580 to 122.2482	45.4453 to 45.4457, respectively	Years 2009-2059

7.1.5. STREAM DESCRIPTION (LOWER BULL RUN RIVER):

Limiting Factors

A limiting-factors analysis was conducted on the lower Bull Run River below the Bull Run Dam 2 rock weir using EDT in order to identify appropriate mitigation measures. The limiting factors analysis investigated the features of the habitat in its current condition that most decreased survival through the freshwater life cycle of each salmon and steelhead species from the survival expected under pristine (historical) conditions.

Fall Chinook were most impacted (greater than 25% decrease in freshwater survival from that expected under pristine conditions) by scouring of spawning gravels and were moderately impacted (between 5% and 25% decrease) by daily fluctuations in flow affecting spawning and egg incubation.

Spring Chinook were most impacted (greater than 25% decrease in freshwater survival from that expected under pristine conditions) by scouring of spawning gravels and were moderately impacted (between 5% and 25% decrease) by daily fluctuations in flow affecting spawning and egg incubation.

Winter steelhead were most impacted (between 5% and 25% decrease in freshwater survival from that expected under pristine conditions) by low summer flows and warm summer water temperatures affecting juvenile rearing.

Coho were most impacted (more than 25% decrease in freshwater survival from that expected under pristine conditions) by scouring of spawning gravels affecting incubating eggs and warm summer water temperatures affecting juvenile rearing and moderately impacted (between 5% and 25% decrease) by daily fluctuations in flow affecting juvenile rearing.

Table 13 summarizes the current state and achievable post-mitigation condition for habitat attributes targeted by the above mitigation measures:

TABLE 13. CURRENT AND ANTICIPATED POST-IMPLEMENTATION VALUES FOR HABITAT ATTRIBUTES EXPECTED TO BENEFIT FROM MITIGATION ACTIONS. POST-IMPLEMENTATION VALUES WERE AGREED ON COLLABORATIVELY BY THE SANDY RIVER BASIN AGREEMENT TECHNICAL TEAM (SRBATT).

Reach	Habitat Attribute	Current Condition	Habitat Benefit	After Mitigation

Bull Run 1 (RM 0.0-1.5)	Summer minimum flows	Low flows increased to approximately 80% of natural base flows during summer rearing period and approximately 60% of natural base flows during salmon spawning period.		
	Summer wetted width	62 ft	15% increase	72 ft
	Bed Scour	Approx. 30cm	20% decrease	Approx. 24 cm
	Maximum Water Temperature	Significant decrease in maximum water temperatures.		
	Small Cobble Riffles	2.7% of total habitat	19% increase	3.2% of total habitat
	Pool Tail Habitat	2.7% of total habitat	15% increase	3.1% of total habitat
	Daily variation in flow stage	Up to 24 inches per hour	Up to 90% improvement in ramping rates	<2 inches per hour
Bull Run 2 (RM 1.5-3.0)	Summer minimum flows	Low flows increased to approximately 80% of natural base flows during summer rearing period and approximately 60% of natural base flows during salmon spawning period.		
	Summer wetted width	35 ft	19% increase	42 ft
	Bed Scour	Approx. 34cm	20% decrease	Approx. 27 cm
	Maximum Water Temperature	Significant decrease in maximum water temperatures.		
	Small Cobble Riffles	5.1% of total habitat	4% increase	5.3% of total habitat
	Daily variation in flow stage	Up to 24 inches per hour	Up to 90% improvement in ramping rates	<2 inches per hour
Bull Run 3 (RM 3.0-3.8)	Summer minimum flows	Low flows increased to approximately 80% of natural base flows during summer rearing period and approximately 60% of natural base flows during salmon spawning period.		
	Summer wetted width	54 ft	7% increase	58 ft
	Bed Scour	Approx. 34cm	12% decrease	Approx. 30 cm
	Maximum Water Temperature	Significant decrease in maximum water temperatures.		
	Small Cobble Riffles	5.0% of total habitat	6% increase	5.3% of total habitat
	Daily variation in flow stage	Up to 24 inches per hour	Up to 90% improvement in ramping rates	<2 inches per hour
	Riparian Function (% of pristine state)	83%	21% improvement	100%
Bull Run 4 (RM 3.8-5.8)	Summer minimum flows	Low flows increased to approximately 80% of natural base flows during summer rearing period and approximately 60% of natural base flows during salmon spawning period.		
	Summer wetted width	44 ft	24% increase	55 ft
	Bed Scour	Approx. 34cm	12% decrease	Approx. 30 cm
	Maximum Water Temperature	Significant decrease in maximum water temperatures.		
	Small Cobble Riffles	13.6% of total habitat	8% increase	14.7% of total habitat
	Daily variation in flow stage	Up to 24 inches per hour	Up to 90% improvement in ramping rates	<2 inches per hour

	Riparian Function (% of pristine state)	38%	167% improvement	100%

Table 2 (above, under "Downstream" heading) summarizes pertinent aspects of the lower Bull Run River. Further details of the Bull Run River are discussed in Appendix A.

7.2. HCP Mitigation Measures in the Little Sandy River

The lowest reach of the Little Sandy River has not provided significant habitat for salmonids due to PGE's hydroelectric power project and dam on the river. The hydroelectric project and dam was decommissioned in 2008. PGE's water right on the Little Sandy River has been converted to an instream right, which has increased flows in the Little Sandy River. The City will forgo its water right for consumptive use of the water for the term of the HCP (50 years). With the increased flows and upstream fish passage, the Little Sandy River could support anadromous fish production. The City is not claiming benefits from its mitigation efforts in the Little Sandy or its decision not to pursue development of its water rights on the Little Sandy because of the difficulty in discerning benefits from these measures from the greater benefits provided by the removal of the Little Sandy Dam by PGE.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.

7.2.1. DISTANCE BETWEEN MITIGATION SITE(S) AND ARTIFICIAL OBSTRUCTION (LITTLE SANDY): Approximately 2.3 miles. Mitigation activities will occur within an approximately 1.8 mile reach of the Little Sandy below and immediately above the site of the Little Sandy Dam, prior to its removal in 2008.

7.2.2. OWNER *(if different than Applicant)* **(LITTLE SANDY):** Same as Applicant
CONTACT: **TITLE:**
ADDRESS:
CITY: **STATE:** **ZIP:**
PHONE:
FAX:
E-MAIL ADDRESS:

7.2.3. DATE THE MITIGATION IS SCHEDULED TO BE COMPLETED (LITTLE SANDY): years 2014-2018

7.2.4. LOCATION (LITTLE SANDY):

COUNTY: Clackamas
ROAD CROSSING (if applicable)**:** Upstream and downstream of old Little Sandy Dam Site
RIVER/STREAM: Little Sandy River
TRIBUTARY OF: Bull Run River
BASIN: Sandy
COORDINATES[a]**:** Longitude: 122.1918°W Latitude: 45.4210°N

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

7.2.5. STREAM DESCRIPTION (LITTLE SANDY):

Limiting Factors

A limiting-factors analysis was conducted on all stream reaches within the historical range of anadromy in the Little Sandy watershed using EDT in order to identify appropriate mitigation measures. The limiting factors analysis investigated the features of the habitat in its current condition that most decreased survival through the freshwater life cycle of each salmon and steelhead species from the survival expected under pristine (historical) conditions.

Fall Chinook were most impacted (greater than 5% decrease in freshwater survival from that expected under pristine conditions) by a lack of large wood (LW) affecting fry colonization and refuge from flows. Other impacts associated with the Little Sandy Dam are no longer relevant after dam removal.

Spring Chinook were most impacted (greater than 5% decrease in freshwater survival from that under pristine conditions) by a lack of LW affecting fry colonization and refuge from flows. Other impacts associated with the Little Sandy Dam have since been removed.

Winter steelhead were most impacted (less than 5% decrease in freshwater survival from that expected under pristine conditions) by a lack of LW affecting fry colonization and refuge from flows. Other impacts associated with the Little Sandy Dam are no longer relevant after dam removal.

Coho were most impacted (greater than 5% decrease in freshwater survival from that expected under pristine conditions) by a lack of large wood (LW) affecting fry colonization, refuge from flows, and availability of over-wintering sites. Other impacts associated with the Little Sandy Dam are no longer relevant after dam removal.

Table 14 summarizes the current state and achievable post-mitigation condition for habitat attributes targeted by the above mitigation measures:

TABLE 14. CURRENT AND ANTICIPATED POST-IMPLEMENTATION VALUES FOR HABITAT ATTRIBUTES EXPECTED TO BENEFIT FROM MITIGATION ACTIONS. POST-IMPLEMENTATION VALUES WERE AGREED ON COLLABORATIVELY BY THE SANDY RIVER BASIN AGREEMENT TECHNICAL TEAM (SRBATT).

Reach	Habitat Attribute	Current Condition	Habitat Benefit	After Mitigation
Little Sandy 1 (RM 0-1.7)	Instream Wood (≥4 inches diam.)	300 pcs/mile	33% increase	400 pcs/mile

Table 15 summarizes pertinent aspects of the Little Sandy River. Further details of the Little Sandy River are discussed in Appendix A in the description of the Bull Run Subwatershed.

TABLE 15. SUMMARY OF CURRENT HABITAT AND FISH PRESENCE IN THE LITTLE SANDY SUBWATERSHED:

	LITTLE SANDY (BULL RUN SUBWATERSHED)
NMF Species Present Currently[1]	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey (?)
NMF Species Present Historically[1]	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey (?)
Habitat Quality	Degraded from decreased gravel and large wood recruitment. The channel has a gradient of 3%, is naturally confined, and dominated by bedrock and large boulder substrate. Spawning gravels are rare below the dam site, but will begin receiving some gravel recruitment from the upper river now that the dam has been removed. Summer habitat is composed of approximately 30% pools and 70% mostly large-cobble riffles. Habitat in the upper river (above RM 1.7) is similar (20% pools, 80% mostly large-cobble riffle) but with gravel and large wood at nearly pristine levels.
Flows	With the removal of Little Sandy Dam, flows have returned to a natural hydrograph, driven primarily by rainfall rather than snowmelt. Minimum flows vary between 10 and 20 cfs and generally occur in August through the end of September. Maximum flows generally vary between 600 cfs and 3,200 cfs and occur November through February.
Water Quality	Water quality is high and oligotrophic. There are no water temperature compliance issues.
Water Right Availability	The City of Portland has been granted exclusive rights to use the waters of the Bull Run and Little Sandy Rivers. PGE's water diversion rights have been converted to an instream water right and the City has agreed, as a part of its HCP, to forego development of its Little Sandy water rights, at least for the duration of the HCP (50 years).
Land Use/Zoning	The majority of the Little Sandy Subwatershed is federally owned and administered, with a portion around the old dam site owned by the Western Rivers Conservancy. Most of the subwatershed is included in

	the Bull Run Management Unit and acts as a buffer for the portion that provides high-quality water for the City of Portland's municipal water use. There is no timber harvest and public access is restricted.

[1] The following native migratory fish in the Bull Run Subbasin are ESA-listed as threatened: Spring and fall Chinook salmon, coho salmon, and winter steelhead; State-listed sensitive species: Pacific lamprey.

7.3. Habitat Conservation Measures in the Lower Sandy River

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 Evolutionarily Significant Unit (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 historical 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 following log jam and LW measures for reaches in the lower Sandy basin 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 side-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 Re-establishment 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.

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. 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 River basin.

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.

7.3.1. DISTANCE BETWEEN MITIGATION SITE(S) AND ARTIFICIAL OBSTRUCTION (LOWER SANDY): See Table 16 below

7.3.2. OWNER (*if different than Applicant*) **(LOWER SANDY):** Same as Applicant

CONTACT: **TITLE:**
ADDRESS:
CITY: **STATE:** **ZIP:**
PHONE:
FAX:
E-MAIL ADDRESS:

7.3.3. DATE THE MITIGATION IS SCHEDULED TO BE COMPLETED (LOWER SANDY): See Table 16 below

7.3.4. LOCATION (LOWER SANDY):

COUNTY: Multnomah and Clackamas
ROAD CROSSING (if applicable)**:** Downstream of Lusted Road crossing
RIVER/STREAM: Sandy River
TRIBUTARY OF: Columbia River
BASIN: Sandy
COORDINATES[a]**:** see Table 16 below

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

TABLE 16. HCP MITIGATION PROJECTS IN THE LOWER SANDY RIVER, THEIR DISTANCE FROM THE BULL RUN DAM 2 ROCK WEIR (NO PASSAGE), THEIR APPROXIMATE GEOGRAPHIC COORDINATES, AND THE TIME FRAME THEY ARE SCHEDULED TO BE IMPLEMENTED.

PROJECT	DISTANCE	LONGITUDE	LATITUDE	IMPLEMENT
Sandy 1 and 2 Log Jams	11.6	122.3703	45.5200	Years 2014-2018
Gordon 1A and 1B Large Wood Placement	5.7	122.2433	45.4913	Years 2009-2013
Trout 1A Large Wood Placement	6.7	122.2793	45.4903	Years 2009-2013
Trout 2A Large Wood Placement	6.7	122.2824	45.4870	Years 2009-2013
Sandy 1 Reestablishment of River Mouth	13.2	122.3786	45.5539	Years 2014-2018
Sandy 1 Channel Reconstruction	13	122.3858	45.5460	Years 2014-2018
Sandy 1 Riparian Easement and Improvement	11.9	122.3717	45.5302	Years 2009-2013
Sandy 2 Riparian Easement and Improvement	4.3	122.2443	45.4500	Years 2009-2013
Gordon 1A/1B Riparian Easement and Improvement	4.4	122.2112	45.4958	Years 2009-2013

7.3.5. STREAM DESCRIPTION (LOWER SANDY):

Limiting Factors

A limiting-factors analysis was conducted on all stream reaches within the historical range of anadromy in the lower Sandy basin using EDT in order to identify appropriate mitigation measures. The limiting factors analysis investigated the features of the habitat in its current condition that most decreased survival through the freshwater life cycle of each salmon and steelhead species from the survival expected under pristine (historical) conditions.

Fall Chinook were most impacted (between 5% and 20%) by channelization affecting habitat diversity and fine sediments in spawning gravels. Minor impacts (less than 5%) included channel instability associated with riparian zone impacts and decreased LW; decreases in flow due to withdrawals and storage for municipal water supply; food availability due to riparian zone impacts; harassment of adults by humans in the absence of buffering riparian zones and deep pools; predation on fry by numerous native, introduced, and stocked fish species (exacerbated by warm water temperatures); and a decrease in pools and spawning gravels.

Spring Chinook were most impacted (greater than 20%) by temperature stress on spawners (between 5% and 20%). Lesser effects (between 5% and 20%) included channelization affecting habitat diversity and fine sediments in spawning gravels. Minor impacts (less than 5%) included channel instability associated with riparian zone impacts and decreased LW, decreases in flow due to withdrawals and storage for municipal water supply, food availability due to riparian zone impacts, harassment of adults by humans in the absence of buffering riparian zones and deep pools, and a decrease in pools and spawning gravels.

Winter steelhead were most impacted (between 5% and 20%) by channelization affecting habitat diversity and fine sediments in spawning gravels. They were also impacted to a minor degree (less than 5%) by channel instability associated with riparian zone impacts and decreased LW; decreases in flow due to withdrawals and storage for municipal water supply; food availability due to riparian zone impacts; harassment of adults by humans in the absence of buffering riparian zones; increased pathogens due to elevated temperatures; a decrease in appropriate spawning gravels; predation on fry by numerous native, introduced, and stocked fish species (exacerbated by warm water temperatures); elevated water temperature effects; and a decrease in pools and spawning gravels.

Coho were most impacted by channelization affecting habitat diversity. They were also impacted to a large degree (between 5% and 20%) by the channel instability associated with riparian zone impacts and decreased LW; decreases in flow due to withdrawals and storage for municipal water supply; fine sediments in spawning gravels; and a lack of rearing and over-wintering sites provided by backwater pools, beaver ponds, and off-channel habitat. Minor effects (less than 5%) came from competition with hatchery fish, food availability due to riparian zone impacts, and harassment of adults by humans in the absence of buffering riparian zones.

Table 17 summarizes the current state and achievable post-mitigation condition for habitat attributes targeted by the above mitigation measures. The post-impelementation values were agreed on collaboratively by the Sandy River Basin Agreement Technical Team (SRBATT).

TABLE 17. CURRENT AND ANTICIPATED POST-IMPLEMENTATION VALUES FOR HABITAT ATTRIBUTES EXPECTED TO BENEFIT FROM MITIGATION ACTIONS.

Reach	Habitat Attribute	Current Condition	Habitat Benefit	After Mitigation
Beaver 1A (RM 0.0-1.8)	Riparian Function (% of pristine state)	63%	3% improvement	65%
	Instream Wood (≥4 inches diam.)	137 pcs/mile	21% increase	157 pcs/mile
Gordon 1A (RM 0.0-1.8)	Fine Sediment (% in spawning gravels)	24%	25% decrease	18%
	Backwater Pools	0% of total area	increase from 0% to 5%	5% of total area
	Large-Cobble Riffles	30% of total area	17% decrease	25% of total area
	Pools	14% of total area	115% increase	30% of total area
	Pool-Tails	3% of total area	46% increase	5% of total area
	Small-Cobble Riffles	52% of total area	33% decrease	35% of total area
	Riparian Function (% of pristine state)	38%	118% improvement	83%
	Instream Wood (≥4 inches diam.)	207 pcs/mile	567% increase	1380 pcs/mile
Gordon 1B (RM 1.8-4.0)	Backwater Pools	0% of total area	increase from 0% to 5%	5% of total area
	Pools	6% of total area	212% increase	20% of total area
	Pool-Tails	1% of total area	326% increase	5% of total area
	Small-Cobble Riffles	58% of total area	40% decrease	35% of total area
	Riparian Function (% of pristine state)	38%	118% improvement	83%
	Instream Wood (≥4 inches diam.)	207 pcs/mile	567% increase	1380 pcs/mile
Sandy 1 (RM 0.0-5.4)	Artificial Confinement (% of banks)	25%	20% reduction	20%
	Riparian Function (% of pristine state)	63%	19% improvement	75%
	Instream Wood (≥4 inches diam.)	117 pcs/mile	35% increase	158 pcs/mile
Sandy 2 (RM 5.4-17.8)	Riparian Function (% of pristine state)	38%	69% improvement	64%
	Maximum Water Temperature	Slight decrease in maximum water temperatures.		
	Instream Wood (≥4 inches diam.)	111 pcs/mile	121% increase	245 pcs/mile
Trout 1A (RM 0.0-0.5)	Instream Wood (≥4 inches diam.)	168 pcs/mile	7% increase	190 pcs/mile
Trout 2A (RM 0.5-0.8)	Instream Wood (≥4 inches diam.)	248 pcs/mile	13% increase	281 pcs/mile

Table 18 summarizes pertinent aspects of the lower Sandy. Appendix A discusses the subwatershed in greater detail.

TABLE 18. SUMMARY OF CURRENT HABITAT AND FISH PRESENCE IN THE LOWER SANDY SUBWATERSHED:

	LOWER SANDY SUBWATERSHED
NMF Species Present Currently[1]	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, Pacific eulachon (Thaleichthys pacificus), mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey (?), sucker species, and northern pikeminnow.
NMF Species Present Historically[1]	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, Pacific eulachon (Thaleichthys pacificus), mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey (?), sucker species, and northern pikeminnow.
Habitat Quality	Degraded from urbanization, agricultural use, channelization, removal of large wood, and decreased or cut-off access to certain tributary reaches by culverts. The lower six miles of the mainstem are affected by tidal backwater from the Columbia River and are largely sand substrate. Gordon and Trout creeks are in relatively good condition, but with reduced loads of large wood, relative to historic conditions. See below for additional details.
Flows	Flows have returned to a near-natural hydrograph with the removal of the PGE Hydroelectric Project. Dam operation on the Columbia River has reduced the backwater effect in the lower river during high spring flows. Beaver Creek and its tributaries are flashy due to urban runoff.
Water Quality	Water quality generally is high and oligotrophic. The mainstem is often turbid due to glacial melt. Beaver Creek especially is affected by pollutants arising from urban and agricultural runoff.
Water Right Availability	See Table AA4 (Appendix A) for a list of water rights amounts and their uses in the Lower Sandy Subwatershed.
Land Use/Zoning	See Table AA5 (Appendix A) for a summary of land ownership in the Lower Sandy subwatershed. The majority of the lower Sandy Subwatershed is federally owned and administered, with a portion around the old dam site owned by the Western Rivers Conservancy. Most of the subwatershed is included in the Bull Run Management Unit and acts as a buffer for the portion that provides high-quality water for the City of Portland's municipal water use. There is no timber harvest and public access is restricted.
	NMF = native migratory fish

7.4. Habitat Conservation Measures in the Middle Sandy River

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 et al. 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.

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 bereallocated 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.

7.4.1. DISTANCE BETWEEN MITIGATION SITE(S) AND ARTIFICIAL OBSTRUCTION (MIDDLE SANDY): See Table 19 below

7.4.2. OWNER (*if different than Applicant*) **(MIDDLE SANDY):** Same as Applicant

CONTACT: **TITLE:**
ADDRESS:
CITY: **STATE:** **ZIP:**
PHONE:
FAX:
E-MAIL ADDRESS:

7.4.3. DATE THE MITIGATION IS SCHEDULED TO BE COMPLETED (MIDDLE SANDY): See Table 19 below

7.4.4. LOCATION (MIDDLE SANDY):

COUNTY: Clackamas
ROAD CROSSING (if applicable)**:** Upstream of Lusted Road crossing of the Sandy River and downstream of E. Barlow Trail Road crossing of the Sandy River. Extends upstream of E. Barlow Trail Road to the mouth of the Salmon River.
RIVER/STREAM: Sandy River
TRIBUTARY OF: Columbia River
BASIN: Sandy
COORDINATES[a]: See Table 19 below

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

TABLE 19. HCP MITIGATION PROJECTS IN THE MIDDLE SANDY RIVER, THEIR DISTANCE FROM THE BULL RUN DAM 2 ROCK WEIR (NO PASSAGE), THEIR APPROXIMATE GEOGRAPHIC COORDINATES, AND THE TIME FRAME THEY ARE SCHEDULED TO BE IMPLEMENTED.

PROJECT	DISTANCE	LONGITUDE	LATITUDE	IMPLEMENT
Cedar Creek Purchase Water Rights	5.4	122.2452	45.3976	Years 2014-2018
Sandy 3 Riparian Easement and Improvement	4.9	122.2573	45.4323	Years 2019-2023
Cedar 2 and 3 Riparian Easement and Improvement	4.9	122.1991	45.3806	Years 2014-2018
Alder 1A and 2 Riparian Easement	7.1	122.0942	45.3516	Years 2009-2013
Cedar 2 and 3 Large Wood Placement	4.9	122.2138	45.3841	Years 2014-2018
Alder 1 Fish Passage	5.4	122.1007	45.3775	Years 2009-2013
Alder 1A Fish Passage	6.7	122.0988	45.3608	Years 2009-2013
Cedar Creek 1 Fish Passage	5.5	122.2540	45.4057	Years 2009-2013

7.4.5. STREAM DESCRIPTION (MIDDLE SANDY):

Limiting Factors

A limiting-factors analysis was conducted on all stream reaches within the historic range of anadromy in the Middle Sandy subwatershed using EDT in order to identify appropriate mitigation measures. The limiting factors analysis investigated which features of the habitat in its current condition most decreased survival through the freshwater life-cycle of each salmon and steelhead species from the survival expected under pristine (historic) conditions.

Fall Chinook were most impacted by decreases in flow due to the Marmot diversion, food availability due to riparian zone impacts, channelization affecting habitat diversity, the interaction of increased water temperature with naturally turbid waters, and a decrease in pools and spawning gravels. All decreases in fall Chinook survival, however, were minor (less than 5%). They were little impacted by passage barriers because the SRBATT did not believe that they used upper Cedar Creek or Alder Creek historically.

Spring Chinook were most impacted by channel instability associated with riparian zone impacts and decreased LW, decreases in flow due to the Marmot diversion, food availability due to riparian zone impacts, channelization affecting habitat diversity, the interaction of increased water temperature with naturally turbid waters, temperature stress on spawners in lower Cedar Creek and the lower Sandy mainstem, and a decrease in pools and spawning gravels. All decreases in spring Chinook survival, however, were minor (less than 5%). They were little impacted by passage barriers because the SRBATT did not believe that they used upper Cedar Creek or Alder Creek historically.

Winter steelhead were most impacted by obstructions on Cedar Creek and Alder Creek (more than 20% in total survival). They were also impacted to a minor degree (less than 5%) by decreases in flow due to the Marmot diversion, food availability due to riparian zone impacts, channelization affecting habitat diversity, the interaction of increased water temperature with naturally turbid waters, and a decrease in appropriate spawning gravels.

Coho were most impacted by obstructions on Cedar Creek and Alder Creek (more than 20% in total survival). They were also impacted to a large degree (between 5% and 20%) by channelization affecting habitat diversity, the interaction of increased water temperature with naturally turbid waters, and a lack of rearing and over-wintering sites provided by backwater pools, beaver ponds, and off-channel habitat. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW, decreases in flow due to the Marmot diversion, food availability due to riparian zone impacts.

Table 20 summarizes the current state and achievable post-mitigation condition for habitat attributes targeted by the above mitigation measures:

TABLE 20. CURRENT AND ANTICIPATED POST-IMPLEMENTATION VALUES FOR HABITAT ATTRIBUTES EXPECTED TO BENEFIT FROM MITIGATION ACTIONS. POST-IMPLEMENTATION VALUES WERE AGREED ON COLLABORATIVELY BY THE SANDY RIVER BASIN AGREEMENT TECHNICAL TEAM (SRBATT).

Reach	Habitat Attribute	Current Condition	Habitat Benefit	After Mitigation
Alder 1	Habitat Access	Partial barrier at		Access to 1.6 river

(RM 0.0-0.9)		RM 0.1		miles
	Instream Wood (≥4 inches diam.)	330 pcs/mile	7% increase	352 pcs/mile
Alder 1A (RM 0.9-2.0)	Habitat Access	Partial barrier at RM 1.7		Access to 3.8 river miles
	Riparian Function (% of pristine state)	63%	59% improvement	100%
	Instream Wood (≥4 inches diam.)	330 pcs/mile	100% increase	660 pcs/mile
Alder 2 (RM 2.0-2.6)	Riparian Function (% of pristine state)	63%	59% improvement	100%
	Instream Wood (≥4 inches diam.)	330 pcs/mile	100% increase	660 pcs/mile
Cedar 1 (RM 0.0-0.7)	Habitat Access	Partial barrier at ~ RM 0.5		Access to ~ 11.5 river miles
	Dissolved Oxygen	7 mg/l	14% increase	8 mg/l
	Fish Pathogens	Decrease in exposure to pathogens through the securing of instream water rights.		
	Minimum Water Temperature	Decrease in the number of very cold days (<4 degrees Celsius), affecting the survival of overwintering fish and colonizing fry through the securing of instream water rights.		
	Maximum Water Temperature	Slight decrease in maximum water temperatures through the securing of instream water rights.		
	Spatial Variation in Water Temperature/Presence of Thermal Refuges	Increase in the spatial variation in water temperatures through the securing of instream water rights.		
Cedar 2 (RM 0.7-4.2)	Dissolved Oxygen	7 mg/l	14% increase[c]	8 mg/l
	Fish Pathogens	Decrease in exposure to pathogens through the securing of instream water rights.		
	Off-Channel Habitat	15% of total is off-channel habitat	75% increase[b]	26% of total is off-channel habitat
	Riparian Function (% of pristine state)	63% of full riparian function	19% improvement[b]	75% of full riparian function
	Minimum Water Temperature	EDT minimum water temperature score of 1	20% decrease in the score[c]	EDT minimum water temperature score of 0.8
	Maximum Water Temperature	EDT maximum water temperature score of 2	20% decrease in the score[c]	EDT maximum water temperature score of 1.6
	Spatial Variation in Water Temperature/Presence of Thermal Refuges	EDT temperature moderation by groundwater score of 3	33% improvement in the score[b]	EDT temperature moderation by groundwater score of 2
	Instream Wood (≥4 inches diam.)	1.5 pieces LW per channel width	167% increase[c]	4 pieces LW per channel width
Cedar 3 (RM 4.2-9.5)	Dissolved Oxygen	7 mg/l of dissolved oxygen	14% increase[c]	8 mg/l of dissolved oxygen
	Fish Pathogens	EDT fish pathogen score of 2	20% improvement[c]	EDT fish pathogen score of 1.6
	Beaver Pond Habitat	6% of total area	39% increase[c]	8% of total area

	Off-Channel Habitat	Area equals 15% of total in-channel area.	45% increase[c]	Area equals 22% of total in-channel area.
	Pools	21% of total area	25% increase[c]	26% of total area
	Riparian Function (% of pristine state)	63%	19% improvement[c]	75%
	Minimum Water Temperature	Decrease in the number of very cold days (<4 degrees Celsius), affecting the survival of overwintering fish and colonizing fry through the securing of instream water rights.		
	Maximum Water Temperature	Slight decrease in maximum water temperatures through the securing of instream water rights.		
	Spatial Variation in Water Temperature/Presence of Thermal Refuges	Increase in the spatial variation in water temperatures through the securing of instream water rights.		
	Instream Wood (≥4 inches diam.)	227 pcs/mile	100% increase[c]	453 pcs/mile
Sandy 3 (RM 17.8-23.6)	Riparian Function (% of pristine state)	83%	5% improvement	87%
	Maximum Water Temperature	Slight decrease in maximum water temperatures through increased shading.		
	Instream Wood (≥4 inches diam.)	66 pcs/mile	31% increase	86 pcs/mile
Sandy 7 (RM 31.1-36.7)	Maximum Water Temperature	Slight decrease in maximum water temperatures through increased shading.		

Table 21 summarizes pertinent aspects of the Middle Sandy Subwatershed. Appendix A discusses the subwatershed in greater detail.

TABLE 21. SUMMARY OF CURRENT HABITAT AND FISH PRESENCE IN THE MIDDLE SANDY SUBWATERSHED:

	MIDDLE SANDY SUBWATERSHED
NMF Species Present Currently	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey (?), bridgelip sucker, largescale sucker, and northern pikeminnow. Fall Chinook are thought to have only used the river below the Marmot Dam site consistently.
NMF Species Present Historically	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey (?), bridgelip sucker, largescale sucker, and northern pikeminnow. Fall Chinook are thought to have historically used the entire Sandy River mainstem.
Habitat Quality	Degraded from residential and agricultural use, channelization, removal of large wood, and decreased or cut-off access to certain tributary reaches. See below for additional details.
Flows	Flows have returned to a near-natural hydrograph with the removal of the PGE Hydroelectric Project.
Water Quality	Water quality generally is high and oligotrophic. The mainstem is often turbid due to glacial melt.
Water Right Availability	See Table AA7 (Appendix A) for a list of water rights amounts and their uses in the Middle Sandy Subwatershed.
Land Use/Zoning	See Table AA8 (Appendix A) for a summary of land ownership in the

	Middle Sandy Subwatershed. The majority of the Middle Sandy Subwatershed is privately owned and used for residences, agriculture, and timber harvest. Additional uses of the Subwatershed include recreation, and municipal water supply.
	NMF = native migratory fish

7.5. Habitat Conservation Measures in the Upper Sandy River

Compared with the other watersheds in the Sandy River Basin, the Upper Sandy River Subwatershed contains the most stream miles of habitat currently used by anadromous fish in the Sandy River Basin (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 generally pass Marmot Dam in the Middle Sandy after its installation. The Upper Sandy River Subwatershed 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.

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. 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 $\geq$70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be

[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.

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.

7.5.1. DISTANCE BETWEEN MITIGATION SITE(S) AND ARTIFICIAL OBSTRUCTION (UPPER SANDY): See Table 22 below

7.5.2. OWNER (*if different than Applicant*) **(UPPER SANDY):** Same as Applicant

CONTACT: **TITLE:**

ADDRESS:

CITY: **STATE:** **ZIP:**

PHONE:

FAX:

E-MAIL ADDRESS:

7.5.3. DATE THE MITIGATION IS SCHEDULED TO BE COMPLETED (UPPER SANDY): See Table 22 below

7.5.4. LOCATION (UPPER SANDY):

COUNTY: Clackamas

ROAD CROSSING (if applicable)**:** Upstream of E. Barlow Trail Road.

RIVER/STREAM: Sandy River

TRIBUTARY OF: Columbia River

BASIN: Sandy

COORDINATES[a]**:** See Table 22 below

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

TABLE 22. HCP MITIGATION PROJECTS IN THE UPPER SANDY RIVER, THEIR DISTANCE FROM THE BULL RUN DAM 2 ROCK WEIR (NO PASSAGE), THEIR APPROXIMATE GEOGRAPHIC COORDINATES, AND THE TIME FRAME THEY ARE SCHEDULED TO BE IMPLEMENTED.

PROJECT	DISTANCE	LONGITUDE	LATITUDE	IMPLEMENT
Sandy 8 Riparian Easement and Improvement	11.6	121.9652	45.3569	Years 2019-2023

7.5.5. STREAM DESCRIPTION (UPPER SANDY):

Limiting Factors

A limiting-factors analysis was conducted on all stream reaches within the historic range of anadromy in the Upper Sandy Subwatershed using EDT in order to identify appropriate mitigation measures. The limiting factors analysis investigated which features of the habitat in its current condition most decreased survival through the freshwater life-cycle of each salmon and steelhead species from the survival expected under pristine (historic) conditions.

Fall Chinook have not used the Upper Sandy Subwatershed to a significant degree since the construction of Marmot Dam, although the dam provided fish passage in the form of a fish ladder. They may extend their range to reoccupy the Upper Sandy River now that Marmot

Dam has been removed. In the EDT limiting factors analysis, fall Chinook were most impacted (between 5% and 20%) by channelization and riparian zone impacts affecting habitat diversity and by fine sediments in spawning gravels. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW, decreased refuge from flow due to riparian zone impacts and decreased LW, and a decrease in pools and spawning gravels.

Spring Chinook were most impacted (between 5% and 20%) by channelization and riparian zone impacts affecting habitat diversity and by fine sediments in spawning gravels. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW, decreased refuge from flow due to riparian zone impacts and decreased LW, and a decrease in pools and spawning gravels.

Winter steelhead were most impacted (between 5% and 20%) by fine sediments in spawning gravels. They were also impacted to a minor degree (less than 5%) by decreased refuge from flow due to riparian zone impacts and decreased LW, channelization and riparian zone impacts affecting habitat diversity, and a decrease in appropriate spawning gravels.

Coho were most impacted (between 5% and 20%) by channelization and riparian zone impacts affecting habitat diversity. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW, decreased refuge from flow due to riparian zone impacts and decreased LW, food availability due to riparian zone impacts, fine sediments in spawning gravels, and a lack of rearing and over-wintering sites provided by backwater pools, beaver ponds, and off-channel habitat.

Table 23 summarizes the current state and achievable post-mitigation condition for habitat attributes targeted by the above mitigation measures:

TABLE 23. CURRENT AND ANTICIPATED POST-IMPLEMENTATION VALUES FOR HABITAT ATTRIBUTES EXPECTED TO BENEFIT FROM MITIGATION ACTIONS. POST-IMPLEMENTATION VALUES WERE AGREED ON COLLABORATIVELY BY THE SANDY RIVER BASIN AGREEMENT TECHNICAL TEAM (SRBATT).

Reach	Habitat Attribute	Current Condition	Habitat Benefit	After Mitigation
Sandy 8 (RM 36.7-42.3)	Riparian Function (% of pristine state)	63%	14% improvement	72%
	Maximum Water Temperature	Slight decrease in maximum water temperatures through shading.		
	Instream Wood (≥4 inches diam.)	106 pcs/mile	34% increase	143 pcs/mile

Table 24 summarizes pertinent aspects of the Upper Sandy Subwatershed. Appendix A discusses the subwatershed in greater detail.

TABLE 24. SUMMARY OF CURRENT HABITAT AND FISH PRESENCE IN THE UPPER SANDY SUBWATERSHED:

	UPPER SANDY SUBWATERSHED
NMF Species Present Currently	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western

	brook lamprey, and river lamprey (?). Fall Chinook are thought to have only used the river below the Marmot Dam site consistently, but may be extending their range now that the dam has been removed.
NMF Species Present Historically	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, and river lamprey (?). Fall Chinook are thought to have historically used the entire Sandy River mainstem.
Habitat Quality	Degraded from development near and along its banks between Zigzag and Brightwood, Oregon, channelization, and road construction. See below for additional details.
Flows	Flows follow a natural, generally snowmelt-driven hydrograph.
Water Quality	Water quality generally is high and oligotrophic. The mainstem is often turbid due to glacial melt. Several tributaries, however, are clear-water.
Water Right Availability	See Table AA10 (Appendix A) for a list of water rights amounts and their uses in the Upper Sandy Subwatershed.
Land Use/Zoning	See Table AA11 (Appendix A) for a summary of land ownership in the Upper Sandy Subwatershed. The majority of the Upper Sandy Subwatershed is owned and managed by the federal government (USFS and BLM) for timber harvest, recreation, and fish and wildlife needs. A portion of both the USFS-owned land and the privately owned land in the subwatershed is used for residences.
	NMF = native migratory fish

7.6. Habitat Conservation Measures in the Salmon River

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.

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.

7.6.1. DISTANCE BETWEEN MITIGATION SITE(S) AND ARTIFICIAL OBSTRUCTION (SALMON):
See Table 25 below

7.6.2. OWNER *(if different than Applicant)* **(SALMON):** Same as Applicant

CONTACT: **TITLE:**

ADDRESS:

CITY: **STATE:** **ZIP:**

PHONE:

FAX:

E-MAIL ADDRESS:

7.6.3. DATE THE MITIGATION IS SCHEDULED TO BE COMPLETED (SALMON): See Table 25 below

7.6.4. LOCATION (SALMON):

COUNTY: Clackamas
ROAD CROSSING (if applicable)**:** Hwy 26 crosses at RM 0.7
RIVER/STREAM: Salmon River
TRIBUTARY OF: Sandy River
BASIN: Sandy
COORDINATES[a]**:** See Table 25 below

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

TABLE 25. HCP MITIGATION PROJECTS IN THE UPPER SANDY RIVER, THEIR DISTANCE FROM THE BULL RUN DAM 2 ROCK WEIR (NO PASSAGE), THEIR APPROXIMATE GEOGRAPHIC COORDINATES, AND THE TIME FRAME THEY ARE SCHEDULED TO BE IMPLEMENTED.

PROJECT	DISTANCE	LONGITUDE	LATITUDE	IMPLEMENT
Salmon 1 Riparian Easement and Improvement	8.3	122.0227	45.3741	Years 2014-2018
Salmon 2 Riparian Easement and Improvement	10.4	121.9895	45.3500	Years 2019-2023
Salmon 3 Riparian Easement and Improvement	14.7	121.9431	45.2849	Years 2019-2023
Boulder 1 Riparian Easement and	8.7	122.0257	45.3639	Years 2009-2013

Improvement				
Salmon 2 Miller Quarry Acquisition	9.1	122.0158	45.3600	Years 2014-2018
Salmon 2 Miller Quarry Restoration	9.1	122.0158	45.3600	Years 2019-2023
Boulder 0 and 1 Large Wood Placement	8.7	122.0257	45.3639	Years 2009-2013

7.6.5. STREAM DESCRIPTION (SALMON):

Limiting Factors

A limiting-factors analysis was conducted on all stream reaches within the historic range of anadromy in the Salmon Subwatershed using EDT in order to identify appropriate mitigation measures. The limiting factors analysis investigated which features of the habitat in its current condition most decreased survival through the freshwater life-cycle of each salmon and steelhead species from the survival expected under pristine (historic) conditions.

Fall Chinook have not used the Salmon Subwatershed to a significant degree since the construction of Marmot Dam, although the dam provided fish passage in the form of a fish ladder. They may extend their range to reoccupy the Salmon River now that Marmot Dam has been removed. In the EDT limiting factors analysis, fall Chinook were most impacted (between 5% and 20%) by channelization and riparian zone impacts affecting habitat diversity and a decrease in pools and spawning gravels relative to historic conditions. and by fine sediments in spawning gravels. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW, decreased refuge from flow due to riparian zone impacts and decreased LW, and food availability due to riparian zone impacts.

Spring Chinook were most impacted (between 5% and 20%) by channelization and riparian zone impacts affecting habitat diversity and a decrease in pools and spawning gravels relative to historic conditions. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW, decreased refuge from flow due to riparian zone impacts and decreased LW, food availability due to riparian zone impacts, and elevated water temperature.

Winter steelhead were most impacted (between 5% and 20%) by decreases in pool, glide, and small cobble riffle habitat. They were also impacted to a minor degree (less than 5%) by decreased refuge from flow due to riparian zone impacts and decreased LW, channelization and riparian zone impacts affecting habitat diversity, and increased predation on fry and juveniles from native fish species and hatchery outplants.

Coho were most impacted (between 5% and 20%) by channelization and riparian zone impacts affecting habitat diversity and a lack of rearing and over-wintering sites provided by backwater pools, beaver ponds, and off-channel habitat. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW, decreased refuge from flow due to riparian zone impacts and decreased LW, and food availability due to riparian zone impacts.

Table 26 summarizes the current state and achievable post-mitigation condition for habitat attributes targeted by the above mitigation measures:

TABLE 26. CURRENT AND ANTICIPATED POST-IMPLEMENTATION VALUES FOR HABITAT ATTRIBUTES EXPECTED TO BENEFIT FROM MITIGATION ACTIONS. POST-IMPLEMENTATION VALUES WERE AGREED ON COLLABORATIVELY BY THE SANDY RIVER BASIN AGREEMENT TECHNICAL TEAM (SRBATT).

Reach	Habitat Attribute	Current Condition	Habitat Benefit	After Mitigation
Boulder 0	Fine Sediment (% in spawning gravels)	24%	5% decrease	22.8%
	Maximum Water Temperature	Slight decrease in maximum water temperatures through shading.		
	Instream Wood (≥4 inches diam.)	103 pcs/mile	315% increase	412 pcs/mile
Boulder 1	Riparian Function (% of pristine state)	83%	20% improvement	100%
	Maximum Water Temperature	Slight decrease in maximum water temperatures through shading.		
	Instream Wood (≥4 inches diam.)	221 pcs/mile	133% increase	515 pcs/mile
Salmon 1	Off-Channel Habitat	3% of total in-channel habitat	66% increase	4% of total in-channel habitat
	Small Cobble Riffles	3% of total habitat	54% increase	5% of total habitat
	Riparian Function (% of pristine state)	75%	8% improvement	81%
	Maximum Water Temperature	Slight decrease in maximum water temperatures through shading.		
	Instream Wood (≥4 inches diam.)	106 pcs/mile	62% increase	170 pcs/mile
Salmon 2	Bed Scour (average depth)	14.0 cm	3% reduction	13.6 cm
	Artificial Confinement (% of banks)	25%	12% reduction	22%
	Off-Channel Habitat	3% of total in-channel habitat	90% increase	5% of total in-channel habitat
	Riparian Function (% of pristine state)	50%	33% improvement	67%
	Maximum Water Temperature	Slight decrease in maximum water temperatures through shading.		
	Instream Wood (≥4 inches diam.)	106 pcs/mile	67% increase	175 pcs/mile
Salmon 3	Instream Wood (≥4 inches diam.)	112 pcs/mile	90% increase in the amount of LW	213 pcs/mile

Table 27 summarizes pertinent aspects of the Salmon Subwatershed. Appendix A discusses the subwatershed in greater detail.

TABLE 27. SUMMARY OF CURRENT HABITAT AND FISH PRESENCE :

	SALMON SUBWATERSHED
NMF Species Present Currently	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey (?), bridgelip sucker, largescale sucker, and northern pikeminnow. Fall Chinook are thought to have only used

	the river below the Marmot Dam site consistently, but may be extending their range now that the dam has been removed.
NMF Species Present Historically	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, river lamprey (?), bridgelip sucker, largescale sucker, and northern pikeminnow. Fall Chinook are thought to have historically used the Salmon River at least as far upstream as Boulder Creek.
Habitat Quality	Degraded from removal of LW by floods and the US Army Corps of Engineers (USACOE). USACOE also deepened and straightened the channel. The banks have been armored in several places and a number of meanders and side-channels have been cut off from use by fish. The stream is now characterized by long stretches of relatively deep riffle habitat.
Flows	Flows follow a natural, generally snowmelt-driven hydrograph.
Water Quality	Water quality generally is high and oligotrophic.
Water Right Availability	See Table AA13 (Appendix A) for a list of water rights amounts and their uses in the Salmon Subwatershed.
Land Use/Zoning	See Table AA14 (Appendix A) for a summary of land ownership in the Salmon Subwatershed. The majority of the Salmon subwatershed is owned and managed by the federal government (USFS and BLM) for timber harvest, recreation, and fish and wildlife needs. A significant portion of the privately owned land in the subwatershed is used for residences.
	NMF = native migratory fish

Stream channel lengths and land ownership were determined using ArcGIS. Taxlot coverages were obtained from Multnomah and Clackamas Counties. Stream coverages were obtained from the USFS Mt. Hood N.F. EDT stream coverages are maintained by the City. Fish presence, water quality, water rights, and land use information was drawn from the City of Portland's Bull Run Water Supply Habitat Conservation Plan. See Appendix D for a full list of references.

7.7. Habitat Conservation Measures in the Zigzag River

Spring Chinook, steelhead, and coho use most of the stream miles available to anadromous fish in the Zigzag River subwatershed. 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 subwatershed 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 ≥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.

7.7.1. DISTANCE BETWEEN MITIGATION SITE(S) AND ARTIFICIAL OBSTRUCTION (ZIGZAG):
See Table 28 below

7.7.2. OWNER *(if different than Applicant)* **(ZIGZAG):** Same as Applicant

CONTACT: **TITLE:**

ADDRESS:

CITY: **STATE:** **ZIP:**

PHONE:

FAX:

E-MAIL ADDRESS:

7.7.3. DATE THE MITIGATION IS SCHEDULED TO BE COMPLETED (ZIGZAG): See Table 28 below

7.7.4. LOCATION (ZIGZAG):

COUNTY:	Clackamas
ROAD CROSSING (if applicable)**:**	East Lolo Pass Rd. crosses at approximately RM 0.5
RIVER/STREAM:	Zigzag River
TRIBUTARY OF:	Sandy River
BASIN:	Sandy
COORDINATES[a]**:**	See Table 28 below

[a] *Geographic projection using NAD_83 and formatted as decimal degrees to at least 4 places.*

TABLE 28. HCP MITIGATION PROJECTS IN THE ZIGZAG RIVER, THEIR DISTANCE FROM THE BULL RUN DAM 2 ROCK WEIR (NO PASSAGE), THEIR APPROXIMATE GEOGRAPHIC COORDINATES, AND THE TIME FRAME THEY ARE SCHEDULED TO BE IMPLEMENTED.

PROJECT	DISTANCE	LONGITUDE	LATITUDE	IMPLEMENT
Zigzag 1A Channel Design	13.3	121.9280	45.3424	Years 2019-2023
Zigzag 1A and 1B Riparian Easement and Improvement	14.1	121.9986	45.3346	Years 2019-2023

7.7.5. STREAM DESCRIPTION (ZIGZAG):

Limiting Factors

A limiting-factors analysis was conducted on all stream reaches within the historic range of anadromy in the Zigzag subwatershed using EDT in order to identify appropriate mitigation measures. The limiting factors analysis investigated which features of the habitat in its current condition most decreased survival through the freshwater life-cycle of each salmon and steelhead species from the survival expected under pristine (historic) conditions.

Fall Chinook have not used the Zigzag subwatershed to a significant degree since the construction of Marmot Dam, although the dam provided fish passage in the form of a fish ladder. They may extend their range to reoccupy the Zigzag River now that Marmot Dam has been removed. In the EDT limiting factors analysis, fall Chinook were most impacted (between 5% and 20%) by channelization and riparian zone impacts affecting habitat diversity. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW, decreased refuge from flow due to riparian zone impacts and decreased LW, fine sediments in spawning gravels, and a decrease in pools and spawning gravels.

Spring Chinook were most impacted (between 5% and 20%) by channelization and riparian zone impacts affecting habitat diversity. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW, decreased refuge from flow due to riparian zone impacts and decreased LW, food availability due to riparian zone impacts, fine sediments in spawning gravels, and a decrease in pools and spawning gravels.

Winter steelhead were impacted to a minor degree (less than 5%) by decreased refuge from flow due to riparian zone impacts and decreased LW, channelization and riparian zone impacts affecting habitat diversity, fine sediments in spawning gravels, and a decrease in appropriate spawning gravels.

Coho were most impacted (more than 20%) by channelization and riparian zone impacts affecting habitat diversity. Moderate effects (5%-20%) included fine sediments in spawning gravels, and a lack of rearing and over-wintering sites provided by backwater pools, beaver ponds, and off-channel habitat. Minor effects (less than 5%) came from channel instability associated with riparian zone impacts and decreased LW and decreased refuge from flow due to riparian zone impacts and decreased LW.

Table 29 summarizes the current state and achievable post-mitigation condition for habitat attributes targeted by the above mitigation measures:

TABLE 29. CURRENT AND ANTICIPATED POST-IMPLEMENTATION VALUES FOR HABITAT ATTRIBUTES EXPECTED TO BENEFIT FROM MITIGATION ACTIONS. POST-IMPLEMENTATION VALUES WERE AGREED ON COLLABORATIVELY BY THE SANDY RIVER BASIN AGREEMENT TECHNICAL TEAM (SRBATT).

Reach	Habitat Attribute	Current Condition	Habitat Benefit	After Mitigation
Zigzag 1A	Artificial Confinement (% of banks)	40% artificial confinement	38% reduction	25% artificial confinement
	Harassment	Decrease in harassment of adults through the securing of riparian easements.		
	Large Cobble Riffles	20% of total habitat	20% decrease	15% of total habitat
	Small Cobble Riffles	55% of total habitat	4% increase	57% of total habitat
	Pools	15% of total habitat	15% increase	17% of total habitat
	Pool-Tail Habitat	3% of total habitat	27% increase	4% of total habitat
	Riparian Function (% of pristine state)	63%	7% improvement	68%
	Instream Wood (≥4 inches diam.)	46 pcs/mile	323% increase	185 pcs/mile
Zigzag 1B	Riparian Function (% of pristine state)	63%	7% improvement	68%
	Instream Wood (≥4 inches diam.)	62 pcs/mile	30% increase	79 pcs/mile

Table 30 summarizes pertinent aspects of the Zigzag. Appendix A discusses the subwatershed in greater detail.

TABLE 30. SUMMARY OF CURRENT HABITAT AND FISH PRESENCE IN THE ZIGZAG SUBWATERSHED:

	ZIGZAG SUBWATERSHED
NMF Species Present Currently	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, and river lamprey (?). Fall Chinook are thought to have only used the river below the Marmot Dam site consistently, but may be extending their range now that the dam has been removed.

NMF Species Present Historically	Spring and fall Chinook salmon, coho salmon, winter steelhead/rainbow trout, cutthroat trout, mountain whitefish, Pacific lamprey, western brook lamprey, and river lamprey (?). Fall Chinook are thought to have historically used portions of the Zigzag River before the construction of Marmot Dam.
Habitat Quality	Degraded from development near and along its banks around Zigzag, Rhododendron, and Welches, Oregon. River and floodplain habitat have been impacted by channelization, road construction and maintenance, and recreation. See below for additional details.
Flows	Flows follow a natural, generally snowmelt-driven hydrograph.
Water Quality	Water quality generally is high and oligotrophic. The mainstem is often turbid due to glacial melt. Several tributaries, however, are clear-water.
Water Right Availability	See Table AA16 (Appendix A) for a list of water rights amounts and their uses in the Zigzag subwatershed.
Land Use/Zoning	See Table AA17 (Appendix A) for a summary of land ownership in the Zigzag subwatershed. The majority of the Zigzag subwatershed is owned and managed by the USFS for timber harvest, recreation, and fish and wildlife needs. A portion of both the USFS-owned land and the privately owned land in the subwatershed is used for residences.
	NMF = native migratory fish

8. Information Sources

Stream channel lengths and land ownership were determined using ArcGIS. Taxlot coverages for ownership were obtained from Multnomah and Clackamas Counties (2003). Stream coverages were obtained from the USFS Mt. Hood N.F. EDT stream coverages are maintained by the City. Fish presence, water quality, water rights, and land use information was drawn from the City of Portland's Bull Run Water Supply Habitat Conservation Plan. See Appendix D for a full list of references.

9. How the Mitigation Relates to Existing Fish Management Plans, Including the Oregon Plan:

The Sandy River is not specifically addressed in the Oregon Plan. It is, however, specifically addressed in the Oregon Administrative Rules (OARs) 635-500-3400 through 635-500-3520. In these rules, the habitat management objectives for the Sandy River are summarized as follows:

1. Maintain and improve upstream and downstream passage for fish in the Sandy River basin at dams, water diversions, existing fishways, culverts and, where needed, at in-channel debris jams.
2. Protect, enhance, and restore fish habitat in the Sandy River basin.
3. Inventory stream and watershed conditions using current methods to assess factors limiting fish production in the Sandy River basin.
4. Reduce artificial introductions of sediment into the Sandy River and basin tributaries.
5. Restore natural streamflows where possible, and protect existing streamflows and water quality from degradation associated with operation of dams, water diversions, effluents, mining, timber harvest, recreation, and other instream activities.

The work of the City and the Partners to identify limiting factors and appropriate restoration measures is consistent with objective 3. The HCP mitigation measures described above include actions that are consistent with objectives 1, 2, 3, 4, and 5.

These rules set recovery goals for winter steelhead, coho, spring Chinook, and fall Chinook, all of which would be assisted by the implementation of the City's HCP mitigation measures. Wild trout habitat would also be enhanced (OAR 635-500-3480 (2)(c)).

8. Describe Any Known Restoration or Land Use Plans Which Might Have an Impact on the Mitigation *(e.g., is the watershed included within an expanded Urban Growth Boundary or does a Local Comprehensive Plan limit future development in the watershed)*:

A portion of the Lower Sandy basin lies within the Urban Growth Boundary (UGB) for the Portland Metro Area—mostly the Beaver Creek drainage, though portions of the mainstem are also included. The Sandy 1 Riparian Easement and Improvement measure will help to alleviate associated development pressure in the riparian zone of the Lower Sandy basin.

One of the City of Sandy's City Council goals for 2009-2011 (http://www.ci.sandy.or.us/) is to consider an expansion of the City of Sandy's Urban Growth Boundary, which currently does not include any of the Sandy River or its major tributaries. No riparian easements are planned for areas adjacent to Sandy's UGB, but the Cedar Creek Purchase Water Rights measure should help guarantee sufficient flow in Cedar Creek in the face of future development.

9. If the Mitigation Entails Providing Passage at an Existing Artificial Barrier, What is the Expected Date of Replacement or Major Repair for the Structure if it were Not Used as Mitigation:

For Todd Alsbury to fill in

10. Does the Mitigation Include Any Activity that is a Requirement or Condition of Any Other Agreement, Law, Permit, or Authorization *(if "Yes", describe)*:

The City's HCP mitigation measures 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. A number of mitigation measures are included in the HCP, but not summarized here or proposed by the City as offset for blocked fish passage, that address requirements to comply with the CWA.

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 portion of the 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. The City's FERC license is valid until 2029.

All of the City's HCP off-site mitigation measures, except for the Little Sandy 1 & 2 LW Placements, occur on private or local government land. They are not required or scheduled to occur under any other regulatory framework or plan that the City or its partners know of.

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.

11. Describe How the Mitigation Will be Funded *(include a cost estimate, funding sources, and whether funds are currently secured)*:

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. The costs are for implementing the HCP mitigation measures and the associated monitoring. Most of the costs are associated with providing in-stream flows and temperature control downstream of the Bull Run dams, including the installation of new infrastructure.

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's funding of these expenses is not an automatic process, the City understands that the Incidental Take Permit (ITP) coverage that it obtains for coverage of its water supply operations under the ESA would be at risk, and federal enforcement measures would be possible, if adequate budgets are not approved and measures are not implemented as planned.

12. Describe How the Mitigation Will be Evaluated, Monitored, and Maintained:

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 (termed "measurable habitat objectives" in the HCP). 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 effectiveness monitoring is focused on whether the City has achieved its measurable habitat objectives, not the actual count of returning adult salmon and steelhead or the emigration of JOMs. There are a myriad of other factors both within and outside of the Sandy Basin that can influence the overall performance of these populations over time, most of which the City has no control over. For this reason, the City will monitor the quality of the aquatic and riparian habitat that it directly affects through its mitigation measures.

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 HCP Adaptive Management program incorporates 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 a Habitat Fund established in the HCP and a separate $3 million HCP Insurance Fund to address adaptive management needs, if necessary.

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

MAP(S)

- *Please attach one or more maps indicating the Artificial Obstruction, Mitigation, the streams on which they are located, and other barriers in those streams. A 7.5 minute USGS quad map is sufficient.*

☐ -- Map(s) included

PHOTOS

- *Please include photographs of the following (.JPG files are preferred):*

☐ -- Artificial Obstruction
☐ -- Mitigation Site(s)
☐ -- up- and downstream habitat at the Artificial Obstruction and Mitigation Site(s)
☐ -- other barriers up- and downstream of the Artificial Obstruction and Mitigation Site(s)

Please submit this application electronically to the ODFW Fish Passage Coordinator and send one signed original paper copy of the application to the ODFW Fish Passage Coordinator at 3406 Cherry Avenue NE, Salem, OR 97303.

Appendix A. Additional Details Regarding the Information Provided in Summary of Current Habitat and Fish Distribution Tables

Bull Run Subwatershed

Overview of the subwatershed

The Bull Run River watershed (Figure AA1) encompasses approximately 90,000 acres. Elevations in the watershed range from 260 to 4,750 feet. 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. 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).

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 (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) 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 and pocket water 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). Habitat in the upper river, above the reservoirs, is similar to the lower river, but with a larger percent of cobble and gravel substrates.

Native Migratory Fish Species

The following native migratory fish in the Bull Run Basin are ESA-listed as threatened: Spring and fall Chinook salmon, coho salmon, and winter steelhead; State sensitive species: Pacific lamprey.

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 AA1). 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 Subwatershed.

Table AA1. Estimated Stream Miles for Current and Historical Anadromous Fish Distribution in the Bull Run Subwatershed

Total Stream Miles in Watershed	Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
	Current	Historical	Current	Historical	Current	Historical	Current	Historical
170	8	40	8	40	8	49	8	40

Habitat Quality

Habitat Types

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.

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.

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.

Large Wood

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. Large wood that falls into the upper river is generally intercepted in the reservoirs before it can recruit to the lower river. The structure of the lower river channel also discourages the accumulation of large wood. Large wood densities at the time of the most recent surveys by USFS were about 1 piece per mile in the lower river and from 23 to 31 pieces per mile for the majority of the upper river.

Spawning Gravel

Protected from glacial and laharic influences, the Bull Run watershed has a more stable valley floor than the Sandy River 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).

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. The mean annual sediment yield from the upper basin to the reservoirs is estimated to be between 37 and 62 tons per year with an estimated gravel component of 52-624 yd^3/year. This gravel supply is captured by the reservoirs and gravel inputs to the lower Bull Run River are limited to those from the Little Sandy River, several minor tributaries, and to slow erosion of the canyon walls.

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. Subsequent provisional minimum flow release for the lower Bull Run River has dramatically increased the available spawning gravels and likelihood of fry recruitment from anadromous fish spawning. The quantity of gravel, however, may still limit the production potential of the lower reaches. A gravel supplementation program to further increase spawning production potential is included as an HCP measure.

Flows

Most precipitation in the Bull Run Watershed 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. Annual precipitation ranges from 52 to 143 inches, with a mean of 80 inches at the Headworks and 140 inches at the North Fork SNOTEL site. Spring rains 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. 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.

Historically, flows from the Bull Run watershed represented approximately a third of the average annual flow in the Sandy River entering the Columbia River. Table AA2 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 AA2. High, low, and 10, 50, and 90 percentile estimated natural flows (cfs) in the lower Bull Run River at USGS Gauge No. 14140000 (RM 4.7)

Month	High	10%	50%	90%	Low
January	19,821	2905	782	341	169
February	16,072	2420	785	368	159
March	9,560	1774	780	409	180
April	12,828	1620	896	493	175
May	6,340	1478	755	357	128
June	5,224	1040	408	201	91
July	2,465	362	180	117	73
August	2,382	216	122	88	52
September	6,214	427	128	84	42

October	9,696	1258	255	89	60
November	15,964	2620	771	243	65
December	22,327	2,947	857	362	110

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.

Climate Change

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 (Palmer and Hahn 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.

Water Quality

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. 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).

Water Rights

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.

Current Land Use/ Regulation

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.

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.

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.

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.

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). 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.

Lower Sandy Subwatershed

Overview of the Subwatershed

The lower Sandy River encompasses 43,330 acres and ranges in elevation from 40 to 3,920 feet (Figure AA2). The lower Sandy River Subwatershed 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.

Native Migratory Fish Species

The following native migratory fish in the lower Sandy Subbasin are ESA-listed as threatened: Spring and fall Chinook salmon, coho salmon, and winter steelhead. Pacific lamprey is a state sensitive species. Pacific eulachon is a federal candidate species.

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

AA3, 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. Fall and spring Chinook currently use about 20 stream miles in the lower Sandy River watershed, the 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.

Table AA3. Estimated Stream Miles for Current and Historical Anadromous Fish Distribution in the Lower Sandy Subwatershed

Total Stream Miles in Watershed	Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
	Current	Historical	Current	Historical	Current	Historical	Current	Historical
107	20	20	20	20	36	36	35	35

Habitat Quality

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.

Flows

Flows in the mainstem of the Sandy River are affected by several large tributaries upstream with both rain and snowmelt-driven hydrographs. Minimum flows are typically between 200 and 400 cfs and occur in September and early October. Maximum flows can vary from about 7,000 cfs up to about 60,000 cfs and typically occur between November and February. Tributaries to the Lower Sandy River have rain-driven hydrographs so tend to be very low during the summer. Beaver Creek is an urban stream and tends to be flashy due to rainfall running off of impervious surfaces.

Water Quality

Both the Lower Sandy mainstem and Beaver Creek were added to the ODEQ 303d list of water-quality-limited streams in 2004 for having a 7-day average maximum water temperature exceeding 18 degrees Celsius, impacting rearing and migrating salmonids. The Lower Sandy mainstem has exceeded the 7-day average maximum water temperature criterion of 17.8 degrees Celsius and the lower 10.5 miles of Gordon Creek have exceed the 7-day average maximum water temperature criterion of 12 degrees Celsius for spawning salmonids in the past and have had total maximum daily loads (TMDLs) developed for them (ODEQ 2005), as required by the Clean Water Act. The Lower Sandy and Beaver Creek have also had TMDLs developed for them to address excessive levels of E. coli in the summer months.

Water Rights

Table AA4 summarizes the quantities of water allocated to various water rights and their intended uses:

TABLE AA4. USES FOR WATER RIGHTS IN THE LOWER SANDY RIVER.

USE	QUANTITY (CFS)
Aesthetics	0.1
Agricultural Uses	1.5
Air Conditioning or Heating	2.3
Anadromous and Resident Fish Rearing	1,633.00
Commercial Uses	1.2
Domestic	6.8
Domestic and Livestock	0.2
Domestic inc. Lawn and Garden	0.4
Fish Culture	6.4
Greenhouse	0.2
Group Domestic	0.2
Irrigation	28.2
Irrigation and Domestic	1.5
Irrigation, Livestock, and Domestic	0.2
Manufacturing Uses	18.3
Municipal Uses	17.3
Nursery Uses	15.8
Pond Maintenance	4.7
Power Development	2.1
Primary and Supplemental Irrigation	0.5
Quasi-Municipal Uses	0.8
Recreation	0.5
Supporting Recreational Boating	1,600.00

Current Land Use/Regulation

Table AA5 summarizes the land ownership for the Lower Sandy Subbasin. The majority of land is in private ownership with both urban and agricultural areas, including the incorporated cities of Troutdale, and Gresham. Agricultural areas are used to grow row crops, berries, and nursery stock, and to support livestock.

TABLE AA5. LAND OWNERSHIP IN THE LOWER SANDY RIVER.

USFS	STATE	PWB	PGE	METRO	COUNTY	CITY	CONSERVATION GROUP	BLM	PRIVATE	TOTAL ACRES
9.5%	1.4%	0.7%	0.1%	3.7%	0.2%	0.7%	1.0%	8.1%	74.7%	43,327

Middle Sandy Subwatershed

Overview of the Subwatershed

The Middle Sandy River encompasses 33,500 acres and ranges in elevation from 204 to 4,160 feet. The middle Sandy River watershed (Figure AA3) 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.

Native Migratory Fish Species

The following native migratory fish in the Middle Sandy Subbasin are ESA-listed as threatened: Spring and fall Chinook salmon, coho salmon, and winter steelhead. Pacific lamprey is a state sensitive species. The upper distribution of sucker species and northern pikeminnow is unknown, but they are documented in the Bull Run Subwatershed and are assumed here to extend into the Middle Sandy River.

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 Subwatershed 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 Subwatershed 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.

The SRBTT estimated anadromous fish currently use about 24 stream miles of habitat in the middle Sandy River Watershed (see Table AA6). 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 Subwatershed historically used about 37 stream miles of habitat. The stream mileage estimates for this subwatershed 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 subwatershed. Both species used about 37 stream miles in the subwatershed historically. Fall Chinook currently use about 12 stream miles in the Middle Sandy River Subwatershed, compared to about 20 miles used historically. Spring Chinook currently use about 20 stream miles in the Middle Sandy River Subwatershed, approximately the same number of miles used historically. Anadromous cutthroat trout are assumed to use only the portion of the Middle Sandy River Subwatershed below the Marmot Dam site, but resident cutthroat trout are well distributed throughout the subwatershed.

Table AA6. Estimated Stream Miles for Current and Historical Anadromous Fish Distribution in the Middle Sandy Subwatershed

Total Stream Miles in Watershed	Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
	Current	Historical	Current	Historical	Current	Historical	Current	Historical
65	12	20	20	20	24	37	24	37

Habitat Quality

Fish habitat has been altered in some areas of the Middle Sandy River Subwatershed. 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.

A detailed study of physical habitat features was conducted by S.P. Cramer & Associates Inc. (1998) for portions of the mainstem Sandy River. They 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, in contrast to the EDT definition of >4 inches in diameter and 6 feet long) 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.

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 Subwatershed. 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 Subwatershed. 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 portion of the Bull Run Subwatershed), and USFS Policy Implementation Guide (PIG) standards were used to assess habitat quality. [5] Pool frequency in Alder Creek was within the range of natural variation (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.

Flows

Flows in the mainstem of the Sandy River are affected by several large tributaries upstream with both rain and snowmelt-driven hydrographs. Minimum flows are typically between 200 and 350 cfs and occur in September and early October. Maximum flows can vary from about 6,000 cfs up to about 25,000 cfs and typically occur between November and February.

Water diversions in the Middle Sandy River Subwatershed can affect stream temperatures and alter natural hydrologic flow regimes. Reductions in stream flows on portions of Alder Creek and Cedar Creek occur as a result of water diversions for municipal water supply and fish hatchery operations, respectively.

Water Quality

The Middle Sandy River mainstem was added to the ODEQ 303d list of water-quality-limited streams in 2004 for having a 7-day average maximum water temperature exceeding the following criteria: 18 degrees Celsius, impacting rearing and migrating salmonids (year

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[5] 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 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).

around), 13 degrees Celsius, impacting spawning salmon and steelhead (August 15-June 15), and 16 degrees Celsius for core cold-water habitat (year around). The Middle Sandy mainstem has exceeded the 7-day average maximum water temperature criterion of 17.8 degrees Celsius for rearing and migrating salmonids in the past and has had a TMDL developed for it (ODEQ 2005), as required by the Clean Water Act. Cedar Creek has also had a TMDL developed for it to address excessive levels of E. coli in the summer months. The mainstem tends to be turbid from glacial melt. All tributaries, however, are clear-water

Water Rights

Table AA7 summarizes the quantities of water allocated to various water rights and their intended uses:

TABLE AA7. USES FOR WATER RIGHTS IN THE MIDDLE SANDY RIVER.

USE	QUANTITY (CFS)
Agricultural Uses	0.3
Anadromous and Resident Fish Rearing	51.8
Commercial Uses	0.1
Domestic	1.9
Domestic inc. Lawn and Garden	0.4
Fish Culture	28.8
Group Domestic	0.1
Irrigation	1.8
Municipal Uses	4
Nursery Uses	1.5
Power Development	1.5
Hydraulic Ram	0.1

Current Land Use/Regulation

Table AA8 summarizes the land ownership for the Middle Sandy Subbasin. 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. The majority of land is in private ownership with both urban and agricultural areas, including the incorporated city of Sandy.

TABLE AA8. LAND OWNERSHIP IN THE MIDDLE SANDY RIVER.

USFS	STATE	PWB	PGE	METRO	COUNTY	CITY	CONSERVATION GROUP	BLM	PRIVATE	TOTAL ACRES
12.4%	0.8%	0.1%	2.4%	0.0%	1.0%	0.8%	0.0%	18.8%	63.7%	33,459

Upper Sandy Subwatershed

Overview of the Subwatershed

The Upper Sandy River Subwatershed (Figure AA4) 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 subwatershed 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 subwatershed include Muddy and Clear forks of the Sandy River, and Rushing Water, Lost, Cast, Clear, and Hackett creeks.

Native Migratory Fish Species

The following native migratory fish in the Upper Sandy Subbasin are ESA-listed as threatened: Spring and fall Chinook salmon, coho salmon, and winter steelhead. Pacific lamprey is a state sensitive species. The upper distribution of sucker species and northern pikeminnow is unknown, but they are considered relatively warm water species and are assumed here to not extend into the very cold waters of the Upper Sandy River and its tributaries. The possibility remains, however, that they are present.

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 Subwatershed contains about 44 stream miles of habitat that are currently used by anadromous fish (Table AA9), 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 subwatershed 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 Subwatershed—also about the same number of miles as used historically. Fall Chinook have not used this subwatershed while Marmot Dam was in place, although historically the habitat might have supported use of about 23 stream miles. Now that the dam has been removed, they may reoccupy the subwatershed. Anadromous (sea-run) cutthroat trout are assumed no longer to occur in the Upper Sandy River Subwatershed, but resident cutthroat trout are well distributed throughout the subwatershed.

Table AA9. Estimated Stream Miles for Current and Historical Anadromous Fish Distribution in the Upper Sandy Subwatershed

Total Stream Miles in Watershed	Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
	Current	Historical	Current	Historical	Current	Historical	Current	Historical
107	23	23	29	29	44	44	30	30

Habitat Quality

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 (USFS 1999).

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 Sandy River Subwatershed. 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)

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 Subwatershed 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 Subwatershed. 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 portion of the Bull Run Subwatershed 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 Subwatershed, with the exception of the mainstem Upper Sandy River. However, all of the streams in the Upper Sandy River Subwatershed were below the PIG standards. A large portion of 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 Subwatershed, pool area was assessed as square feet of pools per mile of stream. Pool area 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 low pool frequency and pool area in larger streams in the Upper Sandy River Subwatershed 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.

Flows

Snowmelt and glacial melt provide ample flow of cold water during the summer months in the Upper Sandy Subwatershed. The highest flows, however, seem to occur during the winter and are associated with rainfall or rain-on-snow events. The USGS does not maintain any gaging stations in the subwatershed, however, precluding a more detailed analysis of the Upper Sandy River hydrograph.

Water Quality

The Upper Sandy River mainstem and Clear Creek were added to the ODEQ 303d list of water-quality-limited streams in 2004 for having a 7-day average maximum water temperature exceeding the following criteria: 13 degrees Celsius, impacting spawning salmon and steelhead (August 15-June 15), and 16 degrees Celsius for core cold-water habitat (year around). The mainstem Upper Sandy, Muddy Fork of the Sandy, and Rushing

Water Creek tend to be turbid from glacial melt. All other tributaries, however, are clear-water.

Water Rights

Table AA10 summarizes the quantities of water allocated to various water rights and their intended uses:

TABLE AA10. USES FOR WATER RIGHTS IN THE UPPER SANDY RIVER.

USE	QUANTITY (CFS)
Anadromous and Resident Fish Rearing	35
Domestic	0.5
Domestic inc. Lawn and Garden	0.1
Fish Culture	2
Irrigation and Domestic	0.1
Power Development	4.2

Current Land Use/Regulation

Table AA11 summarizes the land ownership for the Upper Sandy Subbasin. The majority of land is in federal ownership. It is managed for timber harvest, recreation, and fish and wildlife needs. Private residences are concentrated around Clear Creek and the downstream portion of the Upper Sandy River.

TABLE AA11. LAND OWNERSHIP IN THE UPPER SANDY RIVER.

USFS	STATE	PWB	PGE	METRO	COUNTY	CITY	CONSERVATION GROUP	BLM	PRIVATE	TOTAL ACRES
81.5%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	4.0%	13.5%	40,089

Salmon Subwatershed

Overview of the Subwatershed

The Salmon River originates from the Palmer Glacier on the south slope of Mount Hood and empties into the Sandy River at RM 38 (Figure AA5). 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 subwatershed are not currently glacially influenced. Consequently, the Salmon River Subwatershed 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.

The Salmon River Subwatershed 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.

Native Migratory Fish Species

The following native migratory fish in the Salmon Subbasin are ESA-listed as threatened: spring and fall Chinook salmon, coho salmon, and winter steelhead. Pacific lamprey is a state sensitive species.

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 Subwatershed. 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 Subwatershed.

Currently, fall Chinook salmon do not use the Salmon River Subwatershed. It is estimated that fall Chinook used about 21 miles historically. Sea-run coastal cutthroat trout are assumed no longer to occur in the Salmon River Subwatershed, but resident cutthroat trout are well distributed throughout the subwatershed.

Table AA12. Estimated Stream Miles for Current and Historical Anadromous Fish Distribution in the Salmon Subwatershed

Total Stream Miles in Watershed	Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
	Current	Historical	Current	Historical	Current	Historical	Current	Historical
130	21	21	22	22	28	28	28	28

Habitat Quality

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 Subwatershed is dominated by moderate-sized stream reaches with boulder and cobble 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.[6] 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 Subwatershed is a moderate-sized stream with boulder and cobble substrate. The streams are riffle-dominated, with frequent

[6] 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.

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 Subwatershed. Percentages of habitat types in the subwatershed accessible to anadromous salmonid fishes were compared with percentages of 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 subwatershed supporting resident fish, a diversity of adequate habitats exists for all life stages of the species.

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 subwatershed. 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.

USFS (1995a) also assessed the frequency of LW (pieces per mile) for the Salmon River and major tributaries. The frequency of pieces of LW were compared to RNV and PIG standards. RNV was approximated from unmanaged stream reaches in the Salmon and Bull Run subwatersheds.

For the purpose of the assessments, the subwatershed 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 subwatershed 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.

LW frequency in the lower subwatershed was below both the RNV and PIG standards. Streams in the middle section of the subwatershed were within the RNV but well below PIG standards. Even unmanaged portions in the wilderness area were below PIG standards. Streams in the upper section of the subwatershed were near the lower end of the RNV and below PIG standards.

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.

Flows

Snowmelt provides ample flow of cold water during the summer months in the Salmon Subwatershed. The highest flows, however, seem to occur during the winter and are associated with rainfall or rain-on-snow events. The USGS does not maintain any gaging stations in the subwatershed, however, precluding a more detailed analysis of the Salmon River hydrograph.

Water Quality

The Salmon River mainstem and Boulder Creek were added to the ODEQ 303d list of water-quality-limited streams in 2004 for having a 7-day average maximum water temperature exceeding the criterion of 16 degrees Celsius for core cold-water habitat (year around). The Salmon River also exceed the criterion of 13 degrees Celsius for salmon and steelhead spawning (August 15-June 15). All streams in the subwatershed are clear-water.

Water Rights

Table AA13 summarizes the quantities of water allocated to various water rights and their intended uses:

TABLE AA13. USES FOR WATER RIGHTS IN THE SALMON RIVER.

USE	QUANTITY (CFS)
Anadromous and Resident Fish Rearing	451.2
Campsite	0.1
Commercial Uses	0.1
Domestic	8.2
Domestic inc. Lawn and Garden	0.1
Group Domestic	0.3
Human Consumption	0.2
Irrigation	0.8
Manufacturing Uses	0.1
Municipal Uses	25
Primary and Supplemental Irrigation	1.7
Quasi-Municipal Uses	1.6

Storage	0.8

Current Land Use/Regulation

Table AA14 summarizes the land ownership for the Salmon Subbasin. The majority of land is federally owned and managed for timber harvest, recreation, and fish and wildlife.

TABLE AA14. LAND OWNERSHIP IN THE SALMON RIVER.

USFS	STATE	PWB	PGE	METRO	COUNTY	CITY	CONSERVATION GROUP	BLM	PRIVATE	TOTAL ACRES
81.5%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	4.0%	13.5%	40,089

Zigzag Subwatershed

Overview of the Subwatershed

The Zigzag River Subwatershed (Figure AA6) covers about 37,730 acres in Clackamas County (USFS 1995b). Most of the subwatershed 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 subwatershed include the Little Zigzag River and Lady, Devils, Camp, Henry, and Still creeks.

Only about three percent of the subwatershed 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.

Native Migratory Fish Species

The following native migratory fish in the Zigzag Subbasin are ESA-listed as threatened: Spring and fall Chinook salmon, coho salmon, and winter steelhead. Pacific lamprey is a state sensitive species. The upper distribution of sucker species and northern pikeminnow is unknown, but they are considered relatively warm water species and are assumed here to not extend into the very cold waters of the Zigzag River and its tributaries. The possibility remains, however, that they are present.

Habitat Access

The SRBTT estimated anadromous fish currently use about 30 stream miles of habitat the Zigzag River Subwatershed (see Table AA15). 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. 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 subwatershed also make a significant contribution to overall natural fish production (ODFW 1997).

All 30 miles of habitat currently utilized in the Zigzag River Subwatershed 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 Subwatershed, which is also the same number of miles as used historically. Fall Chinook do not currently utilize the Zigzag River Subwatershed. 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 subwatershed.

Table AA15. Estimated Stream Miles for Current and Historical Anadromous Fish Distribution in the Zigzag Subwatershed

Total Stream Miles in Watershed	Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
	Current	Historical	Current	Historical	Current	Historical	Current	Historical
100	18	18	23	23	30	30	23	23

Habitat Quality

Habitat conditions for salmonids in the Zigzag River Subwatershed 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 subwatershed is a moderate to small-sized stream with boulder and cobble substrate, moderate to steep gradients, moderate to low levels of pools, and in-channel LW.

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 subwatershed 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 subwatershed. 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 subwatershed. 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 subwatershed.

Habitat types for the Zigzag River Subwatershed 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 subwatershed. The mix of habitat types was similar to the relatively undisturbed Bull Run River Subwatershed (USFS 1995b). The major difference between the subwatersheds was lower levels of pool habitat in the anadromous reaches of the Zigzag River compared with those in the Bull Run River Subwatershed. 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 subwatershed 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 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 subwatersheds 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 Subwatershed. Excluding Wind Creek, the frequency of pools in the Zigzag River Subwatershed 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 Subwatershed, 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 subwatershed (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 subwatershed, 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 Subwatershed 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.

USFS (1995a) also assessed the frequency of LW (pieces per mile) for the Zigzag River and major tributaries. The frequency of pieces of LW were compared to RNV and PIG standards. RNV was approximated from unmanaged stream reaches in the Salmon and Bull Run Subwatersheds. Levels of LW were below or at the low end of the RNV for all streams but Still Creek and Henry Creek. All streams were well below PIG standards, including reaches in unmanaged wilderness areas.

Flows

Snowmelt and glacial melt provide ample flow of cold water during the summer months in the Zigzag Subwatershed. The highest flows, however, seem to occur during the winter and are associated with rainfall or rain-on-snow events. The USGS does not maintain any gaging stations in the subwatershed, however, precluding a more detailed analysis of the Zigzag River hydrograph.

Water Quality

The Zigzag River mainstem and Still Creek were added to the ODEQ 303d list of water-quality-limited streams in 2004 for having a 7-day average maximum water temperature exceeding the criterion of 13 degrees Celsius, impacting spawning salmon and steelhead (August 15-June 15). The mainstem Zigzag River tends to be turbid from glacial melt. Most other tributaries, however, are clear-water.

Water Rights

Table AA16 summarizes the quantities of water allocated to various water rights and their intended uses:

TABLE AA16. USES FOR WATER RIGHTS IN THE ZIGZAG RIVER.

USE	QUANTITY (CFS)
Anadromous and Resident Fish Rearing	229.4
Domestic	5.9
Fish Culture	1.5
Irrigation	0.5
Manufacturing Uses	0.9
Quasi-Municipal Uses	1.5
Temperature Control	0.2

Current Land Use/Regulation

Table AA17 summarizes the land ownership for the Zigzag Subbasin. The majority of land is owned by the USFS and is managed for timber harvest, recreation, and fish and wildlife. A portion of USFS land and private land is used for rural residences. The communities of Zigzag and Rhododendron are located in the downstream portion of this subwatershed.

TABLE AA17. LAND OWNERSHIP IN THE ZIGZAG RIVER.

USFS	STATE	PWB	PGE	METRO	COUNTY	CITY	CONSERVATION	BLM	PRIVATE	TOTAL

							GROUP			ACRES
95.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%	37,756

Appendix B. Members of the Sandy River Basin Partners

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

Columbia Land Trust

Multnomah County

East Multnomah Soil and Water Conservation District

Metro

NOAA National Marine Fisheries Service

The Nature Conservancy

Northwest Steelheaders

Oregon Dept. of Environmental Quality

Oregon Dept. of Fish and Wildlife

Oregon Trout

Portland General Electric

Portland Water Bureau

Sandy River Basin Watershed Council

USDI Bureau of Land Management

USDA Forest Service, Mt. Hood National Forest

USDI Fish and Wildlife Service

Western Rivers Conservancy

Appendix C. 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 (Table AD-1) 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 (reach 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 (table AD-1).

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 (table AD-2). 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.[7]

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 AD-1. Figure AD-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.

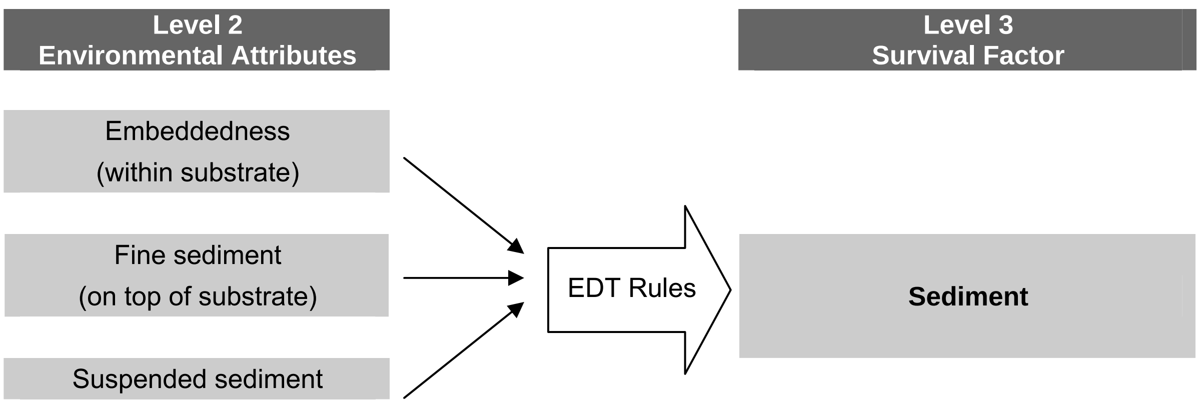

Figure AD-1. Relationship of Level 2 Environmental Attributes to Level 3 Survival Factors in EDT

Table AD-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 AD-2 lists the 16 Level 3 survival factors and provides a description for each survival factor.

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.

[7] These survival factors correspond to the types of factors typically referred to by biologists as limiting factors.

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 was the approach taken by the City of Portland (City) in the 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 AD-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.

Table continued on next page

Table AD-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.

Table continued on next page

Table AD-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.

Table continued on next page

Table AD-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).

Table continued on next page

Table AD-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 AD-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 AD-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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