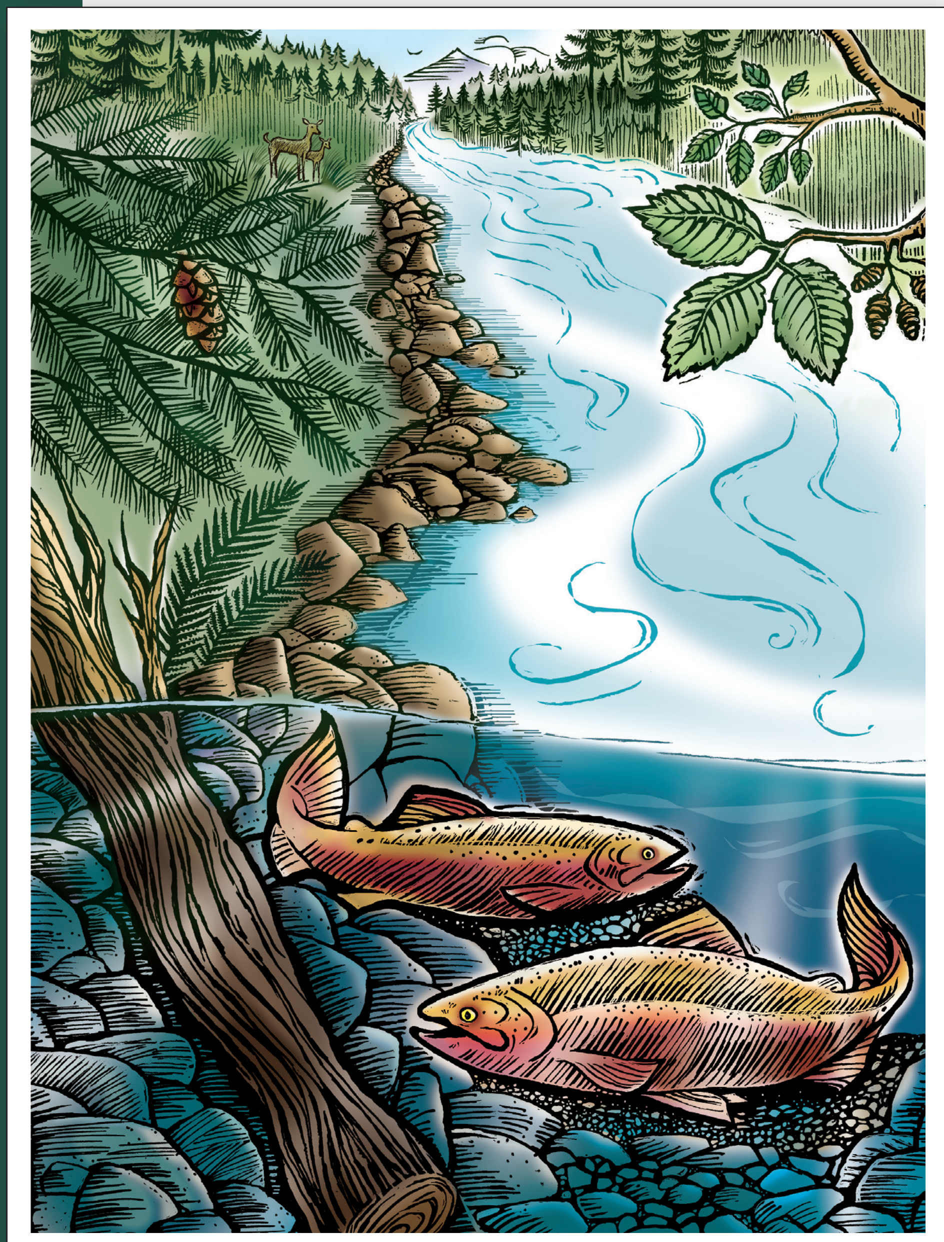
Bull Run Water Supply
Habitat Conservation Plan

Annual Compliance Report 2014 – Year 5



Final · May 2015

Portland Water Bureau
From Forest to Faucet

City of Portland, Oregon 1851

Under penalty of law, I certify that, to the best of my knowledge, after appropriate inquiries of all relevant persons involves in the preparation of this report, the information submitted is true, accurate, and complete.

Stephen T Kucas Jr.

Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

5/6/2015

Date

Contents

Appendixes

Tables

Figures

Acronyms and Abbreviations

cfs	cubic feet per second
DO	dissolved oxygen
EDT	Ecosystem Diagnosis and Treatment
ESA	Endangered Species Act
HCP	Habitat Conservation Plan
JOM	juvenile outmigrants
LCR	Lower Columbia River
MSL	mean sea level
NMFS	National Marine Fisheries Service
O&M	operations and maintenance
ODFW	Oregon Department of Fish and Wildlife
PGE	Portland General Electric
PHP	Portland Hydroelectric Project
PWB	Portland Water Bureau
RM	river mile
TDG	total dissolved gas
USGS	U.S. Geological Survey

1. Executive Summary

For 2014, the City met the terms and conditions of every HCP conservation measure with the exception of downstream water temperature targets. For 37 days, from September 26 to November 1, the temperature of the Bull Run River exceeded the HCP temperature target. The City presented the 2014 water temperature information to the Oregon Department of Environmental Quality, the National Marine Fisheries Service, and the Oregon Department of Fish and Wildlife. Those agencies directed the City to continue to monitor water temperatures in the lower Bull Run River in 2015 and to work with the agencies, starting in May, on operational measures to improve performance of the system for temperature control.

The Bull Run Water Supply Habitat Conservation Plan (HCP) is a 50-year plan to protect and improve aquatic habitat while continuing to manage the Bull Run River watershed as a water supply for the City of Portland (City), Oregon. The City created the HCP, with technical assistance from the Sandy River Basin Partners, to minimize and mitigate the effects of covered activities associated with the Bull Run water supply operations on listed and unlisted Endangered Species Act species and their associated habitat. The primary focus of the HCP is protection for ESA-listed anadromous fish under the jurisdiction of the National Marine Fisheries Service (NMFS), but the plan also includes other species. In 2009, NMFS issued an Incidental Take Permit to the City pursuant to Section 10(a)(1)(B) of the Endangered Species Act and signed an Implementing Agreement with the City. The HCP and each of its provisions are incorporated into those agreements.

In addition, in 2008, the Oregon Department of Environmental Quality's (ODEQ) approved the City's Temperature Management Plan for the Lower Bull Run River (Appendix G of the HCP). The City's plan addresses temperature requirements for the lower Bull Run River that are articulated in the Sandy River Basin Total Maximum Daily Load (TMDL) report.

In 2012, the City obtained a Clean Water Act 401 Certification from ODEQ for Portland's Bull Run Reservoir Hydroelectric Project associated with the improvements to the water intake towers at Bull Run Dam 2. A report on water quality monitoring required by the certification is included in this compliance report as Appendix B.

The HCP includes 49 conservation measures to protect and improve habitat and to avoid or minimize the impacts of the Bull Run water supply system. Annual reports from the

City are required to document compliance with the conservation measures, monitoring requirements, research efforts, and adaptive management actions that are implemented.

The fifth year of the HCP was 2014, referred to as Year 5 throughout this document. This is the fifth Annual Compliance Report.

Changing circumstances and conditions have required modifications to some of the original HCP measures. The changed measures were implemented with target amounts or locations that accounted for other measures that could not be implemented (for example, canceling a large wood project in one location and increasing the amount of large wood pieces in a second location). These changes are noted in this report and documented in an appendix of key correspondence with NMFS (Appendix H).

The City met the terms and conditions of every HCP conservation measure for 2014 with the exception of downstream water temperature targets. For 37 days, from September 26 to November 1, the temperature of the Bull Run River exceeded the HCP temperature target. The City presented the 2014 water temperature information to the Oregon Department of Environmental Quality, the National Marine Fisheries Service, and the Oregon Department of Fish and Wildlife. Those agencies directed the City to continue to monitor water temperatures in the lower Bull Run River in 2015 and to work with them, starting in May, on operational measures to improve performance of the system for temperature control.

2. Introduction

2.1 Habitat Conservation Plan Background

In April 2009, the National Marine Fisheries Service (NMFS) signed a Permit for Incidental Take of Threatened Species number 13812, granting the City of Portland (City) authorization to operate its Bull Run water supply subject to the provisions of the implementing agreement for the Bull Run Water Supply Habitat Conservation Plan (HCP). The Incidental Take Permit covers four anadromous fish species listed under the Endangered Species Act (ESA) of 1974—Lower Columbia River (LCR) Chinook salmon *(Oncorhynchus tshawytscha)*, Columbia River chum salmon *(O. keta)*, LCR coho salmon *(O. kisutch)*, LCR steelhead *(O. mykiss)*—and Pacific eulachon *(Thaleichthys pacificus)*.

The Bull Run HCP includes 49 habitat conservation measures that are expected to minimize and mitigate, to the maximum extent practicable, the effects of take on the covered fish. The measures are designed to improve habitat conditions for the fish and 18 additional wildlife species in the Bull Run subbasin and the Sandy River Basin, watersheds that are part of the lower Columbia River Basin in northwest Oregon. The Sandy River Basin was included in the plan in order to fully address the Incidental Take Permit requirements.

Measures in the Bull Run include modifying water supply infrastructure, implementing seasonal flow regimes and downramping rates, placing gravel and large wood, establishing fish passage in certain streams, removing invasive species, and defining operational standards to avoid or minimize the effects of operations on the covered species. The measures in the Sandy River Basin, called offsite measures, include large wood and log jam placement, channel redesign and reconstruction, establishing fish passage in certain streams, establishing easements and making improvements in riparian zones, and acquiring land parcels and water rights.

The HCP measures are being implemented and monitored over the course of 50 years. Measures in some reaches are being implemented early in the term of the HCP to provide the greatest improvements over time. Not every measure was implemented in the first year, however. Other measures slated to be implemented later in the HCP time frame are mentioned by name in this report but are not extensively discussed. By necessity, the terms of some measures have changed in response to changes in the Sandy River watershed. The City has maintained full records of measure adjustment terms, including correspondence with NMFS, documenting approval of the changes. Correspondence is summarized in the compliance report appendix each year.

A key element of the HCP involves improving water temperature conditions for spawning and rearing salmonid fish. Compliance with this objective also fulfills the temperature objectives for the lower Bull Run River that are articulated in the Oregon Department of Environmental Quality's (ODEQ's) Sandy River Basin Total Maximum

Daily Load (TMDL) report (ODEQ 2005). The City's Temperature Management Plan for the Lower Bull Run River, approved by ODEQ in 2008, is Appendix G of the City's HCP.

2.2 Annual Report Organization

This report is organized to provide the status of work and planned accomplishments for HCP monitoring, the research efforts, and the Portland Water Bureau's adaptive management program. The monitoring section is divided into compliance and effectiveness monitoring. Within each of these monitoring subsections, information is provided for the Bull Run Watershed measures and for the offsite measures in the Sandy River Basin, respectively. Measures that share similar objectives (such as large wood placement or obtaining riparian easements) are grouped together. The introductory subsections titled Measure Commitments are taken directly from the HCP and are characterized by a different font than the rest of the report text.

The HCP outlines a specific program of monitoring, research, and adaptive management to evaluate habitat improvements resulting from the measures. The monitoring component includes both compliance and effectiveness monitoring. This fifth yearly report of accomplishments includes compliance monitoring information in Section 4.1, effectiveness monitoring information in Section 4.2, and a summary of the planned research in Section 4.3. Reports describing the monitoring, research, and results in detail are available as Appendixes A–G. Appendix H summarizes key correspondence between PWB and NMFS on obtaining authorization for changes to measures, including adjustments to the terms of selected measures.

Table 10, beginning on page 55, provides summary information for the status of each measure. The table outlines the measurable habitat objective, the method of compliance monitoring described in the HCP, the years in which the measure is planned to be implemented, and a description of the status. Table 10 also indicates where the effectiveness monitoring reports (Appendixes A, B, and G) and the research reports (Appendixes C through F) are relevant to measures in this annual report. Measures that are not relevant to the current reporting year are shown with a gray background. Measures that are due to be started in future years are blank in the "Status" column.

3. HCP Monitoring, Research, and Adaptive Management Programs

3.1 Monitoring Program

The monitoring program for the HCP is designed to document compliance and verify progress toward meeting the goals and objectives outlined in Chapter 6 of the HCP. The monitoring program comprises both compliance and effectiveness monitoring. Compliance monitoring tracks progress implementing the HCP measures. Effectiveness monitoring is provided for those measures for which the habitat outcomes are somewhat uncertain.

Compliance monitoring reports focus on the work completed and planned for the following calendar year. Effectiveness monitoring reports focus on the measurable habitat objectives identified for each relevant measure in the HCP. The effectiveness monitoring data will enable an assessment of whether the measurable habitat objectives have been met.

Two new reports, introduced in 2013 and 2014 respectively, provide additional monitoring information. Monitoring Results for Certification According to Section 401 of the Clean Water Act, introduced in 2013, provides results of water quality monitoring in Bull Run Reservoir 2 and lower Bull Run River before and after the modifications to the water intake towers at Bull Run Dam 2 (see Appendix B). Riparian Forest Protection Monitoring, introduced in 2014, documents the City's efforts to monitor shading of the lower Bull Run River channel through time (see Appendix G).

3.2 Research Program

The research program for the HCP focuses on four components in the Bull Run River Watershed and one component in the larger Sandy River Basin. In the Bull Run Watershed, the City is studying the placement of spawning gravel, the degree of gravel scour in spawning beds suitable for Chinook spawning, the concentrations of total dissolved gases at certain locations, and the abundance of spawning Chinook adults. For the Sandy River Basin, the City is collaborating with other organizations doing research to measure the number of juvenile salmonid outmigrants at the reach and basin levels.

3.3 Adaptive Management Program

Adaptive management is an approach that involves monitoring the outcomes of a project and, on the basis of the monitoring results, improving the way the project is managed. The City anticipates that, over the course of its 50-year HCP, scientific understanding of the issues relating to salmonid habitat will improve and some conditions will change such that some reconsideration and adaptation of its approach will be appropriate. The adaptive management program provides for ongoing evaluation of individual measures as well as milestones for evaluating the HCP as a whole. A key measure for adaptive management is the Habitat Fund, described in Section 4.4.

4. Monitoring Measures Status and Accomplishments

4.1 Compliance Monitoring

Most of the HCP measures pose very little uncertainty as to whether implementing the measures will meet the objectives. For these measures, the City is conducting compliance monitoring to track implementation and document completion.

4.1.1 Bull Run Measures

The City is using established United States Geological Survey (USGS) sites on the lower Bull Run and Little Sandy rivers to monitor river flow and water temperature. River flow compliance will be measured at USGS Gage No. 14140000 (at river mile [RM] 4.7 on the Bull Run River). This gage will also be used to determine compliance with the downramping rate. Compliance with temperature measures will be based on the temperature data recorded at USGS Gage No. 14140020 on the lower Bull Run River (at RM 3.8, the Larson's Bridge site) and at USGS Gage No. 14141500 on the Little Sandy River (at RM 1.95, the Little Sandy Dam site), as shown in Figure 1.

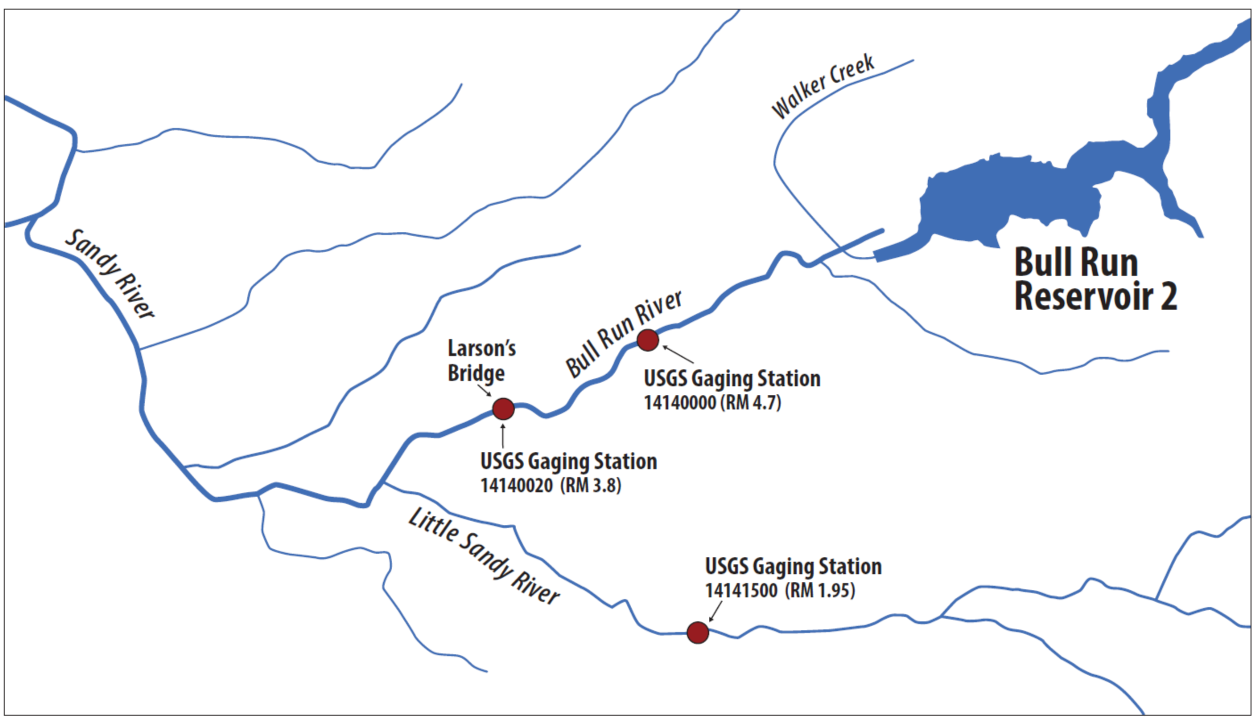


Figure 1. USGS Gaging Stations for Compliance Monitoring

Measure F-1—Minimum Instream Flow, Normal Water Years

Location: Bull Run Watershed

Benefits: Bull Run River flow

Contact: Kristin Anderson, Environmental Specialist, PWB Resource Protection

Primary Objective

Measure F-1 describes minimum instream flows to improve fish habitat conditions in the lower Bull Run River during normal water years. 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 Commitments

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

Table 1. Flow Commitments for the Lower Bull Run River During Normal Water Years, Measured at USGS Gage No. 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 Gage 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 1. 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 Gage 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 Gages (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 gages will be added and then multiplied by 1.2 to account for the ungaged 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 1 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 Gage No. 14140000, to allow safe surveying. The surveys are expected to occur approximately once per week from August through November. See Appendix F of the HCP for more details on the Chinook survey procedures.

Status of Work for Calendar Year 2014

The City met the minimum instream flow requirements of HCP Measure F-1 in 2014. Guaranteed minimum flows for normal water years were used as the flow targets during July through September in 2014. See Measure F-2 for spring and fall flow requirements for 2014. Lower Bull Run River flows at USGS Gage No. 14140000 are depicted in Figure 2.

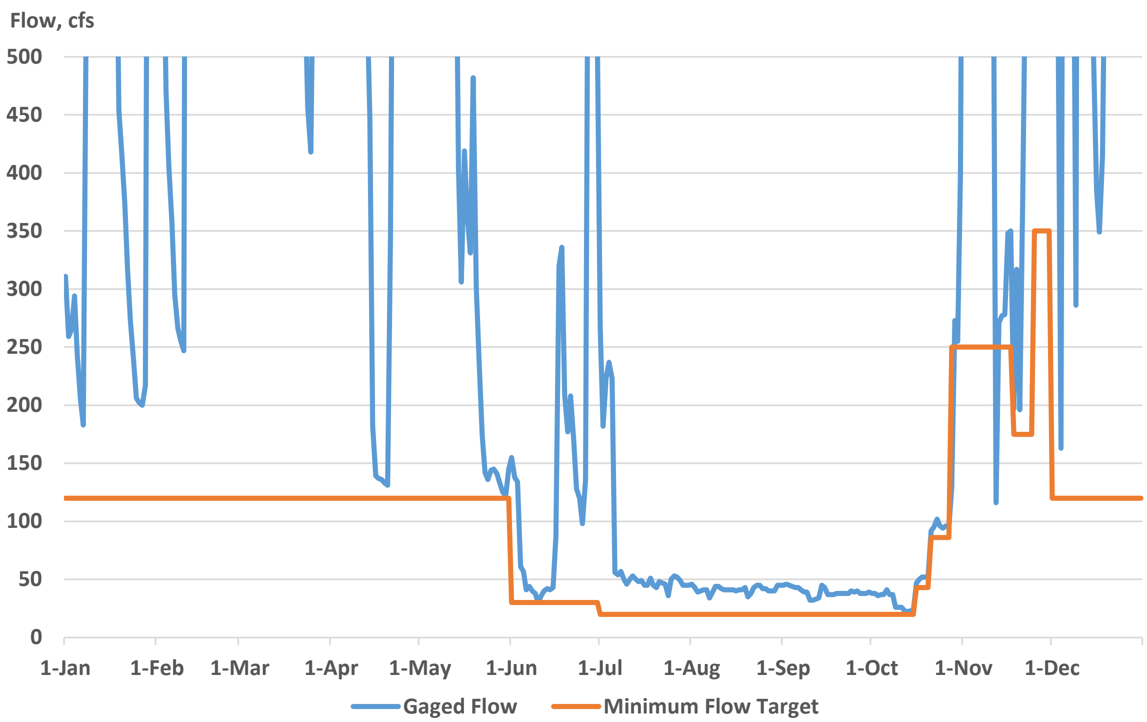


Figure 2. Lower Bull Run River Minimum and Actual Flows[a] in 2014
[a]Flows exceeding 500 cfs are not shown.

Releases from Bull Run Reservoir 2 were reduced on two days in October-November 2014 in order to permit Portland Water Bureau (PWB) fish biologists to safely conduct spawning surveys in the lower Bull Run. On these days, the mean daily flow at the gage was less than the guaranteed minimum level, a reduction in stream flow that is allowed under the terms of the HCP measure.

Planned Accomplishments for Calendar Year 2015

The City will continue to set the minimum flow levels early each day so that the daily averages meet or exceed the HCP minimum flow targets. Flow levels will be monitored in 2015 and compared to the guaranteed minimum flows. Normal-year or critical-year flow criteria will be applied as appropriate.

Measure F-2—Minimum Instream Flows, Water Years with Critical Seasons

Location: Bull Run Watershed

Benefits: Bull Run River flow

Contact: Kristin Anderson, Environmental Specialist, PWB Resource Protection

Primary Objective

Measure F-2 describes minimum instream flows that will be used during water years with critical seasons. These minimum flows will be used to achieve the guaranteed flows in the lower Bull Run River.

Measure Commitments

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 2 and 3 (in mean daily flow in cfs). Fall flows in Table 3 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 2.

Table 2. 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 historical record (1940 to current HCP Year)

The response to a critical spring season is outlined in Table 4.

Table 3. 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 Gage 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 4. 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.

The response to a critical fall season is outlined in Table 4.

Table 4. 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 Gage No. 14140000 (RM 4.7)

The percentage of inflow and maximum flow requirements might not be met during the days that the Chinook surveys occur. Flows will be held to less than 150 cfs, as measured at USGS Gage No. 14140000, to allow safe surveying. The surveys are expected to occur approximately once per week from August through November. See Appendix F for more details on the Chinook survey procedures.

The City will control streamflow releases at Headworks (RM 5.9 on the Bull Run River) and the lower Bull Run River flow will be measured at USGS Gage 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 Gages (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 gages will be added and then multiplied by 1.2 to account for the ungaged 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.

Status of Work for Calendar Year 2014

The critical spring trigger was met in 2014. Drawdown initially commenced on May 31, 2014. Downstream flows were decreased below 120 cfs. Additional rains in mid-June refilled Bull Run reservoirs. Reservoir drawdown began again on July 3, 2014.

The lowest 10 percent of total reservoir inflow during August and September from 1940 through 2013 was 3.71 billion gallons. Total reservoir inflow during August and September 2014 was 3.53 billion gallons; therefore critical fall conditions occurred, and critical fall flows were implemented in 2014. Lower Bull Run River flows at USGS Gage No. 14140000 are depicted in Figure 3.

During October and November, guaranteed minimum flows were based on a percentage of total inflow to the Bull Run reservoirs during the previous week. Table 5 summarizes the dates and flows used to derive these calculations.

Table 5. Dates, Inflow, and Flow Targets for October and November 2014

Flow Target Period		Index Period		Average Inflow (cfs) During Index Period	Flow Target (cfs)
From	To	From	To		
16-Oct	20-Oct	6-Oct	12-Oct	87	43
21-Oct	27-Oct	13-Oct	19-Oct	171	86
28-Oct	3-Nov	20-Oct	26-Oct	1038	250
4-Nov	10-Nov	27-Oct	2-Nov	1375	250
11-Nov	17-Nov	3-Nov	9-Nov	1561	250
18-Nov	24-Nov	10-Nov	16-Nov	437	175
25-Nov	30-Nov	17-Nov	23-Nov	953	350

Planned Accomplishments for Calendar Year 2015

Critical spring and fall triggers will be assessed in 2015. If either of the triggers is met, the City will decide whether to implement the appropriate guaranteed critical-year minimum flows per the conditions of the HCP.

Measure F-3—Flow Downramping

Location: Bull Run Watershed

Benefits: Bull Run River flow

Contact: Frank Galida, Hydroelectric Project Manager, Portland Bureau of Hydroelectric Power

Primary Objective

The City is committing to a low downramping rate to reduce effects on covered fish in the lower Bull Run and Sandy rivers.

Measure Commitments

Measure F-3—Flow Downramping: For HCP Years 1-50, the City will release flow into the lower Bull Run River, below Dam 2 as a result of hydropower operation, at a maximum downramping rate of no more than 2"/hour (0.17'/hour), as measured at USGS Gage No. 14140000 (RM 4.7). City staff will monitor recordings at USGS Gage 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 Gage No. 14138850 (Bull Run RM 14.8), decrease by more than 2"/hour.

Status of Work for Calendar Year 2014

The City was in compliance with Measure F-3.

Downward-stage fluctuations in the lower Bull Run River, as measured at USGS Gage No. 14140000, were maintained at or below a rate of 2"/hour (hr) for 99.60 percent of the time in 2014. Downramping exceedences occurred during 35 hours, or 0.40 percent of total operating hours during the monitoring year. Of those 35 hours, 34 hours of the related exceedences were caused by circumstances that are described in Measure F-3 as being excluded from the 2"/hr downward fluctuation limit. This means there was one hour of reportable exceedence during 2014. That one exceedance occurred during one of the twice-a-day summer flow changes at the Headworks. That maximum exceedance rate was 0.19'/hr (2.3"/hr).

The effects analysis outlined in the HCP was based on predicted flow exceedences of 0.4 percent of total operating hours—a level of downramping flow exceedences that was determined to have minimum effects on covered fish species in the Plan. The City, at 0.0001 percent (1 hour out of a total of 8,715 hours) of flow exceedences in 2014, operated within this limit.

Even though the 34 downramping exceedances were excluded from the fluctuation limit, the City analyzed the flow data to determine why the exceedences occurred. Accounting for each hour of the allowed downramping exceedences is as follows:

- 14 hours were associated with normal daily shutdowns of Portland Hydroelectric Project (PHP) Powerhouse 1 at times when the Dam 2 North Tunnel was unavailable for use. The Dam 2 North Tunnel normally carries water to Powerhouse 2. The City uses this combination to dampen the fluctuations of flows in the lower Bull Run River. From February 23 through February 28, the City's Bull Run Dam 2 Tower project precluded use of the Dam 2 North Tunnel, and hence PHP Powerhouse 2. During that 6-day period, PHP Powerhouse 1 was started and stopped 7 times resulting in 6 exceedance events.
- 7 hours were associated with storm events that generated high flows followed by sharp declines (stage drops greater than 2"/hr) in those flows as measured at USGS Gage No. 141438850.
- 6 hours were associated with windstorm events on January 11 and November 11 when damage to the power transmission lines between the PHP Powerhouses and the PGE power grid caused the two PHP Powerhouses to be instantaneously knocked off-line.
- 4 hours were associated with mandatory testing of the new selective-level gates on the North Intake Tower of Dam 2.
- 2 hours were associated with equipment failures of the controls for the North Howell-Bunger valves below Dam 2 and the governor controls for PHP 2.
- 1 hour was associated with the necessary flushing of the Dam 2 South Tunnel in response to an active rise in turbidity levels in Reservoir 2. This action was taken to assure compliance with Safe Drinking Water Act standards.

Planned Accomplishments for Calendar Year 2015

Flow downramping will continue to be monitored in 2015.

Measure F-4—Little Sandy Flow Agreement

Location: Bull Run Watershed

Benefits: Little Sandy River flow

Contact: Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

Primary Objective

The City is forgoing consumptive use of Little Sandy River water under the 1892 claim and the 1909 right for the term of the HCP. When coupled with the conversion of the Portland General Electric (PGE) 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), are 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 Commitments

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.

Status of Work for Calendar Year 2014

The City believes that through the HCP Implementation Agreement it is achieving its obligations under Measure F-4 to create a Little Sandy Flow Agreement. The City suggested this to NMFS in a November 18, 2014, letter) and, on December 4, 2014, NMFS affirmed that the City has met its obligations under the measure(see Appendix H, Item 9).

This measure has been completed.

Planned Accomplishments for Future Calendar Years

The City will provide documentation if it exercises any of its water rights in the Little Sandy River.

Measure T-1—Pre-infrastructure Temperature Management

Location: Bull Run Watershed

Benefits: Bull Run water temperature

Contact: Kristin Anderson, Environmental Specialist, PWB Resource Protection

Primary Objective

The City has altered 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 will store cold water in the reservoirs in early summer when overall temperatures are lower and will release it in the late summer when river temperatures are warmer. The multilevel intakes already existing at Dam 1 are used for this purpose. 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. Compliance with this measure fulfills the objectives of the City's Temperature Management Plan (TMP) for the Lower Bull Run River (Appendix G of the HCP).

Measure Commitments

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 main stem Bull Run River (USGS Gage No. 14140020).

Status of Work for Calendar Year 2014

Infrastructure changes as described in Measure T-2 were completed in 2014; Measure T-1 is no longer in effect. See Measure T-2 for reporting of downstream temperatures.

Planned Accomplishments for Calendar Year 2015

The City is managing flow releases from Headworks to maintain the 7-day average of daily maximum temperatures at Larson's Bridge according to Measure T-2, Post-Infrastructure Temperature Management. The second year operating the new multi-level intakes at Bull Run Dam 2 will be 2015.

Measure T-2—Post-infrastructure Temperature Management

Location: Bull Run Watershed

Benefits: Bull Run water temperature

Contact: Kristin Anderson, Environmental Specialist, PWB Resource Protection

Primary Objective

The City has altered 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 will store cold water in the reservoirs in early summer when overall temperatures are lower and will release it in the late summer when river temperatures are warmer. The multilevel intakes already existing at Dam 1 are used for this purpose. With the new multi-level intakes at Dam 2, the City's target is to maintain the 7-day moving average of the maximum daily water temperature (7DADM) of the lower Bull Run River below either the numeric stream temperature criteria or the 7-day moving average of the maximum water temperature of the Little Sandy River, whichever is greater, with additional air temperature and calendar exceptions. Compliance with this measure fulfills the objectives of the City's Temperature Management Plan (TMP) for the Lower Bull Run River (Appendix G of the HCP).

Measure Commitments

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 main stem 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 6 when the Little Sandy River temperature is below the criteria

Table 6. Appropriate Numeric Temperature Criteria

River Reach	Time Period	Habitat Use	Numeric Criterion (7-Day Average Maximum)
River Mile 0 to 5.3	June 16 to August 14	Salmonid rearing	16°C
	August 15 to June 15	Salmonid spawning	13°C
River Mile 5.3 to 5.8	June 16 to October 14	Salmonid rearing	16°C
	October 15 to June 15	Salmonid spawning	13°C

Source: ODEQ 2005

Or

- at or below the Little Sandy River temperature (as adjusted, see below) when the Little Sandy River temperature is above the numeric criteria

Also per the TMDL, the Bull Run water temperature target will be adjusted above the actual measured Little Sandy temperatures as follows:

- Between August 16 and October 15, allowances will be made for a 1.0 °C departure above the Little Sandy temperature.
- If the 7-day moving average of daily maximum air temperature is above 27 °C, the lower Bull Run water temperature target will be the lower Little Sandy River water temperature plus 1 °C.
- If the 7-day moving average of daily maximum air temperature is above 28 °C, the lower Bull Run water temperature target will be the lower Little Sandy River water temperature plus 1.5 °C

The ODEQ temperature standards [OAR 340-041-0028(12)(c)] provide an additional exception if the maximum daily air temperature exceeds the 90th percentile of the 7-day average of the daily maximum air temperature calculated in a yearly series over the historical record. If this situation occurs in the lower Bull Run River, the numeric criteria and natural condition criteria (Little Sandy water temperatures as adjusted above) would not apply.

Daily maximum air temperatures will be recorded at the Water Bureau's Headworks facility below Dam 2 (approx. RM 6).

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.

Status of Work for Calendar Year 2014

Infrastructure changes (the addition of multi-level water intake gates on the north tower at Bull Run Reservoir No. 2 as described in the Measure T-2 commitments) were completed in 2014, and the new multi-level intakes were placed into operation for temperature management.

Several challenges arose in 2014. On April 1, the bottom gates of the north tower were closed to bank cold water for the summer season. Between April 21 and 25, the gates were tested as part of approving the final construction of the new infrastructure. The testing resulted in a release of 750 million gallons, nearly the total volume of the banked water at the bottom of the reservoir. This increased the temperature of the bottom layer of water approximately 1 °C. On June 6, contractors working on the electrical system on the North Tower opened the lower gate and accidently left it open. Approximately 60 million gallons of water was released from the cold water bank in the reservoir before the gate was closed.

In addition, the beginning and end of the temperature management period were both marked by dry conditions. This led to an early start of reservoir drawdown on May 31, triggering a critical spring in which instream flows are decreased as early as June 1. Temperature targets in the lower Bull Run River were low (13 °C) at that time, and would have required large releases from Reservoir 2 of bottom water to meet targets. At that time, the City convened with regulators from ODFW, NMFS, and ODEQ regarding this issue, and the regulatory agencies allowed a target increase to 16 °C for June 6 through June 15. August and September stream flows in the Bull Run Watershed were also lower than the tenth percentile of historic inflows; therefore, a critical fall was also triggered. This allowed for the lower flow levels to continue through October 15 instead of ending September 30. In addition, the critical fall criteria allowed for lower instream flows from October 16 through November 30, than are permitted in a normal year.

Fall rains returned in late October, ending the period of reservoir drawdown approximately two weeks later than normal. The end of drawdown also coincides with rapid cooling of the reservoirs. Therefore, warm reservoir conditions persisted in 2014 about two weeks longer than the historical norm.

The City created a flow calculator for determining flow releases on a twice-daily basis, from spring through the fall, utilizing data from previous years to estimate instream heating under various conditions. However, historical data did not include release water temperatures in the range of the water temperatures that were observed in 2014; empirical data for the new conditions of cold water banked behind in Reservoir No. 2 did not exist. As a result, many flow decisions were made on a daily basis and were sometimes different from the output of the flow calculator.

The lower Bull Run 7DADM stayed below the moving temperature target through the summer management period, early June through the end of September. On July 1 and August 11, the 90th percentile air temperature was exceeded. For all days that included these dates in its 7-day average (i.e. from six days before to six days after these dates), the temperature target did not have to be met. The City met the target in these two periods despite this exception.

From September 26 through November 1, the lower Bull Run 7DADM exceeded the target temperature. All cold water in Reservoir 2 had been depleted, and temperatures did not cool until sufficient rains came in late October. Downstream maximum temperatures were decreasing in the first half of October. However, due to larger minimum instream flow releases, the downstream temperatures increased in the second half of October until rains cooled Reservoir 2. Even though the water temperature targets for the lower Bull Run were exceeded, they were in the 14–15 °C range. The numeric criterion for that time period was 13 °C.

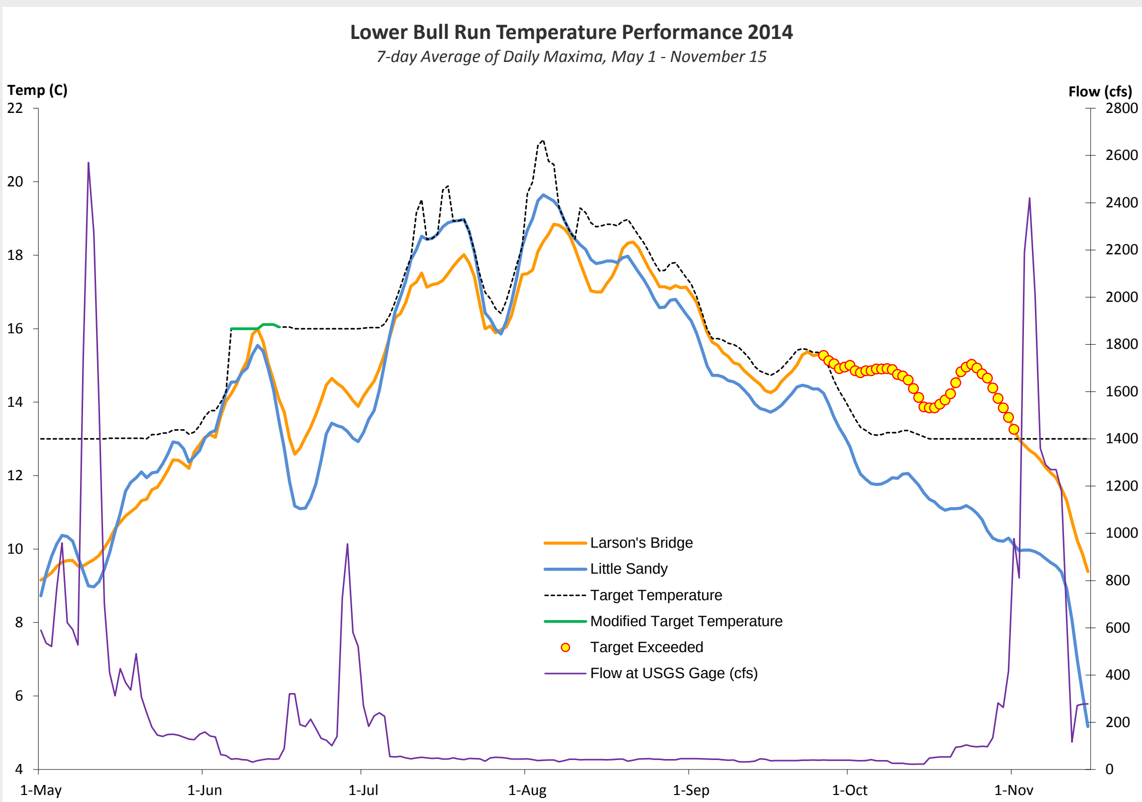


Figure 3. 7-Day Moving Average of Daily Maximum Water Temperature in the Lower Bull Run River at Larson's Bridge (USGS Gage No. 14140020) and at Little Sandy River (USGS Gage No. 14141500) for 2014. Target temperature combines numeric criteria, Little Sandy temperature, and air temperature and calendar exceptions. The modified target temperature represents the joint decision by Portland Water Bureau and regulators to preserve the cold water resource for later critical periods.

Planned Accomplishments for Calendar Year 2015

The City presented the 2014 water temperature information to ODEQ, NMFS and the ODFW. Those agencies directed the City to continue to monitor water temperatures in the lower Bull Run River in 2015 and to work with them, starting in May, on operational measures to improve performance of the system for temperature control.

The City will manage flow releases from Headworks to maintain the 7-day average of daily maximum temperatures at Larson's Bridge according to Measure T-2, Post-Infrastructure Temperature Management. The second year operating the new multi-level intakes at Bull Run Dam 2 will be 2015. The City will incorporate knowledge from the first year of operating with the new multi-level intakes to improve management tools and operations in 2015.

Measure R-1—Reservoir Operations

Location: Bull Run Watershed

Benefits: Avoids or minimizes cutthroat and rainbow trout mortality

Contact: Kristin Anderson, Environmental Specialist, PWB Resource Protection

Primary Objective

The City is continuing to manage the reservoirs to assure compliance with federal Safe Drinking Water Act standards and to avoid or minimize mortality of cutthroat and rainbow trout.

Measure Commitments

Measure R-1—Reservoir Operations: For HCP Year 1-50, the City will operate the two Bull Run reservoirs to avoid or minimize mortality of cutthroat and rainbow trout. The operating criteria for the reservoirs will be the following:

1. When the City is operating its hydroelectric powerhouses at the two Bull Run dams during the winter, the reservoir surface elevations will not normally vary outside of the upper two feet of the reservoirs' normal full pool range (except as noted in items 2 and 3 below). For Bull Run Reservoir No. 1, the elevation range is 1,034 to 1,036 feet above MSL. For Reservoir 2, the range is 858 to 860 feet above MSL.

2. The City will lower the surface elevation of the two reservoirs beyond the upper two feet of the normal full pool level only for water supply and/or quality reasons, for downstream fish habitat reasons, for dam safety reasons, or for repairs or maintenance to the dam or hydropower project facilities.

3. The City will operate the two reservoirs as needed to maintain required streamflows and water temperatures in the lower Bull Run River for covered species.

4. During the summer drawdown season, Reservoir 1 may be lowered to approximately elevation 970 feet above MSL and Reservoir 2 may be lowered to approximately 832 feet above MSL as needed for water supply purposes

5. At the end of each drawdown season, the two Bull Run reservoirs will be filled as rainfall, streamflow, and required downstream releases permit.

6. The spillway gates on Bull Run Dam No. 1 will be lowered onto the spillway crest in the spring to store additional water for use in the summer months. After the risk of major flooding has passed, and any habitat maintenance work has been completed in the upper reaches of Bull Run Reservoir No. 1 (see Measure R-3, Reed Canarygrass Removal), the water surface level in that reservoir will be raised to a summer supply full pool level of 1045 feet.

7. The City will use 4-cycle engines on its boats to minimize reservoir water pollution.

Status of Work for Calendar Year 2014

The Bull Run reservoirs were operated to meet the requirements of Measure R-1 in 2014. Graphs of the daily surface elevations of each reservoir are shown in Figures 4 and 5.

Reservoir 1 was operated within 2 feet of the spillway elevation from January 1 through May 2.

The spillway gates were lowered (closed) on April 14, and Reservoir 1 was operated about halfway up the gates (1,038–1,042 feet) from April 14 to May 13. Once Measure R-3 (Reed Canarygrass Removal) was completed on May 13, Reservoir 1 was filled to the top of the spillway gates and held there (1,044–1,045 feet) until May 31. Reservoir 1 started drawing down on May 31 until rains refilled it again on June 17. Drawdown on Reservoir 1 began again on July 3. Reservoir 1 reached its minimum elevation for 2014 of 982.4 feet on October 18, then refilled to spillway elevation (1,036 feet) on November 4. Another shorter period of drawdown started on November 6 due to high fish flow releases. The Reservoir 1 level was reduced to 1027.5 feet on November 10 and refilled again to spillway elevation on November 26. Reservoir 1 remained within 2 feet of spillway elevation after November 26 except for the period of December 3 and 4, when reservoir levels were managed to accommodate downstream fish surveys.

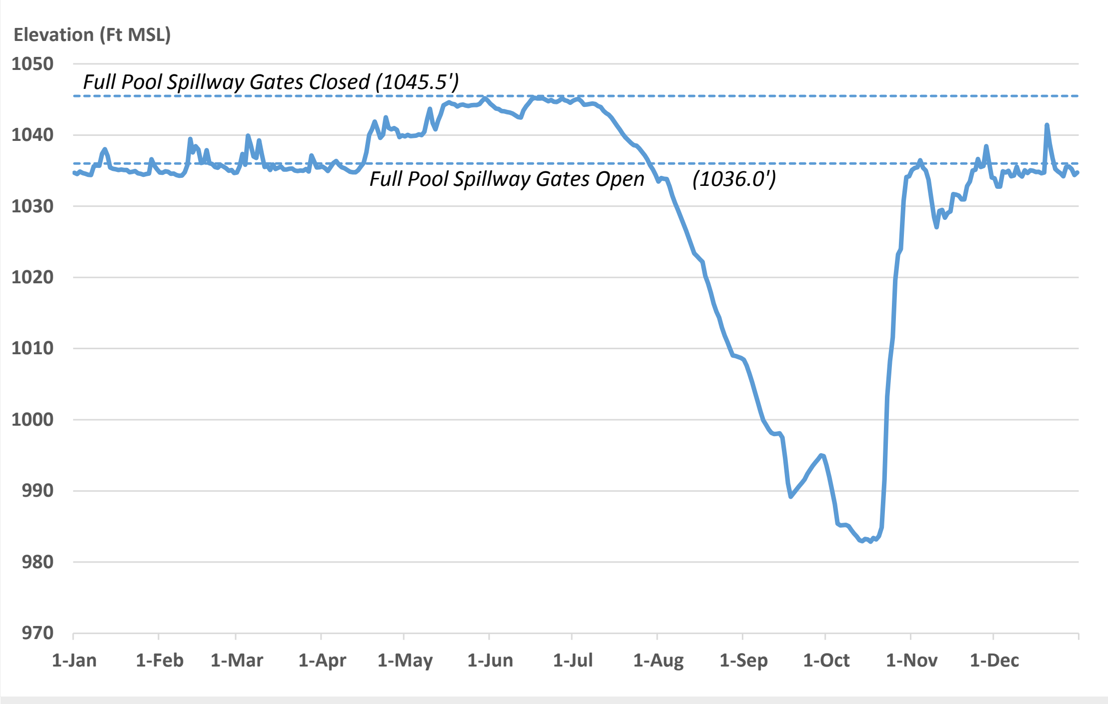


Figure 4. Reservoir 1 Elevations[a] During 2014

[a]Reservoir elevations were recorded at midnight at USGS Gage No. 14139000 in feet above mean sea level (MSL). Reservoir elevations are also tracked via the Portland Water Bureau's SCADA system, one data point from the SCADA system was used to fill in a missing point of USGS data.

Reservoir 2 was operated within 2 feet of spillway elevation until August 4, when the level reached 857.7 feet. The reservoir refilled again shortly thereafter, and then entered a longer period of drawdown starting August 26. Reservoir 2 reached its minimum elevation for 2014 of 845.8 on October 22, then refilled to spillway elevation (860 feet) on November 3. As with Reservoir 1, other shorter periods of drawdown occurred due to higher fish flow releases. Secondary drawdowns occurred between November 11 and 22. Reservoir 2 remained within 2 feet of spillway elevation after November 22 except for the periods December 2-4 and December 7-8, when reservoir levels were managed to accommodate downstream fish surveys.

The City used only 4-cycle engines on all powered boats operated on the Bull Run reservoirs.

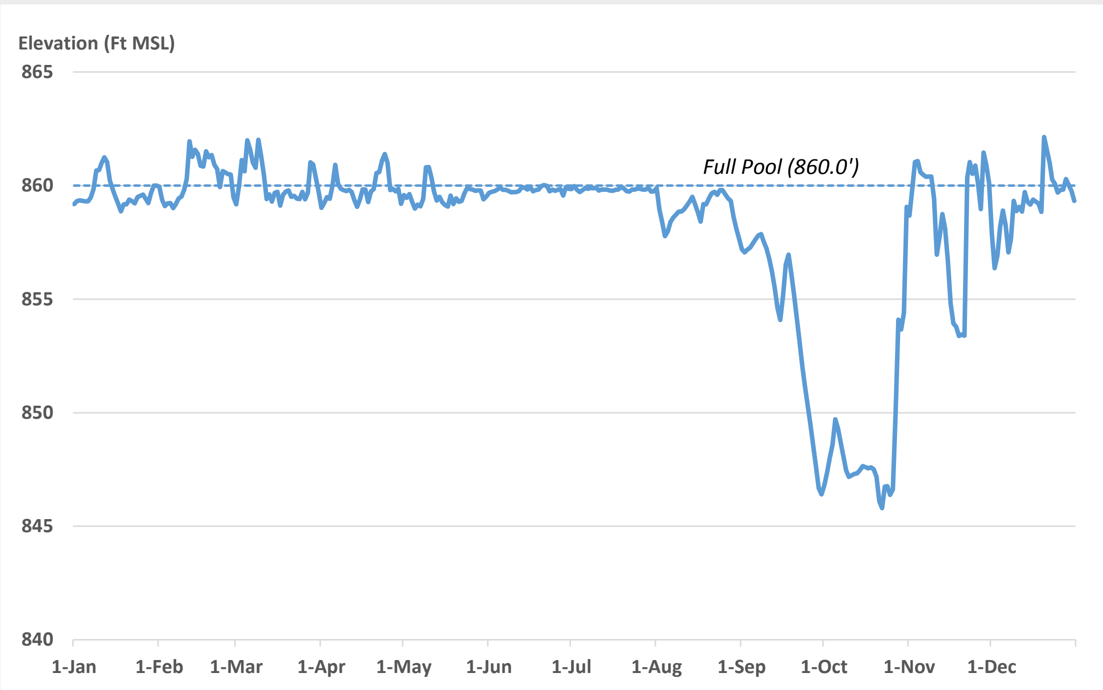


Figure 5. Reservoir 2 Elevations[a] During 2014

[a]Reservoir elevations were recorded at midnight at USGS Gage No. 14139900 in mean feet above sea level (MSL). Reservoir elevations are also tracked via the Portland Water Bureau's SCADA system.

Figure 6. Reservoir 1 and Dam 1 During A Drawdown Period

Planned Accomplishments for Calendar Year 2015

Reservoir elevations will be managed in 2015 according to the commitments of this measure. All boats operated on the Bull Run reservoirs will be powered by 4-cycle engines or human power.

Measure R-3—Reed Canarygrass Removal

Location: Bull Run Watershed

Benefits: Improve terrestrial habitat for wildlife

Contact: John Deshler, Wildlife Biologist, PWB Resource Protection

Primary Objective

The City has identified three areas along the upper end of Bull Run Reservoir 1 that are important for reproduction and egg incubation for western toads and red-legged frogs to improve breeding and rearing habitat for these species.

Measure Commitments

Measure R-3—Reed Canarygrass Removal: For HCP Years 1-50, the City will cut and rake reed canarygrass away from three areas along the north bank of the upper end of Bull Run Reservoir 1. The City will access the site by boat from the reservoir and by trail. Power tools will be used for cutting the grass. Neither heavy equipment nor additional road access will be needed. The cutting will occur just prior to the summer season lowering of the spillway gates on Dam 1, which will flood the shallow area of the reservoir. The areas to be cut are approximately 10' x 15', 100' x 100', and 100' x 40'; this total area to be cut is approximately one-third acre.

Status of Work for Calendar Year 2014

The City met the requirements of Measure R-3. On May 12, 2014, City staff worked at the north bank of the upper end of Bull Run Reservoir 1. Staff cut reed canarygrass in three areas within the western toad and red-legged frog breeding areas (Figure 7). Once the three areas were cut, the grass was removed from breeding locations with rakes and pitchforks, leaving grass stubble approximately 2–4 inches in height and exposed mineral soil.

Figure 7. Reed Canarygrass Removal

Planned Accomplishments for Calendar Year 2015

As this compliance report was being completed in the spring of 2015, and since rainfall and snow amounts were very low in the Bull Run Watershed, the City decided to raise the water level on Reservoir No. 1 much earlier than normal. Before that was done, City staff also looked at the three areas to determine the height of the reed canarygrass. It was only 2-3 inches high in March 2015. With the raising of the reservoir, the City believes that the grass will be flooded and its growth will be restricted. Also, if the growth would be limited the grass may not need to be cut.

City staff will return to the three sites in April and determine if the grass height is still being restricted. However, if the grass grows enough and could shade the three areas, the grass will be cut as it has been done in past years.

Measure H-1—Spawning Gravel Placement

Location: Bull Run Watershed

Benefits: Improve instream habitat

Contact: Burke Strobel, Fish Biologist, PWB Resource Protection

Primary Objective

The City is replenishing spawning gravel and mimic natural supply and accumulation in the lower Bull Run River. 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 Commitments

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 Gage 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 arises, the City will work with the NMFS to modify implementation of the measure as needed.

Appendix F of the HCP describes how the City will assess the effectiveness of the placed spawning gravel.

Status of Work for Calendar Year 2014

The City met the requirements of the HCP measure. The City successfully placed 1,200 cubic yards of spawning gravel in the lower Bull Run River in January 2014, at three specified locations. Using trucks with conveyor belts, the City placed a total of 400 cubic yards of gravel into the river at each location on January 6 through January 9, 2014. The gravel was obtained from a gravel quarry located near Estacada, Oregon, on an old alluvial terrace above the Clackamas River. The material complies with the specifications described in the measure.

Conveyor trucks were able to throw gravel to the middle of the Bull Run River, where it later was moved downstream by high flows. River flows during implementation of the project ranged from approximately 176 cfs to approximately 1,850 cfs. No gravel was placed in pools. Gravel placement did not result in accumulations great enough to hinder the movement of fish at any of the three sites. A high flow (4,070 cfs) on January 13, 2014, redistributed most of the placed gravel.

Planned Accomplishments for Calendar Year 2015

Spawning gravel will be placed in the lower Bull Run River in January 2015. The placement methods will be similar to those used in previous years, however the quantity of gravel placed will be less. Next year (2015) will be the sixth year of spawning gravel placement. Measure H-1 calls for the placement of a total of 600 cubic yards of spawning gravel in HCP Years 6-50.

Measure H-2—Riparian Land Protection

Location: Bull Run Watershed

Benefits: Improve riparian and instream habitat

Contact: Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

Primary Objective

City-owned lands along the lower Bull Run River are 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.

Measure Commitments

Measure H-2—Riparian Land Protection: For HCP Years 1-50, City-owned lands adjacent to the lower Bull Run River will be managed for the conservation of riparian habitat. The City will not cut trees within 200 feet of the river's average high water level on City-owned lands for the term of the HCP. A tree, as defined here, is any coniferous species with a minimum average diameter at breast height of 12 inches. Exceptions will include selective tree cutting to construct, maintain, and operate water supply and treatment facilities, water monitoring facilities, power lines, roads, and bridges. The City will also remove trees if they threaten City facilities, pose a significant risk to human safety, or when the City and NMFS determine selective cutting is desirable for the purpose of maintaining or improving riparian habitat. If trees are removed, the City will assess the site to determine whether an appropriate riparian species could be planted where the tree (or trees) was removed and will replant trees where feasible. The planted trees will be species that do not grow as tall as the removed trees. See also Measures W-1 and W-2.

Status of Work for Calendar Year 2014

The City met the requirements of Measure H-2. The City did not cut trees within 200 feet of Bull Run River's average high water level on City-owned lands in 2014. The City also managed invasive species on lower Bull Run River riparian land.

Planned Accomplishments for Calendar Year 2015

The City will continue to monitor activities within 200 feet of the Bull Run River.

Measure O&M-1—Bull Run Infrastructure Operations and Maintenance

Location: Bull Run Watershed

Benefits: Avoid or minimize effects of operations and maintenance activities on covered lands

Contact: Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

Primary Objective

The City will implement the Bull Run Infrastructure Operations and Maintenance (O&M) measure to address the potential impacts of maintaining and operating its water supply facilities in the watershed.

Measure Commitments

Measure O&M-1—Bull Run Infrastructure Operations and Maintenance: For HCP Years 1-50, the City will take the following actions to avoid or minimize effects on species covered or addressed in the HCP in the Bull Run watershed:

Covered Lands

- The City will prevent paint and debris from falling in the river during bridge and conduit maintenance at all active stream crossings.
- The City will avoid or minimize erosion during repair and maintenance of all water supply infrastructure.
- Water drained from the conduits will be dechlorinated and routed through energy dissipaters prior to releases in the nearest waterway.
- The City will not use insecticides on covered lands. The City will allow BPA to use the herbicide Garlon 3A in a limited manner on the BPA transmission line easement on City land (see Section 8.7 for more information). The City will avoid or minimize use of other herbicides on covered lands except as necessary to control invasive plants. Plans for herbicide use that might affect habitat for covered species will be provided to NMFS for preapproval.
- The City will use fertilizers on lands if necessary to encourage plant establishment and growth after projects that cause ground disturbance (e.g., as part of hydroseeding).
- The City will remove trees in riparian areas if they threaten City facilities or pose a significant risk to human safety. The City will plant replacement trees, in the same approximate locations, if trees of greater than 12 inches diameter at breast height are cut.

Sandy River Station

- Within HCP Years 1-10, the City will evaluate stormwater drainage at Sandy River Station and improve facilities if needed.

Status of Work for Calendar Year 2014

The City followed all of the commitments stated in Measure O&M-1.

Planned Accomplishments for Calendar Year 2015

The City will continue to monitor the commitments stated in Measure O&M-1.

Measure O&M-2—Bull Run Spill Prevention

Location: Bull Run Watershed

Benefits: Avoid or minimize effects of operations and maintenance activities on covered lands

Contact: Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

Primary Objective

The City will implement the Bull Run Spill Prevention measure to address the potential impacts of maintaining and operating its water supply facilities in the watershed.

Measure Commitments

Measure O&M-2—Bull Run Spill Prevention: For HCP Years 1–50, the City will implement the following actions to avoid or minimize spill effects on the species covered or addressed in the HCP in the Bull Run and Sandy rivers:

Headworks

- Fuel and chlorine deliveries will be escorted by a pilot car via paved roads.
- Secondary containment will be provided for the fuel tanks.
- Containment basins will be inspected and pumped out as needed.

Sandy River Station

- Secondary containment systems will be provided for the fuel tanks and pumps to contain any leaks. Containment basins will be inspected and pumped out as needed.
- Within Years 1–5 of the HCP, the City will evaluate the feasibility of moving existing fuel tanks and pumps out of the Sandy River floodplain. This feasibility analysis will be done in conjunction with a City capital improvement project.

Status of Work for Calendar Year 2014

The City has complied with all of the commitments in Measure O&M-2 in 2014.

Planned Accomplishments for Calendar Year 2015

The City will continue to monitor adherence to the commitments in Measure O&M-2.

4.1.2 Offsite Measures

The City is implementing conservation measures on land in various locations throughout the Sandy River Basin. The measures are grouped by type: riparian easements and improvements, acquisition of water rights, fish passage, carcass placement, large wood and log jam placement, channel restoration, and terrestrial wildlife habitat conservation.

4.1.2.1 Riparian Easements and Improvements

The City will obtain easements from willing landowners for a total of 373 acres of riparian lands. The current easement targets are 166, 99, and 108 acres for the lower, middle, and upper Sandy River watershed, respectively (Table 7). For adaptive management reasons, the easement targets have been changed slightly for individual conservation measures. Compliance will be determined by the acres specified, aggregated into the three portions of the basin. The City must obtain the total target acreage by Year 15 of the HCP (2024).

When applicable, the measurable habitat objectives define a number of acres for riparian easements. The intent is for the easements to provide a minimum of a 100-foot-wide buffer from the top of the mean high-water level in the specified reach. The total acres per reach may or may not be contiguous, depending on the opportunities to contact willing sellers.

Table 7. Easement Acre Targets and Acres Obtained for HCP Implementation, Year 5 (2014)

Measure Code	Reaches	HCP Years	Easement Acre Targets	Acres Obtained by Year 2010–2013	Acres Obtained by Year 2014	Total Acres Obtained
Lower Sandy						
H-11	Sandy 1	2010-2014	0	—	—	—
H-12	Sandy 2	2010-2014	143	54	91[a]	145
H-13	Gordon 1A, 1B	2010-2014	23	23	—	23
		Subtotal	166	77	91	168
Middle Sandy						
H-14	Sandy 3	2020-2024	7	17	0	17
H-15	Cedar 2 & 3	2015-2019	49	0	0	0
H-16	Alder 1A & 2	2010-2014	43	0	0	0
—[b]	Lower Bull Run River	2012	0	0	34	34
		Subtotal	99	17	34	51
Upper Sandy						
H-18	Sandy 8	2020-2024	25	2	0	2
H-19	Salmon 1	2015-2019	23	0	0	0
H-20	Salmon 2	2020-2024	36	0	0	0
H-21	Salmon 3	2020-2024	12	0	0	0
H-22	Boulder 1	2010-2014	0	—	—	—
H-28	Zigzag 1A & 1B	2020-2024	12	0	0	0
		Subtotal	108	2		
	Grand Total		**373**	**96**	**125**	**221**

White table cells indicate easements targeted for implementation in HCP Years 1–5. Gray shading indicates easements targeted for future HCP years.

[a]Exchange of acreage authorized by NMFS on September 25, 2012 (see summary in Appendix H, Item 6).

[b]No associated HCP measure. The City of Portland acquired land around the lower Bull Run River, as authorized by NMFS on September 16, 2011 (see summary in Appendix H, Item 3).

Measures H-12 and H-13–Riparian Easements and Improvements

Location: Lower Sandy River, middle Sandy River, and upper Sandy River watersheds

Benefits: Improve riparian and instream habitat

Contact: Angie Kimpo, Environmental Program Coordinator

Primary Objective

The City has identified habitat conservation measures that will improve riparian-zone conditions. The land easements will improve a minimum of 100 feet of riparian forest on either side of the active channel width of the river or creeks. The conservation measures include silvicultural practices (e.g., selective thinning and tree planting) to improve the riparian zones. The acreage totals for the land protection easements are calculated by multiplying the lineal distance of the stream by the amount of riparian forest protected by the easement.

A general riparian easement and improvement measure description is provided so that duplicate text is not repeated. The specific HCP measures from the three areas of the Sandy River Basin differ only by the total acreage targets.

Measure Commitments

Within HCP Years 1-5, the City will acquire 100-foot-wide land protection easements from willing private landowners for at least XX acres which will comprise the total number of lineal feet x 100 feet of riparian width on either side of the Sandy River in the named reaches. 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.

Status of Work for Calendar Year 2014

Since the creation of the conservation easement measures in the HCP, land ownership in the Sandy River Basin has changed tremendously. Many private land parcels have been purchased and converted to public lands in the target areas for the HCP easements. The City will continue to assess potential easements and communicate with NMFS about potential habitat benefits and acreage totals for various locations in the Sandy River Basin.

The City is ahead of schedule for acquiring conservation easements in the Sandy River Basin. Currently, the City has finalized easements for 221 acres (Table 7). The City was successful in working with willing landowners and finalized one easement in 2014. The easement was finalized for 91 acres in reach Sandy 2 (The Nature Conservancy). The acquired easement counts towards the overall easement targets for Sandy River tributaries (Gordon Creek). Authorization for this adaptive management change was granted via letter (NMFS letter to Steve Kucas, dated September 25, 2012), summarized in Appendix H, Item 6).

For all easements or acquired riparian buffer areas, canopy cover is estimated both prior to work on site and after planting to determine progress towards canopy cover goals (see Figures 8 and 9). PWB is currently evaluating the use of remote sensing to collect canopy data on larger parcels.

Table 8 summarizes the location, acreage total, and condition of the canopy cover for the easements that the City has obtained to-date.

Table 8. Location, Amount, and Estimate of Canopy Cover for Easements, HCP Year 5 (2014)

Reach/ Property Owner	Year Acquired	Number of Easements	Acres	Initial Canopy Cover Estimate[a]
Gordon 1A & 1B		**2**	**23 Total**	
Maunder	2011		3	47%
Bonner	2012		20	33%
Lower Bull Run			**34 Total**	
City of Portland	2013		34	52%
Sandy 2		**1**	**54 Total**	
Camp Collins	2013		54	85%
Sandy 3		**1**	**17 Total**	
Rayne	2011		17	28%
Sandy 8		**1**	**2 Total**	
Mench	2011		2	92%

[a]Canopy cover data are collected within the first year of easement acquisition and every 5 years after that. First monitoring results will be available in 2016 for the Maunder, Rayne, and Mench easements and will be reported in the appropriate HCP Compliance Report. Initial canopy data for The Nature Conservancy (TNC) parcels are being collected in 2015 and will be provided in future compliance reports. The TNC easements are not shown in this table in this HCP year.

The City is obligated to treat all easement areas so that the canopy cover exceeds 70 percent conifer trees, or native hardwood species as the site conditions dictate, over the term of the HCP. The canopy cover for the Camp Collins and Mench easements exceed the ≥70 percent criterion stated in the HCP. The City will continue to track the canopy cover for all easements.

Planned Accomplishments for Calendar Year 2015

The City will continue to pursue easements on Cedar Creek and the Salmon River to meet specific HCP targets.

The City will also meet with NMFS in 2015 to discuss the overall HCP easement program, accomplishments, and future direction of the program.

Figure 8. The Rayne Easement after Planting—the Middle Sandy Gorge on the Sandy River

Figure 9. The Nature Conservancy Cornwall Easement—the Lower Sandy River

4.1.2.2 Water Rights

Measure F-5—Cedar Creek Purchase Water Right

Location: Cedar Creek in Sandy River Basin

Benefits: Improve instream habitat

Contact: Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

Primary Objective

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 water withdrawals. The City will acquire water rights to improve water quality and base flows in Cedar Creek for steelhead, coho, and cutthroat trout.

Measure Commitments

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.

Status of Work for Calendar Year 2014

The City finished researching all of the currently held surface water rights in the Cedar Creek watershed for Measure F-5 in 2012. The City started to approach willing landowners to discuss the acquisition of their surface water rights. For this measure, the City has until 2019 to obtain the water rights.

Planned Accomplishments for Calendar Year 2015

The City will continue talking to willing landowners to discuss the acquisition of their surface water rights in 2015.

4.1.2.3 Fish Passage

Measures P-3 and P-4—Alder and Cedar Creek Fish Passage

Location: Alder and Cedar creeks in the Sandy River Basin

Benefits: Provide fish passage

Contact: Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

Primary Objective

Alder Creek, one of the larger tributaries to the middle Sandy River, currently supports steelhead and coho. The two fish passage conservation measures provides access to 5.5 miles of good quality steelhead and coho habitat in reaches 1 and 1A.

Cedar Creek is one of the largest, low-gradient tributaries to the Sandy River. 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 Oregon Department of Fish and Wildlife's commitments to fish passage on Cedar Creek, provides passage to approximately 12–14 miles of stream habitat on Cedar Creek reach 1 for coho, steelhead, and anadromous cutthroat trout.

Measure Commitments

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.

Measure P-4—Cedar Creek 1 Fish Passage: Within HCP Years 1-5, the City will provide up to a maximum of $3.7 million dollars to fund three components of fish passage improvements on Cedar Creek. The City will provide the money to ODFW to fund the following:

1. Upgrades to the Sandy Fish Hatchery water intake screens and associated features to conform to NMFS criteria

2. Passage improvements at the adult diversion ladder, downstream passage pipeline, and downstream plunge pool

3. Upgrades at the discharge channel to the plunge pool, the sluice gates, the diversion dam, and safety improvements for daily maintenance

The City will not provide money to fund the necessary water treatment improvements and any operations and maintenance costs that may be necessary for fish passage on Cedar Creek.

If ODFW cannot secure money for the other components necessary to implement this passage project, the City will redirect the $3.7 million to the Habitat Fund to finance other capital projects in the Sandy River Basin. This reallocation will occur in consultation with NMFS and the Sandy River Basin Partners. The $3.7 million will be reallocated in a manner (e.g., time frame) that will not adversely affect the City's water rate payers, as determined by the City.

The City will not be responsible for monitoring fish passage on Cedar Creek after the improvements have been made. The City assumes that ODFW will be responsible for monitoring, treatment, and operation and maintenance.

Status of Work for Calendar Year 2014

The City has complied with all of the commitments for fish passage measures P-3 and P-4.

Measure P-3 was completed in 2014 (Figure 10). The City continues to monitor the new fish ladder.

For Measure P-4, the City provided all funds to ODFW to fund fish passage improvements on Cedar Creek. The conservation measure has now been completed.

Figure 10. Final Alder Creek Fish Ladder at City of Sandy Municipal Water Diversion (P-3)

Planned Accomplishments for Calendar Year 2015

Measures P-3 and P-4 have been completed. The City will continue to monitor the P-3 fish ladder.

4.1.2.4 Large Wood Placement

Measures H-3 and H-17—Large Wood Placement

Location: Little Sandy River and Cedar Creek

Benefits: Improve instream habitat

Contact: Burke Strobel, Fish Biologist, PWB Resource Protection

Primary Objective

The City's large wood measures are being implemented to help restore key habitat for fish (see Figure 11 for a typical structure). The large wood additions will increase habitat complexity, providing benefits such as pools and cover for migrating, spawning, and rearing fish in the Little Sandy River, reach 1 and in Cedar Creek, reaches 2 and 3.

Section 4.2.1 of this report describes the effectiveness monitoring methods for these measures.

A general large wood measure description is provided in the following subsection so that duplicate text is not repeated. The specific measures for the Sandy River Basin reaches differ only by the number of logs to be placed. In future HCP compliance reports, the specific measure commitments will be included to track City compliance.

Measure Commitments

Within HCP Years 1–5, the City will work with willing landowners to place a minimum of 410 key logs into Gordon Creek and Trout Creek. Within HCP Years 6–10, the City will work with willing landowners to place a minimum of 650 key logs into the Little Sandy River and Cedar Creek. Large wood will be placed avoiding federal land, land without landowner permission, and land where the preexisting large wood quantity is already adequate. Large wood quantities were chosen to achieve placement densities of approximately 75 pieces per mile on average for the originally planned treatment reaches, Little Sandy 1 and 2, Gordon 1A and 1B, Trout 1A and 2A, Cedar 2 and 3, and 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 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 placements will be maintained for 15 years. Year 1 of the maintenance will be the calendar year following the wood placement.

Effectiveness monitoring is described in Section 4.2.1 of this report.

Status of Work for Calendar Year 2014

Under the terms of HCP measures H-3, Little Sandy 1 and 2 LW Placement, and H-17, Cedar 2 and 3 LW Placement, the City is obligated to place 50 and 600 key logs in the Little Sandy River and Cedar Creek, respectively. The HCP also stipulates that large wood placements will be maintained for 15 years. The City is obligated to conduct compliance monitoring of these placements and their functional integrity.

H-3 Little Sandy 1 and 2 LW Placement

The Little Sandy 1 and 2 LW placement (Measure H-3) was successfully implemented in 2014. A total of 63 pieces of large wood were placed along 0.75 miles of the Little Sandy River using a heavy-lift helicopter. This count includes a 20 percent contingency in case some pieces are not retained in the stream as intended. Large wood pieces include both tree stems with and without root wads. Stems with root wads are at least 30 feet long, with an average diameter at approximately breast height of 18 to 24 inches. Root-wad diameter is at least 4.5 feet. Stems without root wads are at least 40 feet long with an average diameter of 18 to 24 inches at the large end. The wood pieces are aggregated into 10 structures. Structures are built to withstand a flood with a 100-year recurrence interval.

H-17 Cedar 2 and 3 LW Placement

Preparations for H-17 were continued in 2014. Landowner permissions were obtained for two properties. Discussions were initiated with additional landowners to attempt to gain further permissions.

Planned Accomplishments for Calendar Year 2015

H-3 Little Sandy 1 and 2 LW Placement

In 2015 the City plans to conduct compliance monitoring of all large wood placements in Little Sandy 1 and 2. All structures built in 2014 will be revisited and any changes to structures will be documented.

H-17 Cedar 2 and 3 LW Placement

In 2015, the City plans to finalize placement locations and configurations for large wood in Cedar Creek. Hydrologic and hydraulic analyses will be conducted on Cedar Creek and initial designs for large wood structures will be drafted and analyzed for stability. Landowner permissions will be obtained. The City intends to implement this measure in 2016.

Figure 11. A Typical Large Wood Structure

4.1.2.5 Carcass Placement

Measure H-29 Carcass Placement

Location: Sandy River Basin

Benefits: Enhance species habitat

Contact: Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

Primary Objectives

The objective for Measure H-29 is to enhance in-stream productivity and benefit fish.

Measure H-29 Commitments

Measure H–29—Zigzag 1A, 1B, and 1C Carcass Placement: Within HCP Years 11–15, the City will provide funding, for one season, to place at least 1,800 salmon carcasses (approximately 300 carcasses per mile) in reaches 1A, 1B, and 1C of the Zigzag River. The carcass placement will be implemented as part of a basin–wide partnership project by ODFW, USFS, and the Sandy River Basin Watershed Council. This measure will occur during one year only and the City will work with the Partners to determine the best timing and method for implementation of the measure, which will depend on available carcasses at ODFW's hatchery facilities and other considerations.

Status of Work for Calendar Year 2014

In the HCP under the conditions of Measure H-29, the City agreed to a one-time payment to place 1,800 salmon carcasses in reach Zigzag 1A, 1B, and 1C. The Sandy River Basin Partners, including NMFS, identified the reaches of Clear Fork, Clear Creek, Still Creek, Lost Creek, and Camp Creek as more likely to benefit from the carcass placements than reaches of the Salmon River described in the HCP. The City has an agreement with the Sandy River Basin Watershed Council (SRBWC) to place salmon carcasses. The carcass placements will be implemented as part of a basin-wide partnership project by SRBWC, ODFW, and USFS.

In 2014, the City paid the SRBWC to place 1,970 salmon carcasses in the Zigzag River basin and in the upper Sandy River area. NMFS authorized the substitution of stream reaches for carcass placements (see Appendix H, Item 8). These carcass placement efforts substitute for the commitments outlined in HCP Measure H-25.

Measure H-29 has been completed early.

Planned Accomplishments for Calendar Year 2015

This measure has been completed.

4.1.2.6 Terrestrial Wildlife Habitat Conservation

Measures W-1, W-2, and W-3—Minimum Impacts to Spotted Owls, Bald Eagles, and Fishers

Location: Sandy River Basin

Benefits: Avoid disturbance of species' habitat

Contact: Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

Primary Objectives

The objective for Measures W-1 and W-2 is to avoid or minimize the periodic, temporary disturbance of habitat that might otherwise result from the routine operation, maintenance, and repair of water supply facility from implementation of HCP measures.

Although fishers have not been found in the Sandy River Basin, the City developed Measure W-3 as a contingency habitat measure to avoid or minimize impacts to fishers during the performance of covered activities in the basin.

Measure W-1 Commitments

Measure W–1—Minimize Impacts to Nesting Spotted Owls: For the term of the HCP, the City will take steps to avoid or minimize impacts to nesting spotted owls on all covered lands. The terms of the measure are described on page 7–66–7–69 of the HCP.

Measure W-2 Commitments

Measure W–2—Minimize Impacts to Bald Eagles: For the term of the HCP, the City will take steps to avoid or minimize impacts to bald eagles on all covered lands. The terms of the measure are described on page 7–69–7–74 of the HCP.

Measure W-3 Commitment

Measure W–3—Minimize Impacts to Fishers: If the fisher is found to occur within 30 miles of the Bull Run watershed, or the locations of any unfinished HCP measures, the City will meet with USFWS to discuss whether any steps need to be taken to avoid or minimize impacts to fishers during the performance of the covered activities.

Status of Work for Calendar Year 2014

For Measures W-1, W-2, and W-3, the City avoided or minimized impacts to spotted owls and bald eagles for all City projects in 2014.

Fishers have not been found to occur anywhere near the Bull Run Watershed, and therefore no avoidance or minimization actions were necessary.

Planned Accomplishments for Calendar Year 2015

The City will continue to evaluate potential impacts to spotted owls and eagles when considering City projects. The City will continue to be vigilant about any information related to fishers and will consider such information during the performance of covered activities.

4.1.3 Monitoring for Clean Water Act 401 Certification Conditions

As part of HCP Measure T-2—Post-infrastructure Temperature Management—PWB has completed a project to modify a water intake tower at Bull Run Dam 2 to allow withdrawal of water from the reservoir at different levels. PWB has a non-capacity license amendment with the Federal Energy Regulatory Commission (FERC) for the tower modifications. According to Section 401 of the Clean Water Act (CWA) and as part of the condition of the amended hydroelectric project license from FERC, the Oregon Department of Environmental Quality (ODEQ) reviewed the impacts of the proposed Bull Run Dam 2 Tower project on water-quality parameters that have the potential to be affected by construction on the intake tower. The five water-quality standards that have the potential to be affected by work in Bull Run Reservoir 2 are listed in Table 9 with the language from the Oregon Administrative Rule that describes the standard.

Table 9. Water Quality Parameters To Monitor for CWA Section 401 Certification

Water Quality Parameter	Potential Impact Description In Oregon Administrative Rule
Nuisance Phytoplankton Growth	Changes in reservoir circulation may lead to changes in nutrient concentrations, which in turn may lead to algal blooms.
Creation of Taste, Odors, Toxic Conditions	Taste and odor or toxic conditions can occur from nuisance algal blooms.
Dissolved Oxygen	Changes in water circulation in reservoir may alter dissolved oxygen concentration, especially at depth with change in residence time deep in reservoir; algal bloom respiration and decay may also consume dissolved oxygen.
pH	Algal blooms may cause spikes in pH values.
Temperature	Changes in withdrawal depth may result in temperature changes downstream.

Prior to the Dam 2 Tower improvements (from 2009 to 2013), PWB gathered monitoring data to provide baseline results. Monitoring data from 2014 were compared to the baseline data. Reservoir monitoring for 401 certification conditions in 2014 showed results were within anticipated ranges and do not represent significant changes to water quality. Appendix B of this report describes the monitoring efforts and results.

4.2 Effectiveness Monitoring

The City is conducting effectiveness monitoring for some of the HCP conservation measures. Those measures include large wood placement/log jam creation, side-channel development, river mouth reestablishment, and floodplain reconnection. For these measures, there is some degree of uncertainty about the biological effectiveness.[1] All effectiveness monitoring is conducted to test the hypothesis that at least 80 percent of the projected changes in the key habitat variables will occur in each stream reach. The City is using the habitat variable ratings from the Ecosystem Diagnosis and Treatment (EDT) model and has provided estimated improvements from HCP measures in Appendix E of the HCP. For a detailed description of effectiveness monitoring for offsite in-channel conservation measures, including sampling methods and assessment procedures, see Appendix F of the HCP.

For the first monitoring year, the City conducted baseline monitoring to serve as a benchmark for effectiveness monitoring of large wood and log jam placement.

4.2.1 Large Wood and Log Jam Placement

Measures H-3 and H-17—Large Wood Placement

Location: Little Sandy River, Cedar Creek, and the Salmon River in the Sandy River Basin

Benefits: Instream habitat

Contact: Burke Strobel, Fish Biologist, PWB Resource Protection

Primary Objective

The City's large wood measures are being implemented to help restore key habitat for fish. The large wood additions will increase habitat complexity, providing benefits such as pools and cover for migrating, spawning, and rearing fish in the Little Sandy River reach 1, Cedar Creek reaches 2 and 3, and Salmon River reach 2.

Measure Commitments

The measure commitments for HCP Measures H-3 and H-17 are described in Section 4.1.2.4, which starts on page 41 of this report.

Measurable Habitat Objectives

The measurable habitat objectives for the large wood measures share the common objective of achieving 80 percent of the predicted increase in pieces of large wood within 15 years of implementation. Additional habitat objectives created for reaches 2 and 3 of Cedar Creek are to achieve 80 percent of the predicted increase in beaver ponds and

---

[1] In some cases, the City does not plan to conduct effectiveness monitoring because the outcomes are already known and are well-supported by the available scientific literature.

pools within 15 years of implementation. The additional habitat objective created for reach 2 of Salmon River is to achieve 80 percent of the predicted decrease in artificial confinement (that is, riprap).

Effectiveness Monitoring Method

To test whether the habitat variable ratings in the current EDT database are representative of pre-project conditions, and to determine whether the projected increases in habitat ratings are an accurate representation of post-project conditions, the City is implementing the following monitoring methodology:

- Conduct baseline habitat surveys in both the project reaches and in upstream control reaches, where no habitat enhancement projects are planned.
- Conduct post-project habitat surveys in both the project reaches and in upstream control reaches.
- Compare the baseline and post-project survey results for project and control reaches. Effectiveness will be evaluated by comparing observed changes with the measurable habitat objectives, after adjusting for background changes observed in control reaches.

Status of Work for Calendar Year 2014

The City fully complied with the effectiveness monitoring as required by the HCP for Measures H-3 and H-17. Effectiveness monitoring was also conducted to prepare for anticipated HCP restoration activities on the Salmon River, reach 2. The specific monitoring accomplishments are referenced by measure name (e.g., little Sandy LW Placement) in Appendix A of this report.

Planned Accomplishments for Calendar Year 2015

The collection of baseline data for effectiveness monitoring will be conducted in 2015 in Cedar Creek for Measure H-17, to be implemented in 2016, in the Sandy River, reach 2, for Measure H-4, to be implemented in 2017, and in the Salmon River. Post-treatment data collection for effectiveness monitoring will be conducted in 2015 in the Little Sandy River. Baseline and post-treatment habitat surveys will follow protocols identical to those used in 2014.

4.3 Research Program

4.3.1 Bull Run Research

4.3.1.1 Spawning Gravel Placement

Under the HCP, the City places spawning gravel in the lower Bull Run River to increase spawning habitat, primarily for Chinook salmon and steelhead. Each year, the City evaluates the gravel placement to determine the amount of resulting surface area covered by gravel suitable for spawning salmon and steelhead (see Figure 12).

The City conducted this evaluation of spawning gravel placement as planned in 2014. The combined surface area of adequately sized spawning gravel patches was significantly higher than the baseline average for steelhead and for Chinook at all flows. The surface area of spawning gravel in 2014 was higher than what had been observed in all previous years (2010-2013) at most locations and flows. A detailed account of the gravel placement protocol is available in Appendix F of the HCP. The current status of spawning gravel placement is detailed in Appendix C of this report.

Figure 12. PWB Staff Evaluating Spawning Gravel in the Lower Bull Run River

4.3.1.2 Total Dissolved Gas

No new TDG data were collected in 2014 because the target streamflow levels for monitoring were not observed.

The City has evaluated the structures, valves, and turbines in the Bull Run water supply system since 2005 to determine whether any facilities would exceed the state standard for total dissolved gas (TDG). For the state standard, the concentration of total dissolved gas relative to atmospheric pressure at a sample collection point may not exceed 110 percent of saturation, except when stream flow exceeds the ten-year, seven-day average flood.

The City has measured TDG levels in excess of 110 percent at river flows below the 10-year, 7-day average flood (7Q10) flow on three occasions in the past. On all three occasions the water with high TDG levels had not yet had a chance to mix with the low-TDG water from Powerhouse 2. The average saturation level for TDG in the river was calculated to be less than 110 percent.

The detailed account of the TDG evaluation protocol is available in Appendix F of the HCP. The results of the TDG evaluation are in Appendix D of this report.

4.3.1.3 Bull Run Adult Chinook Population

In conjunction with other agencies in the Sandy River Basin, the City has partially funded research of the status of fish listed under the Endangered Species Act. The results of the research will be evaluated along with the results of the City's effectiveness monitoring to determine the City's adaptive management response over time.

The City collects adult Chinook salmon information for the lower Bull Run River. The City conducts annual surveys of the lower river from RM 0 to RM 6.0 to count adult spring and fall Chinook salmon from August through mid-December. Surveys will be conducted on a weekly basis, provided instream flows allow for safe navigation of the river channel. Overall, the City anticipates funding 20 years of surveys over the 50-year term of the HCP.

The City conducted this annual survey of the Bull Run Chinook population as planned in 2014, but high flows prevented scheduled surveys from being conducted on two occasions. The peak adult Chinook count and minimum escapement[2] estimate in 2014 were among the lowest recorded since annual surveys were initiated in 2005. The cumulative redd count was in the middle of the range of what has been observed in past years, suggesting that poor visibility during several surveys resulted in relative undercounts of live adults and carcasses.

[2] Escapement is the number of fish that avoid or escape all harvest and return to spawn in their home streams.

A detailed description of the Bull Run Adult Chinook Population Research protocol is available in Appendix F of the HCP. Protocols followed on one occasion in early September 2014 differed from those described in HCP Appendix F because of the operation of a weir near the mouth of the Bull Run River by ODFW to collect returning adult hatchery Chinook salmon. These protocol changes and the results of the current year's survey are available in Appendix E of this report.

4.3.2 Sandy River Basin Research

4.3.2.1 Sandy River Basin Juvenile Outmigrants

Although the HCP is habitat-based and not focused on the specific population responses of the species, information about juvenile outmigrants (JOM) is needed to obtain a complete picture of the condition and change in freshwater productivity through time. The results of the JOM research will be evaluated with other monitoring results to determine the City's adaptive management response over time.

The City will provide funds for collecting JOM information in the Sandy River Basin. This money will be leveraged with other funds to create a coordinated monitoring program. Twelve sites in the basin will be monitored and will serve as an index for the entire basin.

The City and its partners monitored JOM production in seven streams as planned in 2014: Clear Creek, Still Creek, Zigzag River, Cedar Creek, Bull Run River, Little Sandy River, and Beaver Creek. Provisional population estimates were calculated for steelhead and coho smolts in all seven streams, but no fork length analysis or condition factor analysis were conducted on fish from the Zigzag River. The average age of smolts was calculated by aging fish using fish scale samples collected between 2009 and 2013.

Steelhead and coho smolts from different streams in the Sandy River Basin showed significant differences in weighted mean fork length of smolts. Low-elevation streams had longer smolts than high-elevation streams.

Steelhead and coho smolts from different streams in the Sandy River Basin also showed significant differences in mean condition factors. Condition factors, however, did not correlate positively or negatively with fork length, as they have in previous years.

Steelhead smolts emigrated earlier than coho smolts, on average, in all streams. Both steelhead and coho emigrated earlier from low-elevation than from higher-elevation streams.

High-elevation streams had a larger proportion of older age steelhead and coho smolts. Length-at-age calculations revealed that steelhead smolt fork lengths are shorter on average for a given age in higher-elevation streams than in lower elevation streams, as is seen in coho, but this fact is masked by their older average age

The City's specific commitments and the approach to JOM research are outlined in Appendix F of the HCP. The results of this research are presented in Appendix F of this report.

4.4 Adaptive Management Program

The Bull Run HCP defined adaptive management along two concurrent tracks: adaptive responses for individual measures and decision milestones for addressing the effectiveness of the HCP as a whole. Through monitoring, the City will evaluate its progress on implementation as well as effectiveness of the measures. Should monitoring results indicate, the City will use its adaptive management program to change its approach.

If monitoring results indicate that a measure cannot be implemented, that an instream measure has not met its measurable objective, or that factors outside the City's control have reduced the habitat benefits of a measure by more than 20 percent, then the City will implement adaptive management. The adaptive management response includes several factors: consultation with NMFS, site surveys, and rerunning the EDT model to characterize baseline watershed conditions.

If, after taking these steps, the City and NMFS reach the conclusion that an additional or substitute measure is necessary, the City will follow the guidelines outlined in Chapter 9 (Section 9.4.3) of the HCP in its approach. Costs for implementing additional measures after the original measure has been implemented will be paid from the adaptive management section of the Habitat Fund. See the description of the Habitat Fund measure, below.

Measure H-30—Habitat Fund

Location: Covered lands

Benefits: Assists in meeting HCP objectives

Contact: Steve Kucas, Environmental Compliance Manager, PWB Resource Protection

The adaptive management portion of the Habitat Fund will be used to implement additional projects if one or more of the offsite measures does not meet its objectives. The Sandy River Basin Partners' portion of the fund will be used to implement additional habitat projects that help compensate for water system impacts not fully addressed by other projects. The details of the Habitat Fund measure are presented in Chapters 7 and 11 of the HCP.

Primary Objective

The Habitat Fund enables adaptive management and allows the City to address water system impacts that may not otherwise be addressed, respond to unknown future opportunities, and contribute to partnership projects.

Measure Commitments

The City will provide money to create a Habitat Fund of $9 million. A $5-million portion of the Habitat Fund is available in four increments prior to HCP Year 20 and is dedicated to partnership projects. The increments are described in Chapters 9 and 11 of the HCP (see also Figure 11-1). The remaining $4 million is dedicated to adaptive management needs but will be used for additional partnership projects if not needed for adaptive management (see Chapters 9 and 11). Projects will be selected in consultation with the HCP Implementation Committee (see Chapter 9) and will be guided by the Sandy River Basin Restoration Strategy. The City and NMFS will make the final project selection decisions.

Of the $5 million, the City will specifically dedicate $1.7 million toward habitat enhancement projects on the Salmon River to be implemented jointly by the Sandy River Basin Partners, and with additional funds from the Partners and/or from grants. If partnership funds cannot be obtained to implement these projects, the City funds will be used for other projects in the Sandy River Basin.

Based on an informal agreement in October 2004, the City will also work with the Partners to provide resources from the $5-million portion of the Habitat Fund to (1) participate in basin-wide efforts to control invasive plants that threaten riparian habitat, and (2) build the organizational capacity of the Partners to implement the basin-wide Restoration Strategy, including outreach.

Status of Work for Calendar Year 2014

The City was in full compliance with Measure H-30—Habitat Fund. The City has committed $373,280 of Habitat Fund dollars through 2014 to Sandy River Basin Partners projects. The following projects have been funded:

Oregon Trout, $25,000

The City executed a grant agreement (Ordinance Number 182484) with Oregon Trout to build the capacity of the Sandy River Basin Partners in obtaining additional funding to help implement the Partners' restoration strategy. That work has been completed and the funds have been spent.

The Freshwater Trust, $50,000

The City executed a grant agreement (Number 302000260) with The Freshwater Trust to partially fund implementation of the Sandy River Basin Short-Term Restoration Strategy. The money was used to partially fund stream restoration measures in the Salmon River, a tributary to the Sandy River. The funds were used for implementing actions in the Salmon River subbasin. The work was done from July 2009 to June 2010. The funds have been spent.

The Freshwater Trust, $50,000

The City executed a grant agreement (Number 30001899) with The Freshwater Trust to partially fund design and construction of habitat restoration projects to reconnect isolated habitat, restore habitat complexity, and monitor project impacts. The funds were used for implementing actions in the Salmon River subbasin. The work was scheduled from July 2010 through June 2011. The funds have been spent.

Because HCP implementation began in 2010 and few projects have been implemented, the City used the Habitat Fund dollars for funding Sandy River Basin Partners projects only.

The Freshwater Trust, $50,000

The City executed a grant agreement (Number 32000592) with The Freshwater Trust to fund design and construction of habitat restoration projects to reconnect isolated habitat and restore habitat complexity. The funds were used for implementing actions in the Salmon River subbasin. The work was scheduled from July 2011 through June 2012. As of December 31, 2011, a portion of the funds has been spent.

The Freshwater Trust, $70,780

The City executed a grant agreement (Number 30002765) with The Freshwater Trust to fund the purchase and installation of a culvert on side-channel 18 of the Salmon River. The construction work was done in the summer of 2012. This was the first Habitat Fund project that used capital dollars from the City. All of the funds have been spent.

The Freshwater Trust, $127,500

The City executed a grant agreement (Number 32001021 with the Freshwater Trust to fund the design and construction of habitat restoration projects on the Salmon River and Still Creek, in the Sandy River watershed. The work is scheduled from July 2014 through June 2015.

Planned Accomplishments for Calendar Year 2015

The City has approved three projects from Sandy River Basin Partners to be implemented between February 2015 and June 30, 2016. They are: 1) The Freshwater Trust, $100,000, to fund construction of habitat restoration projects on the Salmon River and Still Creek, 2) the Sandy River Basin Watershed Council, $120,000, to fund construction of habitat restoration efforts on the upper Sandy River, and 3) Oregon Department of Fish and Wildlife, $12,365, to fund scale analysis of juvenile coho salmon and steelhead smolts to determine age structure and freshwater productivity.

Table 10. Summary of All Measures

This table includes all of the HCP measures. Measures that are not relevant to this reporting year are shaded with a gray background. The Status column shows the activity for the measure in 2014 (HCP Year 5), whether the measure has been completed or removed from the HCP, and other relevant information. If the Status column is blank, the measure is yet to be implemented. In some cases, the status description includes a reference to an appendix where more detailed measure information is available.

Bull Run Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
F-1	**Minimum Instream Flow, Normal Water Years**	Provide instream flows	Record hourly flows at USGS Gage No. 1414000	2010–59	Ongoing measure. Measure was in full compliance for 2014.
F-2	**Minimum Instream Flows, Water Years with Critical Seasons**	Provide instream flows	Record hourly flows at USGS Gage No. 1414000	2010–59	Ongoing measure. Measure was in full compliance for 2014.
F-3	**Flow Downramping**	Maintain downramping rate at or below 2”/hour	Record hourly flows at USGS Gage No. 14140000	2010–59	Ongoing measure. Measure was in full compliance in 2014.
F-4	**Little Sandy Flow Agreement**	Avoid conflicts with natural instream flows	Document completion of flow agreement	2010–14	Measure was completed in 2014. Confirmed by NMFS December 4, 2014 (see Appendix H, Item 9).
T-1	**Pre-infrastructure Temperature Management**	Pre-infrastructure objective: Maintain water temperatures at or below 21 °C at Larson’s Bridge	Record water temperatures hourly for the lower Bull Run River and Little Sandy River	2010–13	Measure was in full compliance for 2010–2013.

Bull Run Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
T-2	**Post-infrastructure Temperature Management**	Post-infrastructure objective: Maintain water temperatures at their natural thermal potential	Record water temperatures hourly for the lower Bull Run River and Little Sandy River Document implementation and completion of Dam 2 tower and spillway rock weir improvements (tower improvements will be complete and operational by 2014)	2014–59	Ongoing measure. Removal of the rock weir was completed in 2011 and improvements to the towers were completed in 2014. More stringent water temperature commitments started in 2014. The City did not meet all water temperature targets in 2014.
P-1	**Walker Creek Fish Passage**	Provide year-round upstream and downstream passage for steelhead and coho	Document passage conditions compared with NMFS design criteria	2010–14	Measure was completed in 2010.
R-1	**Reservoir Operations**	Avoid or minimize mortality of cutthroat and rainbow trout	Document reservoir surface elevations	2010–59	Ongoing measure. Measure was in full compliance for 2014.
R-2	**Cutthroat Trout Rescue**	Prevent mortality of cutthroat trout in spillway canal	Document any fish mortality that occurs in the canal and/or during handling (prior to release)	2010–59	Measure was implemented from 2010–2012. Benefits to cutthroat trout were very low. The measure was cancelled in 2013. Change authorized by NMFS, April 26, 2013 (see Appendix H, Item 7 in the 2013 report).
R-3	**Reed Canarygrass Removal**	Improve one-third acre of habitat for Western toad, red-legged frog, and northwestern salamander through annual removal of reed canarygrass	Provide photo documentation of sites after reed canarygrass removal	2010–59	Ongoing measure. Measure was in full compliance for 2014.

Bull Run Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
H-1	**Spawning Gravel Placement**	Supply spawning gravel in amounts equivalent to natural accumulation	Survey the lower Bull Run River (RM 1.5–RM 6.0) annually in Years 2–11 and every five years thereafter Document the amount of gravel placed, the placement locations, and amount of gravel usable for spawning by fish in annual report as described in Appendix F of the HCP	2010–59	Ongoing measure. Measure was in full compliance for 2014.
H-2	**Riparian Land Protection**	Preserve the riparian forest on City land along the lower Bull Run River	Survey riparian forest condition during annual spawning and gravel surveys; document results in annual report	2010–59	Ongoing measure. Measure was in full compliance for 2014.
O&M-1	**Bull Run Infrastructure Operations and Maintenance**	Avoid or minimize the effects of operations and maintenance activities on covered lands in the Bull Run Watershed	Document any releases of sediment or debris to the reservoirs, the lower Bull Run River, or any tributary streams Document changes in stormwater facilities at Sandy River Station, if needed Document tree planting and success of revegetation efforts	2010–59	Ongoing measure. Measure was in full compliance for 2014.
O&M-2	**Bull Run Spill Prevention**	Avoid or minimize effects of spills from water supply operations on covered species in the Bull Run River and the Sandy River below the confluence with the Bull Run	Document any spills to the reservoirs, the lower Bull Run River, or to any tributary streams	2010–59	Ongoing measure. Measure was in full compliance for 2014.

Offsite Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
Riparian Easements and Improvements					
H-11	**Sandy 1 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 11 acres (with 100-foot buffer widths) within 15 years	Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site potential forest is established	2010–14	Measure will not be implemented. Acreage target was moved to Measure H-12 Sandy 2 Riparian Easement and Improvement. Change authorized by NMFS on January 5, 2012 (see Appendix G, Item 5 in the 2012 report).
H-12	**Sandy 2 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 62 acres (with 100-foot buffer widths) within 15 years	Same as above	2010–14	Measure was completed in 2014. All easement acreage targets have been met for the lower Sandy River Basin. Canopy cover monitoring is ongoing.

Offsite Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
H-13	**Gordon 1A and 1B Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 78 acres within 15 years of establishment of easement Fifteen (15) acres are added to this measure to compensate for the acreage anticipated from Boulder 1 Riparian Easement and Improvement (H-22).	Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site potential forest is established	2010–14	23 acres of easement area obtained in Gordon Creek (20 acres in 2012; 3 acres in 2011). 70 acres moved to Sandy 2 Riparian Easement and Improvement. Change authorized by NMFS on September 25, 2012 (see Appendix G, Item 6 in the 2012 report). Measure was completed in 2014. All easement acreage targets have been met for the lower Sandy River Basin. Canopy cover monitoring is ongoing.
H-14	**Sandy 3 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 7 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2020–24	Measure was completed in 2012. Canopy cover monitoring is ongoing.
H-15	**Cedar 2 and 3 Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 49 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2015–19	Measure is in process—PWB anticipates obtaining easement acreage in Cedar Creek by 2019.

Offsite Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
H-16	**Alder 1A and 2 Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 43 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2010–14	PWB is not pursuing easement acreage in Alder Creek due to unwillingness of private landowners to participate in program.
H-18	**Sandy 8 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 25 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2020–24	Measure has been partially completed—PWB anticipates full compliance by 2024.
H-19	**Salmon 1 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 23 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2015–19	
H-20	**Salmon 2 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 36 acres (with 100-foot buffer widths) within 15 years. of establishment of easement	Same as above	2020–24	
H-21	**Salmon 3 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 12 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2020–24	

Offsite Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
H-22	**Boulder 1 Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 15 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2010–14	This measure will not be implemented. The City has obtained easements in Gordon Creek and the lower Sandy River to compensate for the acreage that could not be obtained in Boulder Creek. Change authorized by NMFS, May 11, 2011 (see Appendix F, Item 1, in the 2011 report).
H-28	**Zigzag 1A/1B Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 12 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2020–24	
H-23	**Salmon 2 Miller Quarry Acquisition**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 40 acres (with 100-foot buffer widths) within 15 years of acquisition	Document purchase of the site in annual report Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site potential forest is established	2015–19	PWB is working with two Sandy River Basin Partners to negotiate a sales agreement for the Miller Quarry property.

Offsite Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
Water Rights					
F-5	**Cedar Creek Purchase Water Rights**	During HCP Years 1-10, purchase approximately 50% of the current surface water rights that affect summer flows	Document the rights purchased and the estimated amount of additional flow for fish	2010–19	Measure is in process—PWB anticipates full compliance by 2019.
Fish Passage					
P-2	**Alder 1 Fish Passage**	Provide year-round upstream and downstream passage for steelhead	Document passage conditions compared with NMFS design criteria once every three years after project implementation	2010–14	Measure was completed in 2013.
P-3	**Alder 1A Fish Passage**	Provide upstream and downstream passage for native fish during the months of water diversion operation	Same as above	2010–14	Measure was completed in 2014.
P-4	**Cedar Creek 1 Fish Passage**	Provide up to $3.7 million dollars to fund fish passage improvements on Cedar Creek.	Same as above	2010–14	Measure was completed in 2014.
Carcass Placement					
H-25	**Salmon 2 Carcass Placement**	Place 1,800 salmon carcasses in one season	Document number of carcasses, release sites, and year of implementation	2015–19	Measure was completed in the Zigzag and upper Sandy Rivers in 2013. Change authorized by NMFS, December 3, 2013 (see Appendix H, Item 8 in the 2013 report). Measure was completed early.

Offsite Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
H-29	**Zigzag 1A, 1B, and 1C Carcass Placement**	Place 1,800 salmon carcasses in one season	Same as above	2020–24	Measure was completed in the Zigzag and upper Sandy Rivers in 2014. Change authorized by NMFS, December 3, 2013 (see Appendix H, Item 8 in the 2013 report). Measure was completed early.
Large Wood					
H-3	**Little Sandy 1 and 2 LW Placement**	Place 50 key pieces of LW and achieve 80% of predicted woody debris levels within 15 years of placement	Monitor number of pieces of wood in the stream as described in HCP Appendix F	2015–19	Measure was completed in 2014, earlier than specified in the HCP.
H-4	**Sandy 1 and 2 Log Jams**	Place 10 engineered log jams in reaches Sandy 1 and 2	Same as above	2015–19	Planning for the measure has started. Implementation is planned for 2017.
H-5	**Gordon 1A and 1B LW Placement**	Place 300 key pieces of LW in reaches Gordon 1A and 1B and achieve 80% of predicted woody debris levels within 15 years of placement An additional 65 key pieces of LW will be placed in reaches Gordon 1A and 1B to compensate for the wood that was not placed in Boulder 0 and 1.	Same as above	2010–14	Measure was completed in 2013.
H-6	**Trout 1A LW Placement**	Place 25 key pieces of LW and achieve 80% of predicted woody debris levels within 15 years of placement	Same as above	2010–14	Measure was completed in 2013.

Offsite Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
H-7	**Trout 2A LW Placement**	Place 20 key pieces of LW in reach Trout 2A and achieve 80% of predicted woody debris levels within 15 years of placement	Same as above	2010–14	Measure will not be implemented. Large wood placements planned for this measure have been added to Trout 1A LW Placement project instead. Change authorized by NMFS, August 16, 2011 (see Appendix F, Item 2 in the 2011 report) and March 15, 2012 (see Appendix G, Item 4 in the 2012 report).
H-17	**Cedar 2 and 3 LW Placement**	Place 600 key pieces of LW in reaches Cedar 2 and 3 and achieve 80% of predicted woody debris levels within 15 years of placement	Same as above	2015–19	Planning for the measure has been started. Implementation is planned for 2016.
H-26	**Boulder 0 and 1 LW Placement**	Place 65 key pieces of LW in reaches Boulder 0 and 1 and achieve 80% of predicted woody debris levels within 15 years of placement	Same as above	2010–14	Measure will not be implemented. Large wood placements planned for this measure have been added to Gordon 1A and 1B LW Placement instead. Change authorized by NMFS, August 16, 2011 (see Appendix F, Item 2 in the 2011 report).
Channel Restoration					
H-8	**Sandy 1 Reestablishment of River Mouth**	Create one additional mile of stream by reconnecting with original river mouth	Document reestablishment of the historical Sandy River mouth	2015–19	The measure was completed in 2013, approximately five years ahead of schedule.

Offsite Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
H-9	**Sandy 1 Channel Reconstruction**	Open one-third river miles of side-channel habitat Place 25 logs in side channel	Tag all side-channel logs at the time of placement for later identification Once every three years, resurvey the stream to document seasonal flooding of the side-channel habitat and determine how many pieces of LW are still within the side channel	2015–19	
H-10	**Sandy 1 Turtle Survey and Relocation**	Avoid direct impacts to western painted turtles and northwestern pond turtles	Document surveys of potential turtle habitat. Document all turtle relocations (species, number, locations, and dates) Note: Measure H-10 is only necessary for projects conducted in the Sandy River delta.	2015–19	Measure was completed in 2013 in conjunction with Measure H-8.
H-27	**Zigzag 1A Channel Redesign**	Maintain one-third mile of floodplain habitat for steelhead, coho, and spring Chinook Place 25 pieces of LW in reaches Zigzag 1A and 1B	Tag all pieces of LW at the time of placement for later identification Once every three years, resurvey the stream to determine how many pieces of LW are still within the side channel	2020–24	
Terrestrial Wildlife Habitat Conservation					
W-1	**Minimize Impacts to Spotted Owls**	Avoid disturbance of active nesting habitat	Survey protocols for owls, eagles, and fishers have not yet been determined Protocols will be available within six months of the start of the HCP term	2010–59	Ongoing measure. Measure was in full compliance in 2014.
W-2	**Minimize Impacts to Bald Eagles**	Avoid disturbance of active winter night roosts or nests	Survey protocols for owls, eagles, and fishers have not yet been determined Protocols will be available within six months of the start of the HCP term	2010–59	Ongoing measure. Measure was in full compliance in 2014.

Offsite Measures–Compliance

#	Measure	Measurable Habitat Objective	Compliance Monitoring	HCP Years	Status
W-3	**Minimize Impacts to Fishers**	Avoid disturbance of fisher habitat	Survey protocols for owls, eagles, and fishers have not yet been determined Protocols will be available within six months of the start of the HCP term	2010–59	Ongoing measure. Measure was in full compliance in 2014.

Monitoring for Clean Water Act Section 401 Certification

Topic	Monitoring Protocol & Analysis	Results Reporting	Duration	Status and Report Location
Monitoring for CWA Section 401 Certification	Monitor for five required water-quality parameters	Include with annual compliance report	For the first 5 years of operation of the modified Bull Run Dam 2 Tower	Baseline data collection period was August 2012–December 2013. Monitoring will continue through 2019, or as determined by ODEQ. See Appendix B.

Offsite Measures—Effectiveness					
#	**Measure**	**Measurable Habitat Objective**	**Effectiveness Monitoring**	**HCP Years**	**Status**
Large Wood					
H-5	**Gordon 1A and 1B LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2010–14	Measure was completed in 2013. Effectiveness monitoring will continue through 2025. See Appendix A.
H-6	**Trout 1A LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2010–14	Measure was completed in 2013. Effectiveness monitoring will continue through 2025. See Appendix A.
H-7	**Trout 2A LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2010–14	Measure will not be implemented and associated effectiveness monitoring has been cancelled. Change approved by NMFS March 15, 2012 (see Appendix G, Item 4 in the 2012 report.)
H-3	**Little Sandy 1 and 2 LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation Achieve 80% of predicted increase in backwater pools, pools, and pool-tail habitat within 15 years of implementation Achieve 80% of predicted increase in percentage of total habitat that is large-cobble riffles, within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2015–19	Measure was implemented in 2014. Effectiveness monitoring will continue through 2027.

Offsite Measures—Effectiveness

#	Measure	Measurable Habitat Objective	Effectiveness Monitoring	HCP Years	Status
H-26	**Boulder 0 and 1 LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation.	Conduct habitat surveys per monitoring protocol	2010–15	Measure will not be implemented and associated effectiveness monitoring has been cancelled. Change authorized by NMFS, August 16, 2011 (see Appendix F, Item 2 in the 2011 report).
H-4	**Sandy 1 and 2 Log Jam Placements**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2015–19	Effectiveness monitoring associated with this measure will be initiated in 2015.
H-17	**Cedar 2 and 3 LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation Achieve 80% of predicted increase in percentage of off-channel, beaver pond and pool habitat within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2015–19	Measure was in full compliance in 2014. Effectiveness monitoring was initiated in 2014 and will continue through 2029.
Channel Restoration					
H-9	**Sandy 1 Channel Reconstruction**	Achieve 80% of predicted increase in percentage of off-channel habitat within 15 years of implementation	Every three years, resurvey the site to determine whether the gradient control structure is maintaining flow in the side channel and the river	2015–19	
H-24	**Salmon 2 Miller Quarry Restoration**	Achieve 80% of predicted improvements in off-channel habitat within 15 years of implementation	Once every three years after measure implementation, survey opened floodplain area and side channels	2020–24	

Offsite Measures—Effectiveness					
#	**Measure**	**Measurable Habitat Objective**	**Effectiveness Monitoring**	**HCP Years**	**Status**
H-27	**Zigzag 1A Channel Design**	Achieve 80% of predicted habitat improvements within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2020–24	
H-30	**Habitat Fund**	The City will provide money to create a Habitat Fund of $9 million to contribute to large-scale partnership projects and to implement additional projects for adaptive management, if necessary	Determined through measure effectiveness monitoring	2010–59	Ongoing measure. Measure was in full compliance in 2014.

Research				
Topic	**Research Protocol & Analysis**	**Results Reporting**	**HCP Years**	**Status and Report Location**
Spawning Gravel Placement	Change in gravel from baseline each year, trends over time, using t-tests & linear regression	HCP Years 6 and 12	2010–59	Measure was in full compliance in 2014. See Appendix C.
Spawning Gravel Scour	Change in bed elevation, depth of scour, percentage of redds with significant scour	Monitoring starts HCP Year 5; reporting in Year 2016	2015–19	Monitoring was in progress in 2014. Reporting will be in 2016.
Total Dissolved Gas	Exceedence of 110% TDG saturation, rate of TDG dissipation downstream of monitoring. Regression analysis, possibly modeling	Include with annual compliance report	2010–59	Measure was in full compliance in 2014. See Appendix D.
BR Adult Chinook Population	Survey, sampling, linear regression	Include with annual compliance report	2010–59	Measure was in full compliance in 2014. See Appendix E.
Sandy River Basin Smolt Monitoring	Mark recapture study, various analyses methods	Include with annual compliance report	2010–59	Measure was in full compliance in 2014. See Appendix F.

Appendixes

A. Effectiveness Monitoring for Offsite In-Channel Conservation Measures

B. Monitoring Results for Certification According to Section 401 of the Clean Water Act

C. Lower Bull Run River Spawning Gravel Research

D. Total Dissolved Gases in the Bull Run River

E. Lower Bull Run River Adult Chinook Population

F. Sandy River Basin Smolt Monitoring

G. Riparian Forest Protection Monitoring

H. Correspondence on Measures

Appendix A

Bull Run HCP Effectiveness Monitoring Report

Effectiveness Monitoring for Offsite In-Channel Conservation Measures

April 2015

Burke Strobel
City of Portland Water Bureau

PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

Contents

Tables

1. Summary

The City of Portland Water Bureau (PWB) is in full compliance with its Habitat Conservation Plan obligations in 2014 with regard to effectiveness monitoring for offsite in-channel conservation measures. Fish habitat surveys were conducted for two offsite measures—H-3, Little Sandy 1 and 2 Large Wood Placement and H-17, Cedar Creek Large Wood Placement. Baseline effectiveness monitoring was also continued in the Salmon River in anticipation of the implementation of habitat enhancement measures there in the near future.

This appendix summarizes the results of the 2014 surveys. The data collected in 2014 for H-3, Little Sandy 1 and 2 Large Wood Placement and the Salmon River contribute to the baseline conditions, with which the post-treatment conditions of each stream will be compared. This was the final year of baseline monitoring in the Little Sandy. H-3, Little Sandy 1 and 2 Large Wood Placement was implemented in September, 2014.

2. Introduction

PWB committed through its Bull Run Water Supply Habitat Conservation Plan (HCP; Portland Water Bureau 2008) to implement a number of in-channel fish habitat enhancement measures at offsite locations. Offsite locations are those not in the Bull Run watershed, but at other Sandy River basin streams. These include various tributaries in the basin, portions of the main stem of the Sandy River, and the Little Sandy River. In-channel measures are being completed within the normal high-flow channel of a stream. In-channel measures do not include efforts to improve the riparian zone.

Associated with each offsite in-channel measure are one or more measurable habitat objectives. The effectiveness of PWB's efforts to improve fish habitat at these offsite locations is being evaluated by measuring the habitat attributes associated with these objectives and determining how closely the habitat attributes approach or surpass the value of the respective objective.

In 2014, baseline data and post-treatment data were collected in streams. Baseline data were collected in the Little Sandy River and Cedar Creek. Baseline effectiveness monitoring was also continued in 2014 in the Salmon River, where the City expects to implement habitat enhancement measures in the near future. No post-treatment data were collected in 2014.

This appendix describes the effectiveness monitoring protocols and results to-date for the in-channel measures to be conducted in the Little Sandy River, Cedar Creek, and the Salmon River. These measures involve placing large wood and creating log jams to influence stream morphological features such as pools and riffles and to accumulate spawning gravel.

3. Measurable Objectives

The offsite in-channel measures discussed in Chapter 7 of the HCP and their predicted effects on habitat attributes have been evaluated using the Ecosystem Diagnostic and Treatment (EDT) model (City of Portland and Mobrand Biometrics 2004). The anticipated benefits of these measures are summarized by reach and ranked by the predicted net change in the attributes' respective metrics listed in Table 1. The net attribute changes in Table 1 include only those benefits expected to be derived from the proposed in-channel restoration projects. Other measures, such as riparian easements, may occur in, and have benefits for, the same reaches, but these benefits are expected to occur over time scales that are longer than the time scales for the offsite in-channel measures. The benefits of other measures are not part of the scope of this research.

The net changes predicted in Table 1 represent measurable habitat objectives created for each individual reach. The monitoring objective is to document how effectively the offsite in-channel measures accomplish measurable habitat objectives. PWB's working hypothesis for effectiveness monitoring of these measures is that at least 80 percent of the projected changes in the key habitat attributes (pre-project versus post-project conditions) will occur in each affected stream reach.

PWB has committed to a performance level of 80 percent of projected changes (instead of 100 percent) because there will be a high degree of natural variation year to year and site to site. The natural variation will be further compounded by the error associated with measuring habitat variables in the field. Given this high level of variation, it would not be possible to statistically detect a difference between a 100 percent change in a habitat variable and a much smaller change. PWB chose 80 percent as a minimum performance standard. If that level of habitat response is not met, additional actions may be required, and PWB will follow the adaptive management program described in Chapter 9 of the HCP.

Table 1. Attributes and Measurable Habitat Objectives in Reaches Affected by In-Channel Measures and Surveyed in 2014[a,b]

	Measurable Habitat Objective (80% of Net Change in Metric)		
Attribute	**Metric**	**Net Change**	**Reach**
Large Woody Debris	Number of pieces per channel width	34%	Little Sandy 1
Large Woody Debris	Number of pieces per channel width	100%	Cedar 2
Large Woody Debris	Number of pieces per channel width	67%	Cedar 3
Beaver Ponds	Percentage of reach (by surface area) that comprises beaver ponds	39%	Cedar 3
Pool Habitat	Percentage of reach (by surface area) that comprises pool habitat	25%	Cedar 3
Large woody debris	Number of pieces per channel width	10%	Salmon 2
Artificial confinement	% length of bank artificially confined	-12%	Salmon 2

[a]Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures.

[b]Appendix E of the HCP, Offsite Habitat Effects Tables, provides the list of all attributes, habitat objectives, and reaches that may be affected by the HCP measures.

4. Key Questions and Hypothesis

One key question and its related null hypothesis (H_o) will be answered by the offsite monitoring protocol:

Question: Did the implementation of the restoration projects result in the changes to the monitored habitat attributes that were predicted by the EDT assessment?

> H_o: The difference between the mean of baseline values and the mean of post-treatment values in treatment reaches will not be significantly less than the difference predicted by the EDT assessment.

In order to make this comparison, the baseline values in the EDT model will be updated by collecting at least two years of pre-treatment data on all the habitat attributes that are predicted to significantly change (summarized in Table 1). The differences in habitat conditions between the actual pre-treatment and post-treatment data will be used to determine whether the projected EDT fish benefits, as expressed in the HCP, are realized.

The comparison of the observed changes in monitored habitat attributes to measurable habitat objectives will be analyzed both numerically and statistically (using a 95 percent level of confidence). The numeric test will simply determine whether the mean of post-treatment values is at least 80 percent of the target values. The measurable habitat objective for each offsite, in-channel measure response variable was set at 80 percent of the projected change to account for the fact that each variable is expected to show a large degree of variation. The statistical test will assign a level of confidence to each of the pre-treatment and post-treatment values and determine the power of the statistical test to detect significant shortfalls. Having a level of confidence associated with each value will be helpful during the adaptive management process, should any post-treatment value fall short of the measurable habitat objective.

5. Monitoring Design

5.1 Study Design

PWB uses a Before-After with Control-Impact (BACI) study design to monitor the effects of the HCP offsite, in-stream mitigation projects (Roni et al. 2005). Control reaches upstream of the treated reaches will be surveyed, in addition to the treated reaches, as indicated in Table 2. Control reaches will be entire upstream reaches delineated for EDT or one mile in length, whichever is less, to minimize survey effort and yet provide a representative length of stream. In cases in which a treated reach is very long (more than five miles) and the treatment is restricted to the lower portion of the reach, the upstream portion of the same reach will serve as a control. This approach is used because the further upstream a control reach is, the less representative it probably is of the habitat in which treatment occurred. PWB will use attribute values for the entire EDT reach (including the control reach segment) as the treatment reach values and just use attribute values from the control reach segment as the respective control reach values.

Table 2. Paired Treatment and Control Reaches in Streams Surveyed in 2014

Watershed	Treated Reaches	Control Reaches
Bull Run River	Little Sandy 1	Little Sandy 2
Middle Sandy River	Cedar 2	Cedar 4
	Cedar 3	Cedar 4
Salmon River	Salmon 2	Salmon 3

5.2 Spatial Scale

The measureable habitat objectives (in Table 1) are reach-scale objectives. The survey protocol is to collect data at both the habitat-unit and reach scales, but all the data are used to derive reach-scale assessments of habitat condition. Reaches vary in length, so all attribute values are normalized by either channel length or surface area.

5.3 Replication/Duration

Most habitat attributes are naturally variable from year to year. For example, if wood is added to a reach but high flows do not occur the following winter, there may be no resultant formation of pools. In other years, winter high flows may fill in some pools and create new ones elsewhere. For this reason, before (baseline) and after (post-treatment) data will be replicated over time.

Surveys are conducted in the summer or early fall when flows are low and the stream channels are most navigable. Two to three pre-treatment surveys and five post-treatment surveys are conducted. Pre-treatment surveys will be conducted annually prior to treatment. Post-treatment surveys are conducted at three-year intervals beginning the year after treatment and continuing for 12 additional years, for a total of five post-treatment surveys.

5.4 Variables

The habitat attributes used by EDT to evaluate restoration alternatives are derived from the data types summarized below. All data types are information collected during stream surveys. However, not all attributes are used to evaluate the effectiveness of the offsite in-channel measures.

- Reach-scale data
  - Active channel (bankfull)[1] width (feet)
  - Gradient (percent)
  - Total surface area of off-channel habitat (estimated visually, in square feet)
- Habitat unit-scale data
  - Habitat type (pool, backwater pool, beaver pond, glide, small-cobble riffle, large-cobble riffle)
  - Average length (feet)
  - Average width (feet)
  - Amount of pool tail-out habitat (data collected in pools only; percentage of total surface area that is at the downstream end of the pool and flowing with velocities comparable to those of neighboring glides and riffles)
  - In-channel wood (number of pieces greater than 1 foot in diameter and greater than 7 feet long in the active channel of the habitat unit)

[1] The active channel, or bankfull channel, is the portion of the channel where flows occur often enough to prevent the establishment of vegetation, generally corresponding to a break in the slope of the bank.

- Fine sediment in spawning habitat types (percentage surface area of gravel patches in small-cobble riffles, pool tail-outs, glides)
- Embeddedness in spawning habitat types (percent of the vertical dimension of surface cobbles and large gravel that is buried in fine sediment in gravel patches in small-cobble riffles, pool tail-outs, glides)

These data enable PWB to evaluate how well it has met most of the measurable habitat objectives summarized in Table 1. The percentage of fine sediment in spawning gravels may show too much in-reach variability to allow the detection of the anticipated change.

5.5 Sampling Scheme

Habitat attributes in both treatment and control reaches are monitored using a modified Hankin and Reeves-type stratified systematic inventory of stream channel characteristics (Hankin and Reeves 1988).

Hankin and Reeves-type protocols involve two main sources of error. PWB adjusts its protocols to reduce these sources of error. The first source of error stems from the strategy of estimating habitat dimensions throughout a reach and then using a subset of measurements to correct the estimates. These corrections are associated with a range of variability, which decreases confidence in the final result. To maximize the statistical power of the monitoring data analysis, given the small sample size of pre-treatment data, all habitat unit dimensions are measured. The second source of error is measurement error, which can accumulate over the length of a reach. PWB monuments survey reaches at specific intervals to allow for standardization of lengths between years, unless natural landmarks are identified to serve a similar purpose.

6. Analysis

6.1 Data Storage

Monitoring data collected during the HCP is maintained by PWB in a Microsoft® Access database. Summary data will be added to the Sandy River EDT database. The data will be made available to the National Marine Fisheries Service, U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, and other regulatory agencies (Services) for review at any time and will be extensively discussed during the HCP Year-20 check-in meeting of PWB with the services. Following quality assurance/quality control procedures and review and approval by PWB and the Services, the data will be made available to the StreamNet Library (through the Columbia River Inter-Tribal Fish Commission [CRITFC] technical reports), Oregon Department of Fish and Wildlife AIP (http://oregonstate.edu/Dept/ODFW/freshwater/inventory/index.htm), and the U.S. Forest Service Natural Resource Information System (NRIS) Water Module databases. Each of these databases was consulted extensively in the Sandy River Basin EDT analysis.

Appropriate treatment- and control-reach data that are already in these databases will be used to bolster the sample size of the pre-treatment habitat attributes. Pre-existing data will not be used if the habitat in the respective streams has since been modified by restoration activities other than the planned HCP offsite in-channel measures.

6.2 Hypothesis Testing

Both the numeric and statistical evaluation of the hypothesis for the monitoring plan key question suggest a fundamental comparison between baseline and post-treatment data on a reach-by-reach, attribute-by-attribute basis. Control reaches will be employed to subtract out variation due to large-scale effects outside of PWB's control. An example of how this will occur is given below (T=Treatment reach value, C=Control reach value):

$$\left.\begin{matrix} T_{before1}-C_{before1} \\ T_{before2}-C_{before2} \end{matrix}\right\} \text{ mean vs. mean } \left\{\begin{matrix} T_{after1}-C_{after1} \\ T_{after2}-C_{after2} \\ T_{after3}-C_{after3} \\ T_{after4}-C_{after4} \\ T_{after5}-C_{after5} \end{matrix}\right.$$

The numeric comparison of the means of pre-treatment and post-treatment data will determine whether or not the post-treatment mean is equal to or greater than 80 percent of the measurable habitat objective. For statistical comparisons, t-tests will be performed on the differences between treatment reach and control reach habitat attribute values, with a 95 percent level of confidence.

7. Adaptive Management

If data indicate that the effectiveness monitoring protocol null hypotheses should not be rejected, and if the new EDT results indicate that the predicted changes to freshwater productivity are less than originally described for PWB's offsite in-channel conservation measures, PWB will follow the adaptive management process described in Chapter 9 of the HCP.

8. 2014 Results

Tables 3, 4, and 5 summarize the results for offsite in-stream measure effectiveness monitoring surveys conducted in 2014 in the Little Sandy River, Cedar Creek, and Salmon River, respectively. The tables also compare survey results with the values for the current condition of the same habitat attributes in the EDT database.

Table 3. Comparison of Values for Various Habitat Attributes[a] in the Little Sandy River Derived from the EDT Database and 2014 Survey Results

	Treatment Reach		Control Reach	
	Little Sandy 1 Reach		Little Sandy 2 Reach	
Attribute	EDT Current	2014 Survey	EDT Current	2014 Survey
Large Wood (pieces/CW)[b]	1.5	2.3	5.0	0.7
Backwater Pools	0.0%	0.0%	2.0%	0.0%
Beaver Ponds	0.0%	0.0%	0.0%	0.0%
Pools	27%	38.8%	20.0%	49.8%
Pool Tails	0.0%	0.4%	0.0%	0.3%
Small-Cobble Riffles	5.0%	0.0%	0.0%	0.0%
Large-Cobble Riffles	63.0%	60.8%	74.0%	49.9%
Glides	0.0%	0.0%	0.0%	0.0%
Off-Channel Habitat	0.0%	0.2%	0.0%	0.0%
Percent Fines	8.5%	6.5%	14.5%	4.8%
Embeddedness	0.0%	29.6%	0.0%	36.7%

[a]The selected attributes are expected to respond to HCP in-stream conservation measures.

[b]Large wood is given as a standardized metric (pieces of wood per average high-flow channel width [CW].)

Table 4. Comparison of Values for Various Habitat Attributes[a] in Cedar Creek Derived from the EDT Database and 2014 Survey Results

	Treatment Reaches				Control Reach	
	Cedar 2 Reach		Cedar 3 Reach		Cedar 4 Reach	
Attribute	EDT Current	2014 Survey	EDT Current	2014 Survey	EDT Current	2014 Survey
Large Wood (pieces/CW)[b]	1.5	2.2	1.5	4.9	3.0	4.3
Backwater Pools	14.0%	0.0%	7.0%	0.1%	2.0%	0.0%
Beaver Ponds	1.0%	1.0%	6.0%	0.0%	0.0%	0.0%
Pools	14.0%	16.4%	21.0%	34.5%	19.0%	11.0%
Pool Tails	3.0%	2.4%	4.0%	1.2%	3.0%	0.6%
Small-Cobble Riffles	25.0%	27.4%	24.0%	17.8%	28.0%	1.2%
Large-Cobble Riffles	35.0%	51.1%	33.0%	46.4%	50.0%	87.3%

Table 4. Comparison of Values for Various Habitat Attributes[a] in Cedar Creek Derived from the EDT Database and 2014 Survey Results

	Treatment Reaches				Control Reach	
	Cedar 2 Reach		Cedar 3 Reach		Cedar 4 Reach	
Attribute	EDT Current	2014 Survey	EDT Current	2014 Survey	EDT Current	2014 Survey
Glides	0.0%	1.7%	6.0%	0.0%	4.0%	0.0%
Off-Channel Habitat	8.0%	0.2%	15.0%	1.0%	0.0%	0.0%
Percent Fines	14.5%	7.1%	8.5%	8.8%	8.5%	5.0%
Embeddedness	0.0%	44.4%	0.0%	54.8%	0.0%	41.3%

[a]The selected attributes are expected to respond to HCP in-stream conservation measures.

[b]Large wood is given as a standardized metric (pieces of wood per average high-flow channel width [CW]).

Table 5. Comparison of Values for Various Habitat Attributes[a] in the Salmon River Derived from the EDT Database and 2014 Survey Results

	Treatment Reach		Control Reach	
	Salmon 2 Reach		Salmon 3 Reach	
Attribute	EDT Current	2014 Survey	EDT Current	2014 Survey
Large Wood (pieces/CW)[b]	2.0	8.2	2.0	5.8
Backwater Pools	3.1%	0.0%	0.0%	0.0%
Beaver Ponds	0.0%	0.4%	0.0%	0.0%
Pools	3.1%	14.8%	15.7%	23.6%
Pool Tails	1.2%	1.0%	2.8%	1.5%
Small-Cobble Riffles	3.1%	18.9%	2.8%	0.6%
Large-Cobble Riffles	89.4%	63.9%	78.7%	74.2%
Glides	0.0%	1.1%	0.0%	0.1%
Off-Channel Habitat	2.6%	8.1%	2.6%	0.0%
Percent Fines	8.5%	18.7%	8.5%	18.4%
Embeddedness	0.0%	49.5%	0.0%	56.7%

[a]The selected attributes are expected to respond to HCP in-stream conservation measures.

[b]Large wood is given as a standardized metric (pieces of wood per average high-flow channel width [CW].)

9. Discussion

The results presented in Tables 3, 4, and 5 of this report contribute to the baseline average of values for the respective monitored habitat attributes. Measure H-3 (Little Sandy 1 and 2 Large Wood Placement) was implemented in 2014, so the habitat attribute data collected in this stream in 2014 are the last post-treatment measurements. Post-treatment data will be collected in the Little Sandy in 2015, 2018, 2021, 2024, and 2027. At least two more years of baseline data will be collected on Cedar Creek and at least one more year of baseline data will be collected on the Salmon River.

The comparison of baseline values to the current condition values in the EDT database will help determine whether more restoration is needed than was assumed during the creation of the HCP. The comparison of the averages of post-treatment values for habitat attributes to the averages of baseline values in each treatment reach and with the respective averages in control reaches will determine whether PWB has met its restoration targets in those streams and whether additional efforts are necessary.

10. Works Cited

City of Portland. 2004. Development and Application of the EDT Database and Model for the Sandy River Basin. Prepared with assistance from Mobrand Biometrics, Inc. Portland, Oregon.

Hankin, David G., and Gordon H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. *Can. J. Fish. Aquat. Sci.* 45:834-844.

Portland Water Bureau. 2008. Bull Run Water Supply Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species. Portland, Oregon.

Roni, Philip, Andrew H. Fayram, and Michael A. Miller. 2006. Monitoring and evaluating instream habitat enhancement. Pages 209-236 in *Monitoring Stream and Watershed Restoration* (P. Roni, ed.). American Fisheries Society. Bethesda, Maryland.

Appendix B

Bull Run HCP Monitoring Report

Monitoring Results for Certification According to Section 401 of the Clean Water Act

April 2015

Kristin Anderson
City of Portland Water Bureau

Contents

1. Summary

The City modified its Bull Run Dam 2 water intake towers for the Bull Run Water Supply Habitat Conservation Plan (HCP) Measure T-2. As part of the conditions from the Federal Energy Regulatory Commission that oversees the associated Portland Hydroelectric Project, the City must monitor and report on the impacts of the Dam 2 Tower project to the Oregon Department of Environmental Quality (DEQ). DEQ has issued a Section 401 certification under the Clean Water Act. The certification requirements describe the conditions the City must meet (Oregon Department of Environmental Quality 2012). The 401 conditions require the City to report on five water-quality parameters: 1) nuisance phytoplankton growth; 2) the creation of taste, odors, and toxic conditions; 3) dissolved oxygen levels; 4) pH levels; and 5) temperature.

This report is produced annually, as part of the HCP compliance report. Baseline sampling occurred from 2009 to 2013. Baseline conditions are those that existed before construction and operation of the Dam 2 tower. This report includes results from 2014 water quality sampling effort (see Exhibit A). Starting in 2014, the City collected monitoring data after the completion of the Dam 2 Tower project and those data are compared to pre-construction and operation conditions (baseline conditions).

2. Introduction

As part of the HCP, the City of Portland is implementing its Temperature Management Plan for the Lower Bull Run River to fulfill requirements of the Clean Water Act (City of Portland 2008). The Temperature Management Plan describes the background, scientific basis for, baseline conditions, and implementation plan for HCP Measure T-2. The intent of HCP Measure T-2—Post-infrastructure Temperature Management—is to better control the temperature of water that PWB releases from the reservoir for fish in the lower Bull Run River. The measure requires that PWB design, permit, and complete a project to modify water intake towers at Dam 2 to allow taking water from the reservoir at different levels. For the Dam 2 Tower Improvement Project, only the north intake tower is being modified to have multi-level gates for taking water from Reservoir 2.

Conducting this project affects the operation of the Portland Hydroelectric Project (PHP) Powerhouse 2. Because of the proposed modifications to the Dam 2 infrastructure, the City completed a non-capacity license amendment process with the Federal Energy Regulatory Commission (FERC). As part of that license process, the Oregon Department of Environmental Quality (ODEQ) reviewed the impacts of the Dam 2 Tower project on certain water-quality parameters that have the potential to be affected by the operation of the modified north intake tower. ODEQ approved a 401 certification for the Dam 2 Tower Project and issued certification conditions to the City.

Section 401 of the CWA requires certification that the discharge water from a proposed action, such as work on the intake towers, will comply with water-quality standards in Oregon. The five water-quality parameters identified in the 401 certification that have the potential to be affected by work in Bull Run Reservoir 2 are listed in Table 1 with the Oregon Administrative Rule (OAR) number and the OAR description of the potential impact.

Table 1. Water Quality Parameters To Monitor for CWA Section 401 Certification

Water Quality Parameter	Oregon Administrative Rule	Potential Impact
Nuisance Phytoplankton Growth	OAR 340-041-0019	Changes in reservoir circulation may lead to changes in nutrient concentrations, which in turn may lead to algal blooms.
Creation of Taste, Odors, Toxic Conditions	OAR 340-041-007(12)	Taste and odor or toxic conditions can occur from nuisance algal blooms.
Dissolved Oxygen	OAR 340-041-0016	Changes in water circulation in reservoir may alter dissolved oxygen concentration, especially at depth with change in residence time deep in reservoir; algal bloom respiration and decay may also consume dissolved oxygen.
pH	OAR 340-041-0021	Algal blooms may cause spikes in pH values.
Temperature	OAR 340-041-0028	Changes in withdrawal depth may result in temperature changes downstream.

The initial monitoring from 2009 to 2013 provided baseline results. The monitoring results in subsequent years are compared with the baseline data.

3. Monitoring Design

Monitoring for the five parameters was conducted as specified in Table 2 when conditions were safe to do so.

3.1 Parameters

3.1.1 Nuisance Phytoplankton Growth and the Creation of Taste, Odors, and Toxic Conditions

The purpose of this monitoring is to determine whether operation of the new intake structure will contribute to the formation of nuisance or toxic algal blooms in

Reservoir 2. In 2014, the City completed monthly sampling of nutrient concentrations in Bull Run Reservoir 2. Nutrient samples were analyzed for nitrate ($NO_3^{=}$), nitrite (NO_2^{-}), total nitrogen (N), reactive phosphorus ($PO_4^{=}$), and total phosphorus (P). See Section 3.2 for a description of the sampling methods for these parameters.

3.1.2 Dissolved Oxygen

Dissolved oxygen was monitored upstream and downstream of Bull Run Dam 2 in 2014. This monitoring fulfills two objectives:

- To determine whether operation of the new intake structure contributes to changes in dissolved oxygen (DO) concentrations within the reservoir
- To determine whether operation of the new intake structure provides the level of oxygen saturation established by Oregon DEQ in the Clean Water Act Section 401 Certification Conditions (Oregon Department of Environmental Quality 2012).

Monitoring for reservoir DO concentrations consisted of biweekly DO measurements in Bull Run Reservoir 2. Monitoring for lower Bull Run River flow consisted of biweekly DO measurements in the lower Bull Run River downstream of Reservoir 2. A station for this monitoring has been established at the bridge over the Bull Run River immediately below Headworks (Headworks Bridge). See Section 3.2 for a description of the sampling methods for this parameter.

3.1.3 pH Levels

Compliance with the pH parameter was monitored through biweekly pH measurements in Bull Run Reservoir 2. See Section 3.2 for a description of the sampling methods for this parameter.

3.1.4 Temperature

Compliance with the temperature parameter was monitored upstream and downstream of Bull Run Dam 2. This monitoring fulfills two objectives:

- Provide information on how operation of the new intake affects stratification in Reservoir 2
- Determine how the daily maximum temperature in the lower Bull Run River is affected by operation of the new intake tower

Monitoring for stratification consisted of biweekly temperature measurements in Bull Run Reservoir 2. Monitoring the daily maximum temperature measurements at Larson's Bridge in the lower Bull Run River was already being conducted as part of compliance for HCP Measure T-1 Pre-Infrastructure Temperature Management. For HCP Measure T-2, Post-Infrastructure Temperature Management, the bureau will continue to report on temperatures in the lower Bull Run River at Larson's Bridge for the period required for 401 certification.

3.2 Sampling

Reservoir water sampling was conducted from a boat at the deepest part of Reservoir 2, denoted as Station 60-1. Grab samples for nutrients were collected with a Kemmerer sampler at discrete depths beginning at three meters above the reservoir bottom, continuing up at intervals in the water column and ending with a sample at a depth of one meter.

Measurements of dissolved oxygen, pH, and temperature were collected *in situ* in a vertical profile using a multiparameter probe that logs the data as they are collected. During the baseline monitoring period, a weight was suspended three meters below the sampling device to determine reservoir depth. Investigators interpreted that the action of the weight hitting the bottom of the reservoir caused some sediment to be stirred up, resulting in lower than expected DO concentrations. Late in 2013, reservoir sampling for DO included using a depth finder to determine reservoir depth. Samples at the Headworks Bridge for downstream dissolved oxygen measurements were collected by a multiparameter probe lowered from the bridge into the river.

Temperature measurements at Larson's Bridge were made by the U.S. Geological Survey (USGS) using a temperature probe placed in the river. Data were stored at 15-minute intervals on a data logger on-site and telemetered hourly via satellite to the USGS data center, from which they were made available on the Internet. The 15-minute data are considered provisional and are used by the USGS to determine daily mean, minimum, and maximum temperatures, which are published annually as approved data.

Table 2 summarizes the sampling methods, locations, and baseline sampling periods by parameter.

Table 2. Sampling Methods, Locations, and Baseline Periods for Section 401 Water Quality Parameters

Water Quality Parameter	Sampling Method	Sampling Location	Baseline Sampling Period
Nuisance Phytoplankton Growth	Monthly nutrient samples at specific depths	Reservoir 2 Station 60-1	January 2009 – December 2013
Creation of Taste, Odors, Toxic Conditions	Monthly nutrient samples at specific depths	Reservoir 2 Station 60-1	January 2009 – December 2013
Dissolved Oxygen	Biweekly *in situ* vertical profiles	Reservoir 2 Station 60-1	January 2009 – December 2013
	Biweekly multiparameter probe lowered from bridge	Headworks Bridge	August 2012 – December 2013
pH	Biweekly *in situ* vertical profiles	Reservoir 2 Station 60-1	January 2009 – December 2013
Temperature	Biweekly *in situ* vertical profiles	Reservoir 2 Station 60-1	January 2009 – December 2013
	15-minute monitoring with on-site data logger	USGS Station 14140020 at Larson's Bridge	N/A[a]

[a]Temperature data are continually collected at this location.

3.3 Map of Sampling Sites

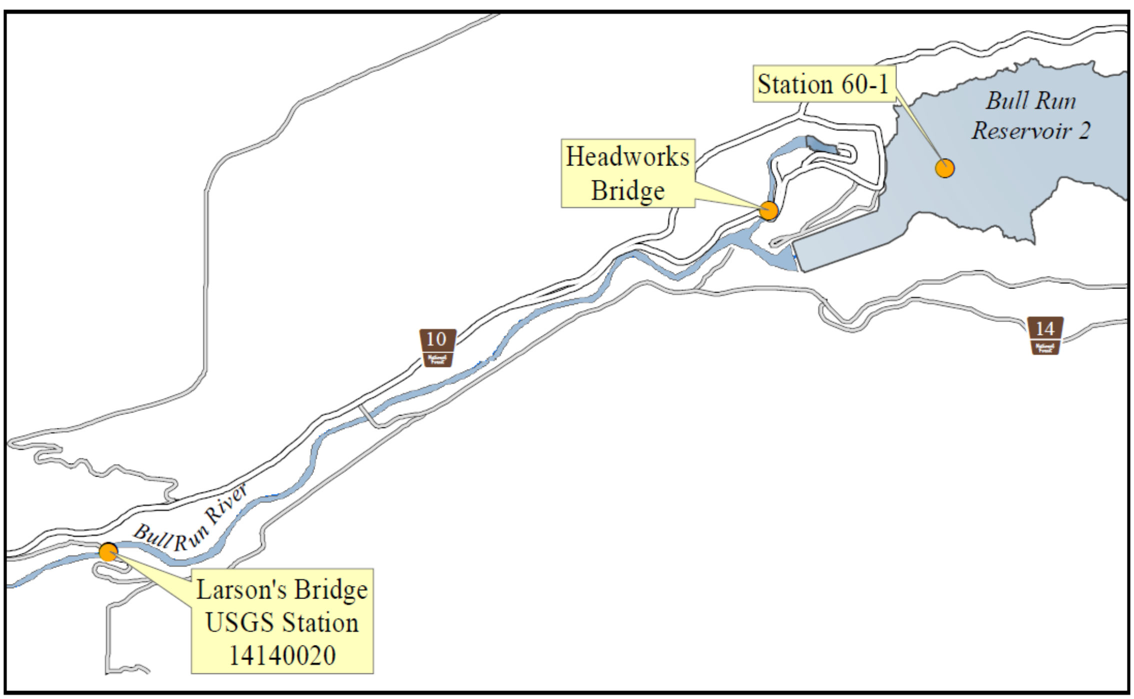


Figure 1. Sampling Sites for Monitoring

4. Analysis

Data for each parameter were analyzed by PWB staff. Reservoir nutrient concentrations were calculated at each sample depth for each nutrient. Reservoir dissolved oxygen concentration and saturation levels, temperatures, and pH levels for the entire reservoir profile were recorded. In the lower Bull Run River, dissolved oxygen concentration and saturation levels and temperatures were recorded for readings taken at Headworks Bridge. Temperature data at Larson's Bridge are available online at the USGS website, http://waterdata.usgs.gov/or/nwis/dv/?site_no=14140020&agency_cd=USGS&referred_module=sw.

5. Results

Data from 2014 were compared to the 2009–2013 baseline results (see Table 2 for the baseline sampling periods). As anticipated with the infrastructure change, stronger stratification occurred in the reservoir, creating more defined zones of water temperature and other water quality parameters within the vertical profile of Reservoir 2. However, water quality parameters monitored for the Section 401 certification still were within the ranges observed during the baseline monitoring period, with the exception of one dissolved oxygen measurement result that was 0.1 mg/L below the lowest value observed during the baseline period. This amount of difference is within the measurement error of the monitoring instrument. Exhibit A includes raw data from the 2014 monitoring effort in Reservoir 2 and at the Headworks Bridge site (see Tables A-1, A-2, and A-3 in Exhibit A). Temperature data for the lower Bull Run River from USGS Station 14140020 at Larson's Bridge are available from the USGS website at the following website: http://waterdata.usgs.gov/or/nwis/dv/?site_no=14140020&agency_cd=USGS&referred_module=sw.

5.1.1 Nuisance Phytoplankton Growth and the Creation of Taste, Odors, and Toxic Conditions

Table A-1 shows nutrient monitoring results for 2014. Samples were often collected and analyzed at a frequency greater than the required frequency.

In 2014, nutrient results were within expected ranges. Reactive phosphorus ranged from <0.003 – 0.009 milligrams per liter (mg/L), and total phosphorus ranged from <0.01 – 0.011 mg/L. Nitrite was <0.005 mg/L, nitrate ranged from <0.01 – 0.064 mg/L, and total nitrogen from <0.05 – 0.18 mg/L.

5.1.2 Dissolved Oxygen

Table A-2 shows results of dissolved oxygen (DO) monitoring at the Headworks Bridge. Sampling in 2014 showed DO saturation values of 96.8 – 104 percent at the Headworks Bridge. Baseline sampling in 2012-2013 showed DO saturation values of 94.5 – 103 percent at the Headworks Bridge.

In the 2013 compliance report, the lowest values of dissolved oxygen that were observed were questionable due to the monitoring practice. Yet with a change in method to using a depth finder rather than a weight to determine the reservoir depth, low DO values were still observed at the base of the reservoir. This changes the interpretation of the lowest DO values observed from 2009 to 2013; it now appears that low DO values occur naturally without sediment disturbance.

Table A-3 includes DO results from Reservoir 2. The baseline monitoring results from 2014 show, overall, high levels of DO. There were a few observations of DO concentrations lower than 6 mg/L toward the base of the reservoir. The lowest result in 2014 was 5.1 mg/L. The lowest observed value during the baseline monitoring period from 2009-2013 was 5.2 mg/L.[1]

5.1.3 pH Levels

Table A-3 includes results for pH observed in Reservoir 2 in 2014 monitoring. Results ranged from pH 6.1 – 7.4. It is notable that many instances of pH less than 6.5 were observed, both in 2014 and in the baseline monitoring period. The range of pH observed in 2014 is within the range observed in the baseline monitoring period.

5.1.4 Temperature

Table A-3 also includes temperature measurements taken during profiling of Reservoir 2 in 2014 monitoring. As expected, temperature stratification was observed to change seasonally.

6. Conclusions

Reservoir monitoring for 401 certification conditions in 2014 showed results within anticipated ranges, and do not represent significant changes to water quality. Continued monitoring will provide results that can be compared with the baseline results to look for changes relative to pre-project conditions.[2] PWB will also review the data to determine whether pre- or post-project conditions are within acceptable ranges according to Oregon DEQ.

The new multi-level Reservoir 2 water intake was placed into service in April 2014. Monitoring in Reservoir 2 and at Headworks Bridge will continue for at least five years

[1] One observed value of 2.5 mg/L during the baseline monitoring period was later discarded due to lack of confidence in the results.

[2] This is true for all parameters except temperatures in the lower Bull Run River, which will be monitored under HCP Measure T-2, Post-Infrastructure Temperature Management.

from that time forward, as required by the conditions of the 401 certification. Expiration of the monitoring requirement will be contingent on PWB's successful operation of the new intakes to meet downstream temperature targets with no significant water quality impact in Reservoir 2 or the lower Bull Run, as demonstrated by the conditional monitoring.

7. Works Cited

City of Portland. 2008. Bull Run Water Supply Habitat Conservation Plan For the Issuance of A Permit to Allow Incidental Take of Threatened and Endangered Species. Appendix G. Temperature Management Plan for the Lower Bull Run River. Portland, Oregon. Available at www.portlandoregon.gov/water/46157.

Oregon Department of Environmental Quality. 2012. Clean Water Act Section 401 Certification Conditions for the City of Portland's Bull Run Reservoir Hydroelectric Project (FERC No. 2821), Sandy River Basin, Clackamas County, Oregon. Available online at www.deq.state.or.us/wq/sec401cert/docs/hydropower/portlandbullrun/CertificationConditions.pdf.

Table A-1. Reservoir 2 Nutrient Monitoring at Station 60-1 for Reactive Phosphorus, Total Phosphorus, Nitrite, Nitrate, and Total Nitrogen[a]

Sample Depth M	Elevation ft MSL	PO_4 mg/L	Total P mg/L	NO_2 mg/L	NO_3 mg/L	Total N mg/L
1/14/2014						
1	855.6	<0.003	<0.01	<0.005	0.047	0.09
6	839.3	<0.003	<0.01	<0.005	0.049	0.09
15	809.8	<0.003	<0.01	<0.005	0.049	0.09
22	786.8	<0.003	<0.01	<0.005	0.050	0.10
31	757.3	<0.003	<0.01	<0.005	0.050	0.09
1/28/2014						
1	853.7	<0.003	<0.01	<0.005	0.041	0.08
5	840.6	<0.003	<0.01	<0.005	0.041	0.08
14	811.1	<0.003	<0.01	<0.005	0.041	0.08
21	788.1	<0.003	<0.01	<0.005	0.041	0.08
29	761.9	<0.003	<0.01	<0.005	0.041	0.08
2/11/2014						
1	853.8	0.003	<0.01	<0.005	0.040	0.08
5	840.5	<0.003	<0.01	<0.005	0.038	0.09
14	811.1	<0.003	<0.01	<0.005	0.039	0.08
21	788.1	<0.003	<0.01	<0.005	0.039	0.07
28	765.2	<0.003	<0.01	<0.005	0.040	0.07
2/27/2014						
1	854.6	<0.003	<0.01	<0.005	0.033	0.07
6	838.3	0.003	<0.01	<0.005	0.031	0.06
14	812.1	<0.003	<0.01	<0.005	0.030	0.06
22	785.8	<0.003	<0.01	<0.005	0.031	0.07
29	762.9	<0.003	<0.01	<0.005	0.031	0.06
3/11/2014						
1	855.52	0.006	<0.01	<0.005	0.023	0.06
6	839.29	0.006	<0.01	<0.005	0.024	0.06
15	809.8	0.007	<0.01	<0.005	0.025	0.08
30	760.6	0.008	<0.01	<0.005	0.025	0.06

Table A-1. Reservoir 2 Nutrient Monitoring at Station 60-1 for Reactive Phosphorus, Total Phosphorus, Nitrite, Nitrate, and Total Nitrogen[a]

3/25/2014						
1	854.5	0.003	<0.01	<0.005	<0.01	0.08
6	838.3	<0.003	<0.01	<0.005	<0.01	0.06
14	812.1	<0.003	<0.01	<0.005	0.013	<0.05
22	785.8	<0.003	<0.01	<0.005	0.015	<0.05
29	762.9	0.003	<0.01	<0.005	0.016	<0.05
4/8/2014						
1	854.7	0.004	<0.01	<0.005	<0.01	0.12
6	838.2	0.003	<0.01	<0.005	<0.01	0.06
14	812.1	<0.003	<0.01	<0.005	<0.01	<0.05
22	785.8	<0.003	<0.01	<0.005	<0.01	<0.05
30	759.6	<0.003	<0.01	<0.005	<0.01	<0.05
4/22/2014						
1	855.7	<0.003	<0.01	<0.005	<0.01	0.06
6	839.3	<0.003	<0.01	<0.005	<0.01	<0.05
15	809.8	<0.003	<0.01	<0.005	<0.01	<0.05
22	786.8	<0.003	<0.01	<0.005	<0.01	<0.05
30	760.3	<0.003	<0.01	<0.005	<0.01	<0.05
5/6/2014						
1	854.6	<0.003	< 0.01	<0.005	<0.010	0.11
6	838.2	<0.003	< 0.01	<0.005	<0.010	0.05
14	812.1	<0.003	< 0.01	<0.005	<0.010	< 0.05
22	785.8	<0.003	< 0.01	<0.005	<0.010	< 0.05
30	759.6	<0.003	< 0.01	<0.005	<0.010	0.05
5/20/2014						
1	855.5	<0.003	<0.01	<0.005	<0.01	0.05
6	839.3	<0.003	<0.01	<0.005	<0.01	0.08
15	809.5	<0.003	<0.01	<0.005	<0.01	0.05
22	786.8	<0.003	<0.01	<0.005	<0.01	<0.05
30	760.6	<0.003	<0.01	<0.005	<0.01	<0.05

Table A-1. Reservoir 2 Nutrient Monitoring at Station 60-1 for Reactive Phosphorus, Total Phosphorus, Nitrite, Nitrate, and Total Nitrogen[a]

6/5/2014						
1	855.5	<0.003	<0.01	<0.005	<0.010	0.07
6	839.1	<0.003	<0.01	<0.005	<0.010	0.08
15	809.8	<0.003	<0.01	<0.005	<0.010	0.05
22	787.2	<0.003	<0.01	<0.005	<0.010	<0.05
30	760.6	<0.003	<0.01	<0.005	0.012	0.07
6/17/2014						
1	855.7	<0.003	<0.01	<0.005	<0.010	0.06
6	839.3	<0.003	<0.01	<0.005	<0.010	0.07
15	809.8	<0.003	<0.01	<0.005	<0.010	<0.05
22	786.8	<0.003	<0.01	<0.005	<0.010	<0.05
30	760.6	<0.003	<0.01	<0.005	0.011	0.05
7/1/2014						
1	855.5	<0.003	<0.01	<0.005	<0.010	0.06
6	839.2	<0.003	<0.01	<0.005	<0.010	0.05
15	809.8	<0.003	<0.01	<0.005	<0.010	<0.05
22	786.5	<0.003	<0.01	<0.005	<0.010	<0.05
28	767.2	<0.003	<0.01	<0.005	<0.010	<0.05
7/15/2014						
1	855.7	0.003	<0.01	<0.005	<0.010	0.05
6	839.2	0.003	<0.01	<0.005	<0.010	0.05
15	809.8	0.009	<0.01	<0.005	0.013	<0.05
22	786.8	0.003	0.011	<0.005	<0.010	<0.05
30	760.6	0.003	<0.01	<0.005	0.013	0.06
7/29/2014						
1	855.7	<0.003	<0.01	<0.005	<0.010	0.06
6	839.2	<0.003	<0.01	<0.005	<0.010	0.06
15	809.8	<0.003	<0.01	<0.005	<0.010	0.05
22	786.8	<0.003	<0.01	<0.005	<0.010	<0.05
30	760.3	<0.003	<0.01	<0.005	0.012	0.05

Table A-1. Reservoir 2 Nutrient Monitoring at Station 60-1 for Reactive Phosphorus, Total Phosphorus, Nitrite, Nitrate, and Total Nitrogen[a]

8/12/2014						
1	855.5	0.003	<0.01	<0.005	<0.01	0.06
6	839.1	0.003	<0.01	<0.005	<0.01	0.07
15	809.8	0.003	<0.01	<0.005	<0.01	0.06
22	786.8	0.003	<0.01	<0.005	<0.01	0.05
30	760.6	0.003	<0.01	<0.005	0.014	0.06
8/26/2014						
1	855.7	<0.003	<0.01	<0.005	<0.010	0.07
6	839.2	<0.003	<0.01	<0.005	<0.010	0.07
15	809.8	<0.003	<0.01	<0.005	<0.010	0.07
22	786.8	<0.003	<0.01	<0.005	0.014	0.06
28	767.2	<0.003	<0.01	<0.005	0.016	0.06
9/9/2014						
1	854.7	<0.003	<0.01	<0.005	<0.01	0.07
6	838.3	<0.003	<0.01	<0.005	<0.01	0.07
14	811.8	<0.003	<0.01	<0.005	0.012	0.09
22	785.8	<0.003	<0.01	<0.005	0.022	0.07
29	762.9	<0.003	<0.01	<0.005	0.024	0.07
9/23/2014						
1	848.7	<0.003	<0.01	<0.005	<0.010	0.07
4	838.8	<0.003	<0.01	<0.005	<0.010	0.07
13	809.4	<0.003	0.011	<0.005	<0.010	0.16
20	786.4	<0.003	<0.01	<0.005	0.020	0.09
25	770	<0.003	<0.01	<0.005	0.020	0.10
10/7/2014						
1	845.5	<0.003	<0.01	<0.005	<0.01	0.07
3	839.1	<0.003	<0.01	<0.005	<0.01	0.06
12	809.6	<0.003	<0.01	<0.005	0.012	0.08
19	786.7	0.003	<0.01	<0.005	0.020	0.10
26	763.4	0.003	<0.01	<0.005	0.032	0.12

Table A-1. Reservoir 2 Nutrient Monitoring at Station 60-1 for Reactive Phosphorus, Total Phosphorus, Nitrite, Nitrate, and Total Nitrogen[a]

10/21/2014						
1	842.6	<0.003	< 0.01	<0.005	<0.010	0.08
11	809.9	<0.003	< 0.01	<0.005	0.017	0.09
18	787	<0.003	< 0.01	<0.005	0.025	0.11
25	763.7	<0.003	< 0.01	<0.005	0.034	0.14
11/4/2014						
1	856.6	<0.003	<0.01	<0.005	0.046	0.12
6	840.1	<0.003	0.010	<0.005	0.054	0.18
15	810.5	<0.003	<0.01	<0.005	0.064	0.14
22	787.8	0.003	<0.01	<0.005	0.064	0.14
30	761.3	<0.003	<0.01	<0.005	0.062	0.14
11/19/2014						
1	849.7	<0.003	<0.01	<0.005	0.060	0.13
4	839.7	<0.003	<0.01	<0.005	0.062	0.13
13	810	<0.003	<0.01	<0.005	0.062	0.13
20	787.4	<0.003	<0.01	<0.005	0.063	0.13
24	774	<0.003	<0.01	<0.005	0.063	0.13
12/2/2014						
1	854.4	<0.003	<0.01	<0.005	0.059	0.12
6	837.9	<0.003	<0.01	<0.005	0.058	0.12
14	812.1	<0.003	<0.01	<0.005	0.058	0.12
22	785.5	<0.003	<0.01	<0.005	0.056	0.12
26	772.4	<0.003	<0.01	<0.005	0.057	0.12
12/16/2014						
1	855.7	<0.003	<0.01	<0.005	0.047	0.10
6	839.3	<0.003	<0.01	<0.005	0.047	0.10
15	809.8	<0.003	<0.01	<0.005	0.046	0.10
22	786.8	<0.003	<0.01	<0.005	0.047	0.10
29	763.9	<0.003	<0.01	<0.005	0.047	0.10

[a]m is meters, ft MSL is feet above mean sea level, mg/L is milligrams per liter, PO_4 is reactive phosphorus, Total P is total phosphorus, NO_2 is nitrite, NO_3 is nitrate, Total N is total nitrogen

Table A-2. Headworks Bridge Data for Dissolved Oxygen (DO) and Temperature[a]

Date	Depth m	DO concentration mg/L	DO saturation %	Temperature °C
1/14/2014	0.09	12.9	99.7	4.5
1/28/2014	0.11	12.8	98.9	4.4
2/12/2014	0.07	13.4	101.0	2.9
2/25/2014	0.08	12.8	102.0	4.8
3/11/2014	0.06	12.7	102.0	5.6
3/25/2014	0.07	12.1	102.0	6.5
4/8/2014	0.05	12.2	102	6.7
4/22/2014	0.58	11.9	100	7.0
5/6/2014	0.07	11.1	97.6	8.8
5/20/2014	0.14	11.3	102.0	9.8
6/5/2014	0.54	11.4	100	9.0
6/17/2014	0.15	11.0	102.0	11.5
7/1/2014	0.09	10.2	102	13.7
7/15/2014	1.39	11.1	101.0	10.0
7/29/2014	0.69	11.1	101	10.3
8/12/2014	0.75	10.6	101	12.3
8/26/2014	1.34	10.9	102	11.1
9/9/2014	1.36	11.0	101.0	11.0
9/23/2014	0.66	10.6	101	12.3
10/7/2014	0.83	10.4	101.0	13.1
10/21/2014	0.30	10.3	104.0	14.8
11/4/2014	0.28	11.2	102.0	11.2
11/19/2014	0.10	12.2	101	7.1
12/2/2014	0.06	11.9	96.8	6.5
12/16/2014	0.12	12.5	103.0	6.1
12/31/2014	0.39	13.0	104.0	5.8

[a] m is meters, mg/L is milligrams per liter, °C is degrees Celsius

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
1/14/2014					
1	855.6	12.4	96.1	4.5	6.9
2	852.4	12.4	96.1	4.47	6.9
3	849.1	12.4	95.9	4.47	6.9
4	845.8	12.4	95.7	4.47	6.8
5	842.6	12.4	95.7	4.47	6.8
6	839.2	12.3	95.1	4.47	6.8
7	836.1	12.4	95.4	4.47	6.8
8	832.7	12.4	95.4	4.47	6.8
9	829.4	12.3	95.3	4.47	6.8
10	826.2	12.3	95.2	4.47	6.8
11	822.9	12.3	95.1	4.47	6.8
12	819.6	12.3	94.7	4.46	6.8
13	816.3	12.3	94.8	4.46	6.8
14	813.1	12.3	94.8	4.46	6.8
15	809.8	12.3	94.7	4.46	6.8
16	806.5	12.2	94.6	4.46	6.8
17	803.2	12.2	94.5	4.46	6.8
18	799.9	12.2	94.2	4.46	6.8
19	796.7	12.2	94.3	4.46	6.8
20	793.4	12.2	94.3	4.46	6.8
21	790.1	12.2	94.2	4.46	6.8
22	786.8	12.2	94.1	4.46	6.8
23	783.5	12.2	94	4.46	6.8
24	780.3	12.1	93.7	4.46	6.8
25	777.0	12.1	93.7	4.45	6.8
26	773.7	12.1	93.7	4.45	6.8
27	770.4	12.1	93.5	4.45	6.8
28	767.1	12.1	93.5	4.45	6.9
29	763.9	12.1	93.4	4.44	6.9
30	760.6	12.1	93.2	4.44	6.9
31	757.3	12.1	93.1	4.44	6.9
1/28/2014					
1	853.7	12.5	95.9	4.22	6.7
2	850.4	12.5	95.9	4.19	6.7
3	847.1	12.5	95.8	4.19	6.7
4	843.9	12.5	95.7	4.19	6.7
5	840.6	12.5	95.6	4.19	6.7
6	837.2	12.4	95.4	4.19	6.7
7	834.0	12.4	95.5	4.19	6.7
8	830.8	12.4	95.4	4.2	6.7
9	827.5	12.4	95.3	4.19	6.7
10	824.2	12.4	95.2	4.2	6.7

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
11	820.9	12.4	95.2	4.19	6.7
12	817.6	12.4	95.1	4.19	6.7
13	814.3	12.4	94.9	4.19	6.7
14	811.1	12.4	94.9	4.19	6.7
15	807.8	12.4	94.8	4.19	6.7
16	804.5	12.4	94.7	4.18	6.7
17	801.2	12.3	94.6	4.18	6.7
18	797.9	12.3	94.6	4.18	6.7
19	794.7	12.3	94.5	4.18	6.7
20	791.4	12.3	94.3	4.18	6.7
21	788.1	12.3	94.3	4.18	6.7
22	784.8	12.3	94.2	4.18	6.7
23	781.5	12.3	94.1	4.18	6.7
24	778.3	12.3	94	4.18	6.7
25	775.0	12.2	93.9	4.18	6.7
26	771.7	12.2	93.9	4.18	6.7
27	768.4	12.2	93.8	4.18	6.7
28	765.1	12.2	93.7	4.18	6.7
29	761.9	12.2	93.6	4.18	6.7
2/11/2014					
1	853.8	12.8	96.7	2.88	6.9
2	850.4	12.7	96.5	2.86	6.9
3	847.1	12.7	96.4	2.86	6.9
4	843.8	12.7	96.3	2.86	6.9
5	840.5	12.7	96.2	2.86	6.9
6	837.3	12.7	96.1	2.86	6.9
7	834.0	12.7	96.1	2.86	6.9
8	830.7	12.7	96.1	2.86	6.9
9	827.4	12.7	96	2.87	6.9
10	824.2	12.6	95.9	2.86	6.9
11	820.9	12.6	95.8	2.87	6.9
12	817.6	12.6	95.8	2.87	6.9
13	814.3	12.6	95.7	2.86	6.9
14	811.1	12.6	95.7	2.87	6.9
15	807.8	12.6	95.6	2.87	6.9
16	804.5	12.6	95.4	2.87	6.9
17	801.2	12.6	95.4	2.88	6.9
18	797.9	12.6	95.3	2.87	6.9
19	794.3	12.6	95.2	2.87	6.9
20	791.4	12.6	95.3	2.87	6.9
21	788.1	12.6	95.1	2.87	6.9
22	784.8	12.5	95.1	2.88	6.9
23	781.5	12.5	94.8	2.9	6.9

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
24	778.3	12.5	94.9	2.9	6.9
25	775.0	12.5	95.1	2.92	6.9
26	771.7	12.5	95	2.93	6.9
27	768.4	12.5	94.9	2.93	6.9
28	765.1	12.5	94.7	2.94	6.9
2/27/2014					
1	854.6	12.5	101	4.58	6.9
2	851.4	12.5	101	4.58	6.9
3	848.1	12.5	101	4.58	6.9
4	844.8	12.5	101	4.58	7.0
5	841.6	12.5	101	4.58	7.0
6	838.3	12.5	101	4.58	7.0
7	835.0	12.5	100	4.58	7.0
8	831.7	12.5	100	4.58	7.0
9	828.4	12.5	100	4.58	7.0
10	825.2	12.5	100	4.58	6.9
11	821.9	12.5	100	4.58	6.9
12	818.3	12.4	100	4.58	6.9
13	815.3	12.4	100	4.58	6.9
14	812.1	12.4	100	4.58	6.9
15	808.5	12.4	99.9	4.58	6.9
16	805.5	12.4	99.8	4.58	6.9
17	802.2	12.4	99.7	4.58	6.9
18	798.9	12.4	99.7	4.58	6.9
19	795.7	12.4	99.6	4.58	6.9
20	792.4	12.4	99.5	4.58	6.9
21	789.1	12.4	99.4	4.58	6.9
22	785.8	12.4	99.3	4.58	6.9
23	782.5	12.4	99.3	4.58	6.9
24	779.3	12.3	99.2	4.58	6.9
25	776.0	12.3	99.2	4.58	6.9
26	772.7	12.3	99.1	4.58	6.9
27	769.4	12.3	99	4.58	6.9
28	766.1	12.3	99	4.58	6.9
29	762.9	12.3	99	4.58	6.9
3/11/2014					
1	855.5	12.6	102	5.75	6.9
2	852.3	12.6	102	5.69	6.9
3	849.0	12.6	102	5.6	6.9
4	845.8	12.6	101	5.57	6.9
5	842.6	12.6	101	5.56	6.8
6	839.3	12.6	101	5.55	6.8
7	836.0	12.6	101	5.54	6.8

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
8	832.7	12.6	101	5.54	6.8
9	829.4	12.6	101	5.53	6.8
10	826.2	12.6	101	5.53	6.8
11	822.9	12.6	101	5.53	6.8
12	819.6	12.6	101	5.53	6.8
13	816.3	12.5	101	5.53	6.8
14	813.1	12.5	100	5.53	6.8
15	809.8	12.5	100	5.53	6.8
16	806.2	12.5	100	5.52	6.8
17	803.2	12.5	100	5.51	6.8
18	799.9	12.5	100	5.51	6.8
19	796.7	12.5	100	5.5	6.8
20	793.4	12.5	100	5.49	6.8
21	790.1	12.5	100	5.47	6.8
22	786.8	12.5	100	5.46	6.8
23	783.5	12.5	100	5.46	6.8
24	780.3	12.5	100	5.45	6.7
25	777.0	12.5	99.8	5.42	6.8
26	773.7	12.5	99.7	5.41	6.7
27	770.4	12.4	99.6	5.4	6.7
28	767.1	12.4	99.5	5.4	6.7
29	763.9	12.4	99.3	5.35	6.7
30	760.6	12.4	99.1	5.34	6.7
3/25/2014					
1	854.5	12.3	105	7.19	7.0
2	851.4	12.3	105	7.17	6.9
3	848.1	12.3	105	7.14	6.9
4	844.8	12.2	105	7.09	6.9
5	841.4	12.2	105	7.07	6.9
6	838.3	12.2	104	7.02	6.9
7	835.0	12.2	104	6.96	6.9
8	831.6	12.2	104	6.87	6.9
9	828.4	12.2	104	6.85	6.9
10	825.2	12.2	103	6.7	6.9
11	821.9	12.2	103	6.57	6.9
12	818.6	12.2	103	6.5	6.9
13	815.0	12.2	103	6.42	6.9
14	812.1	12.2	102	6.37	6.9
15	808.8	12.1	102	6.19	6.9
16	805.5	12.2	102	6.16	6.9
17	802.2	12.2	102	6.1	6.8
18	798.9	12.2	102	6.08	6.9
19	795.7	12.2	101	5.99	6.8

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
20	792.4	12.2	101	5.95	6.8
21	789.1	12.2	101	5.92	6.8
22	785.8	12.1	101	5.9	6.8
23	782.5	12.1	101	5.89	6.8
24	779.3	12.1	101	5.89	6.8
25	776.0	12.1	101	5.89	6.8
26	772.7	12.1	101	5.9	6.8
27	769.4	12.1	101	5.89	6.8
28	766.1	12.1	100	5.89	6.8
29	762.9	12.1	100	5.89	6.8
4/8/2014					
1	854.7	12.2	108	8.84	7.1
2	851.1	12.4	106	7.34	7.1
3	848.2	12.4	105	7.09	7.1
4	845.0	12.4	104	6.85	7.1
5	841.7	12.4	104	6.78	7.1
6	838.2	12.4	104	6.78	7.1
7	834.9	12.4	104	6.62	7.1
8	831.7	12.3	102	6.44	7.1
9	828.6	12.4	102	6.33	7.1
10	825.2	12.4	102	6.31	7.0
11	821.9	12.4	103	6.3	7.0
12	818.6	12.4	102	6.29	7.0
13	815.3	12.3	102	6.28	7.0
14	812.1	12.3	102	6.28	7.0
15	808.8	12.3	102	6.26	7.0
16	805.5	12.3	102	6.25	7.0
17	802.2	12.3	102	6.25	7.0
18	798.9	12.3	102	6.23	7.0
19	795.7	12.3	102	6.23	7.0
20	792.4	12.3	102	6.23	7.0
21	789.4	12.4	102	6.22	7.0
22	785.8	12.4	102	6.21	7.0
23	782.5	12.4	102	6.18	7.0
24	778.9	12.4	102	6.17	7.0
25	776.0	12.4	102	6.17	7.0
26	772.7	12.3	102	6.17	7.0
27	769.4	12.3	102	6.17	7.0
28	766.1	12.3	102	6.17	7.0
29	763.2	12.3	102	6.17	7.0
30	759.6	12.3	102	6.16	7.0
4/22/2014					
1	855.7	11.6	105	9.99	7.2

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
2	852.4	11.6	105	9.93	7.2
3	849.2	11.6	104	9.32	7.2
4	845.8	11.6	104	9.19	7.2
5	842.6	11.6	104	9.17	7.2
6	839.2	11.7	103	8.45	7.2
7	835.9	11.7	102	8.25	7.2
8	832.8	11.7	102	8.2	7.2
9	829.4	11.7	102	8.14	7.1
10	826.2	11.7	102	8.1	7.1
11	822.9	11.7	102	8	7.1
12	819.6	11.7	102	7.84	7.1
13	816.3	11.8	102	7.78	7.1
14	813.1	11.8	101	7.57	7.1
15	809.8	11.8	101	7.42	7.1
16	806.5	11.8	101	7.3	7.1
17	803.2	11.8	101	7.15	7.1
18	799.9	11.8	100	7.06	7.1
19	796.7	11.8	100	6.98	7.1
20	793.4	11.8	100	6.84	7.1
21	790.1	11.9	100	6.73	7.1
22	786.8	11.9	99.8	6.64	7.0
23	783.5	11.9	99.8	6.62	7.0
24	780.3	11.8	99.2	6.57	7.0
25	777.0	11.7	98.2	6.49	7.0
26	773.7	11.7	97.7	6.43	7.0
27	770.4	11.6	97.1	6.36	7.0
28	767.1	11.6	97	6.35	7.0
29	763.9	11.6	96.9	6.35	7.0
30	760.2	11.6	96.3	6.31	6.9
5/6/2014					
1	854.6	10.6	99.6	11.3	7.0
2	851.4	10.6	99.7	11.2	7.0
3	848.1	10.8	99.5	10.5	7.0
4	844.8	10.9	99	10.1	7.0
5	841.5	10.9	97.9	9.34	6.9
6	838.2	11	97.6	9.03	6.9
7	834.9	11	97.5	8.86	6.9
8	831.6	11.1	97.9	8.77	6.9
9	828.4	11.1	97.7	8.67	6.9
10	825.2	11.1	97.3	8.54	6.9
11	821.6	11.1	97	8.45	6.9
12	818.6	11.1	96.8	8.39	6.9
13	815.3	11.1	96.8	8.34	6.9

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
14	812.1	11.1	96.8	8.28	6.9
15	808.5	11.1	96.4	8.15	6.9
16	805.5	11.1	96.5	8.1	6.9
17	802.2	11.1	96	7.96	6.8
18	798.9	11.1	95.7	7.78	6.8
19	795.7	11.1	95.5	7.74	6.8
20	792.4	11.1	95.3	7.65	6.8
21	788.8	11	94.1	7.48	6.8
22	785.8	11	93.8	7.43	6.8
23	782.5	10.9	93.1	7.38	6.8
24	779.3	10.9	92.8	7.36	6.8
25	775.7	10.8	92	7.27	6.8
26	772.7	10.6	89.9	7.08	6.7
27	769.4	10.5	88.9	7.01	6.7
28	766.1	10.4	87.9	6.96	6.7
29	762.9	10.4	87.7	6.94	6.7
30	759.6	10.3	86.6	6.91	6.7
5/20/2014					
1	855.5	10.6	106	14.3	7.1
2	852.3	10.7	106	13.8	7.1
3	849.1	11.3	108	12.1	7.0
4	845.8	11.4	107	11.4	7.0
5	842.5	11.4	105	10.6	7.0
6	839.3	11.4	105	10.3	7.0
7	836.0	11.4	104	9.77	7.0
8	832.7	11.4	103	9.55	6.9
9	829.3	11.4	103	9.45	6.9
10	826.2	11.4	102	9.26	6.9
11	822.6	11.4	101	9.14	6.9
12	819.6	11.4	101	9.02	6.9
13	816.3	11.4	101	8.8	6.9
14	813.1	11.4	100	8.68	6.8
15	809.5	11.4	100	8.62	6.8
16	806.5	11.4	99.9	8.57	6.8
17	803.2	11.4	99.6	8.44	6.8
18	799.9	11.4	99.1	8.36	6.8
19	796.7	11.3	98.8	8.31	6.8
20	793.4	11.3	98.2	8.21	6.8
21	790.1	11.3	97.9	8.15	6.8
22	786.8	11.2	97.2	8.11	6.8
23	783.2	11.1	96	8.02	6.7
24	780.3	11	95.6	7.99	6.7
25	777.0	11	94.8	7.96	6.7

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
26	773.7	11	94.3	7.81	6.7
27	770.4	10.6	90.9	7.56	6.6
28	767.1	10.3	88.3	7.42	6.6
29	763.9	10.3	87.5	7.38	6.6
30	760.6	10.2	86.5	7.34	6.5
6/5/2014					
1	855.5	9.76	104	17.4	7.2
2	852.4	9.8	104	17.2	7.2
3	848.9	10.4	107	15.4	7.1
4	845.8	10.5	105	14	7.1
5	842.5	10.9	107	13.2	7.1
6	839.1	11	105	12	7.1
7	836.1	11	104	11.6	7.1
8	832.6	11.1	103	11	7.0
9	829.4	11.1	103	10.7	7.0
10	826.2	11.1	102	10.6	7.0
11	822.9	11.2	102	10.3	6.9
12	819.3	11.1	101	10.1	6.9
13	816.7	11	100	9.98	6.9
14	813.4	11.1	100	9.74	6.9
15	809.8	11.2	100	9.52	6.9
16	806.5	11.1	98.1	9.06	6.8
17	803.2	11.1	98.3	8.97	6.8
18	799.9	11.1	97.7	8.82	6.8
19	796.7	11	96.7	8.64	6.7
20	793.7	11	96.2	8.56	6.7
21	790.4	11	95.7	8.44	6.7
22	787.2	10.9	95.1	8.34	6.7
23	783.9	10.8	93.7	8.22	6.7
24	779.9	10.7	92.7	8.09	6.7
25	777.3	10.6	92	8.04	6.7
26	773.7	10.6	91.2	7.96	6.7
27	770.4	10.1	86.7	7.74	6.6
28	767.1	9.83	84.3	7.64	6.5
29	763.9	9.61	82.3	7.58	6.5
30	760.6	9.57	81.9	7.57	6.5
6/17/2014					
1	855.7	9.76	101	16	7.2
2	852.4	9.75	101	16	7.2
3	849.0	9.75	101	15.9	7.2
4	845.9	10.1	103	15.2	7.1
5	842.5	10.3	103	14.4	7.1
6	839.3	10.6	104	13.5	7.1

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
7	836.0	10.7	103	12.7	7.0
8	832.8	10.9	104	12.3	7.0
9	829.4	11.1	105	12	7.0
10	826.2	11	104	11.6	7.0
11	822.6	11.1	104	11.3	7.0
12	819.3	11	102	11	6.9
13	816.3	11	101	10.8	6.9
14	813.1	11	101	10.4	6.9
15	809.8	10.9	98.8	10.1	6.9
16	806.5	10.8	97.9	9.89	6.8
17	803.2	10.7	95.8	9.63	6.8
18	799.6	10.7	95.1	9.32	6.8
19	796.7	10.8	95.3	9.08	6.8
20	793.4	10.6	93.2	8.8	6.7
21	789.8	10.6	92.8	8.74	6.7
22	786.8	10.5	91.6	8.51	6.7
23	783.5	10.5	91.2	8.4	6.7
24	780.3	10.4	91	8.29	6.7
25	777.0	10.6	91.8	8.18	6.7
26	773.7	10.4	90	8.11	6.7
27	770.4	10	86.3	7.92	6.6
28	767.1	9.59	82.4	7.81	6.6
29	763.9	9.42	80.9	7.78	6.6
30	760.6	8.97	76.9	7.72	6.5
7/1/2014					
1	855.5	9.5	104	18.2	7.2
2	852.3	9.5	104	18.2	7.2
3	849.1	9.5	104	18.1	7.2
4	845.6	9.5	103	17.9	7.2
5	842.3	9.7	104	17.0	7.2
6	839.2	10.3	104	14.2	7.2
7	836.0	10.2	102	13.5	7.1
8	832.5	10.2	100	13.0	7.0
9	829.2	10.2	99.5	12.7	7.0
10	825.9	10.2	99	12.4	6.9
11	822.9	10.2	98.5	12.4	6.9
12	819.3	10.2	98.1	12.3	6.9
13	816.3	10.1	97.7	12.2	6.9
14	812.7	10.1	97.1	12.1	6.9
15	809.8	10.1	97.2	12.1	6.8
16	806.5	10.1	96.6	11.9	6.8
17	802.9	10.0	95.5	11.8	6.8
18	799.9	10.0	94.6	11.5	6.8

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH[a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
19	796.3	10.2	96.1	11.1	6.7
20	793.4	9.7	88.8	10.0	6.7
21	789.8	9.8	88.3	9.3	6.6
22	786.5	9.8	88	8.9	6.6
23	783.5	9.5	84.2	8.6	6.5
24	780.3	9.5	84	8.5	6.5
25	777.0	9.7	85.2	8.4	6.5
26	773.7	9.2	80.9	8.2	6.5
27	770.4	8.9	78.2	8.1	6.4
28	767.1	8.9	78	8.0	6.4
7/15/2014					
1	855.7	8.8	104	22.8	7.3
2	852.3	9.2	107	21.3	7.2
3	849.1	9.7	108	19.2	7.1
4	845.8	9.8	107	18.3	7.1
5	842.3	10.2	109	17.2	7.1
6	839.2	10.2	107	16.3	7.1
7	836.0	10.2	105	15.4	7.1
8	832.7	10.2	104	14.7	7.0
9	829.3	10.0	99.9	14.3	6.9
10	826.2	10.1	100	14.0	6.9
11	822.9	10.1	100	13.7	6.9
12	819.6	10.1	99.4	13.4	6.9
13	816.3	10.1	98.4	13.1	6.8
14	813.1	10.0	97.6	12.9	6.8
15	809.8	10.0	96.3	12.7	6.8
16	806.5	10.0	96.7	12.4	6.8
17	802.9	10.0	95.5	12.3	6.8
18	799.9	9.9	94.5	12.1	6.8
19	796.3	9.5	89.3	11.6	6.7
20	793.4	9.2	85.1	10.7	6.6
21	789.8	9.4	84.7	9.7	6.5
22	786.8	9.1	81.3	9.3	6.5
23	783.2	9.1	80.5	8.9	6.4
24	780.3	9.0	79.7	8.8	6.4
25	777.0	9.2	80.8	8.7	6.4
26	773.4	9.1	80.4	8.6	6.4
27	770.4	9.0	78.7	8.4	6.4
28	767.1	8.5	74.3	8.2	6.4
29	763.9	8.3	72.3	8.1	6.3
30	760.6	8.0	69.6	8.1	6.3
7/29/2014					
1	856.2	8.8	104	22.2	7.3

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
2	852.8	8.8	103	22.0	7.3
3	849.5	8.9	103	21.1	7.3
4	846.6	9.3	104	19.8	7.2
5	843.4	9.6	104	18.4	7.1
6	839.7	9.7	104	17.5	7.1
7	836.4	9.8	105	17.1	7.0
8	833.5	10.0	104	16.3	7.0
9	830.0	9.9	101	15.4	6.9
10	826.4	9.8	100	15.2	6.9
11	823.4	9.7	98.3	14.8	6.9
12	820.1	9.6	96	14.4	6.8
13	816.8	9.5	94.5	14.0	6.8
14	813.2	9.5	93.9	13.8	6.8
15	810.3	9.4	92.3	13.5	6.8
16	807.0	9.4	91.7	13.4	6.7
17	803.7	9.3	91	13.1	6.7
18	800.4	9.3	90.8	13.0	6.7
19	797.5	9.3	90.1	12.8	6.7
20	793.9	9.3	87.9	11.9	6.6
21	790.6	8.7	81.3	11.1	6.6
22	787.3	8.7	79.8	10.6	6.5
23	784.0	9.0	81	9.7	6.5
24	780.8	8.9	79	9.2	6.5
25	777.5	8.8	77.7	9.1	6.5
26	774.2	8.6	76.2	8.9	6.4
27	770.9	8.4	73.6	8.7	6.4
28	767.6	8.2	71.6	8.6	6.4
29	764.4	8.0	70.1	8.5	6.4
30	760.7	7.7	66.6	8.3	6.3
8/12/2014					
1	855.4	8.7	105	23.4	7.4
2	852.3	8.8	106	22.8	7.3
3	849.0	9.8	111	20.2	7.1
4	845.5	10.1	112	19.1	7.1
5	842.4	9.9	110	18.4	7.0
6	839.0	10.3	111	17.4	7.0
7	835.8	10.1	107	16.7	6.9
8	832.6	9.6	100	16.0	6.8
9	829.3	9.3	96.4	15.5	6.7
10	826.1	9.1	93.1	14.8	6.7
11	822.8	9.3	94.4	14.4	6.7
12	819.6	9.4	94.2	14.2	6.7
13	815.9	9.7	97.4	13.9	6.8

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
14	813.0	9.9	98.8	13.7	6.8
15	809.7	9.5	93.9	13.5	6.7
16	806.4	9.7	95.9	13.4	6.7
17	803.1	9.7	95.4	13.2	6.7
18	799.9	9.8	96.3	13.0	6.7
19	796.6	9.8	95.3	12.8	6.7
20	793.3	9.4	90.8	12.4	6.6
21	790.0	8.6	81.4	11.7	6.5
22	786.7	8.5	79.3	10.9	6.5
23	783.5	8.6	78.9	10.0	6.4
24	780.2	7.6	68.5	9.6	6.3
25	776.9	7.6	68.9	9.4	6.3
26	773.6	7.6	68.3	9.2	6.3
27	770.0	7.5	67.3	9.0	6.3
28	767.1	7.4	65.8	8.8	6.3
29	763.4	6.9	61.1	8.7	6.3
30	760.5	6.4	56.9	8.6	6.2
8/26/2014					
1	855.7	8.9	104	21.9	7.3
2	852.4	8.9	104	21.6	7.3
3	849.1	8.9	104	21.6	7.3
4	845.7	9.0	104	21.3	7.3
5	842.4	9.5	107	19.8	7.1
6	839.2	9.4	104	19.1	7.0
7	835.9	9.4	103	18.8	6.9
8	832.7	9.2	101	18.4	6.9
9	829.3	9.2	100	18.2	6.9
10	826.2	9.5	103	17.9	6.9
11	822.9	9.3	101	17.6	6.9
12	819.3	9.3	98.9	16.9	6.8
13	816.3	9.3	97.4	16.2	6.8
14	813.1	9.2	95.4	15.6	6.7
15	809.8	9.3	95.5	15.2	6.8
16	806.5	9.5	95.9	14.8	6.8
17	803.2	9.5	95.1	14.4	6.8
18	799.9	9.5	94.7	14.1	6.7
19	796.7	9.6	94.6	13.6	6.7
20	793.1	9.5	93	13.1	6.7
21	790.1	9.2	88.1	12.4	6.6
22	786.8	8.3	78.1	11.6	6.4
23	783.2	8.0	74.1	10.8	6.4
24	780.3	7.6	69.3	10.1	6.3
25	777.0	6.6	59.6	9.7	6.2

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
26	773.4	6.9	62.3	9.5	6.2
27	770.4	6.9	61.5	9.4	6.2
28	767.1	6.7	59.9	9.2	6.2
9/9/2014					
1	854.5	9.0	101	19.8	7.3
2	851.2	9.0	101	19.7	7.2
3	847.9	9.0	100	19.6	7.2
4	844.6	8.9	99.8	19.6	7.2
5	841.4	9.0	99.8	19.5	7.2
6	838.1	8.9	98.9	19.5	7.1
7	834.6	8.6	94.5	18.8	6.9
8	831.4	8.5	92.8	18.4	6.8
9	828.2	8.5	91.9	18.2	6.8
10	824.7	8.5	91.4	17.7	6.8
11	821.7	8.5	91.2	17.4	6.8
12	818.1	8.7	92.2	17.0	6.8
13	815.2	9.0	94.7	16.7	6.9
14	811.6	9.0	94	16.6	6.9
15	808.3	8.9	92.6	16.2	6.8
16	805.3	9.0	93.7	16.1	6.9
17	802.0	9.0	93.1	16.0	6.8
18	798.4	8.5	86.9	15.4	6.7
19	795.2	9.0	90.1	14.4	6.7
20	792.2	9.0	89	13.8	6.6
21	788.6	8.9	87	13.1	6.6
22	785.6	8.6	82.6	12.3	6.5
23	782.4	7.7	72.9	11.7	6.4
24	779.1	6.9	63.5	10.9	6.3
25	775.8	6.2	56.2	10.3	6.2
26	772.5	5.7	51.8	10.0	6.2
27	768.9	5.8	52	9.9	6.2
28	766.0	5.9	52.8	9.8	6.2
29	762.7	5.6	50.1	9.6	6.1
9/23/2014					
1	849.5	9.1	100.0	18.7	7.2
2	846.2	9.0	99.8	18.6	7.2
3	843.0	9.0	99.5	18.6	7.2
4	839.6	9.0	99.4	18.6	7.2
5	836.4	9.0	99.4	18.6	7.2
6	833.0	9.0	99.3	18.6	7.2
7	829.8	9.0	99.2	18.6	7.2
8	826.6	9.0	99.1	18.6	7.2
9	823.3	8.8	96.7	18.4	7.1

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
10	819.7	8.7	95.8	18.3	7.0
11	816.8	8.6	94.2	18.1	7.0
12	813.5	8.5	92.3	17.8	6.9
13	810.2	8.4	90.8	17.7	6.9
14	806.9	8.3	89.7	17.5	6.8
15	803.6	8.2	88.3	17.2	6.8
16	800.4	8.3	87.7	16.6	6.7
17	797.1	8.3	87.1	16.2	6.7
18	793.8	8.2	84.9	15.6	6.6
19	790.5	8.0	82.4	15.1	6.6
20	787.2	8.0	80.9	14.5	6.5
21	784.0	8.1	79.9	13.5	6.5
22	780.7	8.1	79.1	12.8	6.4
23	777.4	7.0	67.9	12.4	6.3
24	774.1	6.6	62.9	11.9	6.3
25	770.8	5.6	52.8	11.3	6.2
10/7/2014					
1	845.5	9.0	97.3	18.0	7.1
2	842.3	8.9	97.1	17.9	7.1
3	839.1	8.9	96.9	17.9	7.1
4	835.7	8.9	96.9	17.9	7.1
5	832.5	8.9	96.7	17.8	7.1
6	829.2	8.9	96.3	17.7	7.1
7	826.0	8.8	94.4	17.5	7.0
8	822.7	8.6	93.0	17.5	7.0
9	819.3	8.5	91.7	17.4	6.9
10	816.2	8.3	88.7	17.3	6.8
11	812.9	8.1	86.9	17.2	6.8
12	809.6	8.0	85.8	17.1	6.7
13	806.3	8.0	85.7	17.1	6.7
14	803.1	7.9	84.0	17.0	6.7
15	799.8	7.8	83.4	17.0	6.7
16	796.5	7.8	82.5	16.9	6.7
17	793.2	7.6	80.5	16.7	6.6
18	789.6	7.6	80.0	16.2	6.6
19	786.7	7.5	77.8	15.6	6.5
20	783.1	7.3	74.1	15.0	6.5
21	780.1	7.3	73.2	14.2	6.4
22	776.8	7.2	71.4	13.8	6.4
23	773.5	6.6	65.1	13.3	6.3
24	770.3	6.0	58.2	12.9	6.3
25	767.0	5.3	51.4	12.4	6.2
26	763.4	5.1	49.0	12.1	6.2

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
10/21/2014					
1	842.6	9.3	97.4	16.4	7.1
2	839.3	9.3	97.1	16.4	7.0
3	836.3	9.2	97.0	16.4	7.1
4	832.7	9.2	96.9	16.4	7.0
5	829.5	9.2	96.8	16.4	7.0
6	826.2	9.1	95.8	16.4	7.0
7	823.1	9.1	95.2	16.3	7.0
8	819.9	8.9	93.3	16.2	6.9
9	816.2	8.8	92.2	16.1	6.9
10	813.2	8.9	92.3	16.0	6.9
11	809.9	8.9	92.3	16.0	6.9
12	806.6	8.8	90.9	15.9	6.9
13	803.3	8.7	89.7	15.8	6.8
14	799.7	8.6	89.2	15.8	6.8
15	796.8	8.7	90.2	15.7	6.8
16	793.5	8.5	88.3	15.7	6.8
17	790.2	8.3	85.6	15.6	6.7
18	786.9	8.5	87.6	15.5	6.8
19	783.7	8.5	87.6	15.5	6.8
20	780.4	8.6	88.8	15.5	6.8
21	777.4	8.5	87.0	15.4	6.7
22	773.8	8.2	83.9	15.3	6.7
23	770.2	7.3	73.9	15.0	6.5
24	767.3	6.2	62.1	14.5	6.3
25	763.7	5.6	56.1	14.0	6.3
11/4/2014					
1	856.6	9.7	91.9	12.8	7.1
2	853.2	9.6	90.8	12.8	7.1
3	849.9	9.6	90.6	12.8	7.2
4	846.6	9.7	90.7	12.3	7.1
5	843.4	9.8	91.0	12.2	7.1
6	840.1	9.8	91.0	12.1	7.1
7	836.8	9.9	91.5	11.8	7.1
8	833.6	10.0	91.8	11.7	7.1
9	830.3	10.0	91.8	11.6	7.1
10	826.9	10.0	92.0	11.5	7.1
11	823.9	10.1	92.0	11.4	7.1
12	820.6	10.1	92.4	11.3	7.1
13	817.3	10.1	92.5	11.3	7.2
14	813.7	10.1	92.5	11.3	7.2
15	810.5	10.1	92.4	11.3	7.2
16	807.5	10.1	92.4	11.2	7.2

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH[a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
17	804.2	10.2	92.8	11.1	7.2
18	800.6	10.2	93.0	11.1	7.2
19	797.7	10.2	93.0	11.1	7.2
20	794.4	10.2	93.0	11.1	7.2
21	791.1	10.3	93.1	11.0	7.2
22	787.8	10.3	93.2	11.0	7.2
23	784.5	10.3	93.2	11.0	7.2
24	781.3	10.3	93.1	11.0	7.2
25	778.0	10.3	93.0	11.0	7.2
26	774.7	10.3	93.0	11.0	7.2
27	771.4	10.3	93.1	10.9	7.2
28	768.1	10.3	93.2	10.9	7.2
29	764.5	10.3	93.2	10.9	7.2
30	761.2	10.3	93.2	10.8	7.2
11/19/2014					
1	849.7	11.6	95.7	7.1	7.3
2	846.4	11.4	94.3	7.1	7.3
3	843.0	11.3	93.2	7.1	7.3
4	839.7	11.2	92.8	7.1	7.3
5	836.3	11.2	92.3	7.1	7.3
6	833.2	11.2	92.3	7.1	7.3
7	829.9	11.2	92.3	7.1	7.3
8	826.6	11.2	92.1	7.1	7.3
9	823.5	11.2	92.1	7.1	7.3
10	820.2	11.2	92.1	7.1	7.3
11	816.6	11.2	92.1	7.1	7.3
12	813.6	11.2	92.0	7.1	7.3
13	810.0	11.1	91.9	7.1	7.3
14	806.7	11.1	91.8	7.1	7.3
15	803.5	11.1	91.7	7.1	7.3
16	800.2	11.1	91.7	7.1	7.3
17	796.9	11.1	91.7	7.1	7.3
18	793.9	11.1	91.6	7.1	7.3
19	790.3	11.1	91.5	7.1	7.3
20	787.4	11.1	91.5	7.1	7.3
21	783.8	11.1	91.3	7.1	7.3
22	780.8	11.1	91.2	7.1	7.3
23	777.2	11.0	91.1	7.1	7.3
24	773.9	11.0	91.1	7.1	7.3
12/2/2014					
1	854.4	11.3	91.7	6.4	7.1
2	851.1	11.3	91.7	6.4	7.1
3	847.6	11.3	91.6	6.4	7.1

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
4	845.0	11.3	91.4	6.4	7.1
5	841.5	11.3	91.4	6.4	7.1
6	837.9	11.2	91.4	6.4	7.1
7	835.2	11.2	91.3	6.4	7.1
8	831.7	11.2	91.2	6.4	7.1
9	828.3	11.2	91.2	6.4	7.1
10	825.2	11.2	91.1	6.4	7.1
11	821.6	11.2	91.0	6.4	7.1
12	818.3	11.2	90.9	6.4	7.1
13	815.0	11.2	90.9	6.4	7.1
14	812.1	11.2	90.8	6.4	7.1
15	808.8	11.2	90.8	6.4	7.2
16	805.2	11.2	90.7	6.4	7.1
17	802.2	11.2	90.7	6.4	7.1
18	798.9	11.2	90.6	6.4	7.2
19	795.3	11.2	90.5	6.4	7.2
20	792.4	11.1	90.4	6.4	7.2
21	788.8	11.1	90.4	6.4	7.1
22	785.5	11.1	90.3	6.4	7.1
23	782.2	11.1	90.1	6.4	7.1
24	779.3	11.1	90.1	6.4	7.1
25	775.7	11.1	90.1	6.4	7.1
26	772.4	11.1	90.0	6.4	7.1
12/16/2014					
1	855.7	12.1	100.0	6.0	7.0
2	852.3	12.1	100.0	6.0	6.9
3	849.2	12.0	100.0	6.0	6.9
4	845.7	12.0	99.8	6.0	6.9
5	842.6	12.0	99.8	6.0	6.9
6	839.3	12.0	99.7	6.0	6.9
7	836.0	12.0	99.6	6.0	6.9
8	832.7	12.0	99.5	6.0	6.9
9	829.3	12.0	99.4	6.0	6.9
10	826.2	12.0	99.3	6.0	6.9
11	822.9	12.0	99.3	6.0	6.8
12	819.6	11.9	99.1	6.0	6.8
13	816.3	11.9	99.1	6.0	6.8
14	812.7	11.9	98.9	6.0	6.8
15	809.8	11.9	98.8	6.0	6.8
16	806.5	11.9	98.8	6.0	6.8
17	802.9	11.9	98.7	6.0	6.8
18	799.9	11.9	98.7	6.0	6.8
19	796.7	11.9	98.5	6.0	6.8

Table A-3. Reservoir 2 Profile Data at Station 60-1 for Dissolved Oxygen (DO), Temperature, and pH [a]

Sample Depth m	Elevation ft MSL	DO concentration mg/L	DO saturation %	Temperature °C	pH
20	793.4	11.9	98.5	6.0	6.8
21	790.1	11.9	98.5	6.0	6.8
22	786.8	11.8	98.4	6.0	6.8
23	783.5	11.8	98.3	6.0	6.8
24	780.3	11.8	98.1	6.0	6.8
25	776.7	11.8	98.1	6.0	6.8
26	773.7	11.8	98.0	6.0	6.8
27	770.4	11.8	97.9	6.0	6.8
28	767.1	11.8	97.8	6.0	6.8
29	763.9	11.8	97.8	6.0	6.8
12/31/2014					
1	855.7	12.2	98.6	5.8	6.9
2	852.3	12.2	98.4	5.8	6.9
3	849.0	12.2	98.3	5.8	6.9
4	845.8	12.1	98.1	5.8	6.9
5	842.5	12.1	97.9	5.8	6.9
6	839.1	12.1	97.8	5.8	6.9
7	835.8	12.1	97.7	5.8	6.9
8	832.7	12.1	97.5	5.8	6.9
9	829.2	12.0	97.4	5.8	6.9
10	826.2	12.0	97.3	5.8	6.8
11	822.9	12.0	97.2	5.8	6.8
12	819.3	12.0	97.1	5.8	6.8
13	816.3	12.0	97.0	5.8	6.8
14	813.1	12.0	97.0	5.8	6.8
15	809.8	12.0	96.8	5.8	6.8
16	806.2	12.0	96.7	5.8	6.8
17	802.9	12.0	96.6	5.8	6.8
18	799.9	12.0	96.6	5.8	6.8
19	796.3	11.9	96.5	5.8	6.8
20	793.4	11.9	96.4	5.8	6.8
21	790.1	11.9	96.3	5.8	6.8
22	786.8	11.9	96.2	5.8	6.8
23	783.5	11.9	96.2	5.8	6.8
24	779.9	11.9	96.0	5.8	6.8
25	777.0	11.9	96.0	5.8	6.8
26	773.7	11.9	96.0	5.8	6.8
27	770.1	11.9	95.8	5.8	6.8
28	767.1	11.8	95.7	5.8	6.8

[a] m is meters, ft MSL is feet above mean sea level, mg/L is milligrams per liter, °C is degrees Celsius

Appendix C

Bull Run HCP Research Report

Lower Bull Run River Spawning Gravel Research

April 2015
Burke Strobel
City of Portland Water Bureau

Contents

Tables

Figures

1. Summary

The City of Portland Water Bureau (PWB) was in full compliance with its Habitat Conservation Plan obligations in 2014 with regard to lower Bull Run River spawning gravel research. A survey of gravel patches of sufficient area and with adequately sized substrate for Chinook salmon and steelhead spawning was conducted from the mouth of the Bull Run River (RM 0) to the former site of the Dam 2 spillway plunge pool rock weir (river mile [RM] 5.8).

The combined surface area of adequately sized spawning gravel patches was significantly higher than the baseline average for steelhead and for Chinook at all flows. The surface area of spawning gravel in 2014 was higher than what had been observed in all previous years (2010-2013) at most locations and flows. Large accumulations of gravel were associated with the gravel-addition sites and the river channel downstream of Larson's Bridge. Gravel accumulations in the lowest section of the river between the mouth and the Bull Run Powerhouse (RM 0-1.5) had decreased from the elevated levels observed in 2013 back to near baseline levels. This appendix summarizes the results of this study.

2. Introduction

The availability of appropriate gravel patches can limit the productivity of salmonid populations within a given stream. The dams on the Bull Run River block the downstream movement of streambed substrates. These obstructions have contributed over time to a net loss of spawning gravel patches in the lower Bull Run River, as gravel is washed away and then not replaced.[1]

Under the conditions of the Bull Run Water Supply Habitat Conservation Plan (HCP; Portland Water Bureau 2008), PWB adds gravel annually to the lower Bull Run River to supplement naturally occurring spawning gravel. A total of 1,200 cubic yards of adequately sized gravel was added to the lower Bull Run River in 2014 to benefit spawning salmonids. This was the fifth treatment year. In future years, for the duration of the HCP term, the amount of spawning gravel added to the Bull Run River will be 600 cubic yards. This appendix describes the methods and protocols for monitoring the effectiveness of this effort to increase the surface area of spawning gravel in the lower Bull Run River and provides a summary of the resultant findings for 2014.

[1] More information on the role of gravel in spawning is available in Chapter 8 and Appendix E of the HCP.

3. Research Objective

PWB identified a measurable habitat objective for the spawning gravel placement conservation measure (H-1) detailed in HCP Chapters 7 and 9. PWB is supplying spawning gravel in amounts equivalent to, or exceeding, natural supply rates. PWB augmented spawning gravel in the lower Bull Run River with a total of 1,200 cubic yards of gravel annually for the first five years of HCP implementation. This amount roughly doubled the estimated natural recruitment rate of gravel in the absence of reservoirs (calculations and estimates summarized in CH2M HILL 2003) and is intended to accelerate the accumulation of gravel in the lower Bull Run River.

After five years (in 2015), the rate of gravel supplementation will be decreased to 600 cubic yards annually for the remainder of the HCP, the estimated natural recruitment rate in the absence of upstream reservoirs. PWB, however, cannot predict how the gravel will be distributed or how quickly it will be moved downstream. There is no information on how much gravel was in the lower Bull Run channel and how it varied from year to year before construction of the first Bull Run dam blocked its recruitment from the upper river in 1923.

The objective of the Bull Run River spawning gravel research is to measure the surface area of patches of gravel suitable for spawning steelhead and Chinook in the lower Bull Run River. Effective spawning gravel patches are patches that experience adequate depth and flow throughout the egg and alevin incubation period. Separate estimates will be generated for steelhead and Chinook. PWB will quantify the surface area of all patches that have substrate in suitable size ranges. (The surface area of the subset of the patches that would be effective for spawning may also be analyzed in the future.)

4. Key Questions and Hypotheses

The key questions and related null hypotheses (H_o) to be answered by the Bull Run River spawning gravel research are described below.

4.1 Area of Spawning Gravel

Question 1: What is the summed surface area of gravel patches suitable for steelhead and Chinook spawning in the lower Bull Run River and has it significantly increased from pre-supplementation values?

> H_o: The summed surface area of spawning gravel patches in each post-supplementation year will not be significantly greater than the mean of pre-supplementation years (one-sample t-test, α=0.05).

The pre-supplementation years that will be used for the analysis are 2007, 2008, and 2009. Gravel data were also collected by PWB in 1997, 1999, and 2001. The data from these surveys were not included in the baseline averages, because they were collected using different protocols, with conclusions based on different flow assumptions. The comparison will only use gravel patches between the Dam 2 spillway plunge pool at RM 5.8 and the Portland General Electric (PGE) Bull Run Powerhouse at RM 1.5, because the 2007 survey data do not cover the river downstream of this point.

4.2 Trend over Time

Question 2: What is the trend in the summed surface area of spawning gravel patches and the effective spawning area for each reach?

> H_o: The summed surface area of spawning gravel patches in post-supplementation years will not show a significant increase over time (α=0.05).
>
> H_o: The summed surface area of effective spawning gravel patches at various flow combinations in post-supplementation years will not show a significant increase over time (α=0.05).

4.3 Reach-Level Effective Spawning Gravel

Although the HCP calls for determining the quantity of effective spawning gravel, this objective has proven to be impractical. Determining the effective spawning area for each reach requires information on water surface elevation and water velocity for each gravel patch through time. In 2011, these data were not available because there is no practical method for collecting and summarizing them. Therefore, the following analysis was not attempted.

The following key question and hypothesis were identified in the HCP.

Question 3: What is the effective spawning area of each reach at various combinations of flows and at the flows actually observed during steelhead incubation in the lower Bull Run River?

> H_o: The summed effective spawning area at various flow combinations in each post-supplementation year will not be significantly greater than the mean of pre-supplementation years (one-sample t-test, α =0.05).

The total of the areas of gravel that meet the depth and water velocity criteria for both spawning and incubation of steelhead and Chinook (summarized in Appendix F, Table F-5, of the HCP) during the respective time periods are used to determine the “effective spawning area” of each reach (R2 Resource Consultants 1998). These variables, however, will change continuously through time as they are the sum of current and future conditions for each point in space and time.

If a method for accurately estimating depth and water velocity through time for each gravel patch is devised, an analysis of effective spawning gravel may be attempted in the future.

4.4 Distribution of Spawning Gravel

Although there were no key questions or hypotheses identified in the HCP regarding how gravel will be moved naturally by flows over time in the Bull Run channel, understanding how the longitudinal and lateral distribution of gravel patches changes over time will be useful to evaluate the effectiveness of this measure. The following questions will be investigated. There are no associated null hypotheses:

Question 4: What is the longitudinal distribution of the surface area of gravel patches and how does it change from year to year?

Question 5: Where in the channel laterally (as described in terms of being wetted at specific flows[2]) does gravel accumulate and how does the lateral distribution change from year to year?

5. Methods

5.1 Gravel Estimates per Seasonal Flow

The design of the lower Bull Run River spawning gravel research involved the use of surveys of spawning gravel surface areas to create a snapshot of the distribution of spawning gravel at a particular point in time. Predicted relationships between stage and flow were developed for multiple points along the lower Bull Run River using Hydrologic Engineering Center's River Analysis System (HEC-RAS).[3] These relationships were then used to estimate the amount of spawning gravel that would be wetted at each flow. Although not all wetted gravel patches would have the proper depth, velocity, or degree of turbulence for spawning, it was assumed throughout the subsequent analyses that the change in overall surface area of gravel can serve as a predictor of the surface area of the subset of that gravel that can be used for spawning.

---

[2] Gravel patches that are located laterally further to the edge of the active channel require a higher flow to become wetted.

[3] HEC-RAS is a software package developed by the U.S. Army Corps of Engineers for predicting the behavior of flowing channels using one-dimensional hydraulic modeling.

5.1.1 Steelhead Spawning Gravel

The amount of **steelhead spawning gravel** was estimated for the following peak steelhead spawning time (March, April, and May) flows:

- **1,405 cfs:** 10 percent average exceedence flow
- **614 cfs:** 50 percent average exceedence flow
- **120 cfs:** The lowest allowed flow under the HCP measure for minimum flows (actual flows may be higher)

5.1.2 Spring Chinook Spawning Gravel

The amount of **spring Chinook spawning gravel** was estimated for the following peak spring Chinook spawning time (September and October) flows:

- **358 cfs:** 10 percent average exceedence flow
- **77 cfs** : 50 percent average exceedence flow
- **30 cfs**: The lowest allowed flow under the HCP measure for minimum flows (actual flows may be higher)

5.1.3 Fall Chinook Spawning Gravel

The amount of **fall Chinook spawning gravel** was estimated for the following peak fall Chinook spawning time (October and November) flows:

- **1,480 cfs:** 10 percent average exceedence flow
- **77 cfs** : 50 percent average exceedence flow
- **30 cfs**: The lowest allowed flow under the HCP measure for minimum flows (actual flows may be higher)

Calculating the amount of spawning gravel at the 10 percent and 50 percent exceedence flows, as well as at the minimum allowable flow for each species' peak spawning period, allows for comparisons in the amount of spawning gravel across flows and across years. The amount of gravel wetted at the minimum allowable flow represents the minimum amount of gravel that would be available to each species. The amount of gravel wetted at the 10 percent and 50 percent exceedence flows indicates how far up the margins of the channel gravel accumulates and how much gravel remains available for spawning. This combined information can be used to evaluate the effectiveness of the HCP gravel placement effort at increasing the amount of spawning gravel for steelhead and spring and fall Chinook.

5.2 Spatial Scale

Surveys were used to determine the amount and quality of spawning gravel at various flows within the lower Bull Run River from the mouth (RM 0.0) to the Reservoir 2 spillway plunge pool (RM 5.8). Results are applicable only to the lower Bull Run River and have a reach-scale resolution.

5.3 Replication/Duration

Surveys are conducted once per year in the late spring/early summer or early fall in conjunction with adult Chinook surveys. The surveys occur after high flows associated with winter and spring storms have ceased and spawning gravel patches have stabilized, representing the amount of gravel available to steelhead and later to Chinook spawners for that year. There is no spatial replication; the entire channel is surveyed.

Three pre-treatment surveys were conducted in 2007, 2008, and 2009. These surveys form the baseline against which individual post-treatment years will be compared. One post-treatment survey was conducted each year during HCP Years 2–6, while the maximum amount of gravel supplementation (1,200 cubic yards) occurred. This represents the period of time when gravel was expected to accumulate most rapidly in the lower Bull Run River. The final year of maximum gravel supplementation was 2014.

After gravel supplementation is reduced in Year 6 (2015) of the HCP (to the maintenance level of 600 cubic yards), gravel surveys will continue once per year for an additional five years, HCP Years 7–11. During this phase, gravel supplementation is primarily intended to maintain gravel deposits in the lower Bull Run River and surveys are designed to allow for an analysis powerful enough to detect negative trends in the surface area of spawning gravel.

Provided that gravel supplementation at maintenance levels does not result in a rapid negative trend during HCP Years 7–11, the frequency of gravel surveys will be reduced to once every five years for the duration of the HCP.

5.4 Variables

The following variables were measured for each gravel patch:

Longitudinal Location. Location relative to the beginning of the reach, measured with a hand-held global positioning system (GPS) device

Lateral Location. Location within the channel—in the center of the channel, in the channel margin, or above the channel margin (outside the wetted area but within the active channel)

Retention Feature. Feature that acts on the current to allow gravel deposition: pool-tail, boulder, bedrock, large wood, and/or slow margins

Patch Size. Surface area of patch (square feet), calculated as total length multiplied by average width

Depth or Elevation. For submerged patches, depth of the center of the patch below the water surface; for gravel patches above the water surface, elevation of the center of the patch above the water surface

Embeddedness. The visually estimated percentage of the vertical dimension of surface substrates between 1.8 inches and 4 inches intermediate axis (roughly golf-ball size to softball size) that is surrounded by silt and sand. Average of 10 particles per patch of varying sizes. The percentage of total embeddedness is calculated as

%Total Embedded=([(%Embedded large particles/100)*(100-% fines)]+[% fines])/100

(Embeddedness procedures are reviewed in Sylte and Fischenich 2002).

Percentage of Fines. Estimated surface area of patch covered by silt and sand (not a thin film over other obvious surface substrates)

Upper and Lower 10th Percentile of Substrate Size. The sizes of particles corresponding to the upper and lower 10th percentile for each gravel patch were visually estimated. Particle size reflects the intermediate axis of the particle, or the axis that controls the particle's passage through a sieve

5.5 Sampling Scheme

Sampling protocols were slightly altered from those described in Appendix F of the HCP.

The lower Bull Run River was divided into a total of 16 segments, each one 2,000 feet in length. These smaller divisions will provide for greater resolution when tracking the dispersal of gravel through time than the original six reaches proposed in the HCP.

Segments were surveyed from upstream to downstream.

The 2014 survey was conducted at a discharge flow that varied between 23 cfs and 45 cfs, as measured at U.S. Geological Survey (USGS) Gage No. 14140000.

Patches of gravel suitable for spawning steelhead and/or Chinook were identified along the length of the channel. Patches of spawning gravel were defined as being equal to or greater than 9 square feet, lying within the active channel and composed of substrates between 0.1 and 6.0 inches in diameter along their intermediate axis for Chinook and between 0.1 and 4.0 inches in diameter for steelhead.

A HEC-RAS model was developed for the lower Bull Run River, using cross-sections taken from Light Detection and Ranging (LiDAR)[4] data. The model was calibrated using

[4] LiDAR is a method of determining surface topography using reflected returns from a downward-pointed laser mounted on an aircraft. LiDAR has a resolution of 3 feet squared.

actual stage-discharge relationships from USGS Gage No. 14140000, as shown in Figure 1. The depth at each gravel patch at various flow levels was determined using stage-discharge relationships developed for each 2,000-foot river segment.

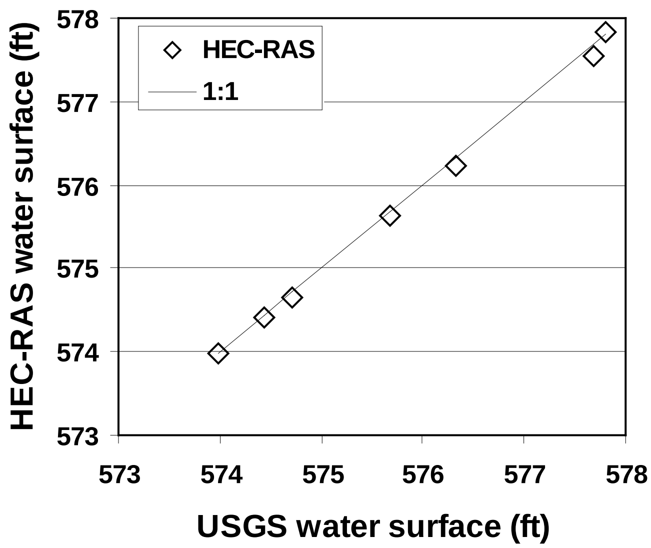


Figure 1. Comparison of HEC-RAS Model River Stage Results with USGS Stage/Discharge Curve Values

6. Analysis

Data Storage. Data are stored in Microsoft® Excel spreadsheets managed by the City of Portland Water Bureau.

Hypothesis Testing. The hypotheses relating each year's measured surface area of gravel to the mean of pre-gravel supplementation years were evaluated using one-tailed, one-sample t-tests (α=0.05).

7. Results

A total of 698 gravel patches with substrate sizes suitable for spawning Chinook were identified within the active channel in 2014, with a total of 62,081 square feet of combined surface area. Of these, 625 patches also had substrate sizes suitable for spawning steelhead, with a total of 53,373 square feet of combined surface area.

7.1 Area of Spawning Gravel

7.1.1 Steelhead

There was more combined surface area of gravel patches with substrate sizes suitable for spawning steelhead in 2014 than the baseline average at all flows. This difference was statistically significant at all flows evaluated (one-sample, one-tailed t-test, α=0.95, df=2). The combined surface area, baseline average, standard deviation, and significance for each flow are summarized in Table 1.

Table 1. Combined Surface Area of Steelhead Spawning Gravel Patches in the Lower Bull Run River, 2014

	120 cfs	614 cfs	1,405 cfs
2014 Survey Results	32,097 ft^2	40,550 ft^2	46,910 ft^2
Baseline Average	5,159 ft^2	8,373 ft^2	12,532 ft^2
Baseline Standard Deviation	2,396 ft^2	4,723 ft^2	5,708 ft^2
Significantly Greater than Baseline?	Yes	Yes	Yes

7.1.2 Spring Chinook

In 2014, there was significantly more combined surface area of gravel patches with substrate sizes suitable for spawning spring Chinook than the baseline average at all flows (one-sample, one-tailed t-test, α=0.95, df=2). The combined surface area, baseline average, standard deviation, and significance for each flow are summarized in Table 2.

Table 2. Combined Surface Area of Spring Chinook Spawning Gravel Patches in the Lower Bull Run River, 2014

	30 cfs	77 cfs	358 cfs
2014 Survey Results	28,264 ft^2	31,710 ft^2	39,730 ft^2
Baseline Average	4,621 ft^2	4,994 ft^2	7,941 ft^2
Baseline Standard Deviation	1,578 ft^2	1,506 ft^2	3,294 ft^2
Significantly Greater than Baseline?	Yes	Yes	Yes

7.1.3 Fall Chinook

In 2014, there was significantly more combined surface area of gravel patches with substrate sizes suitable for spawning fall Chinook than the baseline average at all flows (one-sample, one-tailed t-test, α=0.95, df=2). The combined surface area, baseline average, standard deviation, and significance for each flow are summarized in Table 3.

Table 3. Combined Surface Area of Fall Chinook Spawning Gravel Patches in the Lower Bull Run River, 2014

	30 cfs	77 cfs	1,480 cfs
2014 Survey Results	28,264 ft^2	31,710 ft^2	49,649 ft^2
Baseline Average	4,621 ft^2	4,994 ft^2	13,912 ft^2
Baseline Standard Deviation	1,578 ft^2	1,506 ft^2	5,134 ft^2
Significantly Greater than Baseline?	Yes	Yes	Yes

7.2 Trend over Time

The trend in gravel surface area over time in post-supplementation years has not been statistically significant. Five years of post-supplementation data on gravel surface area have been collected, which is adequate to begin to evaluate whether gravel surface area shows an increasing or decreasing trend over time. Although the total surface area of gravel in post-supplementation years has remained well above the baseline average and increased over time, it has not increased to a statistically significant degree (Figures 2 and 3). The statistical significance of each trend in Figures 2 and 3 is indicated by the p value. Decreasing p values indicate increasing statistical significance, where 95% confidence equates with p=0.05). The lack of statistical significance despite the large increase over time is entirely due to the large amount of variability from year to year.

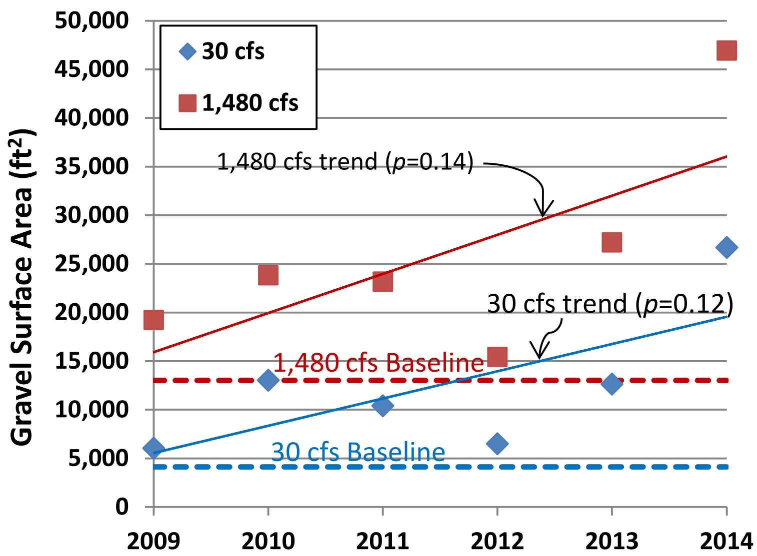


Figure 2. Trends in the Surface Area of Steelhead Spawning Gravel Wetted at 30 cfs and 1,480 cfs in Post-Treatment Years. Baseline Surface Areas are Indicated.

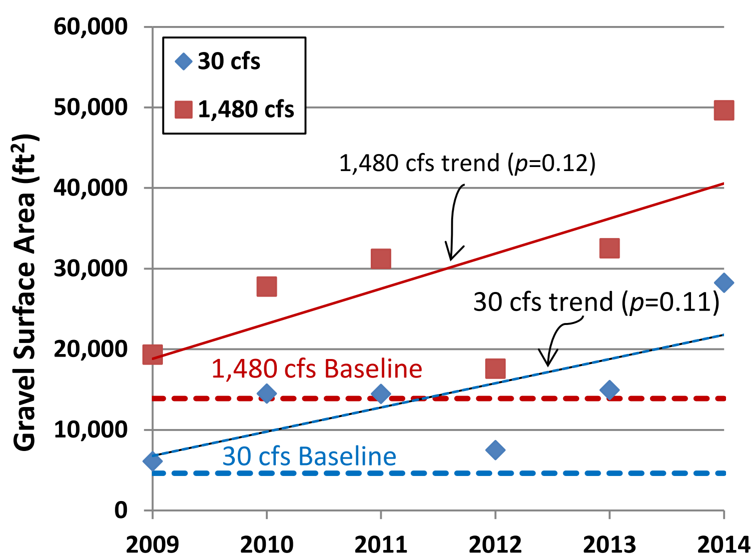


Figure 3. Trends in the Surface Area of Chinook Spawning Gravel Wetted at 30 cfs and 1,480 cfs in Post-Treatment Years. Baseline Surface Areas are Indicated.

7.3 Distribution of Spawning Gravel

7.3.1 Steelhead

In 2014, large accumulations of steelhead spawning gravel were observed adjacent to and downstream of the gravel placement sites (Figure 4). Other accumulations were observed throughout the river downstream of Larson's Bridge. Steelhead gravel accumulations in the lower 1.5 miles of the river channel (mouth to the Bull Run Powerhouse) had decreased from the elevated levels observed in 2013 to the lower range observed in previous years. This suggests that gravel that was placed into the Bull Run River channel in 2010 had, in part, moved to the lowest portions of the river by 2013 and possibly had begun passing out of the river by 2014. Figures 5 and 6 compare the longitudinal distribution of steelhead spawning gravel in 2014 with previous post-treatment years and the baseline at flows that bracket the range of flows being evaluated.

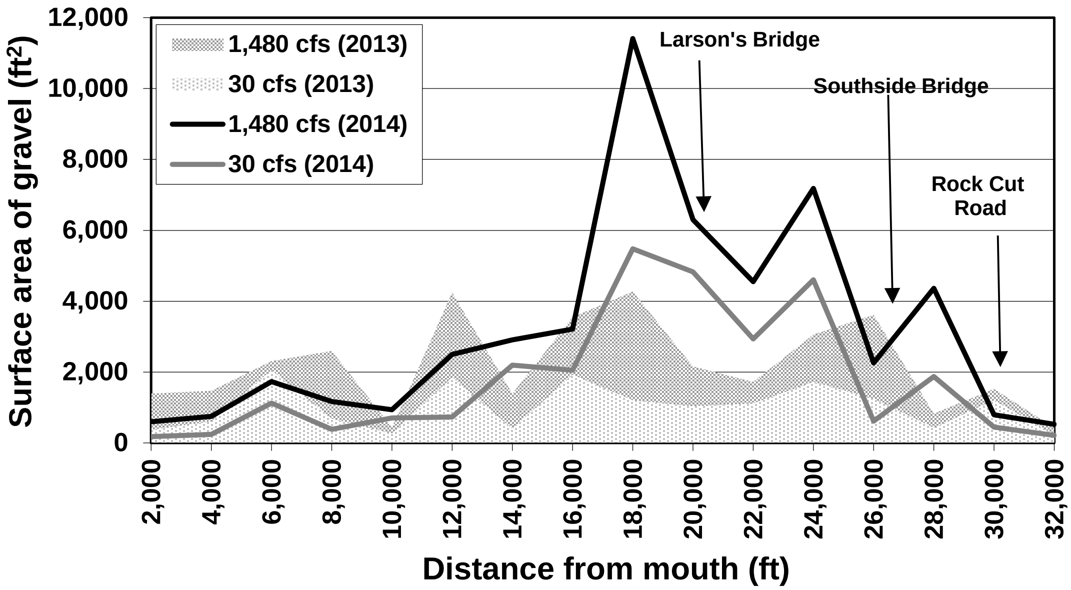


Figure 4. Longitudinal Distribution of Steelhead Spawning-Size Gravel Patches in the Lower Bull Run River in 2014 at 30 cfs and 1,480 cfs Compared to 2013

The largest observed increases in gravel over the baseline occurred in the portion of the channel wetted at relatively low flows (i.e., 120 cfs and less), as shown in Figure 7. The observed increases in the total surface area of steelhead spawning gravel above the baseline were greater in 2014 than what was observed in previous years at all flows. The surface area of steelhead gravel wetted at the lowest flows (120 cfs and less) was over six times the baseline levels.

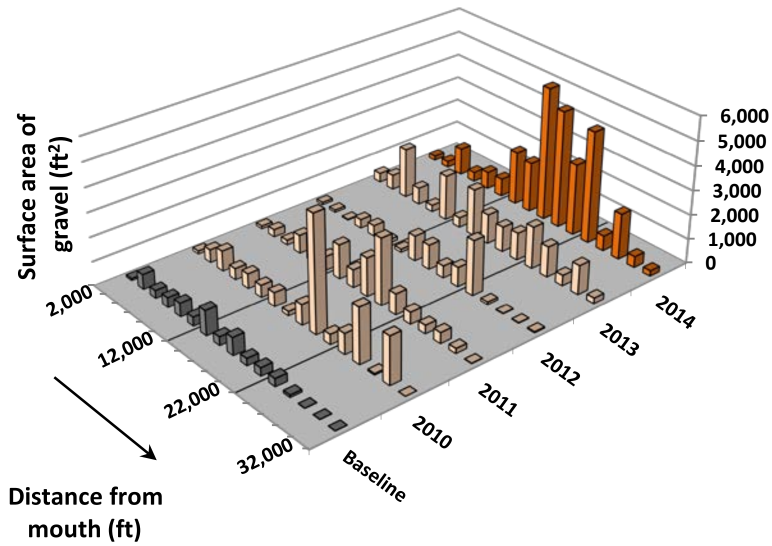


Figure 5. Longitudinal Distribution of Steelhead Spawning-Size Gravel Patches in the Lower Bull Run River in 2010-2014 Compared to the Baseline Average at 30 cfs

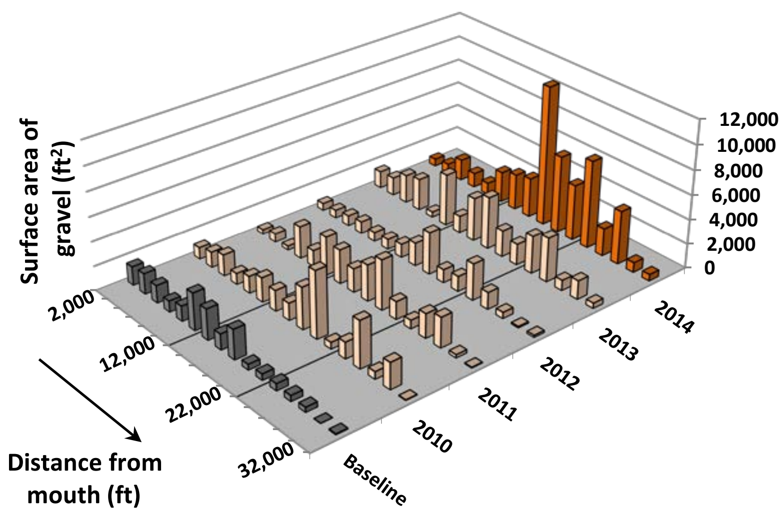


Figure 6. Longitudinal Distribution of Steelhead Spawning-Size Gravel Patches in the Lower Bull Run River in 2010-2014 Compared to the Baseline Average at 1,480 cfs

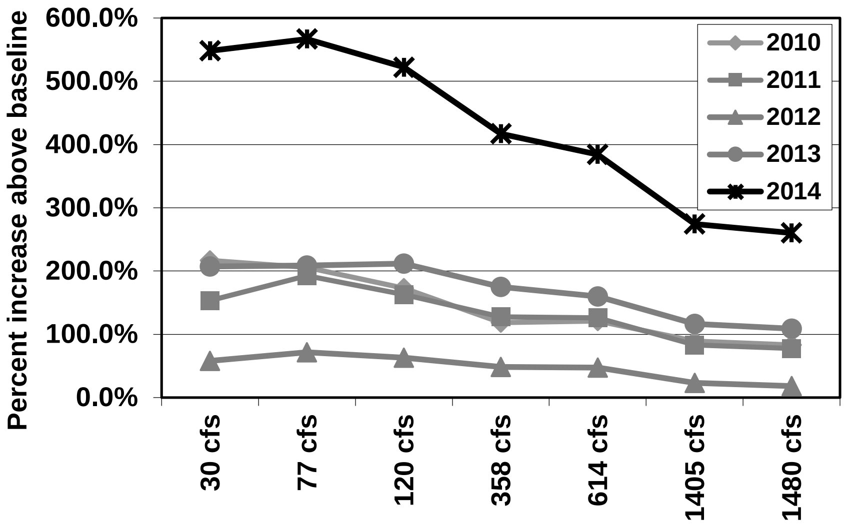


Figure 7. Increase in the Surface Area of Steelhead Spawning-Size Gravel Patches in 2014 above the Baseline Average for Various Flows Compared to Past Years.

7.3.2 Chinook

In 2014, large accumulations of Chinook spawning gravel were observed adjacent to and downstream of the gravel placement sites (Figure 8). Other accumulations were observed throughout the river downstream of Larson's Bridge. Chinook gravel accumulations in the lower 1.5 miles of the river channel (mouth to the Bull Run Powerhouse) had decreased from the elevated levels observed in 2013 to the lower range observed in previous years, as with steelhead gravel. This suggests that gravel that was placed into the Bull Run River channel in 2010 had, in part, moved to the lowest portions of the river by 2013 and had possibly begun passing out of the river by 2014. Figures 9 and 10 compare the longitudinal distribution of Chinook spawning gravel in 2014 with previous post-treatment years and the baseline at flows that bracket the range of flows being evaluated.

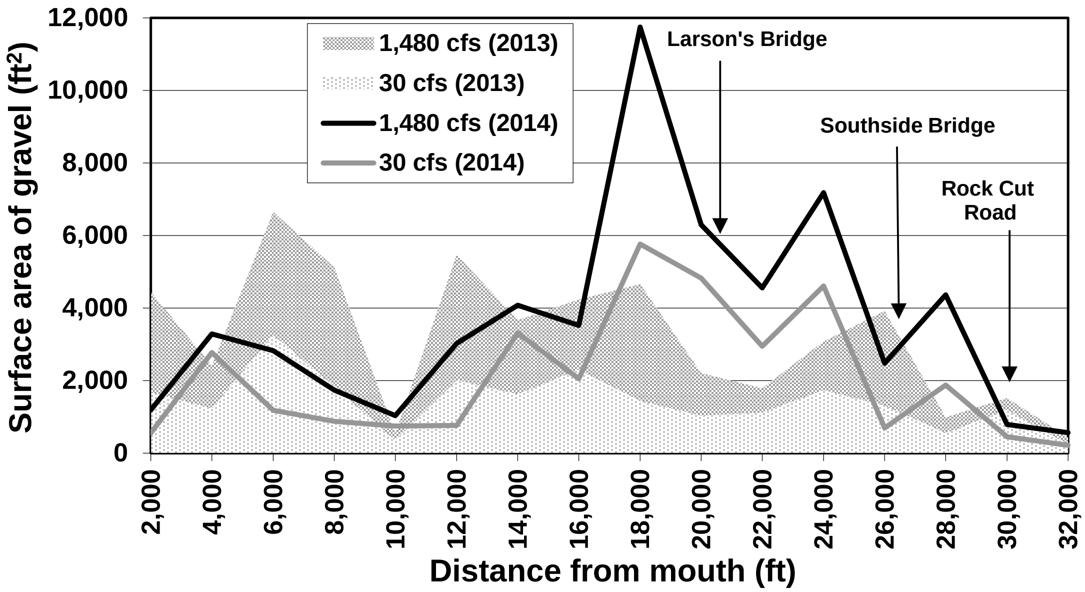


Figure 8. Longitudinal Distribution of Chinook Spawning-Size Gravel Patches in the Lower Bull Run River in 2014 at 30 cfs and 1,480 cfs Compared to 2013

The largest observed increases in gravel over the baseline occurred in the portion of the channel wetted at relatively low flows (i.e., 120 cfs and less), as shown in Figure 11. The observed increases in the total surface area of Chinook spawning gravel above the baseline were greater in 2014 than what was observed in all previous years. The surface area of Chinook gravel wetted at the lowest flows (120 cfs and less) was over six times the baseline levels.

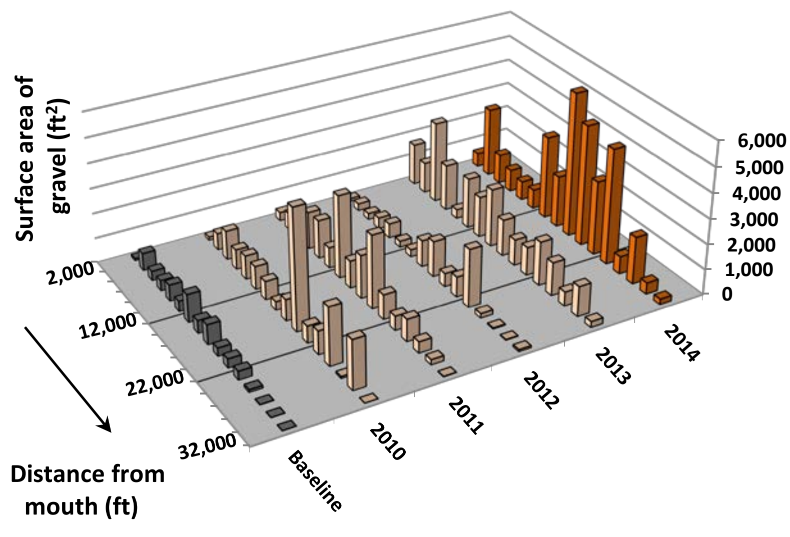


Figure 9. Longitudinal Distribution of Chinook Spawning-Size Gravel Patches in the Lower Bull Run River in 2010-2014 Compared to the Baseline Average at 30 cfs

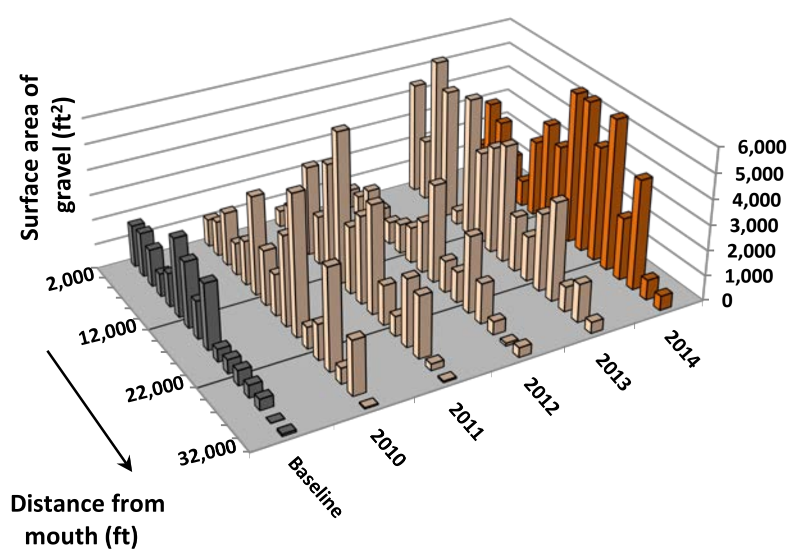


Figure 10. Longitudinal Distribution of Chinook Spawning-Size Gravel Patches in the Lower Bull Run River in 2010-2014 Compared to the Baseline Average at 1,480 cfs

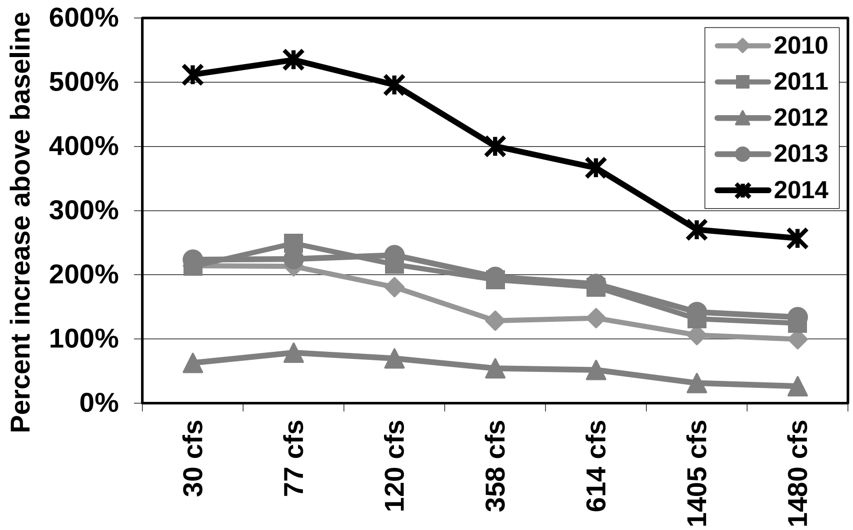


Figure 11. Increase in the Surface Area of Chinook Spawning-Size Gravel Patches in 2014 above the Baseline Average for Various Flows Compared to Past Years

8. Summary and Discussion

The total surface area of spawning-sized gravel was significantly greater in 2014 than in baseline years at all flows for both steelhead and Chinook at a 95% level of statistical confidence. Gravel was concentrated in portions of the Bull Run River immediately downstream of the gravel placement sites, with the largest accumulations downstream of Larson's Bridge. Gravel accumulations in the lowest 1.5 miles of the river were near baseline levels, despite being elevated in 2013. This may suggest that some gravel first placed in 2010 had worked its way to the furthest downstream portions of the Bull Run River and may be starting to pass out of the river. The gravel that was retained in the lower 1.5 miles of the river channel was skewed towards larger sizes, more useful to Chinook than to steelhead (Figure 12). This pattern matches what would be expected if the gravel deposits first observed in 2013 were being washed into deep pools or out of the river, leaving behind only the larger, less mobile stones.

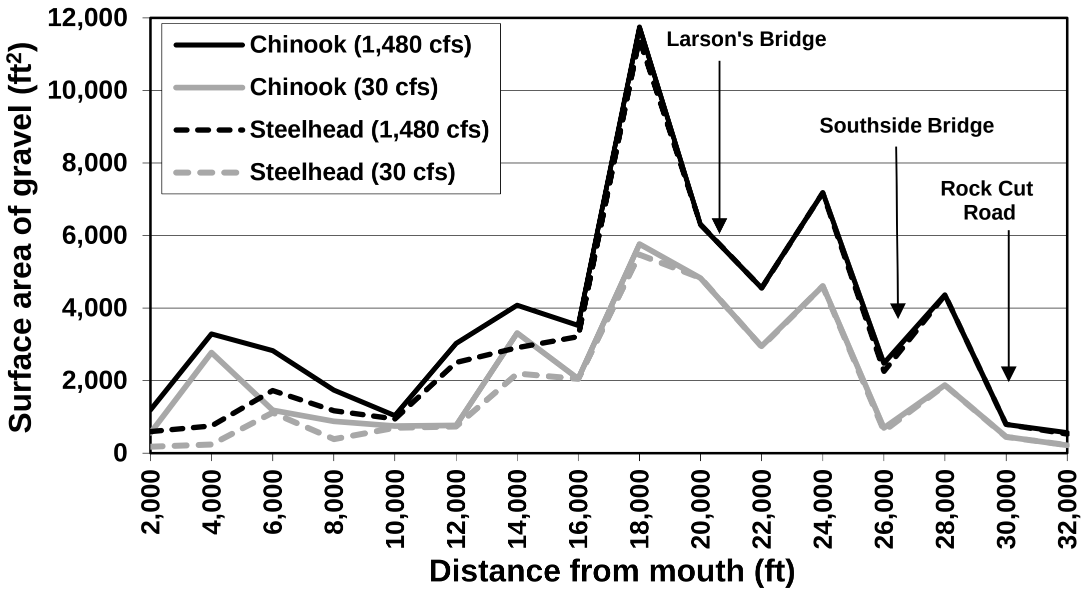


Figure 12. Comparison of Longitudinal Distribution of Chinook and Steelhead Spawning-Size Gravel Patches in the Lower Bull Run River in 2014 at 30 cfs and 1,480 cfs

The largest percentage increases in the surface area of gravel have occurred in the parts of the river that are wetted at relatively low flows. Approximately half of the total surface area of gravel patches was wetted at flows of 120 cfs and less. The surface area of gravel in this part of the channel was more than six times the baseline levels.

9. Works Cited

CH2M HILL. 2003. Lower Bull Run River Bedload Rate Approximations, Technical Memorandum to Steve Kucas, Portland Bureau of Water Works. February 20, 2003. Portland, Oregon.

R2 Resource Consultants. 1998. Spawning Gravel Survey of the Lower Bull Run River, Oregon. Revised draft report, prepared for the Portland Bureau of Water Works. May 27, 1998. Portland, Oregon.

Portland Water Bureau. 2008. Bull Run Water Supply Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species. Portland, Oregon.

Sylte, Traci, and Craig Fischenich. 2002. Techniques for Measuring Substrate Embeddedness. EURPP Technical Notes Collection (ERDC TN-EMRPP-SR-36). U.S. Development Center, Vicksburg, Mississippi.

Appendix D

Bull Run HCP Research Report

Total Dissolved Gases in the Bull Run River

April 2015

Burke Strobel
City of Portland Water Bureau

Contents

Tables

Figures

1. Summary

The City of Portland Water Bureau (PWB) was in full compliance with its Habitat Conservation Plan (HCP; Portland Water Bureau 2008) obligations with regard to total dissolved gas (TDG) monitoring in the Bull Run River in 2014. No additional TDG data were collected in 2014 because the target flows for monitoring never occurred at a time when personnel were available to collect measurements.

PWB has measured TDG levels in the Bull Run River since 2005. PWB has measured TDG levels in excess of 110 percent at river flows below the 10-year, 7-day average flood (7Q10) flow on two occasions at one of the sites and one occasion at a second site. The measurements, however, were made in water which had passed over a spillway and represented only a portion of the total flow in the river at the time. On all of these occasions, the remaining flow had lower TDG levels and the combined flow had a calculated TDG level below 110 percent.

PWB's TDG monitoring has been affected by modifications of water infrastructure associated with the implementation of another HCP measure. The relationship between TDG levels and spill at the Dam 2 spillway has changed since the removal of a rock weir at the spillway plunge pool tailout. TDG levels of water from the diversion pool have also increased since removal of the rock weir. PWB will continue monitoring to describe these changes.

This appendix summarizes the results to date of PWB's TDG monitoring in the Bull Run River.

2. Introduction

The level of total dissolved gas is the sum of the partial pressures of all gases, including water vapor, dissolved in a volume of water. Elevated levels of TDG in water can have various negative impacts on fish, such as the formation of gas bubbles in tissues and the vascular system (gas bubble disease) and over-inflation of the air bladder. Extremely high levels of TDG or long exposure times can lead to immediate or delayed mortality.

Oregon's Water Quality Standards, as enforced by the Oregon Department of Environmental Quality (ODEQ), state that the concentration of TDG relative to local barometric pressure should not exceed 110 percent of saturation [OAR 340-041-0031]. An exception is made when stream flows at a given sampling site exceed the 10-year, 7-day average flood (7Q10), defined as the yearly peak 7-day rolling average high flow that has an average recurrence interval of 10 years.

In 2005, PWB initiated a monitoring plan to check TDG levels associated with the water facilities in the Bull Run Watershed. The plan, developed in consultation with ODEQ, identified sites at risk of elevated TDG levels and established a sampling regime specific to each sampling site, with a set number of data to be collected. Many of these data had already been collected prior to 2012.

The TDG sampling plan developed by PWB has been altered from what was described in the HCP due to two infrastructure modifications in the Bull Run Watershed. These modifications were necessary to comply with another measure in the PWB's HCP, Measure T-2, Post-Infrastructure Temperature Management and include 1) the removal of a rock weir at river mile (RM) 5.8, completed in 2011, and 2) the installation of a multiple-level intake on one of the Dam 2 intake towers, completed in 2014.

Removal of the rock weir has altered the usefulness of certain TDG monitoring sites and may have changed TDG levels under certain flows. The rock weir slowed the passage of water through the Dam 2 spillway plunge pool. Its removal allows cool water to quickly flow downstream with less warming than before, to the benefit of salmon and trout. In the absence of the rock weir, however, spillway water with high TDG levels and Powerhouse 2 water with lower TDG levels, which meet in the plunge pool, have less opportunity to mix before flowing downstream. As a result, certain TDG sites, selected to monitor fully mixed water, are no longer useful. In addition, without the rock weir, spillway water plunges additional feet to the lowered pool surface. This could change TDG levels at the base of the spillway from what they would have been with the rock weir.

Modifications to the intake tower could lead to a change in TDG levels in water coming from the diversion pool. Water that passes from the intake tower through Powerhouse 2 into the diversion pool has relatively low TDG levels. This relatively low-TDG water mixes with water from the spillway, decreasing the higher TDG levels of the spillway water. TDG levels entering the diversion pool from Powerhouse 2 may have been altered, however, by modification of the intake tower. TDG levels for the water from the diversion pool may have been further altered by the removal of the rock weir, which changed the water surface elevation and velocity through the spillway plunge pool. TDG levels greater than 110 percent at flows less than the 7Q10 flow could result.

Alterations have been made to the TDG monitoring plan to accommodate these changing conditions in the Bull Run River. These alterations are described in the 2011 Annual Compliance Report (Portland Water Bureau 2012). This appendix describes results to date for monitoring TDG levels in the lower Bull Run River.

3. Research Objectives

The TDG research results will be used to determine whether there are locations in the lower Bull Run Watershed with elevated concentrations of TDG. The sites will be monitored across a range of flows.

4. Key Questions and Hypotheses

There are three key questions to be answered by this TDG monitoring plan. Two of the questions have a null hypothesis (H_o) that will be tested with the monitoring protocol; the third question will be addressed by field observation. The questions are as follows:

Question 1: Do any of the monitoring sites exceed the ODEQ standard of 110 percent saturation of TDG?

> H_o: At each monitoring site, the observed TDG concentration will not exceed 110 percent of saturation within any range of flow, as defined in Table F-7 of the HCP, unless the flow exceeds the 7Q10 for the lower Bull Run River.

Question 2: At sites where TDG levels exceeding 110 percent are observed, are there flow ranges associated with excessive TDG levels?

> H_o: At each site with observed TDG levels in excess of 110 percent, there is no relationship between amount of flow and measured levels of TDG.

Question 3: How quickly do elevated levels of TDG dissipate downstream when they are observed?

This key question does not have an associated null hypothesis. It involves the collection of information to assist in the adaptive management process.

5. Monitoring Design

5.1 Sites

PWB, in conjunction with ODEQ staff, identified all watershed structures associated with City operations that could cause elevated levels of TDG. These structures include the spillways, valves, and turbines in which air bubbles could be brought under sufficient pressure to cause their dissolution in water beyond the level of saturation.

Monitoring locations were established to monitor the effects of each specific structure on TDG levels, or to provide information on the persistence of TDG downstream. The monitoring sites, the associated structures that increase the risk of elevated TDG concentrations, and the purposes of measuring each site are summarized in Table 1. Additional sites are also monitored to provide information on the effects of water mixing from various sources and the effects of downstream dissipation on elevated TDG levels. All locations of monitoring sites are shown in Figures 1 and 2.

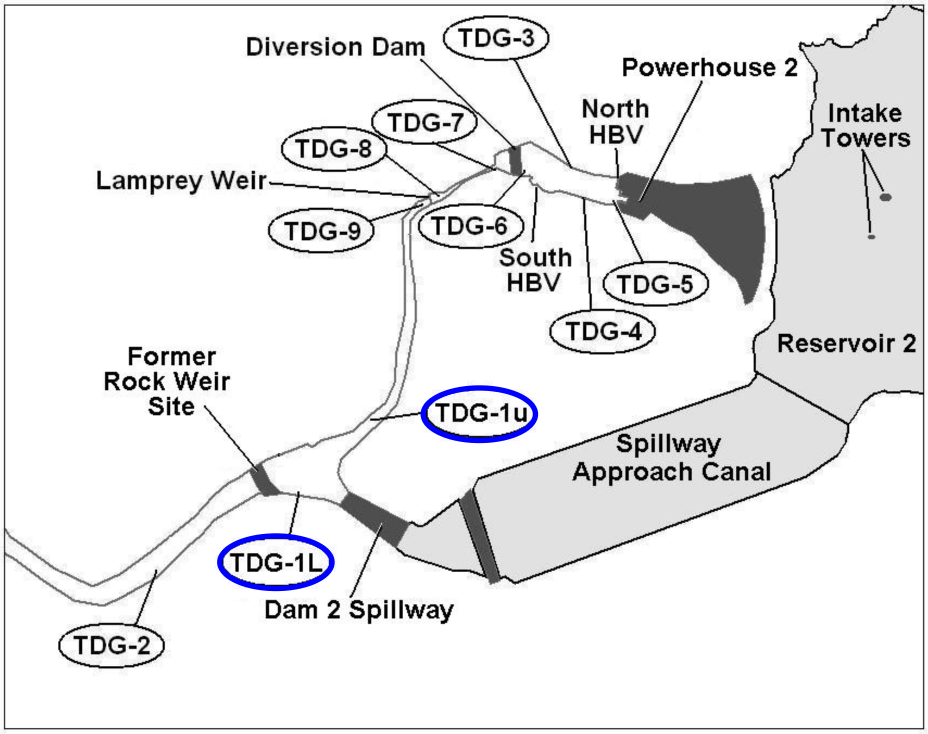


Figure 1. Locations of TDG Monitoring Sites Associated with Dam 2[a]

[a]Monitoring sites TDG-1L and TDG-1u were added in 2011 to replace sites TDG-1 and TDG-1a.

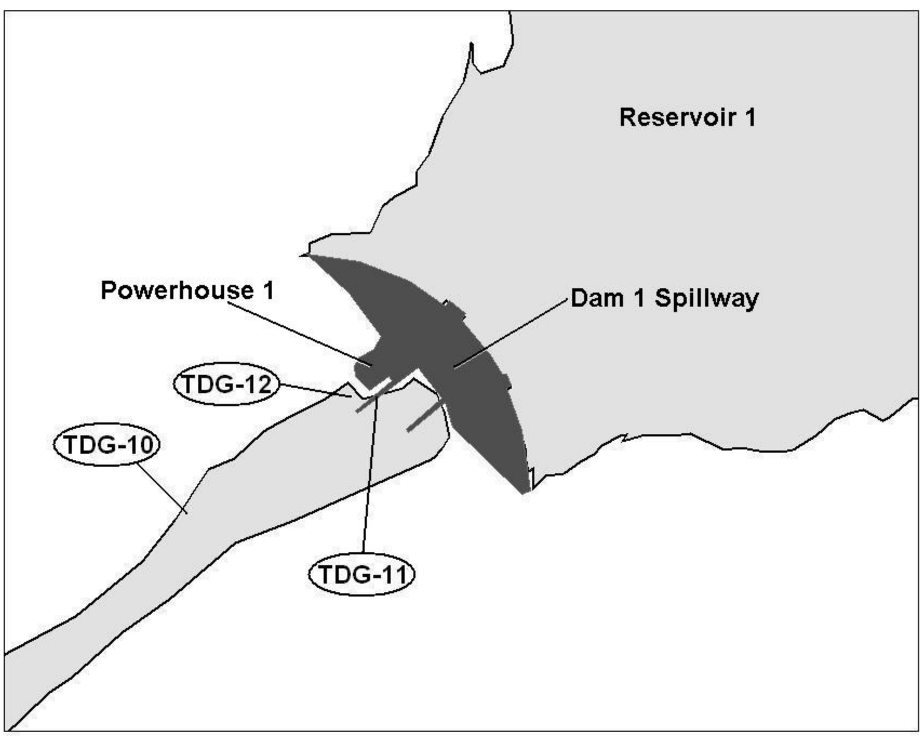


Figure 2. Locations of TDG Monitoring Sites Associated with Dam 1

Two sites listed in Table 1, TDG-1L and TDG-1u, are monitored in tandem and used to calculate a TDG value for mixed water from both the Dam 2 spillway and the diversion pool (Powerhouse 2 flow and Howell-Bunger valve flow). The TDG level of mixed flows was originally monitored at site TDG-1a, located immediately downstream of the Dam 2 spillway plunge pool rock weir. After the removal of the rock weir, however, there was no longer an adequate site where fully mixed flows could be monitored before elevated TDG levels had a chance to dissipate. The City replaced TDG-1a by monitoring the two sources of water that mix in the plunge pool and using their relative contribution to calculate a combined-flow TDG value.

Table 1. TDG Monitoring Sites, Associated Structure, and Purpose of Measuring

Monitoring Site	Associated Structure	Purpose
TDG-1L, TDG-1u[a]	Dam 2 Spillway	Structure Effects
TDG-2	Dam 2 Spillway	Downstream Effects
TDG-3	South Howell-Bunger Valve	Structure Effects
TDG-4	North Howell-Bunger Valve	Structure Effects
TDG-5	Powerhouse 2	Structure Effects
TDG-6	Diversion Dam	Structure Effects (Upstream Value)
	Powerhouse 2	Downstream Effects
TDG-7	Diversion Dam	Structure Effects (Downstream Value)
TDG-8	Lamprey Weir	Structure Effects (Upstream Value)
	Diversion Dam	Downstream Effects
TDG-9	Lamprey Weir	Structure Effects (Downstream Value)
TDG-10	Dam 1 Spillway	Downstream Effects
	Powerhouse 1	Downstream Effects
TDG-11	Dam 1 Spillway	Structure Effects
TDG-12	Powerhouse 1	Structure Effects

[a]TDG-1L and TDG-1u sites were added in 2011; TDG-1 and TDG-1a are no longer monitored.

Each site has a unique span of possible flows, associated with its longitudinal position along the Bull Run River and its function as a part of the City's water and hydroelectric facilities. Flows passing through each of the two powerhouses are measured by flow sensors in the penstocks and are constrained by the minimum flows required to run the turbines and the maximum flows that the turbines can accommodate. Flows passing over each dam's spillway are estimated by employing stage/discharge rating curves established for each spillway. The flows are constrained only by the range of natural variability in the Bull Run River as modified by the water diversions and withdrawals by PWB.

For most of the structures, the historical span of flows was divided into three equal parts or flow ranges. Each flow range will be sampled with replication. The ranges of flows for each structure in cubic feet per second (cfs) and the number of replicates for sampling are identified in Table 2. Sites located downstream of structures are for the purpose of monitoring the persistence of TDG concentrations and will be sampled on the same day as the associated upstream sites (for example, TDG-10 is downstream of TDG-11, the Dam 1 Spillway, and TDG 12, Powerhouse 1).

Table 2. Flow Ranges and Number of Replicates per Flow Range for Sampling TDG

Structure	Flow Ranges (cfs)	Number of Replicates
Dam 2 Spillway	1,700–6,900	5
	6,900–12,000	5
	12,000–17,200	5
Powerhouse 2	210–700	5
	700–1,200	5
	1,200–1,700	5
South HB Valve[a]	While operating	5
North HB Valve[a]	While operating	5
Diversion Dam	Whenever Powerhouse 2 or HB valve readings are taken	15 to 20
Lamprey Weir	Whenever Powerhouse 2 or HB valve readings are taken	15 to 20
Dam 1 Spillway	2,000–5,500	5
	5,500–8,900	5
	8,900–12,400	5
Powerhouse 1	800–1,200	5
	1,200–1,600	5
	1,600–2,000	5

[a]HB =Howell-Bunger

Two Howell-Bunger (HB) valves at Reservoir 2 provide a route for releasing water that bypasses the hydroelectric turbines and the spillway. The HB valves dissipate energy associated with the head pressure behind the dam. Monitoring sites have been located at the outlet of each HB valve. No range of flows has been established for the HB valves. Each site will be sampled several times when the respective valve is in operation.

The 7Q10 for the lower Bull Run River was calculated from historical records from January 1, 1940, to December 31, 2013; it is currently estimated to be 5,712 cfs. The 7Q10 for the Dam 1 spillway was calculated from historical records from January 1, 1976 to December 31, 2013; it is currently estimated to be 4,371 cfs. When flows of these magnitudes occur or are exceeded, sampling will continue; however, the ODEQ standard of 110 percent saturation for TDG will not apply. PWB will update the 7Q10 flow amounts annually for future monitoring purposes.

5.2 Spatial Scale

All data collected on TDG are site-specific. Downstream sites have been included to determine the spatial extent of elevated TDG exposure.

5.3 Replication/Duration

Each site will be monitored until the full set of ranges, as defined in Table 2, has been adequately sampled. Each site will be sampled five times within each flow range; some sampling has already been conducted. The sites associated with the diversion pool dam next to the Headworks facility and the lamprey weir will be sampled as often as possible when the Powerhouse 2 sites are sampled. Downstream sites will be sampled as often as possible when the associated upstream sites are sampled. The HB valve sites will be sampled five times each during valve operation.

Monitoring at all sites associated with the Dam 2 spillway plunge pool was reinitiated after the removal of the rock weir. Once the relationship of TDG percent saturation for each site and set of variables has been established, further monitoring will rely on tracking the environmental variables, such as water temperature and flow, rather than sampling TDG.

5.4 Parameters

On each sampling occasion, the following information is recorded:

- TDG percent saturation
- Water temperature
- Date and time of day
- Flow at the respective structure (e.g., spillway or powerhouse)

5.5 Sampling

TDG percent saturation and water temperature are measured using a Point Four Systems PT4 Tracker Total Dissolved Gas Pressure (TDGP) meter. Flow at the time of measurement is obtained from data gathered at PWB's water facilities by staff.

6. Analysis

Linear regression is used to explore the relationship between TDG levels and flow at each of the dam spillways. In those instances in which the 110 percent TDG criterion is exceeded, a regression model is developed that predicts the conditions under which TDG concentrations might exceed 110 percent at each site. In the future, nonlinear multiple regression may be used to try to use water temperature as a covariate to better model the relationship between flow and TDG concentrations.

The dissipation of elevated TDG concentrations downstream of their sources will be characterized and evaluated across levels of flow using Analysis of Covariance (ANCOVA) of log-transformed data.

7. Results

7.1 Data Collected

Because of the flows observed in the Bull Run River and their timing, no TDG data were collected in 2014. Table 3 summarizes the structures in the lower Bull Run River that are being monitored for TDG and the number of data points that remain to be collected for various flows. The remaining number of replicates for the Dam 2 spillway reflects the fact that monitoring for this structure was reinitiated in 2011 following the removal of the rock weir. All TDG data collected to date are summarized in Exhibit A at the end of this report.

Table 3. Flow Range for Each Structure and Number of TDG Measurements Yet to be Collected

Structure	Flow Ranges (cfs)	Remaining Number of Replicates
Dam 2 Spillway	1,700–6,900	0
	6,900–12,000	4
	12,000–17,200	5
Powerhouse 2	210–700	4
	700–1,200	5
	1,200–1,700	0

Table 3. Flow Range for Each Structure and Number of TDG Measurements Yet to be Collected

Structure	Flow Ranges (cfs)	Remaining Number of Replicates
South HB Valve	While operating	1
North HB Valve	While operating	3
Diversion Dam	Whenever Powerhouse 2 or HB valve readings are taken	3
Lamprey Weir	Whenever Powerhouse 2 or HB valve readings are taken	3
Dam 1 Spillway	2,000–5,500	1
	5,500–8,900	5
	8,900–12,400	4
Powerhouse 1	800–1,200	5
	1,200–1,600	5
	1,600–2,000	0

[a]HB=Howell-Bunger

TDG levels of greater than 110 percent saturation have been measured at three of the monitoring sites illustrated in Figures 1 and 2 in the last eight years, when the total flow of the river was greater than the 7Q10 flow: the Dam 2 spillway on the left bank (TDG-1L), downstream of TDG-1L (TDG-2), and the Dam 1 spillway (TDG-11).

There is the potential for TDG levels to be greater than 110 percent saturation even if the flows are less than the 7Q10 amount. If the total river flow were under the 7Q10 flow for the sites and all flow went over the spillways at either Dam 1 or 2, the levels could be greater than 110 percent. The highest TDG level observed at these sites during spillway flows less than the 7Q10 flow has been 114 percent. On all of these occasions, however, a portion of the total flow of the river had passed through the Dam 1 and Dam 2 powerhouses and the combined flows are calculated to have had TDG levels less than 110 percent.

Subsection 7.2 describes the spillway flow at which the 110 percent threshold is predicted to be exceeded in relationship to the 7Q10 flows for each spillway. Subsection 7.3 describes the calculated effects of mixing of spillway flows and powerhouse flows on TDG levels in the Bull Run River.

7.2 TDG/Spillway Flow Relationships

Because TDG saturation greater than 110 percent has been measured at two of the locations listed in Table 2, the spillways associated with Dam 1 and Dam 2, PWB studied the relationship between spillway flows and TDG levels. At the Dam 2 spillway, there was a relationship (R^2=0.81) between flow over the Dam 2 spillway and TDG measurements at the foot of the spillway (TDG-1L). After the rock weir was removed, that relationship changed. At the Dam 1 spillway, there is no clear relationship between TDG saturation and spillway flow.

After the removal of the rock weir below the Dam 2 spillway, the threshold of 110 percent TDG saturation was predicted to be exceeded at TDG-1L at a spill of approximately 2,580 cfs, as shown in Figure 3. This left a range of flows between 2,580 and 5,712 cfs for which this site had the potential for being in violation of ODEQ's TDG standards if all of the Bull Run flow were to pass over the spillway. This range of flows is larger than it was prior to the removal of the rock weir, when this site had the potential to be in violation of TDG standards between 3,740 cfs and 5,702 cfs. The TDG level at TDG-1L is predicted to be 114 percent at the 7Q10 flow if all of that flow is passing over the spillway and none of it is passing through Powerhouse 2 or the Howell-Bunger valves into the diversion pool.

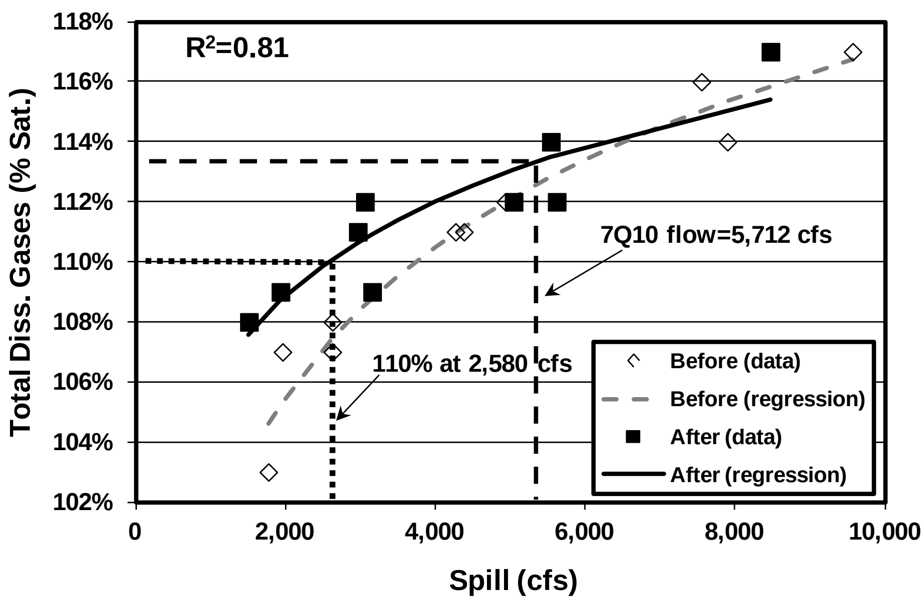


Figure 3. Relationship of TDG Percent Saturation to Flow over the Dam 2 Spillway (TDG-1L) Post-Rock Weir Removal Compared to Pre-Rock Weir Removal Relationship

No TDG data were collected at the Dam 1 spillway in 2014. Figure 4 illustrates the observed effects of Dam 1 spillway flows on measured TDG values. There was no apparent relationship between flow over the Dam 1 spillway and TDG measurements. TDG values in excess of 110 percent saturation have been measured twice in the Dam 1 spillway, at spillway flows of 2,177 cfs and 2,804 cfs. Spillway flows much higher than these (e.g., 10,158 cfs), however, resulted in TDG measurements below 110 percent. The large variation in TDG measurements at this site could result from the extreme water turbulence in the Dam 1 spillway, making it difficult to obtain a reliable measurement.

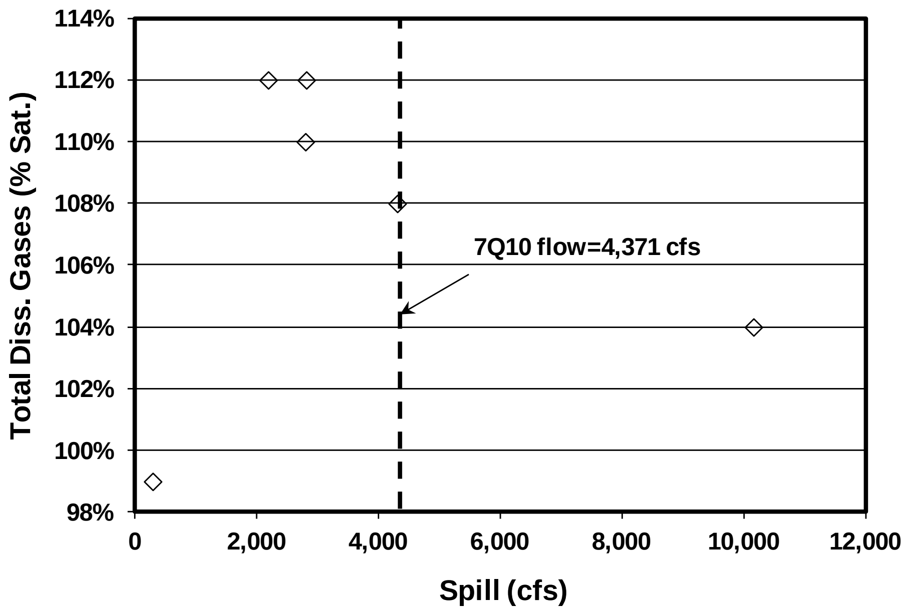


Figure 4. Relationship of TDG Percent Saturation to Flow over the Dam 1 Spillway (TDG-11)

7.3 Effects of Hydropower Water on TDG

The flows from Powerhouse 2, with their lower TDG levels, are expected to reduce the overall TDG level of the flow when combined with Dam 2 spillway flows, similar to what has occurred under previous conditions. Even though TDG levels have exceeded 110 percent at two Bull Run structures, monitoring data indicate that normal water supply operations prior to removal of the rock weir probably had reduced those concentrations through the mixing of powerhouse and spillway water at flows below the 7Q10.

The diluting effect of the water from Powerhouse 2 appears to have changed since the removal of the rock weir. The Bull Run Dam 2 powerhouse diverts a maximum of 1,700 cfs for electricity generation. Typically, this powerhouse has operated at close to maximum capacity when flows in the Bull Run River are high enough to allow it. Prior to rock weir removal, the diverted water downstream of Powerhouse 2 had an average TDG level of 103 percent saturation just before it mixed with water from the Dam 2 spillway. This diverted water had modified the TDG/flow relationships discussed in Section 7.2 and brought the calculated combined TDG level down to below 110 percent at the 7Q10 flow. Since the removal of the rock weir, however, the diverted water downstream of Powerhouse 2 has had an average TDG level of 105.6 percent saturation just before it mixed with water from the Dam 2 spillway. When Powerhouse 2 is operating at full capacity, such as during high-flow events, the water that is diverted is now calculated to decrease the TDG level of the combined flow (powerhouse + spillway) to 110.2 percent saturation at the 7Q10 flow, as shown in Figure 5. The TDG level of the combined flow is predicted to exceed 110 percent saturation above 5,532 cfs. This leaves a narrow window of flows between 5,532 cfs and 5,712 cfs when the 110 percent TDG saturation threshold could theoretically be exceeded below the 7Q10 flow. TDG levels are predicted to be 110.2 percent at the 7Q10 flow, with dilution.

The reason for the observed increase in TDG levels in water from the diversion pool is unclear. The City began using a new TDG meter in 2012, but the new meter has measured values similar to the old meter at locations where there have been no infrastructure changes, such as the Dam 1 Powerhouse (TDG-12). Upstream structures such as the lamprey weir have also shown no corresponding TDG level increase. It is possible that the removal of the rock weir has inadvertently increased TDG levels in water originating from the diversion pool by lowering the water surface of the spillway plunge pool. The accompanying increase in the plunge of water from a cascade immediately upstream of TDG-1u and increased velocity of water from that location to where it joins the water from the Dam 2 spillway may have increased TDG levels slightly and reduced the opportunity for off-gassing.

The relationship between combined TDG levels and combined flows might change if the TDG level of flows from Powerhouse 2 change further under current conditions with a modified intake tower. There has only been one measurement of TDG at TDG-1u after the modification of the intake tower. This measurement is insufficient to determine whether the intake tower modifications will have an effect on the water from the diversion pool. The relationship illustrated in Figure 5 will also change if Powerhouse 2 is operated at less than maximum capacity.

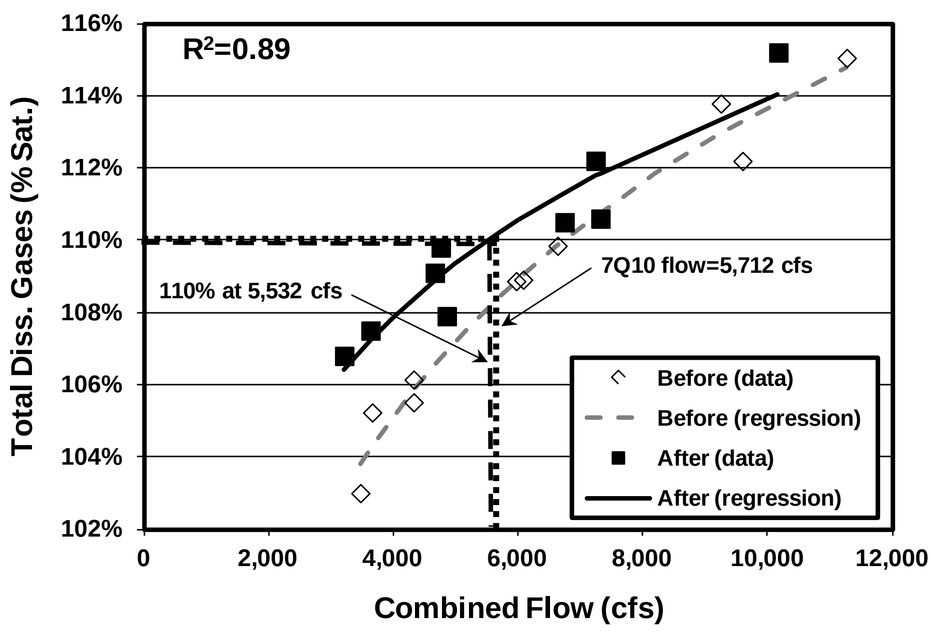


Figure 5. Relationship of TDG Percent Saturation to the Combined Flow of the Dam 2 Spillway and Powerhouse 2 Pre-Rock Weir Removal Compared to Post-Rock Weir Removal

The Bull Run Dam 1 powerhouse generally diverts a maximum of 2,300 cfs for electricity generation. Typically, this powerhouse operates at close to maximum capacity when flows in the Bull Run River are high enough to allow it. Diverted water in the tailrace of Powerhouse 1 has an average TDG level of 108 percent saturation. This diverted water modifies the TDG/flow relationships discussed in Section 7.2. When Powerhouse 1 is operating at full capacity, the calculated TDG levels of the combined powerhouse and spillway flows do not show any relationship to amount of flow, but no TDG levels above 110 percent have occurred below the 7Q10 flow for the site, according to calculations, as indicated in Figure 6.

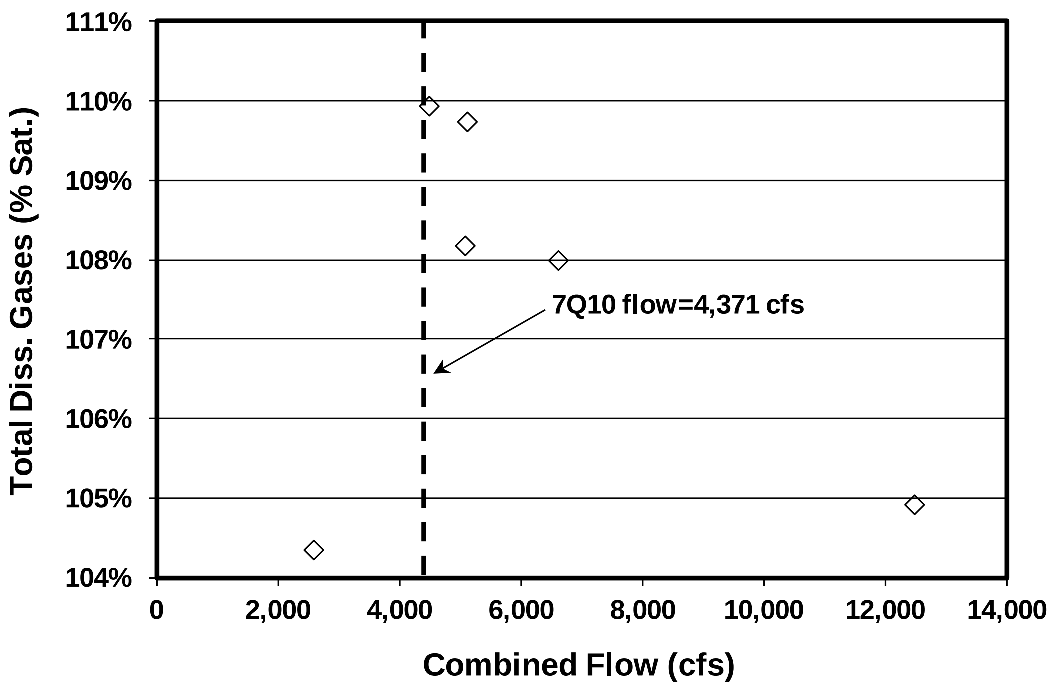


Figure 6. Relationship of TDG Percent Saturation to Combined Flow of the Dam 1 Spillway and Powerhouse 1

PWB does not have a good site to measure the TDG levels of fully mixed water at either the Dam 1 or the Dam 2 spillways, so PWB has started monitoring both spillways and both powerhouse inputs and calculating the TDG of the combined flows. For Dam 1, the flows from the spillway and Powerhouse 1 do not appear to be fully mixed at TDG-10. An island in the middle of the river channel downstream of the Dam 1 spillway pool allows the flow from Powerhouse 1 and the adjacent spillway to remain separate until significant off-gassing is expected to have occurred. For the Dam 2 spillway, in the absence of the rock weir, flows from Powerhouse 2 and the spillway do not appear to mix fully until they have moved further downstream than TDG-2 and some off-gassing has occurred.

Because of these complications, PWB believes that the most meaningful way of estimating the initial TDG of the combined flows at both sites is to calculate TDG using the discharge amount and respective TDG measurements from each powerhouse and each spillway, just before they combine.

7.4 Downstream Dissipation of Elevated TDG

Under the terms of the HCP, PWB monitors the dissipation of TDG levels downstream of the Dam 2 spillway and rock weir structure due to off-gassing. PWB will continue to monitor dissipation rates for various flows above and below the 7Q10 flow to establish rates that can be applied to flows approximately equal to the 7Q10 flow level.

To date, downstream dissipation of TDG levels has been monitored at six flow levels—15,508 cfs (11/7/2006), 6,631 cfs (2/16/2007), 6,097 cfs (12/3/2007), 11,315 cfs (11/13/2008), 6,151 cfs (11/20/2012), and 10,172 cfs (12/2/2013). All of the monitored flows were above the 7Q10 flow for the lower Bull Run River. Two of the monitoring occasions occurred after the removal of the rock weir.

The natural log of TDG percent saturation above equilibrium (i.e., TDG percent saturation minus 100 percent) initially decreased roughly linearly with distance, as depicted in Figure 7. Table 4 summarizes the average distances downstream at which various elevated TDG levels are predicted to dissipate to 110 percent.

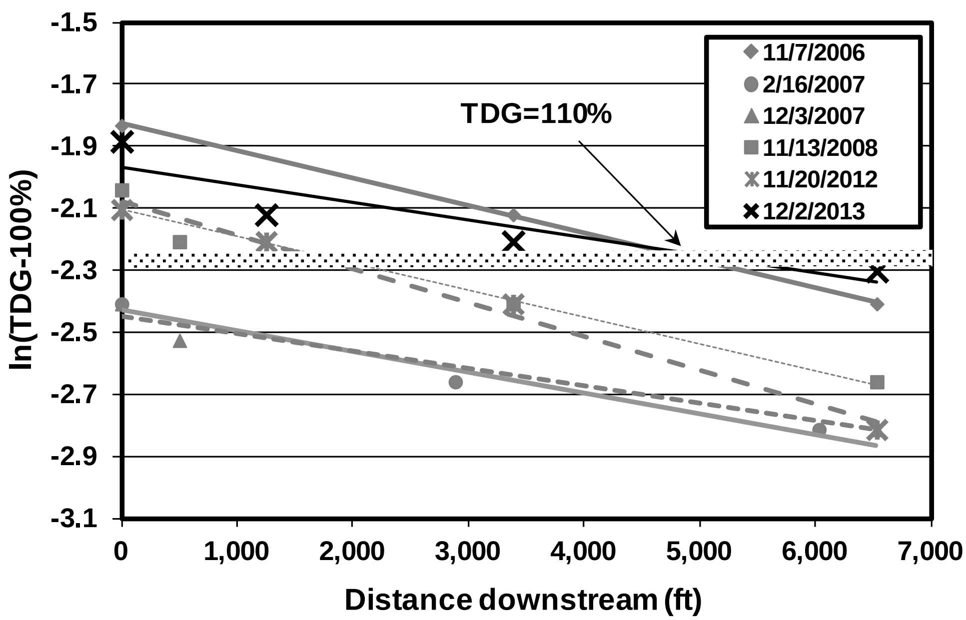


Figure 7. Dissipation of TDG Downstream of the Site of the Rock Weir at the Dam 2 Spillway Plunge Pool on Four Dates

Table 4. Average Distances Downstream at which Various Elevated TDG Levels Are Predicted to Dissipate to 110 Percent

Initial TDG Saturation	Approximate Distance Downstream at which TDG Dissipates to 110%
115%	4,624 feet
114%	3,732 feet
113%	2,774 feet
112%	1,739 feet
111%	613 feet

PWB will continue to monitor the dissipation of TDG levels downstream of the Dam 2 spillway. Future monitoring will focus on lower Bull Run River flows below the 7Q10 level.

8. Conclusions

The monitoring conclusions are organized based on the key questions presented in Section 4.

1. Do any of the monitoring sites exceed the ODEQ standard of 110 percent saturation of TDG?

There were no TDG data collected in 2014. TDG levels have exceeded 110 percent locally at three sites on several occasions, but the combined flow over the spillway and in the river were either above the 7Q10 flow, or had a combined, total TDG for the river of less than 110%.

2. At sites where elevated TDG levels exceeding 110 percent are observed, are there flow ranges associated with excessive TDG levels?

Under current conditions, after removal of the rock weir, TDG levels are predicted to exceed 110 percent at the base of the Dam 2 spillway at a spillway flow above 2,580 cfs.

TDG levels downstream of the spillways are reduced by mixing with water from the powerhouses, which has lower TDG levels than water from the spillways. During normal high-flow conditions in the winter and spring, water is diverted from Reservoirs 1 and 2 and routed through the powerhouses at the base of the dams. If the total river flow is greater than the capacity of the powerhouses, the additional flow goes over the spillways. TDG levels at the Dam 1 and 2 spillway sites are normally reduced by mixing with powerhouse flows downstream of both the Dam 1 and 2 spillways. TDG levels in the water from Powerhouse 2 appear to have increased slightly after the removal of the rock weir, decreasing their diluting benefits. After removal of the rock weir, and with anticipated mixing from Powerhouse 2, TDG levels immediately downstream of the Dam 2 spillway are now calculated to exceed 110 percent at a total river flow of 5,532 cfs.

The TDG levels at the Dam 2 spillway could be slightly higher than 110 percent under flows slightly lower than the 7Q10. This could occur if spillway flows were between 5,532 cfs and the 7Q10 flow of 5,712 cfs and no water was passed through the diversion pool. At the 7Q10 flow, TDG levels are predicted to be 110.2 percent.

There is no apparent relationship between spillway flow and TDG levels at the base of the Dam 1 spillway. TDG levels have exceeded 110 percent saturation at the base of the Dam 1 at flows of 2,177 cfs and 2,804 cfs, but higher flows than these have had lower measured levels of TDG.

3. <u>How quickly do elevated levels of TDG dissipate downstream when they are observed?</u>

If the TDG level is 111 to 115 percent of saturation below the site of the Dam 2 spillway plunge pool rock weir, it dissipates to less than 110 percent within 613 to 4,624 feet downstream. It should be noted that TDG saturation in excess of 110 percent has not been measured below the Dam 2 spillway plunge pool at total river flows below the 7Q10 flow for the site as of the end of 2014.

9. Works Cited

Portland Water Bureau. 2008. Bull Run Water Supply Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species. Portland, Oregon.

Portland Water Bureau. 2012. Bull Run Water Supply Habitat Conservation Plan Annual Compliance Report 2011—Year 2, Final. Portland, Oregon.

Exhibit A. TDG Data Associated with Bull Run Dams 2 and 1

Table A-1. Total Dissolved Gases (TDG) Data Associated with Bull Run Dam 2

Date	Monitoring Site	Percent Saturation	Spillway Flow[a] (cfs)	Powerhouse or HBV[b] Flow (cfs)
1/18/2005	TDG-1	107%	1,959	1,695
1/18/2005	TDG-1	108%	2,624	1,695
12/28/2005	TDG-1	111%	4,380	1,690
1/10/2006	TDG-1	116%	7,550	1,690
11/14/2006	TDG-1	103%	1,770	1,714
12/14/2006	TDG-1	107%	2,624	1,700
2/16/2007	TDG-1	112%	4,932	1,699
12/3/2007	TDG-1	111%	4268	1,690
11/13/2008	TDG-1	114%	7,897	1,560
11/13/2008	TDG-1	117%	9,568	1,560
11/23/2011	TDG-1	105%	2,042	1,585
12/29/2011	TDG-1	111%	3,274	1,596
12/14/2006	TDG-1L	111%	4,346	1,700
2/16/2007	TDG-1L	113%	5,464	1,684
12/3/2007	TDG-1L	111%	3,855	1,710
11/13/2008	TDG-1L	120%	10,611	1,560
11/23/2011	TDG-1L	108%	2,042	1,585
1/19/2012	TDG-1L	112%	3,718	1566
3/16/2012	TDG-1L	111%	3,616	1583
3/30/2012	TDG-1L	112%	6,418	1560
3/31/2012	TDG-1L	109%	2,504	1587
10/29/2012	TDG-1L	112%	5,816	100 (HBV)
11/20/2012	TDG-1L	114%	5,541	510 (HBV)
12/4/2012	TDG-1L	109%	3,155	530 (HBV)
12/2/2013	TDG-1L	117%	8,472	1,700
12/28/2005	TDG-1a	109%	4,380	1,690
11/7/2006	TDG-1a	116%	14,160	1,645
11/14/2006	TDG-1a	102%	1,717	1,714

Table A-1. Total Dissolved Gases (TDG) Data Associated with Bull Run Dam 2

Date	Monitoring Site	Percent Saturation	Spillway Flow[a] (cfs)	Powerhouse or HBV[b] Flow (cfs)
12/14/2006	TDG-1a	103%	2,746	1,700
2/16/2007	TDG-1a	107%	4,932	1,699
12/3/2007	TDG-1a	109%	4,397	1,700
11/13/2008	TDG-1a	113%	7,766	1,560
11/13/2008	TDG-1a	114%	9,755	1,560
11/23/2011	TDG-1a	104%	1,959	1,585
12/29/2011	TDG-1a	109%	3,274	1,596
12/14/2006	TDG-1u	102%		1,700
2/16/2007	TDG-1u	103%		1,699
12/3/2007	TDG-1u	103%		1,700
11/13/2008	TDG-1u	104%		1,560
11/23/2011	TDG-1u	105%		1,596
3/16/2012	TDG-1u	107%		1,583
3/30/2012	TDG-1u	105%		1,560
3/31/2012	TDG-1u	104%		1,587
10/29/2012	TDG-1u	105%		100 (HBV)
11/20/2012	TDG-1u	106%		510 (HBV)
12/4/2012	TDG-1u	106%		530 (HBV)
12/2/2013	TDG-1u	107%	6,871	1,700
1/18/2005	TDG-2	104%	2,444	1,695
11/7/2006	TDG-2	112%	12,155	1,645
11/14/2006	TDG-2	101%	1,797	1,714
12/14/2006	TDG-2	104%	4,046	1,700
2/16/2007	TDG-2	109%	5,464	1,684
12/3/2007	TDG-2	108%	3,924	1,720
11/13/2008	TDG-2	115%	10,323	1,560
11/23/2011	TDG-2	105%	1,932	1,596
1/19/2012	TDG-2	112%	3,873	1566
10/29/2012	TDG-2	114%	5,698	100 (HBV)
11/20/2012	TDG-2	114%	5,503	510 (HBV)
12/4/2012	TDG-2	107%	3,219	530 (HBV)

Table A-1. Total Dissolved Gases (TDG) Data Associated with Bull Run Dam 2

Date	Monitoring Site	Percent Saturation	Spillway Flow[a] (cfs)	Powerhouse or HBV[b] Flow (cfs)
12/2/2013	TDG-2	115%	8,161	1,700
2/3/2005	TDG-3	103%		113 (HBV)
3/25/2008	TDG-3	103%		282 (HBV)
7/2/2008	TDG-3	106%		700 (HBV)
11/20/2012	TDG-3	105%		510 (HBV)
2/3/2005	TDG-4	102%		118 (HBV)
7/2/2008	TDG-4	107%		1,300 (HBV)
12/29/2004	TDG-5	102%		409
12/28/2005	TDG-5	102%		1,690
11/14/2006	TDG-5	100%		1,714
2/16/2007	TDG-5	101%		1,681
12/3/2007	TDG-5	100%		1,700
7/2/2008	TDG-5	109%		1,200
7/2/2008	TDG-5	108%		1,300
7/2/2008	TDG-5	108%		1,700
7/2/2008	TDG-5	108%		1,750
3/16/2012	TDG-5	106%		1,583
3/30/2012	TDG-5	104%		1,560
3/31/2012	TDG-5	106%		1,587
12/2/2013	TDG-5	106%		1,700
5/19/2005	TDG-6	104%		1,725
12/28/2005	TDG-6	102%		1,690
11/14/2006	TDG-6	100%		1,714
2/16/2007	TDG-6	101%		1,681
7/2/2008	TDG-6	107%		2,000 (HBV)
7/2/2008	TDG-6	108%		1,820
3/16/2012	TDG-6	107%		1,583
3/30/2012	TDG-6	106%		1,560
3/31/2012	TDG-6	105%		1,587
11/20/2012	TDG-6	106%		510 (HBV)
12/2/2013	TDG-6	106%		1,700

Table A-1. Total Dissolved Gases (TDG) Data Associated with Bull Run Dam 2

Date	Monitoring Site	Percent Saturation	Spillway Flow[a] (cfs)	Powerhouse or HBV[b] Flow (cfs)
5/19/2005	TDG-7	104%		1,725
11/14/2006	TDG-7	102%		1,714
7/2/2008	TDG-7	106%		1,820
3/16/2012	TDG-7	106%		1,583
3/30/2012	TDG-7	104%		1,560
3/31/2012	TDG-7	104%		1,587
11/20/2012	TDG-7	104%		510 (HBV)
12/2/2012	TDG-7	106%		1,700
12/28/2005	TDG-8	103%		1,690
11/14/2006	TDG-8	101%		1,714
2/16/2007	TDG-8	102%		1,681
12/3/2007	TDG-8	102%		1,700
7/2/2008	TDG-8	105%		2,000 (HBV)
3/16/2012	TDG-8	106%		1,583
3/30/2012	TDG-8	106%		1,560
3/31/2012	TDG-8	105%		1,587
10/29/2012	TDG-8	103%		100
11/20/2012	TDG-8	104%		510 (HBV)
12/2/2013	TDG-8	106%		1,700
11/14/2006	TDG-9	100%		1,714
2/16/2007	TDG-9	103%		1,699
12/3/2007	TDG-9	104%		1,700
3/16/2012	TDG-9	106%		1,583
3/30/2012	TDG-9	105%		1,560
3/31/2012	TDG-9	104%		1,587
10/29/2012	TDG-9	103%		100
11/20/2012	TDG-9	104%		510 (HBV)
12/2/2013	TDG-9	107%		1,700

[a]Blank space indicates that spillway flows are not applicable to this monitoring site.

[b]HBV: Howell Bunger valve. If flow refers to HBV flow, then datum is labeled with (HBV).

Table A-2. Total Dissolved Gases (TDG) Data Associated with Bull Run Dam 1

Date	Monitoring Site	Percent Saturation	Spillway Flow (cfs)	Powerhouse Flow (cfs)
1/18/2005	TDG-10	104%	2,000	2,000
12/28/2005	TDG-10	108%	2,340	2,250
1/10/2006	TDG-10	109%	4,801	2,250
11/7/2006	TDG-10	109%	9,851	2,200
2/16/2007	TDG-10	107%	2,042	2,200
12/3/2007	TDG-10	107%	2,834	2,200
11/13/2008	TDG-10	108%	4,111	2,560
3/16/2012	TDG-10	108%	1,059	2,562
12/2/2013	TDG-10	105%	2,909	2,200
11/7/2006	TDG-11	104%	10,158	2,200
11/14/2006	TDG-11	99%	278	2,200
2/16/2007	TDG-11	112%	2,177	2,200
12/3/2007	TDG-11	112%	2,804	2,200
11/13/2008	TDG-11	108%	4,300	2,560
12/2/2013	TDG-11	110%	2,769	2,200
1/4/2005	TDG-12	103%	0	1,385
12/28/2005	TDG-12	108%	2,145	2,250
11/7/2006	TDG-12	109%	9,667	2,200
11/14/2006	TDG-12	105%	278	2,200
2/16/2007	TDG-12	108%	2,062	2,200
12/3/2007	TDG-12	107%	2,822	2,200
11/13/2008	TDG-12	108%	4,286	2,560
3/16/2012	TDG-12	107%	1,059	2,562
12/2/2013	TDG-12	105%	3,004	2,200

Appendix E

Bull Run HCP Research Report

Lower Bull Run River Adult Chinook Population

April 2015

Burke Strobel
City of Portland Water Bureau

Contents

Tables

Figures

1. Summary

The City of Portland Water Bureau (PWB) was in full compliance with its Bull Run Water Supply Habitat Conservation Plan (HCP; Portland Water Bureau 2008) obligations in 2014 regarding lower Bull Run River adult Chinook salmon population research. Monthly surveys of spawning and holding Chinook adults and redds were conducted in the lower Bull Run River beginning in early July. Weekly surveys were conducted from the end of August through early December. The surveyed portion of the lower Bull Run River includes the entire lower river from its mouth to the base of the Bull Run diversion dam at Headworks (river mile [RM] 6.0). In 2014, spawning surveys could not be conducted on two occasions because of high flows. The peak adult Chinook count and minimum escapement[1] estimate in 2014 were among the lowest recorded since annual surveys were initiated in 2005. The cumulative redd count was in the middle of the range of what has been observed in past years, suggesting that poor visibility during several surveys resulted in relative undercounts of live adults and carcasses. This year's two missed surveys may have also contributed to a lower minimum escapement estimate and cumulative redd count.

In addition to the surveys protocol described in the HCP, three additional surveys were conducted with modified protocols. These additional surveys were necessary to evaluate efforts by the Oregon Department of Fish and Wildlife (ODFW) to use an adult fish weir and trap near the mouth of the river to prevent adult hatchery Chinook from entering the lower Bull Run River. Modified survey protocols included snorkeling large portions of the river to better count adults holding in deep pools and to attempt to determine whether live fish had clipped or intact adipose fins. Although some adult hatchery Chinook had entered the Bull Run River prior to the installation of the ODFW weir, the weir appeared to be effective at excluding hatchery fish.

2. Introduction

This section describes the results of surveys of spawning Chinook salmon adults and redds in the lower Bull Run River. Both spring and fall runs of Chinook salmon spawn in the lower Bull Run River.

Various agencies have conducted surveys of Chinook adults and redds in the Sandy River Basin since the 1980s. ODFW has conducted surveys of spring Chinook adults and redds in the Sandy River Basin by boat and on foot from 1996 to the present, and surveys on foot of fall Chinook adults and redds in index reaches in the lower Sandy River Basin from 1984 to the present. These surveys, however, have not included the lower Bull Run River. ODFW conducted weekly surveys of spawning spring and fall Chinook salmon

[1] Escapement is the number of fish that avoid or escape all harvest and return to spawn in their home streams.

and redds in the lower Bull Run River (RM 0–RM 5.8) in 1997. PWB continued weekly surveys from RM 1.5 to RM 5.8 in 1998 and 1999. An index reach of the lower Bull Run River (RM 1.5–RM 3.7) was surveyed by PWB in 2005 and 2006. This index reach was expanded to include RM 0–RM 3.7 for surveys conducted from 2007 to 2009.

For HCP Years 1–20 (2010–2029), PWB will annually count spawning Chinook salmon and redds in the lower Bull Run River. The lower Bull Run River Chinook population research is designed to provide biologists with meaningful data within a 20-year time frame to evaluate the long-term trend in adult Chinook abundance for the Bull Run. The Bull Run data could then be used with information gathered by other agencies to determine the status of federally listed Sandy River Chinook populations.

In addition to meeting its HCP obligations, PWB added a new monitoring consideration in 2013, which it retained in 2014. This new consideration assesses the effects of an ODFW program, begun in 2011, to acclimate and release hatchery Chinook smolts in the lower Bull Run River. Adult Chinook belonging to those acclimated cohorts began returning to the Bull Run River in 2013. PWB was concerned that many adult hatchery Chinook might begin returning to the Bull Run River. A percentage of hatchery spring Chinook adults on the spawning grounds in the upper Sandy Basin is considered to be acceptable if it is below 10 percent (ODFW 2011). A large return of hatchery fish could quickly exceed that threshold in the Bull Run River, undermining the City's restoration efforts. ODFW began installing a river channel-spanning weir near the mouth of the Bull Run River in 2013 to remove hatchery Chinook adults while allowing wild Chinook adults to enter the river. The weir was also installed in early June 2014. Spawning survey timing and protocols were adjusted in 2014 to support ODFW's efforts to prevent adult hatchery Chinook from entering the Bull Run River.

3. Research Objectives

In 2014 and continuing through HCP Year 20, PWB will conduct annual counts of spawning Chinook salmon and redds in the lower Bull Run River from RM 0–RM 6.0.

The objectives of the lower Bull Run River Chinook population research are to

- document use of the lower Bull Run River by spring and fall Chinook salmon.
- contribute to ODFW's annual assessment of spring Chinook in the Sandy River Basin.

4. Key Questions and Hypotheses

The key questions to be answered by the research are the following:

- How many Chinook salmon adults enter the Bull Run River to spawn each year? This key question does not have an associated null hypothesis (H_o).

- How many Chinook salmon redds are built in the Bull Run River each year? This key question has been added since PWB's adoption of the HCP and does not have an associated null hypothesis.
- What is the long-term trend (20 years) in spawning Chinook salmon abundance?

  H_o: The abundance of spawning Chinook salmon will not change significantly over the long term (20 years, α=0.05, β=0.20).
- What is the timing (range of dates and peak date) of adult Chinook presence and redd creation in the lower Bull Run River? This key question does not have an associated null hypothesis.
- What percentage of the spawning Chinook salmon are of hatchery origin?[2] This key question does not have an associated null hypothesis.

Three additional key questions—to be answered by the lower Bull Run River adult Chinook population research—were pursued in 2014:

- Does the number of adipose-clipped spring Chinook in the Bull Run River increase while the ODFW weir is in operation?

  H_o: The weekly count of adipose-clipped Chinook salmon will not change significantly while the ODFW weir is in operation (α=0.05).
- What percentage of spring Chinook salmon holding in the Bull Run River while the ODFW weir is in operation are of hatchery origin? This key question does not have an associated null hypothesis.
- What percentage of spawning spring Chinook salmon are of hatchery origin? Spring Chinook represent only a portion of the Chinook adults observed in the lower Bull Run River and are expected to have a different hatchery proportion than the aggregate population of both spring Chinook and fall Chinook. This key question does not have an associated null hypothesis.

The City will also collect otolith,[2] tissue, and scale samples from adult carcasses found in the lower Bull Run River. The City will send the samples to ODFW to assist in ODFW's assessment of spring Chinook in the Sandy River Basin. In return, PWB will receive information from ODFW about the proportion of unclipped Chinook salmon that are of hatchery origin, the relative number of spring and fall Chinook salmon in the lower Bull

[2] The protocols followed by PWB provide the proportion of carcasses found with clipped adipose fins. The proportion of unclipped carcasses that are of hatchery origin will be provided by ODFW analysis of otoliths. Otoliths are tiny bones that form a portion of a fish's inner ear. A fish lays down new bone material on the ototlith's edge as it grows, forming bands that record the fish's growth rate over time. ODFW thermally "marks" otoliths in hatchery Chinook by exposing juvenile fish to varying water temperatures. Because fish growth increases in warm water and decreases in cold water, characteristic banding patterns are created, which provide an indication of fish origin (Schroeder et al. 2005).

Run River, and the proportion of Chinook adults showing aspects of various life history types.[3] The compilation of this information, however, depends on analyses conducted by ODFW and is therefore not reflected in the key questions.

The City conducts surveys throughout the spawning season for both spring Chinook and fall Chinook, but several of the statistics associated with the key questions and hypotheses apply primarily to spring Chinook. The spring Chinook run in the Bull Run River generally tapers off by the end of October, at about the time the fall Chinook run is beginning. There is undoubtedly overlap between the two runs, although the degree of overlap has not been quantified. ODFW uses October 31 as a cutoff date to distinguish between the two runs in the Bull Run River. The dates for peak counts consistently occur before October 31 and, for this reason, reflect the spring Chinook run. Other statistics, such as cumulative redd count and percentage of hatchery fish, are influenced to varying degrees by the inclusion of fall Chinook.

5. Methods

The study design for the lower Bull Run River Chinook population research uses weekly surveys to count live Chinook adults, Chinook salmon carcasses, and newly created redds. The surveys are coordinated with operators at the City's Headworks facility and the Portland General Electric (PGE) powerhouses at Bull Run Dam 1 and Dam 2. During surveys, operators maintain flows of 150 cubic feet per second (cfs) or less above the Little Sandy confluence. This is the level of flow necessary for safety and for accurate counts. The HCP allows for departures from minimum flow criteria in the lower Bull Run River (Measures F-1 and F-2) to make Chinook spawning surveys possible.

5.1 Spatial Scale

The lower Bull Run River was divided into the following reaches to provide greater spatial resolution of counts than a simple count of the entire river would provide and to reflect the reaches used in previous surveys for comparison:

<u>Reach 1</u>: The confluence of the Bull Run River with the Sandy River to the upstream end of the large pool adjacent to the Bull Run PGE Powerhouse (RM 0–RM 1.5)

<u>Reach 2</u>: The upstream end of the large pool adjacent to the Bull Run PGE Powerhouse to Bowman's Bridge (RM 1.5–RM 2.3)

<u>Reach 3</u>: Bowman's Bridge to the upstream end of the pool at the confluence with the Little Sandy River (RM 2.3–RM 2.8)

[3] A Chinook salmon's life history type is defined by when, where, and how it lives over the course of its lifetime. This includes the number of years that it spent in freshwater and in saltwater before returning to freshwater to spawn.

Reach 4: The upstream end of the Little Sandy River confluence pool to the upstream end of the pool at Larson's Bridge (RM 2.8–RM 3.7)

Reach 5: The upstream end of the pool at Larson's Bridge to the Road 14 bridge (RM 3.7–RM 4.8)

Reach 6: The Road 14 bridge to the Headworks diversion dam (RM 4.8—RM 6.0)

These reaches correspond to those used for the HCP Chinook spawning gravel research (see Appendix C, Lower Bull Run River Spawning Gravel Research), with the exception that spawning gravel research is not conducted between RM 5.8 and RM 6.0. Reaches 2, 3, and 4 are also the reaches used in previous Chinook spawning surveys conducted by ODFW and PWB. Reach 4 also corresponds to one of ODFW's probabilistic, randomly selected reaches for the Sandy River Basin steelhead and coho spawning surveys and snorkel surveys. Reaches 5 and 6 were not believed to be used by spawning Chinook salmon prior to 2011. These reaches were surveyed twice in 2010 to confirm whether they were being used; one spawning coho salmon was observed. Based on this result, starting in 2011, Reaches 5 and 6 were surveyed every week after October 1. They were not surveyed earlier in the year because low summer flows make it very unlikely that salmon would be able to pass Larson's Falls at RM 3.7.[4]

Adult and redd abundance and timing information is summarized at the reach scale. The percentage of hatchery fish is summarized at the scale of the entire lower Bull Run River.

5.2 Replication/Duration

The City is committed to funding the Chinook population research in the lower Bull Run River for the first 20 years of the HCP. Annual surveys of spawning Chinook salmon and redds are conducted.

Weekly surveys in 2014 were conducted from late August through mid-December. Two weeks were missed because of high flows. Two additional snorkel surveys were conducted, one in early July and one in early August. There was no spatial replication, because the entire channel was surveyed.

5.3 Parameters

The following information and samples were collected during each survey.

- Live Adults
  - Number of adults and number of jacks
  - Species

[4] Flows generally begin increasing with the autumn rains in October, making it possible, though difficult, for salmon to pass Larson's Falls.

  - Reach
  - Additional behavioral information (e.g., spawning, defending a redd)
- Carcasses
  - Species
  - Reach
  - Length (both total length from the snout-tip to the fork of the tail and the middle-of-eye-to-posterior-scale (MEPS) length, in centimeters)
  - Sex
    - If a female, whether it died before spawning
  - Presence of adipose fin
    - If no adipose fin, whether it has coded-wire tags (CWT). If CWT were present, researchers collected the snout
    - If an adipose fin was present, researchers collected
      - an otolith sample (for ODFW determination of hatchery origin)
      - a tissue sample (for National Marine Fisheries Service distinction of spring from fall Chinook)
      - a scale sample (for ODFW determination of age and life history)
  - Additional information (e.g., whether the individual appeared to be eaten by scavengers or was found in the riparian zone)
- Redds
  - Reach
  - Species (researchers assumed the individual was Chinook unless another species was seen creating or defending it)
  - Size (length x width, in square feet)
  - Substrate size range (visual estimate of the range from approximately the 10th to the 90th percentile of substrate sizes, in inches)[5]
  - Channel feature retaining the gravel patch (e.g., whether the redd is a behind boulder or bedrock, a pool-tail or riffle margin)
  - Evidence of superimposition over a previous redd

[5] Substrate sizes are discussed in the HCP, Appendix F. The HCP is available at www.portlandonline.com/water/46157.

- Environmental data
  - Weather (description)
  - Water clarity/visibility
  - Flow (determined from U.S. Geological Survey [USGS] Gage No. 14140000)

5.4 Sampling

Sampling methods have been altered slightly from those proposed in the HCP. The City intended to conduct spawning surveys by walking the river channel in flows of up to 150 cfs. This was regarded as the maximum flow that would still allow for safe navigation by surveyors on foot, wearing waders. Between flows of 150 and 500 cfs, PWB intended to survey while floating the river with kayaks. An initial trial run with kayaks conducted by PWB before 2010 at 400 cfs, however, convinced PWB that this method would not produce reliable data and was not a safe survey approach.

Instead, surveys were conducted by two observers walking downstream on each side of the channel. Between flows of 150 and 400 cfs (which included contributions from the Little Sandy River), surveyors wore drysuits and life vests. This enabled them to safely swim through otherwise impassable areas. If the combined flows of the Bull Run River and Little Sandy River could not be maintained below 400 cfs, surveys were cancelled.

Live adults and jacks were counted and their locations recorded. Any carcasses that were found with an intact tail were counted. All carcasses that could be retrieved were measured and their sex was recorded. Females were opened to check for eggs, which would determine whether they died before spawning. All carcasses were checked for the presence of an adipose fin. All carcasses with adipose fins found before October 31 (corresponding to an approximate date used by ODFW to distinguish between spring and fall Chinook—ODFW has an interest only in samples collected from the earlier, spring-run fish—were sampled for otoliths, tissue, and scales. After October 31, tissue samples were only collected from Chinook carcasses with adipose fins.

ODFW also conducted several independent surveys of adults and carcasses on portions the lower Bull Run River in September and October of 2014. ODFW carcass counts and carcass data were added to PWB data for the following PWB survey date.

Redds were counted and their locations recorded. The approximate surface area of each redd and the size of its substrate were visually estimated. Once these and other data had been collected, each redd was marked with a flag with the date attached to the bank adjacent to the redd. The following week, if there were no signs of adult fish that could still be building the redd, a painted rock comparable in size to those comprising the redd was placed on the redd. The painted rock helped distinguish new redds from old ones. Painted rocks from previous surveys that had been dislodged or buried indicated that further spawning activity had occurred at that location. The flag on the bank aided in confirming the presence of an old redd if the painted rock was missing. If live adults were still observed on or near a redd after two weeks, it was assumed that a new redd was in the process of being built superimposed on the old redd. No rock was placed, but the bank was flagged. If no adults were observed the following week, a rock was placed at that time and a note of it was made.

Additional surveys were conducted in 2014 before the usual start of surveys (late August) following an adjusted protocol to provide data to ODFW personnel to evaluate OFDW's efforts to prevent adult hatchery Chinook from entering the lower Bull Run River. The purpose of the additional surveys was to determine whether adult hatchery Chinook had entered the Bull Run River before ODFW installed its weir and to detect any large increase in the number of adult hatchery Chinook in the river, which might indicate that fish had managed to pass the weir. Under the modified protocols, as much of the lower Bull Run River as possible (Reaches 1-4) was snorkeled. Snorkelers counted adult Chinook and identified whether each observed fish had a clipped or intact adipose fin or whether the adipose fin status could not be determined. Snorkelers did not look for redds in snorkeled portions of the river. Portions of the river that were too shallow to snorkel effectively were surveyed according to the regular protocols described above. These modified surveys were conducted in early July, early August, and early September.

6. Analysis

Data Storage: Monitoring data collected during the HCP Chinook Population Research were entered by PWB in a Microsoft® Excel spreadsheet and stored with spreadsheets containing data from previous years' surveys.

Hypothesis Testing: The number and timing of Chinook salmon in the lower Bull Run in a given year were compared to the number and timing of Chinook salmon in other years. Individual years were not compared statistically, however, because of the lack of replication.

The trend in peak spawner count (live + dead fish on a given date) and minimum escapement estimate (peak count of live fish on a given date plus cumulative carcass count up to and including that date) was calculated for all surveys to date using linear regression (α=0.05).

The percentage of hatchery fish in the lower Bull Run in a given year was compared to the percentage of hatchery fish in other years. Individual years were not compared statistically, however, because of the lack of replication.

The percentage of hatchery fish in the spring Chinook population, as opposed to the percentage of hatchery fish in the aggregate population of spring and fall Chinook, was estimated by applying a cutoff date of November 7 for distinguishing between carcasses that were considered to be spring Chinook (carcasses of fish that could have spawned on or before October 31) or fall Chinook (carcasses of fish that probably spawned in November or later).

7. Results and Discussion

7.1 Surveys

Seventeen weekly surveys were conducted in 2014 between July 7 and December 9, three following modified protocols which included snorkeling, and 14 following standard protocols. Surveys were cancelled due to high flows on two dates, November 4 and November 25. The survey conducted on December 11 was a partial survey, from Larson's Bridge to the PGE Bull Run Powerhouse. Reaches 5 and 6 were not surveyed on November 12 and December 9 because of staffing issues.

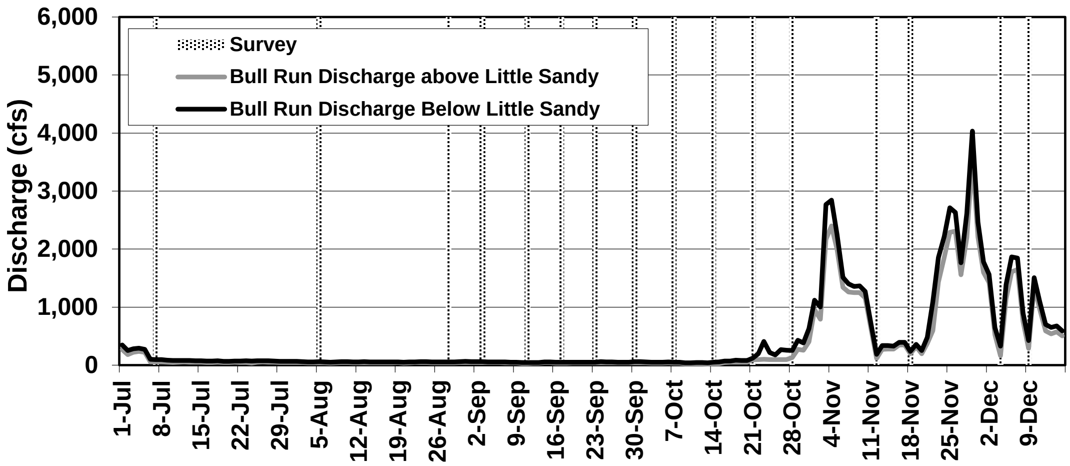


Figure 1. Bull Run River Discharge Above and Below the Little Sandy Confluence and Dates of Chinook Spawning Surveys

7.2 Live Adults

7.2.1 Peak Counts and Minimum Escapement Estimates

Both peak counts and minimum escapement estimates for Chinook salmon in the lower Bull Run River in 2014 were at the lower end of the range of previous survey years, whereas cumulative redd count was in the middle of the range of previous years, as indicated in Table 1.

Table 1. Summary Statistics for Chinook Spawning Runs in the Lower Bull Run River, 2007–2014[a]

Year	Peak Count	Minimum Escapement	Cumulative Redd Count	% Hatchery (n)[b]	% Female (n)
2014	21	37	67	3.7% (27)	37.0% (27)
2013	54	69	124	16.3% (48)	64.6% (47)

Table 1. Summary Statistics for Chinook Spawning Runs in the Lower Bull Run River, 2007–2014[a]

Year	Peak Count	Minimum Escapement	Cumulative Redd Count	% Hatchery (n)[b]	% Female (n)
2012	30	33	31	60.0% (5)	40.0% (5)
2011	84	99	94	43.1% (72)	54.7% (75)
2010	70	77	43	36.8% (19)	75.0% (16)
2009	61	70	89	11.8% (34)	52.9% (34)
2008	31	38	37	11.5% (26)	73.1% (26)
2007	34	39	62	41.7% (12)	76.9% (13)

[a]Includes peak count, minimum escapement estimate, percent of identifiable carcasses with clipped adipose fins (n=number of carcasses where the state of the adipose fin could be determined), and percent of identifiable carcasses that were female (n=number of carcasses where the sex could be determined).

[b]Fish with clipped adipose fins. A small portion of unclipped fish may also be of hatchery origin. Determined from carcass data only. Three live hatchery Chinook were observed in the Bull Run River in 2014.

Peak adult counts continue to be lower, on average, than they had been prior to the Marmot Dam removal in 2007 (t-test$_{\text{one-tailed}}$, p=0.003, df=14), as indicated in Figure 2, but with a large amount of variation. The average peak count prior to removal was 129 (±133 95% confidence interval). In the years after decommissioning, the average has been 48 (±44 95% confidence interval). There is no trend in the data observed between 2007 and 2014 (p=0.87).

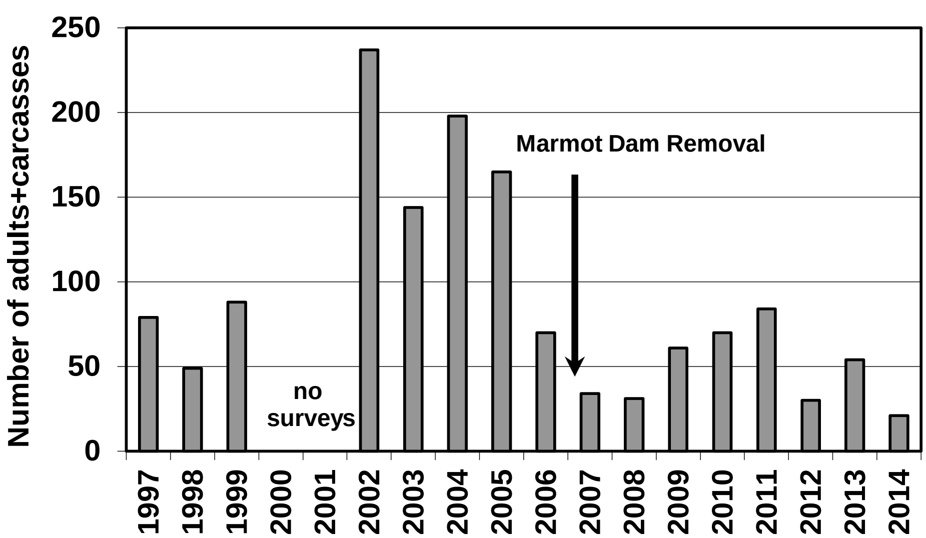


Figure 2. Chinook Salmon Peak Counts for All Years when Surveys Were Conducted

The peak count statistic generally reflects the status of spring Chinook, whereas minimum escapement, cumulative redd count, percent hatchery, and percent female reflect the combined total for spring Chinook and fall Chinook. Dates for peak counts consistently occur in October, at the height of spring Chinook spawning activity and before fall Chinook are believed to be present in the river in significant numbers. For this reason, this statistic can be legitimately compared across years, reflecting spring Chinook populations with little influence from fall Chinook. The minimum escapement estimate, cumulative redd count, and percent of hatchery fish and females, in contrast, can be heavily influenced by the inclusion of fall Chinook and, therefore, should be compared across years with caution. It is difficult to apply a cut-off date to distinguish between spring Chinook and fall Chinook redds and carcasses because of overlap in their run timing at the end of October and early November. In the future, genetic analysis may help to separate these combined statistics.

The relative size of the peak count of spring Chinook in the Bull Run River in 2014 does not necessarily reflect the relative size of the spring Chinook escapement to the Sandy River in general. An estimate of the total Sandy River Basin spring Chinook spawner escapement for 2014 was not available at the writing of this report. In previous years since the removal of Marmot dam, however, there has been no correlation between the Bull Run River peak Chinook counts and the Sandy River Basin spring Chinook escapement estimates for the respective years. Prior to the removal of Marmot Dam, adult Chinook counts in the Bull Run River reflected trends in the greater Sandy River Basin.

Marmot Dam diverted Sandy River water to the adjacent Little Sandy River Basin, where it was further diverted by way of Roslyn Lake to the Bull Run River at RM 1.5. Following chemical cues in the water, a portion of adult Chinook salmon intent on returning to their natal streams in the upper Sandy River Basin apparently strayed into the Bull Run River by mistake. During these years, lower Bull Run adult Chinook peak counts showed a significant positive correlation (R^2=0.715, p=0.008) with the estimated spring Chinook run size upstream of Marmot Dam (Sandy spring Chinook data 2007 and after from ODFW; Kirk Schroeder and Luke Whitman, pers. comm. Data prior to 2007 from PGE. See Figure 3). After Sandy River water was no longer diverted into the Bull Run River, adult Chinook peak counts declined dramatically and showed no significant correlation with Sandy River spring Chinook counts (R^2=0.0141, p=0.823 for years 2007-2013; see Figures 2 and 3).

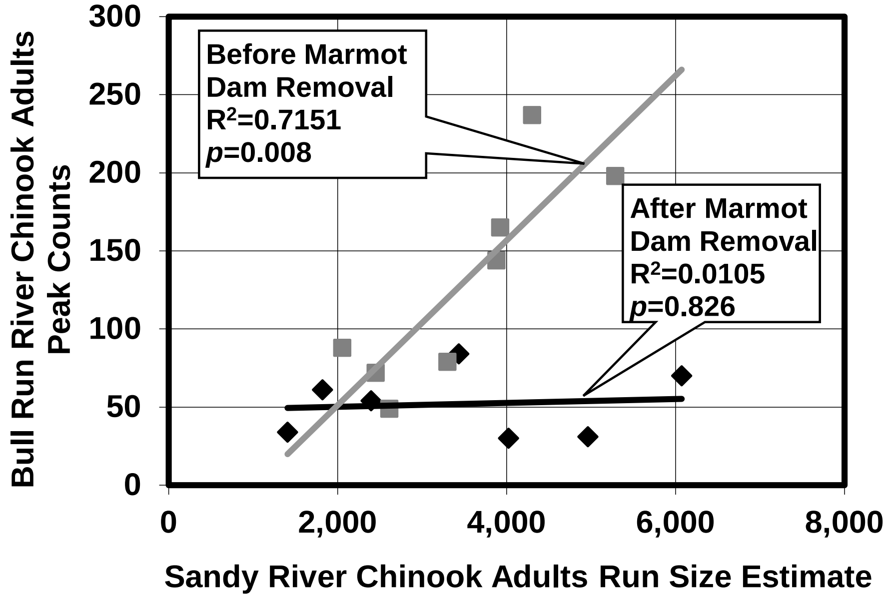


Figure 3. Relationship of Peak Counts of Adult Chinook in the Lower Bull Run River with Estimated Run Size of Spring Chinook in the Upper Sandy River Basin, Before and After the Removal of Marmot Dam

7.2.2 Timing

Adult Chinook salmon were observed in the Bull Run River throughout the survey period, but peaked in October. As Table 2 documents, the peak fish count, minimum escapement estimate, and peak redd count all occurred on the same date in late October.

Table 2. Timing of Adult Chinook Peak Counts, Highest Minimum Escapement Estimate, and Peak Redd Count, 2007–2014

Year	Peak Count	Minimum Escapement	Peak Redd Count
2014	Oct. 28	Oct.28	Oct. 28
2013	Oct. 23	Nov. 14	Oct. 16
2012	Oct. 24	Oct. 24	Oct. 24
2011	Oct. 5	Nov. 10	Oct. 5
2010	Oct. 20	Oct. 20	Oct. 20
2009	Oct. 21	Oct. 21	Oct. 21
2008	Oct. 22	Oct. 29	Oct. 15 & 22
2007	Oct. 24	Oct. 24	Oct. 18

Spring Chinook were observed throughout the summer and probably were mostly hatchery fish that had been acclimated in the Bull Run River in 2011 and 2012. Adult Chinook observed during July and August were almost exclusively seen while snorkeling and were observed holding in deep pools. It may be that counts would have been much lower during these months if the standard survey protocol had been applied throughout the summer months. Adult salmon become more detectable later in the year with the standard protocol as they move into shallower water to spawn.

The dramatic increase in the number of adult Chinook observed in late September 2014 does not appear to correspond with either an increase in flow or a decrease in water temperature (Figure 4). The discharge values used were the combination of discharges measured at USGS Gage No. 14140000 (Bull Run) and Gage No. 14141500 (Little Sandy). The approximate mean daily water temperature used was the discharge-weighted average of water temperatures measured at the USGS Gage No. 14140020 (Bull Run) and Gage No. 14141500 (Little Sandy).

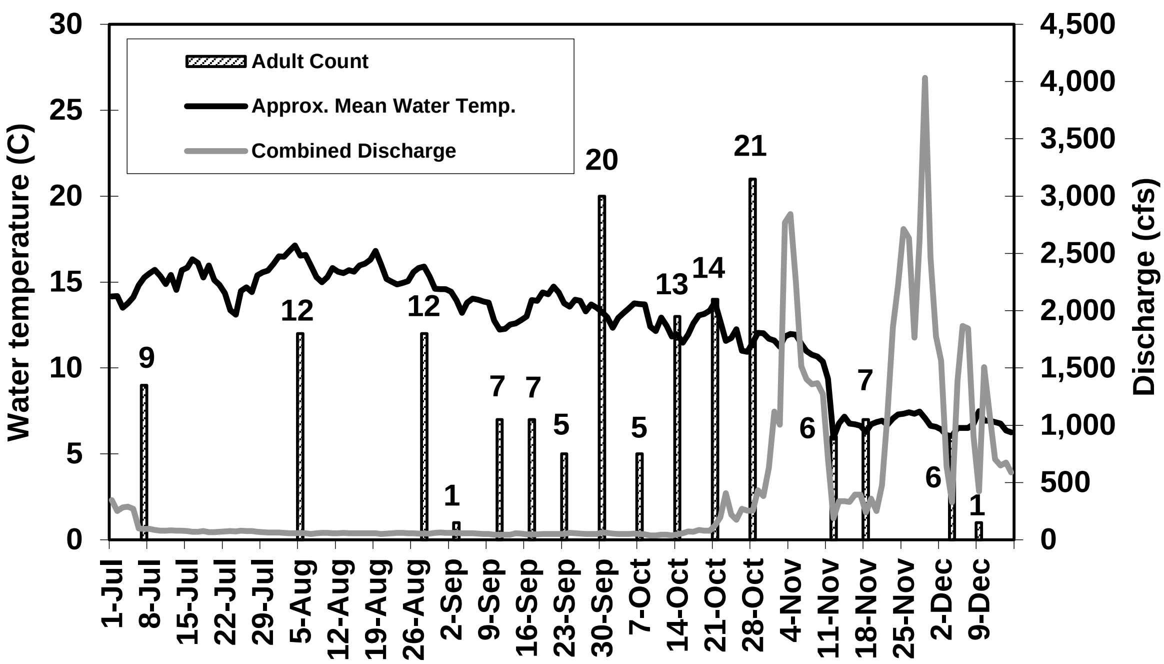


Figure 4. Environmental Variables[a] that May Be Useful in Explaining Chinook Salmon Run Timing in the Lower Bull Run River in 2014

[a]Includes the estimated mean daily water temperature near the mouth and discharge near the mouth.

The ODFW weir appeared to be effective at excluding hatchery adult Chinook from the Bull Run River upstream of the weir while letting wild adult Chinook through. At least 3 hatchery adult Chinook moved into the lower Bull Run River before the weir starting operating on June 16. The number of adipose-clipped adult Chinook salmon observed holding in the Bull Run River in July, August, and September varied but showed no evidence of an increase. The percentage of adipose-clipped adults among fish for which the status of the adipose fin could be determined while snorkeling began at 80 percent (n=5) and decreased to 33 percent (n=6) as wild fish passed above the weir and joined the hatchery fish that had entered the river before the installation of the weir in mid-June. The results of the snorkel surveys conducted between early July and early September are summarized in Exhibit A at the end of this report.

7.3 Redds

7.3.1 Cumulative Count

The cumulative Chinook salmon redd count in the lower Bull Run River was in the middle of the range of years since Marmot Dam was removed in 2007 (Table 1). This contrasts with the low-range peak adult count. It is probable that the adult count was biased toward the lower end because of poor visibility on several occasions and the two missed surveys. The cumulative redd count is probably a better measure of spawning activity in the Bull Run River because redds remain visible for weeks after spawning adult Chinook have died and can no longer be observed. Redds that cannot be seen under poor-visibility conditions can also be observed and added to the cumulative total at later dates.

7.3.2 Timing

Chinook salmon redds were observed in the Bull Run River between September 23 and December 4. The date of the peak Chinook redd count was October 28, which was also the date of the peak fish count. Figure 5 summarizes the timing of redd construction and compares it to the timing of adults observed in the lower Bull Run River. Figure 5 also includes the cumulative redd count.

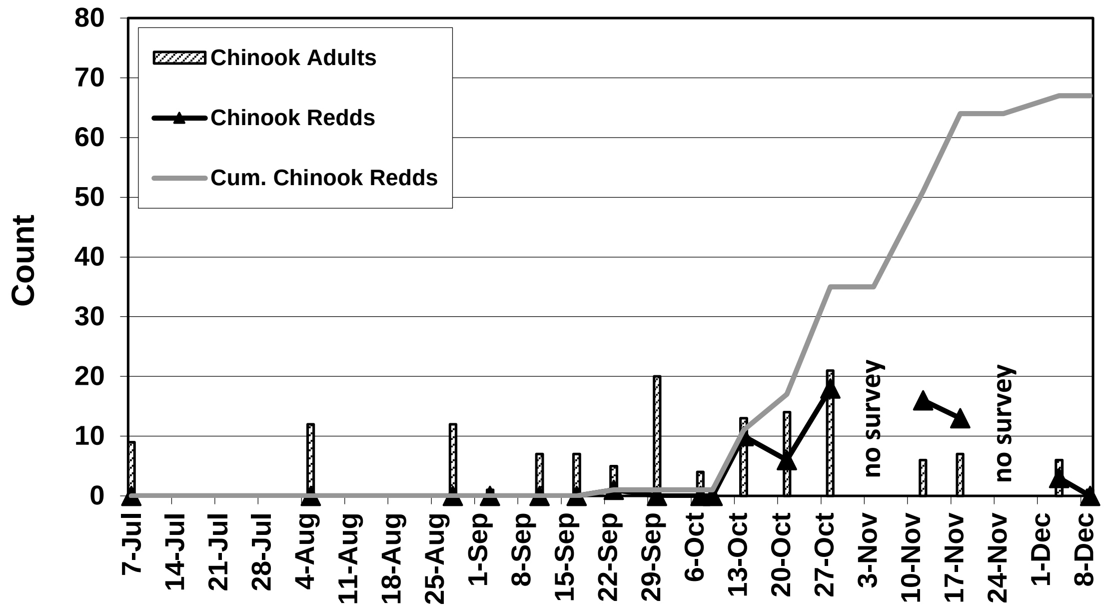


Figure 5. Comparison of the Timing of the Presence of Adult Chinook Salmon and the Construction of Redds in 2014

Chinook that first entered the Bull Run River in July held in the river in deep pools until late September, when they began spawning. Only one redd was created in September.

The majority of redd building began around October 14. Fish holding in the Bull Run River through the summer were primarily hatchery fish without adipose fins (snorkelers' observations). The majority of carcasses found in October (95 percent), however, were apparently wild with intact adipose fins. It appears that wild fish may have been holding in the main stem of the Sandy River.

7.4 Carcasses

7.4.1 Hatchery Fish

The percentage of Chinook carcasses in the lower Bull Run River that were of hatchery origin was relatively low in 2014 based on a sample size of 30 carcasses for which the status of the adipose fin could be determined. The actual percentage of hatchery fish may have been higher than 3.7 percent. Some Chinook have inadequately clipped adipose fins or their fins grow back. For this reason, ODFW collects otolith samples from spring Chinook salmon carcasses with adipose fins. The percentage of unclipped fish that are of hatchery origin can be determined from the growth structure of these otoliths. The percentage of unclipped Chinook salmon carcasses that were of hatchery origin in the Bull Run River was not available at the writing of this report.

The percentage of carcasses considered spring Chinook carcasses that were of hatchery origin was 4.8 percent based on a sample size of 21 carcasses. This represents a very conservative estimate of the percentage of spring Chinook carcasses that are of hatchery origin. Living adult spawners observed at the very end of October would be considered spring Chinook according to the ODFW cutoff date of October 31. These fish would not be found as carcasses until the following survey, when they would be mixed with fall Chinook carcasses.

7.4.2 Sex Ratio

Only one-third of the Chinook carcasses recovered in 2014 were female. Of the 30 carcasses observed in the Bull Run River in 2014, 27 were intact enough to determine sex. Of these 27, 10 (37 percent) were female.

Females have tended to make up a larger percentage of carcasses recovered in the lower Bull Run River. Their percentage has ranged between 52.9 percent and 76.9 percent in six out of eight survey years. 2014 and 2012 are the only years when males made up a larger percentage of recovered carcasses. The reason for the large percentage of male carcasses in 2014 is unknown. The reason for the usual observed asymmetry, biased towards females, is also unknown. The asymmetries may reflect actual difference between the sexes or differences in the detectability of their carcasses. Females, for instance, appear to remain near their redds for longer periods of time than males, and may die, on average, in shallower water where they are more readily found by surveyors. Actual differences in sex ratio can arise through differences between the sexes in marine survival, life history differences, or other factors such as gender reversal.

Differences in marine survival can come about due to differences in (for instance) size, which, in turn, can influence susceptibility to predation or harvest. No differences in size were observed between male and female middle-of-eye-to-posterior-scale (MEPS) lengths in the Bull Run River in 2014, however. In 2014, female Chinook carcasses had an average length of 81.6 cm and male carcasses had an average length of 72.7 cm.

Life history differences can, in theory, lead to differences in sex ratio if, for example, a significant number of one gender return at a different age than the other. A portion of male Chinook salmon return to spawn after only one year in the ocean. These are called jacks. If a large number of males in a given cohort of Chinook return as jacks, returning adults the following year may show a reduced percentage of males.

Gender reversal, generally male to female, can occur when developing embryos are exposed to high water temperatures or estrogen-imitating chemicals in the environment (Olsen et al. 2006). The possible role of either of these factors in influencing the Chinook salmon sex ratio in the Bull Run River cannot be evaluated with current data.

It is also possible that the biased sex ratios observed in the past few years in the Bull Run River are entirely due to chance.

8. Findings and Conclusions

The findings and conclusions directly address the key questions posed in Section 4.0:

- **How many Chinook salmon adults enter the Bull Run River to spawn each year?**

  At least 37 adult Chinook salmon returned to the Bull Run River to spawn in 2014. The peak daily count of live adults plus carcasses was 21.

- **How many Chinook salmon redds are built in the Bull Run River each year?**

  A total of 67 Chinook redds were identified in the Bull Run River in 2014.

- **What is the long-term trend (20 years) in spawning Chinook salmon abundance?**

  The long-term (20-year) trend in spawning Chinook salmon abundance will be calculated in 2028. The number of spawning Chinook salmon in the lower Bull Run River shows no significant trend since the Marmot Dam removal in 2007.

- **What is the timing (range of dates and peak date) of adult Chinook presence and redd creation in the lower Bull Run River?**

  Live adult Chinook salmon were observed in the Bull Run River between July 7 and December 9, 2014. The peak date was October 28, 2014. Chinook redds were observed between September 23 and December 4, 2014. The peak date for redd observation was October 28.

- **What percentage of the spawning Chinook salmon are of hatchery origin (clipped adipose fin)?**

  In 2014, the percentage of hatchery (clipped adipose fin) fish among the observed Chinook salmon carcasses in which the condition of the adipose fin could be determined was 3.7 percent.

- **Does the number of adipose-clipped spring Chinook in the Bull Run River increase while the ODFW weir is in operation?**

  In 2014, the number of adipose-clipped spring Chinook holding in the Bull Run River showed no evidence of increasing while the ODFW weir was in operation.

- **What percentage of spring Chinook salmon, holding in the Bull Run River while the ODFW weir is in operation, are of hatchery origin?**

  Snorkel surveys were conducted on July 7, August 5, and September 11. The percentages of hatchery spring Chinook observed while snorkeling on these dates were 80.0%, 72.7%, and 33.3%, respectively, though sample sizes were small.

- **What percentage of the spawning spring Chinook salmon are of hatchery origin (clipped adipose fin)?**

In 2014, the percent of hatchery (clipped adipose fin) fish among the observed Chinook salmon carcasses, for which the condition of the adipose fin could be determined and assuming that any carcasses observed before the end of October were spring Chinook, was 4.6 percent.

9. Works Cited

Olsen, Jeffrey B., Steve J. Miller, Ken Harper, Kevin Van Hatten, Kellie Whitton, James J. Nagler, and John K. Wenburg. "Sex Ratios of Juvenile and Adult Chinook Salmon in the Kuskokwim and Yukon Rivers." *U.S. Fish and Wildlife Service*, 2006.

Oregon Department of Fish and Wildlife. “Final Hatchery and Genetic Management Plan: Spring Chinook.” 2011.

Portland Water Bureau. “Bull Run Water Supply Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species.” 2008.

Schroeder, R. Kirk, Ken R. Kenaston, and Lisa K. Krentz. “Spring Chinook Salmon in the Willamette and Sandy Rivers.” Oregon Department of Fish and Wildlife *Fish Research Report* F-163-R-10 (2005).

Exhibit A

Table A-1. Lower Bull Run River Adult Chinook Snorkel Survey Results, July 7–September 11, 2014

Date	Hatchery (no adipose)	Wild (adipose)	Undetermined	Total	Percentage hatchery	Visibility	Comments
July 7, 2014	4	1	4	9	80.0%	Excellent	2 unclipped and one unidentified steelhead
August 5, 2014	8	3	0	11	72.7%	Excellent	5 unclipped steelhead
September 11, 2014	2	4	1	7	33.3%	Excellent	4 unclipped steelhead

Appendix F. Sandy River Basin Smolt Monitoring

2014

April 2015

Burke Strobel, Portland Water Bureau

Photo (left) of Mount Hood and Sandy River provided by Josh Kling/Western Rivers Conservancy

Photo (right) of crew measuring fish provided by the Portland Water Bureau.

Contents

Tables

Figures

1. Summary

The Portland Water Bureau, the U.S. Forest Service, and the Oregon Department of Fish and Wildlife collaborated in 2014 to continue a long-term, 50-year study monitoring steelhead and coho smolt production throughout the Sandy River Basin in Oregon. The study, initiated in 2009, is intended to detect declines or increases in abundance and productivity of smolts at the basin scale and to provide useful data at the scale of individual tributaries to guide restoration efforts. The sampling design involves monitoring different sets of tributaries every year. Some tributaries are monitored every year; others are monitored on an irregularly rotating basis. The study is intended to provide basin-scale trends after 20 years.

Trapping efforts were hampered in 2014 by occasional high-flow events, low-flow periods in three streams, and two releases of hatchery Chinook smolts from an acclimation pond upstream of one trap.

Smolt numbers, fork length, condition factors, and emigration timing were monitored using rotary smolt traps in seven streams: Clear Creek, Still Creek, Zigzag River, Cedar Creek, Bull Run River, Little Sandy River, and Beaver Creek. Provisional population estimates were calculated for steelhead and coho smolts in all seven streams, but no fork length analysis or condition factor analysis were conducted on fish from the Zigzag River. The average age of smolts was calculated by aging fish using fish scale samples collected between 2009 and 2013.

Preliminary Sandy River Basin-level population estimates were calculated for each year from 2009 to 2014. Freshwater productivity (smolts per adult) was also estimated, with the help of age data, for steelhead adult year classes 2010 to 2012 and for each coho adult year class from 2007 to 2012.

Steelhead and coho smolts from different streams in the Sandy River Basin showed significant differences in weighted mean fork length of smolts. Low-elevation streams had longer smolts than high-elevation streams.

Steelhead and coho smolts from different streams in the Sandy River Basin also showed significant differences in mean condition factors. Condition factors, however, did not correlate positively or negatively with fork length, as they have in previous years.

Steelhead smolts emigrated earlier than coho smolts, on average, in all streams. Both steelhead and coho emigrated earlier from low-elevation than from higher-elevation streams.

High-elevation streams had a larger proportion of older age steelhead and coho smolts. Length-at-age calculations revealed that steelhead smolt fork lengths are shorter on average for a given age in higher-elevation streams than in lower elevation streams, as is seen in coho, but this fact is masked by their older average age.

2. Introduction

2.1 Background

The Portland Water Bureau (PWB), the Mt. Hood National Forest (U.S. Forest Service [USFS]), and the Oregon Department of Fish and Wildlife (ODFW) collaborated in 2014 to continue a long-term study, monitoring steelhead and coho smolt production throughout the Sandy River Basin in Oregon. The Sandy River enters the lower Columbia River just east of Portland, Oregon, and includes several large tributaries—the Bull Run, Salmon, and Zigzag rivers—as well as many smaller tributaries such as Beaver, Cedar, Clear, Gordon, and Lost creeks, and the Clear Fork Sandy River.

Smolt monitoring has been conducted in various Sandy River tributaries in the past. The USFS has monitored smolt production continuously in Still Creek, a tributary of the Zigzag River, since 1989 and sporadically in the Clear Fork Sandy River, Lost Creek, and the Salmon River. The purpose of these efforts originally included monitoring the benefits of stream restoration projects and, more recently, supporting efforts to evaluate the effects of the removal of Marmot Dam in 2007. The USFS also operated a smolt trap on the Little Sandy River in 2007 and 2008, upstream of a diversion dam operated as part of Portland General Electric's Bull Run Hydroelectric Project. The Portland Water Bureau has operated a smolt trap in the Bull Run River near its mouth since 2008 and assumed the management of the Little Sandy River trap in 2009.Two related factors led to an expansion of salmonid smolt monitoring in the Sandy River Basin, beginning in 2009. The first was the formation of the Sandy River Basin Partners in 1999—a group intended to coordinate the fish and fish habitat management efforts of various agencies and groups. This coordination led to a broadening of the monitoring focus to better correspond with an emerging holistic approach to watershed restoration and to mesh with other programs that collect biological information at a basin scale. The second factor was that PWB created the Bull Run Water Supply Habitat Conservation Plan (HCP; Portland Water Bureau 2008) in 2008 to bring its municipal water supply operations in the Bull Run River into compliance with the Endangered Species Act.[1] Among the many measures detailed in the HCP is a commitment to contribute resources toward smolt monitoring in the Sandy River Basin.

Monitoring smolt production can benefit a number of management efforts on many spatial scales, including viability analyses and adaptive restoration. Given limited resources, however, managers face potential tradeoffs between collecting smolt information that is meaningful at the population scale (that is, enumerating smolts at the mouths of large rivers) and collecting smolt information at a scale that is most meaningful to individual restoration efforts (that is, enumerating smolts in tributaries).

[1] To learn more about the HCP, visit http://www.portlandoregon.gov/water/55040.

The sampling plan adopted by the monitoring subgroup of the Sandy River Basin Partners is intended to provide information at both scales in order to maximize the usefulness of the data-collection effort. The sampling plan is summarized in the HCP Appendix F (Portland Water Bureau 2008).

2.2 Goal and Objectives

The goal of the Sandy River smolt monitoring project is to contribute to the viability assessment of salmonid stocks in the Sandy River Basin and support their adaptive management. The objectives of the Sandy River Smolt Monitoring project are to

- collect information to assess the long-term (20-year) trend in steelhead and coho smolt populations for as much of the Sandy River Basin as possible (population scale),
- collect information to assess the long-term (20-year) trend in steelhead and coho smolt populations at the scale of individual tributaries (tributary scale),
- evaluate steelhead and coho smolt production of individual tributaries relative to one another (tributary scale),
- evaluate steelhead and coho smolt physical quality from individual tributaries relative to one another (tributary scale), and
- determine the values of various life-history characteristics at the scale of individual tributaries in the Sandy River Basin (tributary scale).

The proximate objectives each year will be to determine the values for the following variables for each stream that is trapped:

- Smolt population (for every salmonid species possible)
- Mean fork length (by species)
- Mean condition factor ((weight/(fork length^3))×100,000)
- Mean date of emigration (by species)

In 2014, a collaboration between PWB and ODFW provided age information from scale samples collected by PWB and USFS between 2009 and 2013. This information allowed the pursuit of an additional life-history objective:

- Determine the mean age at emigration for steelhead and coho smolts

2.3 Sample Area and Scope

2.3.1 Study Area

The portions of the Sandy River Basin that are accessible to anadromous fish include approximately 190 miles of streams and rivers spanning a wide range of environments from cold, high-elevation, high-gradient streams in wilderness areas to warm, low-gradient, and tidally influenced streams within the Portland urban growth boundary, as indicated in Figure 2. About 30 percent of these stream miles are influenced by glacial runoff, often with high turbidity.

2.3.2 Sample Area

Not all of the Sandy River Basin that is accessible to anadromous fish is included in the sample area. Streams selected for smolt sampling total 106 miles, or 56 percent of the total habitat in the Sandy River accessible to anadromous fish. Over 80 percent of the clear water stream miles are included. Clear water streams are streams not influenced by glacial runoff. These are the streams expected to contribute most to total smolt production, due to the suitability of spawning habitat (Suring et al. 2006) and relatively greater primary productivity and ease of locating prey. The remaining clear water streams are generally small, have relatively high gradients, and are not expected to produce a large number of salmon or steelhead smolts. This sample area covers nearly the full range of environmental conditions that salmon and steelhead encounter in the Sandy River Basin and is considered by the Sandy River Basin Partners monitoring group to constitute a representative index for the entire basin for steelhead and coho. It also closely corresponds with the area for which steelhead and coho spawner counts are developed annually by the Oregon Department of Fish and Wildlife (ODFW; Suring et al. 2006, Hutchinson et al. 2007). The sample area covered by the Sandy River Basin Smolt Monitoring effort is henceforth referred to as the Sandy River Basin Index Area. The products of this effort will eventually be applicable to the entire index area. Information that is collected will be immediately applicable at the scale of individual tributaries.

Figure 1. USFS personnel check the Clear Creek trap.

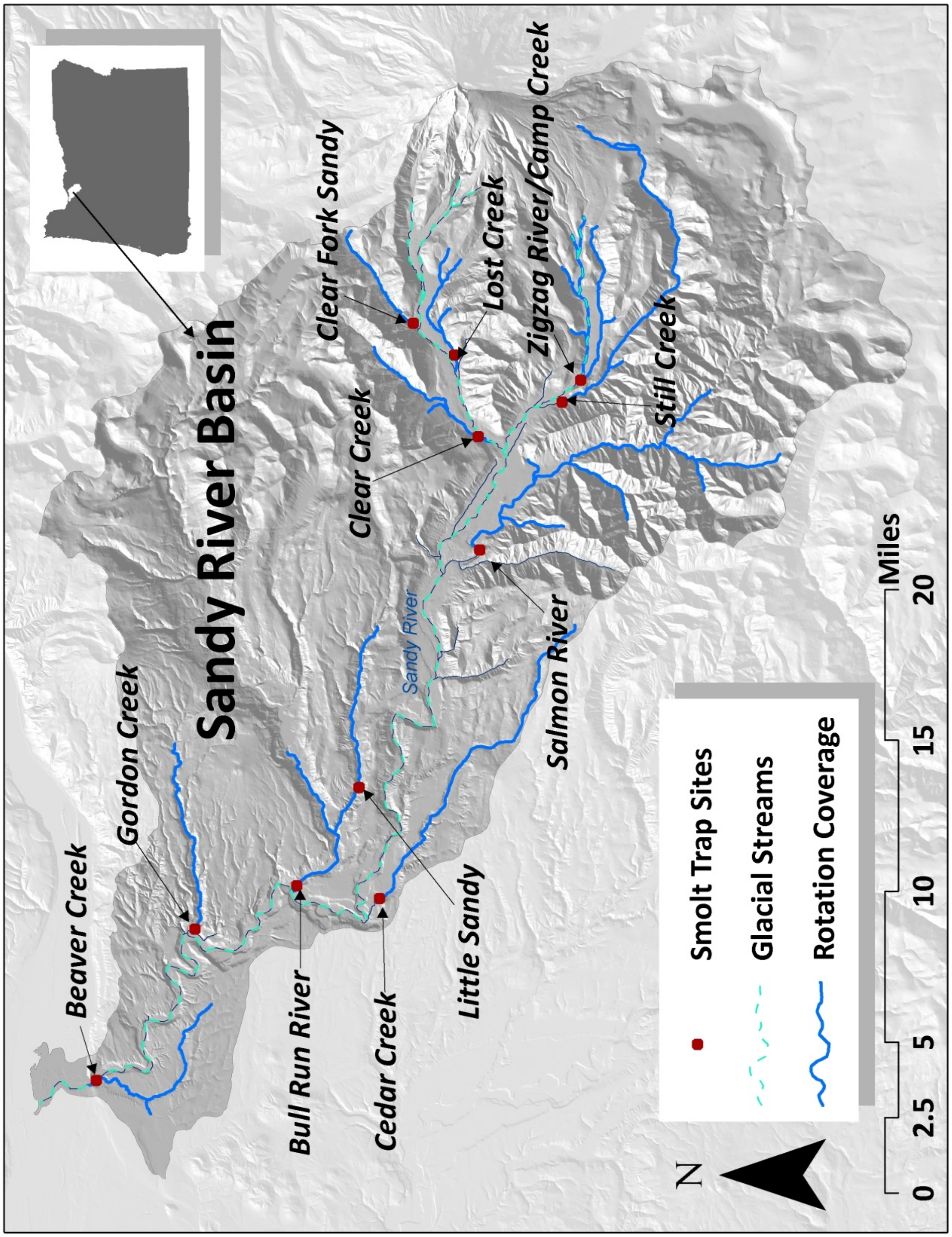


Figure 2. Sandy River Basin—Smolt trap sites, streams covered by rotating smolt trap study, and streams receiving glacial runoff

3. Methods

3.1 Sampling

Juvenile outmigrant (JOM) sampling in the Sandy River Basin is implemented following a carefully coordinated, long-term sampling schedule, using methods that are consistent across geography and time.

3.1.1 Sampling Schedule

Eleven streams were identified by the monitoring subgroup as being feasible and appropriate for operating a smolt trap. These streams are summarized in Table 1.

Table 1. Streams sampled for salmon and steelhead smolts, with sampling category, range of elevations of anadromous reaches, and average gradient

Stream	Miles Used by Anadromous Fish	Sampling Category[a]	Anadromous Elevation Range (feet above mean sea level)	Average Gradient
Bull Run River (without the Little Sandy River)	7.5	Fixed	240–700	1.3%
Little Sandy River	5.9	Fixed	430–1,600	2.9%
Cedar Creek	13.2	Fixed	360–3,240	4.1%
Clear Fork Sandy River	4.3	Rotation	2,130–3,390	5.4%
Lost Creek	4.9	Rotation	1,770–2,660	3.7%
Clear Creek	5.5	Rotation	1,440–2,780	4.6%
Still Creek	8.7	Rotation	1,580–3,120	3.1%
Zigzag River/ Camp Creek	16.4	Rotation	1,840–3,360	4.1%
Salmon River	24.0	Rotation	1,010–1,850	1.2%
Gordon Creek	7.4	Rotation	100–1,630	4.0%
Beaver Creek	7.7	Rotation	20–550	1.3%

[a]Sampling category: Fixed=sampled annually, Rotation=sampled according to rotating schedule

It is anticipated that at least seven smolt traps will be operated each year. The provisional sampling schedule is summarized in Table 2. Three trap locations will be fixed and operated every year, because of additional monitoring needs. The Bull Run River and Little Sandy River will be monitored annually to meet specific commitments in the HCP. Cedar Creek will be monitored annually to document recolonization by salmon and steelhead after 2010, when adult salmon and steelhead were again allowed access to historical habitat blocked by the ODFW hatchery at RM 1.5.

Table 2. Provisional schedule for sampling major tributaries in the Sandy River Basin[a]

Year	Cedar Creek	Little Sandy River	Bull Run River	Clear Fork Sandy River	Lost Creek	Clear Creek	Still Creek	Zigzag River/ Camp Creek	Salmon River	Gordon Creek	Beaver Creek
2009		x	x		x	x	x			x	
2010		x	x	x				x	x		x
2011		x	x		x		x	x		x	
2012		x	x				x	x	x		x
2013	x	x	x	x	x				x	x	
2014	x	x	x			x	x	x			x
2015	x	x	x	x	x		x				x
2016	x	x	x			x			x	x	x
2017	x	x	x		x	x		x	x		
2018	x	x	x		x	x			x		x
2019	x	x	x	x			x	x		x	
2020	x	x	x	x	x	x					x
2021	x	x	x	x		x		x		x	
2022	x	x	x	x			x		x	x	
2023	x	x	x				x		x	x	x
2024	x	x	x	x		x	x		x		
2025	x	x	x		x	x		x		x	
2026	x	x	x	x	x			x			x
2027	x	x	x		x			x		x	x
2028	x	x	x	x		x	x		x		

[a]Schedules for years 2009, 2010, 2018, 2019, 2027, and 2028 (shaded gray) are fixed, but the remaining years may be changed to accommodate other monitoring needs, as long as all sites scheduled for a given year remain grouped together as a unit.

This smolt monitoring plan extends the reference area of the remaining four traps by rotating them among eight streams according to the following constraints (assuming that Camp Creek and the Zigzag River are combined):

- Each site will be trapped, on average, every other year.
- All sites will be trapped once in the first two years, once in the middle two years and once in the last two years of a 20-year period.

Rotated sites will be trapped according to a schedule that maximizes the pair-wise comparisons between them.

The original provisional smolt trap rotation schedule established in 2009 was adjusted in 2011 to accommodate logistical needs. The group of traps scheduled for 2011 was traded with that scheduled for 2021. Table 2 reflects the new schedule.

3.1.2 Sampling in 2014

Smolt production was monitored in Clear Creek, the Zigzag River, Still Creek, Cedar Creek, the Little Sandy River, the Bull Run River, and Beaver Creek in 2014. An eight-foot-diameter rotary trap was used on the Bull Run River. Five-foot-diameter rotary screw traps were used on all other streams. A screw trap modified with wooden pontoons and other trap parts was used on Beaver Creek to discourage metal theft (Figure 3). The Clear Creek, Still Creek, and Zigzag River traps were checked and maintained by USFS Zigzag Ranger District staff and volunteers. ODFW staff checked and maintained the Cedar Creek trap. PWB staff checked and maintained the Little Sandy River, Bull Run River, and Beaver Creek traps. All traps were operated seven days per week throughout the season. The periods of operation for each site are summarized in Table 3, together with the number of days that each trap was not in operation due to scheduling, high flows, or other considerations.

A variety of factors contributed to time periods when traps were not in operation in 2014. Traps were not operated because of high flows on multiple days in all streams. Low flows hampered trapping for long periods of time on Clear Creek, Cedar Creek, and Beaver Creek. Clear Creek was unable to function for two weeks due to low flows. Five days were missed on the Bull Run River to avoid capturing acclimated hatchery Chinook smolts released on two occasions upstream of the trap.

Figure 3. A trap made largely of wood was used in Beaver Creek to discourage metal theft.

Table 3. Dates of operation and the number of days traps did not operate in the Sandy River Basin in 2014

Stream[a]	Trap In	Trap Out	Down Time (Days)
Clear Creek	April 2	June 22	30
Zigzag River	April 8	June 27	5
Still Creek	March 31	June 27	4
Cedar Creek	March 18	May 29	4
Little Sandy	March 13	June 19	10
Bull Run River (without the Little Sandy River)	March 13	June 18	16
Beaver Creek	March 6	June 14	4

[a]Streams are presented in order from highest-elevation Clear Creek to lowest-elevation Beaver Creek.

3.1.3 Data Collection

Traps were checked daily and all fish were removed from the trap's live well. Fish were anesthetized using Alka-Seltzer Gold ™ (buffered sodium bicarbonate). The following data were collected for most fish:

- Species
- Life-stage (smolt, juvenile, fry, or adults)
- Fork length (mm)
- Weight (g)
- Fin marks given or observed (see Mark-Recapture Study section below)
- Comments (e.g., injuries, pathogens, etc.)

Life stage was determined using external characteristics. Smolts show a general silvering, fading of parr marks, and a darkening of the posterior edge of the caudal fin. Juveniles are small fish but larger than 50 mm that show none of the above smolt characteristics. Fry are 50 mm or less. At times, and especially early in the season, steelhead smolts were just beginning to develop their characteristics and could be difficult to distinguish from juveniles. In these borderline cases, the following rule-set was applied:

> If a steelhead is longer than 130 mm fork length, consider it a smolt unless there are absolutely no signs that smoltification may have begun, in which case consider it a juvenile. If a steelhead is 130 mm or less, consider it a juvenile, unless there are clearly signs of it being a smolt.

Tissue and scale samples were collected from steelhead and coho smolts at all sites. Tissue samples were collected according to sampling protocols that varied by trap site to support other monitoring efforts.[2] Scale samples were collected from ten individual fish in each ten-millimeter fork-length increment throughout the fork length range of both steelhead and coho smolts at each trap site. Age of sampled fish will be determined from scale samples by the ODFW Fish Life History Analysis Project laboratory in Corvallis, Oregon. The ages of smolts sampled between 2009 and 2013 were determined in 2014 and are incorporated into this report.

3.1.4 Mark-Recapture Study

An ongoing trap efficiency study was conducted throughout the trapping season to determine the proportion of the outmigration that was being captured in the traps. Following a modified mark-recapture protocol, up to 25 smolts of each species at each site each day were given a fin mark specific to the day of the week. Marked fish were subsequently released from approximately 0.1 to 1.5 miles upstream of the trap, depending on access to appropriate release sites. Fins were marked either with small clips or injected dye. Captured fish were sorted each day to look for fin marks from previous days' releases.

In deciding to mark fish for the trap efficiency study with only seven specific fin-clip markings—one for each weekday—researchers assumed that all marked fish would travel from the release point to the trap within seven days. An analysis of the recapture data appears to bear this assumption out. Most fish appeared to be recaptured after one to three days, with very few indicating a travel time of four or more days. The consequences of some fish taking more than seven days to travel from the release point to the trap are reduced by pooling adjacent weeks together into two-week mark-recapture periods.

Figure 4. Accessing the Bull Run trap

3.2 Assumptions

The mark-recapture procedures are subject to the same limitations inherent to all similar studies. The model assumes the following:

[2] Examples of other monitoring efforts include using tissue samples to describe the recolonization of the Little Sandy River and using scale samples to age smolts throughout the Sandy River Basin. Most of these samples have not yet been analyzed and may eventually be analyzed by agencies other than PWB or USFS. Some tissue samples have been analyzed by the National Oceanic and Atmospheric Administration (NOAA).

- The target species and life-stages are actively moving downstream (equivalent to the "closed population" requirement of the Peterson estimator, discussed in Volkhardt et al. 2007).
- All fish in a capture period (stratum) of a given species and life stage have equal probability of first-time capture.
- Marking fish does not affect their catchability (that is, they do not suffer mortality between marking and potential recapture).
- Marked and unmarked fish traveling together have an equal probability of recapture (that is, fish do not become "trap-shy" or "trap-happy," leading to overestimated or underestimated populations, respectively).
- Fish do not lose their marks.
- All recaptured marked fish are recognized.

3.3 Data Analysis

3.3.1 Smolt Population Estimation

Smolt population sizes for individual streams are estimated using Darroch Analysis with Rank Reduction for R (DARR 2.0.2, Bjorkstedt 2010), a program provided by the National Marine Fisheries Service.[3] DARR 2.0.2 relies on a stratified Peterson estimator for mark-recapture data. Prior to calculation of the estimate, however, time periods are aggregated following rules designed to avoid the pitfalls associated with small populations and low recapture rates.

In the Sandy River Basin, fish total captures (C) and marks (M) are stratified by two-week time periods, to reduce variation associated with flows, water temperature, and changing fish behavior. The associated recaptures (R) are identified by both the time period in which they originated and the time period in which they are recaptured, resulting in a recapture matrix. The Darroch estimator uses the recapture matrix to estimate the number of marked fish passing the trap during a given time period. The total estimate is the sum of the individual time period estimates. Details of the calculation of the total estimate and its variance are fully described in Bjorkstedt (2005).

For the special cases in which all recaptures occur in the same stratum from which they originated (all non-zero values occur along the middle diagonal of the recapture matrix), the Darroch estimator reduces to a simple Peterson estimator (where N refers to population estimate and the subscript s refers to the stratum):

[3] The program is available on the NMFS site: http://swfsc.noaa.gov/textblock.aspx?Division=FED&id=3346.

$$\text{Stratum estimate } (N_s) = C_s\,(M_s / R_s) \qquad \text{(Equation 1)}$$

There were several days at each site when certain smolt traps were not in operation, because of damage, potential damage, or scheduling issues (see Table 3). For these days, the daily smolt output was estimated using a two-week running average of daily population estimates (daily total capture without recaptures ÷ trap efficiency$_{stratum}$; with trap efficiency provided by DARR 2.0.2). Only days with actual captures within seven days before and after a particular date were included in the running average of daily population estimates. The Clear Creek trap was down for 16 continuous days in June. This large of a block of days precluded the use of a running 14-day averaging range. There were enough days of trapping in each two-week trapping period, however, to estimate an average daily emigration for each period. In the case of Clear Creek, the average daily emigration estimate from the period of operation in each of the two trapping periods was used to estimate the emigration during all 30 days in the respective trapping period when the trap was down. The variance of down-time estimates was calculated by adding the variances of each daily estimate, which, in turn, was added to the variance provided by DARR to produce 95 percent confidence intervals for each smolt population estimate in Clear Creek.

The Sandy River Basin Smolt Monitoring Plan is designed to produce Sandy River Basin-level (index area) smolt populations estimates, population trend estimates, and freshwater productivity estimates (smolts per adult) after 20 years of annual smolt monitoring. Preliminary calculations, however, can be made now. The preliminary calculations illustrate the process of filling gaps in each time series of subbasin estimates and the process of adding individual subbasin population estimates in a given year together to produce a Sandy River basin-level estimate.

The Sandy River Basin Smolt Monitoring Plan sampling schedule (Table 2) results in gaps in each subbasin's time series of population estimates that must be filled. These gaps were filled, on a demonstration basis in 2014, by using the average and the associated variance of all past population estimates for each respective subbasin. The number used to fill gaps in a given trap's time series of population estimates is henceforth referred to as a "gap estimate." For each year between 2009 and 2014, all subbasin smolt trap estimates and gap estimates were summed by species to calculate Sandy River Basin-level population estimates for steelhead and coho smolts. The variances associated with each smolt trap estimate and each gap estimate were similarly summed by species to calculate a variance for each Sandy River Basin-level population estimate.

Gap estimates will be recalculated in the future, once more subbasin estimates are available, to retroactively produce refined Sandy River Basin-level smolt population estimates.

Estimates of the number of adult steelhead and coho spawners in the Sandy River Basin for each parent generation that produced the steelhead and coho smolts monitored in 2009 through 2013 were used to tentatively calculate freshwater productivity (smolts per adult) for as many adult spawner years as possible. Adult steelhead and coho spawner estimates were obtained from the ODFW Oregon Adult Salmonid Inventory & Sampling (OASIS) Program. The adult steelhead and coho spawner estimates correspond to approximately the same geographic reference frame (index area) as the Sandy River Basin Smolt Monitoring Plan.

3.3.2 Smolt Fork Lengths

Weighted average fork lengths for all smolt populations were calculated. Smolt fork lengths for each site were compiled and then weighted by capture stratum using trap efficiency (provided by DARR 2.0.2). If trap efficiency for a given stratum was low, the weights for fish captured in that stratum were weighted more heavily. This prevented strata with few fish but high trap efficiencies, for example, from influencing the average more than strata with many fish but low trap efficiencies. Fork lengths of actual captures were compared among streams using analysis of variance (ANOVA). If the resulting F statistic was found to be significant at an α level of 0.05, a Tukey test was applied to all combinations of pairs of streams to determine how average fork lengths differed from one another.

3.3.3 Smolt Condition Factors

Condition factors (K) were determined for all steelhead and coho smolts by basin using weights (W) and fork lengths (L) according to the following formula:

$$K=(W/L^3)*100{,}000 \qquad \textbf{(Equation 2)}$$

Condition factors give an indication of how thin or fat a fish is. Condition factors were compared among basins by statistically testing for differences using ANOVA. If the resulting F statistic was found to be significant at an α level of 0.05, a Tukey test was applied to determine how mean condition factors differed from each other. Condition factors were not weighted by capture stratum using trap efficiency because of the analytical complexities involved.

3.3.4 Emigration Dates

Steelhead and coho smolt mean and peak emigration dates were calculated for each site. The mean emigration date was defined as the sum of the product of daily captures corrected for stratum efficiency (C) and the date of capture (D) on any given day (i for days 1-k), divided by the sum of corrected captures using the following formula:

$$\sum_{i=1}^{k}(CD)_i \Big/ \sum_{i=1}^{k} C_i \qquad \textbf{(Equation 3)}$$

The peak emigration date was defined as the day when most fish of a species and condition were estimated to have passed the trap site (daily captures corrected for stratum trap efficiency).

4. Results

4.1 Smolt Population Estimation

4.1.1 Trap Efficiencies

The efficiencies of traps varied across sites and time. Trap efficiencies are summarized in Table 4 for each site and two-week trapping period. Period 1 for each site started the Sunday of the week that trapping began for the respective site (see Table 3 for start dates). Given a certain number of marked fish, the higher the trap efficiency, the more precise the population estimate. A trap efficiency of at least 0.1 and preferably closer to 0.25 is desirable.

Table 4. Trap efficiencies for each site, species, and two-week trap period in 2014

		Period						
Site[a]	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7[b]**
Clear Creek	Steelhead	0.222	0.222	0.250	0.500	0.167	0.167	—
	Coho	0.217	0.217	0.208	0.179	0.293	0.720	—
Still Creek	Steelhead	0.186	0.341	0.106	0.106	0.106	0.106	0.106
	Coho	0.279	0.178	0.260	0.281	0.386	0.302	0.267
Cedar Creek	Steelhead	0.179	0.179	0.179	0.098	0.071	0.071	—
	Coho	0.412	0.297	0.496	0.284	0.333	0.333	—
Little Sandy River	Steelhead	0.096	0.096	0.096	0.096	0.149	0.231	0.231
	Coho	0.300	0.231	0.231	0.105	0.105	0.105	0.105
Bull Run (without Little Sandy River)	Steelhead	0.040	0.040	0.040	0.040	0.093	0.070	0.070
	Coho	0.048	0.048	0.048	0.048	0.048	0.167	0.167
Beaver Creek	Steelhead	0.143	0.143	0.141	0.141	0.141	0.141	0.141
	Coho	0.130	0.130	0.065	0.104	0.104	0.104	0.104

[a]Streams are presented in order from highest-elevation Clear Creek to lowest-elevation Beaver Creek.

[b]There was no seventh two-week trapping period in Clear Creek or Cedar Creek because those traps were not operated long enough due to low flows or other factors.

4.1.2 Subbasin Population Estimates

Monitored smolt production was relatively high in 2014. As observed in the past, more steelhead smolts were produced by the Bull Run River than all other monitored streams combined. The Bull Run River, however, is also significantly larger than all other streams monitored in 2014. The majority of coho smolts from monitored streams emigrated from Still Creek, as is summarized in Table 5. The estimated steelhead smolt population estimate in 2014 was the second-largest ever observed in the Bull Run, and the largest to-date for the Little Sandy since the dam was removed in 2008 (Table 9). The number of steelhead emigrating from Cedar Creek was higher than in 2013, but the number of emigrating coho was lower. The first year that estimates could be generated for steelhead and coho smolts in Beaver Creek was 2014. Exhibit A summarizes the total captures at all trap sites.

A portion of the emigration of coho smolts from Clear Creek, Still Creek, Cedar Creek the Little Sandy, and Beaver Creek may have been missed. A number of coho were caught on the first day of trapping in each of these streams, and coho were still being caught on the last day of trapping in Clear Creek and Still Creek. Trapping in each of these streams in 2014 coincided with the period of spring smolt emigration observed in the past, so it is likely that the proportion of the population that was missed was small.

The variances associated with estimates in several streams were large relative to the estimates themselves in 2014. Steelhead estimates tended to be less precise than coho estimates because of lower trap efficiencies for steelhead than for coho (see Table 4). Cedar Creek and Beaver Creek estimates were the least precise for steelhead and the Little Sandy and Bull Run estimates were least precise for coho. Lack of precision was generally due to a combination of low marking rates due to small population sizes and low trap efficiencies.

Table 5. Steelhead and coho smolt population estimates and 95% confidence intervals for 2014[a]

	Steelhead		Coho	
Stream[b]	**Estimate**	**95% CI**	**Estimate**	**95% CI**
Clear Creek	418	38%	1,902	20%
Zigzag River[c]	14	NA	0	NA
Still Creek	1,341	42%	6,322	8%
Cedar Creek	791	68%	1,208	14%
Little Sandy River	2,395	39%	473	85%
Bull Run River (without Little Sandy)	17,490	43%	1,009	200%
Beaver Creek	603	53%	2,680	41%

[a]Confidence intervals are expressed as percentages of the associated estimates.

[b]Streams are presented in order from highest-elevation Clear Creek to lowest-elevation Beaver Creek.

[c]Zigzag had no steelhead recaptures so no estimate could be calculated. Actual captures are given.

Of all streams monitored in 2014, steelhead smolt production per unit of stream length and per unit of surface area was highest in the Bull Run River, as summarized in Table 6. The Zigzag River probably had the lowest steelhead smolt production per unit of length and surface area, and, because no population estimate could be made, density estimates were not attempted.

Table 6. Steelhead and coho smolts per mile and smolts per 1,000 ft² for 2014

	Steelhead		Coho	
Streams[a,b]	**Smolts/mile**	**Smolts/1,000 ft²**	**Smolts/mile**	**Smolts/1,000 ft²**
Clear Creek	81.96	0.50	372.94	2.29
Still Creek	90.00	0.51	866.03	3.56
Cedar Creek	53.81	0.28	82.18	0.43
Little Sandy River	405.93	1.22	80.17	0.24
Bull Run River (without Little Sandy)	2107.23	4.52	121.57	0.26
Beaver Creek	78.31	0.68	348.05	3.04

[a]Streams are presented in order from highest-elevation Clear Creek to lowest-elevation Beaver Creek.

[b]Zigzag River had no recaptures so population estimates could not be calculated.

Of all streams monitored in 2014, both coho smolt production per unit of stream length and coho smolt production per unit of surface area were highest in Still Creek. Beaver Creek had the second-highest production of coho smolts per unit of surface area, despite its being an impacted watershed on the urban fringe. The Zigzag River did not have any observed coho smolt production.

4.1.3 Sandy River Basin Index Area Population Estimates

At least two smolt population estimates were compiled from past trapping efforts in each subbasin except for Clear Creek, Cedar Creek, and Beaver Creek. The smolt population estimates were used to create gap estimates. The subbasin smolt population estimate statistics are summarized in Tables 7, for steelhead, and 8, for coho. The average relative contributions of each of the streams monitored in the Sandy River Basin Index Area are illustrated for steelhead and coho in Figures 2 and 3, respectively.

Table 7. Statistics for steelhead subbasin smolt trap population estimates compiled from the Sandy River Basin Index Area, 2009–2014

	Clear Fork Sandy	Lost Creek	Clear Creek	Zigzag River	Still Creek	Salmon River	Cedar Creek	Little Sandy	Bull Run	Gordon Creek	Beaver Creek[a]
n	3	4	2	4	18	3	2	6	6	3	1
Average	634	15	1,466	8	1,579	7,331	480	1,325	13,579	1,511	603
Variance[b]	298,296	327	1,133,378	40	2,128,131	23,50,4832	193,442	744,286	48,375,773	743,484	26,287

[a]Only one estimate is available. If a variance is given, it is the variance associated with the one subbasin estimate, rather than the distribution of subbasin estimates.

[b]Variance describes the spread of individual subbasin estimates around their average.

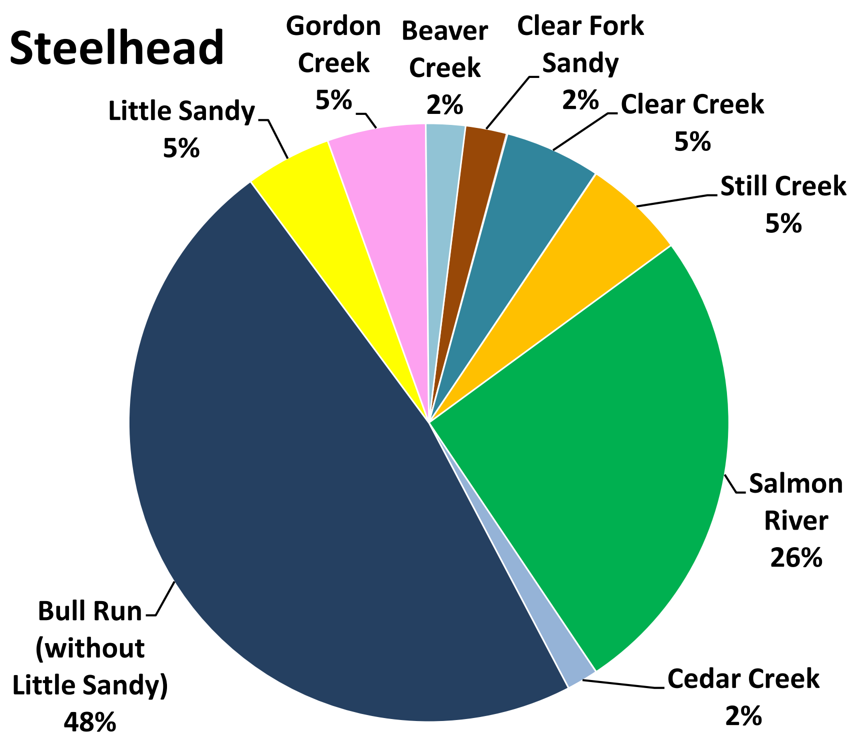


Figure 5. Average relative contributions of monitored streams to steelhead smolt production in the Sandy River Basin Index Area, 2009–2014

Table 8. Statistics for coho subbasin smolt trap population estimates compiled from the Sandy River Basin Index Area, 2009–2014

	Clear Fork Sandy	Lost Creek	Clear Creek	Zigzag River	Still Creek	Salmon River	Cedar Creek	Little Sandy	Bull Run	Gordon Creek	Beaver Creek[a]
n	5	4	2	4	21	3	2	6	6	3	1
Average	1,020	0	2,870	0	3,602	13,879	2,589	209	1,198	877	2,680
Variance[b]	402,899	0	1,874,048	0	4,014,790	47,379,924	953,581	92,510	911,243	78,649	318,902

[a]Only one estimate is available. If a variance is given, it is the variance associated with the one subbasin estimate, rather than the distribution of subbasin estimates.

[b]Variance describes the spread of individual subbasin estimates around their average.

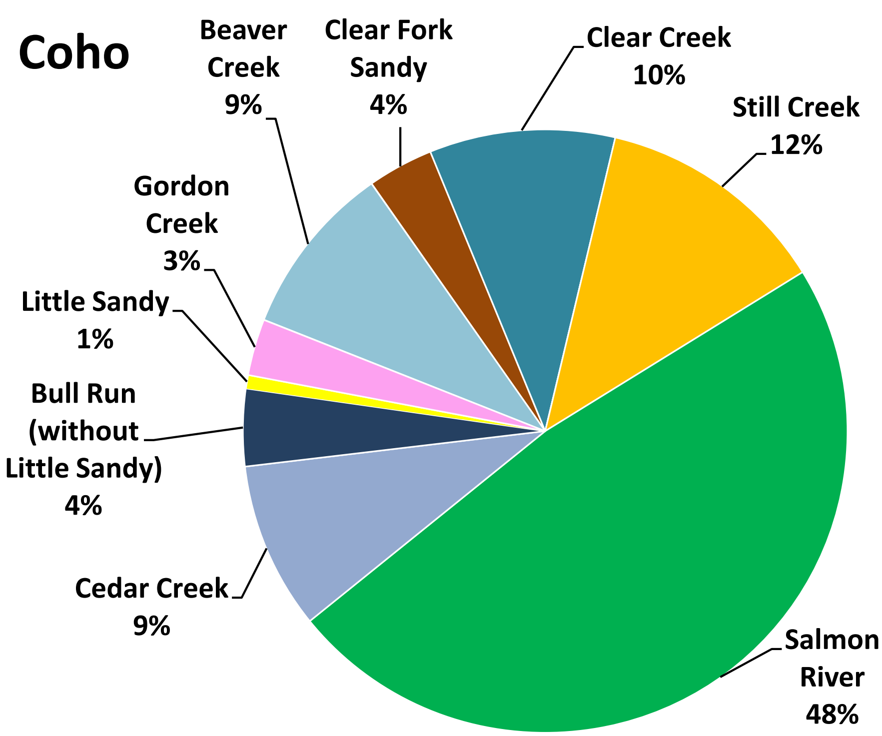


Figure 6. Average relative contributions of monitored streams to coho smolt production in the Sandy River Basin Index Area, 2009–2014

The subbasin steelhead and coho smolt population estimates and demonstrative gap estimates, as well as their 95 percent confidence intervals, are summarized in Tables 9 and 10, respectively, for the six years of the Sandy River Basin Smolt Monitoring Plan period (2009–2014). Expanded estimates were used for the 2011 subbasin population estimates and for Still Creek and the Salmon River in 2012, when trapping started late enough in the season to miss a significant portion of the smolt emigration. Averages of existing subbasin smolt population estimates (from Tables 7 and 8) were tentatively used as the gap estimates for this initial exercise. In the case of Beaver Creek, only one population estimate was available, and was simply used repeatedly with its associated variance, for the purpose of demonstration.

Table 9. Subbasin steelhead smolt population estimates and gap estimates since the inception of the Sandy River Basin Smolt Monitoring Plan[a]

	Clear Fork Sandy	Lost Creek	Clear Creek	Zigzag River	Still Creek	Salmon River	Cedar Creek	Little Sandy	Bull Run	Gordon Creek	Beaver Creek[b]
2009	634	5	2,514	8	3,709	7,331		160	6,637	2,483	603
	169%	na	83%	na	87%	130%		153%	96%	97%	53%
2010	4	15	1,466	5	138	3,419		416	11,701	1,511	603
	na	240%	198%	na	102%	77%		56%	149%	112%	53%
2011	634	1	1,466	1	4,958	7,331		1,552	7,750	839	603
	169%	na	198%	na	15%	130%		51%	33%	63%	53%
2012	634	15	1,466	13	1,236	5,819		1,856	12,495	1,511	603
	169%	240%	198%	na	39%	20%		67%	59%	112%	53%
2013	967	12	1,466	8	1,293	12,755	169	1,569	25,399	1,210	603
	51%	55%	198%	na	38%	47%	56%	40%	36%	122%	53%
2014	634	15	418	14	1,341	7,331	791	2,395	17,490	1,511	603
	169%	240%	38%	na	42%	130%	68%	39%	43%	112%	53%

[a]Shaded cells indicate gap estimates using the best information available.

[b]Only one population estimate is available and is used repeatedly as the gap estimate for this exercise.

Table 10. Subbasin steelhead coho smolt population estimates and gap estimates since the inception of the Sandy River Basin Smolt Monitoring Plan[a]

	Clear Fork Sandy	Lost Creek	Clear Creek	Zigzag River	Still Creek	Salmon River	Cedar Creek	Little Sandy	Bull Run	Gordon Creek	Beaver Creek[b]
2009	1,020	0	3,838	0	5,528	13,879	0	0	661	994	2,680
	122%	0%	24%	0%	21%	97%		0%	109%	41%	41%
2010	1,646	0	2,870	0	3,911	11,077	0	37	2,708	877	2,680
	51%	0%	93%	0%	12%	53%		50%	68%	63%	41%
2011	1,020	0	2,870	0	6,325	13,879	0	39	483	557	2,680
	122%	0%	93%	0%	9%	97%		166 %	61%	70%	41%
2012	1,020	0	2,870	0	4,144	8,838	0	0	314	877	2,680
	122%	0%	93%	0%	28%	14%		0%	141%	63%	41%
2013	853	0	2,870	0	5,435	21,721	2,589	706	2,010	1,080	2,680
	29%	0%	93%	0%	12%	18%	44%	35%	57%	50%	41%
2014	1,020	0	1,902	0	6,322	13,879	1,208	473	1,009	877	2,680
	122%	0%	20%	0%	8%	97%	14%	85%	200%	63%	41%

[a]Shaded cells indicate gap estimates using the best information available.
[b]Only one population estimate is available and is used repeatedly as the gap estimate for this exercise.

Preliminary steelhead and coho smolt population estimates for the entire combined index area of the Sandy River Basin are summarized in Table 11 and Figure 4 with their associated 95 percent confidence intervals.

Table 11. Sandy River Basin Index Area steelhead and coho smolt population estimates and 95% confidence intervals[a]

	Steelhead		Coho	
Year	**Estimate**	**95% CI**	**Estimate**	**95% CI**
2009	24,085	51.3%	28,600	47.9%
2010	19,277	93.1%	25,806	26.7%
2011	25,135	41.3%	27,853	49.8%
2012	25,648	32.8%	20,743	17.6%
2013	45,451	25.1%	39,944	13.0%
2014	32,543	38.0%	29,370	46.9%

[a]Confidence intervals are expressed as percentages of the associated estimates.

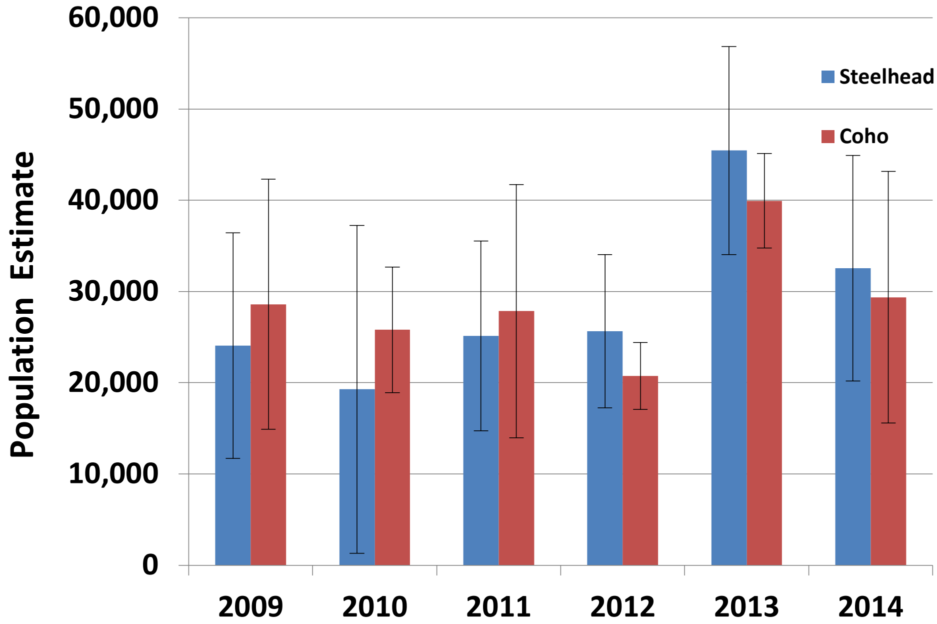


Figure 7. Sandy River Basin Index Area steelhead and coho smolt population estimates and 95% confidence intervals

Estimates of freshwater productivity (smolts per adult) for steelhead are presented in Table 12. Estimates of freshwater productivity (smolts per adult) for coho are presented in Table 13. The number of coho smolts are plotted against the number of coho spawners in the parent generation in Figure 8. Also plotted in Figure 8 is a spawner/recruit curve fitted to the Sandy River Basin coho data using the Beverton-Holt model. A spawner/recruit curve describes how the number of recruits (offspring) produced per spawner (parent) changes depending on the number of spawners there are, according to a given model. One such model is the Beverton-Holt model, which assumes that the number of recruits is dependent on the density of spawners. The Beverton-Holt equation follows:

$$R = \frac{\propto S}{(1+{}^{S}/_{K})} \qquad \textbf{(Equation 4)}$$

where R is the number of recruits, S is the number of spawners, α is a parameter related to the productivity (recruits per spawner) of the population at its maximum (low numbers of spawners) and α and K together describe the maximum production (total number of possible recruits). As the number of spawners becomes very large, the number of recruits (smolts) begins to level off near α/K. No Beverton-Holt spawner/recruit curve was fitted to steelhead data because there are too few data points.

The number of smolts resulting from each parental generation for each species was determined by using age distribution information derived from the reading of scale samples (see Methods) and smolt fork length distribution data from each smolt trap year. Steelhead smolts from a particular parental year class emigrated at age 1, age 2 and age 3 in proportions that varied by stream. Coho smolts are assumed to have emigrated only at ages 2 and 3.[4]

Table 12. Estimates of freshwater productivity for steelhead in the Sandy River Basin Index Area, 2010–2014

Steelhead Spawners		Steelhead Smolts		Freshwater Productivity
Year	Estimate	Year	Estimate	Smolts Per Adult
2010	2,100	2011-13	27,616	13
2011	527	2012-14	35,113	67

Table 13. Estimates of freshwater productivity for coho salmon in the Sandy River Basin Index Area, 2010–2014

Coho Spawners		Coho Smolts		Freshwater Productivity
Year	Estimate	Year	Estimate	Smolts Per Adult
2007	753	2009-10	28,682	38
2008	1,277	2010-11	25,782	20
2009	1,677	2011-12	27,799	17
2010	795	2012-13	20,735	26
2011	3,619	2013-14	37,383	10
2012	1,198	2014	28,135	23

[4] According to aging convention, for steelhead, an age 1 smolt is the offspring of adults which spawned the previous spring, approximately 12 months before. For coho, an age 1 smolt is the offspring of adults which spawned the previous fall, approximately 5-6 months before (ODFW 2014).

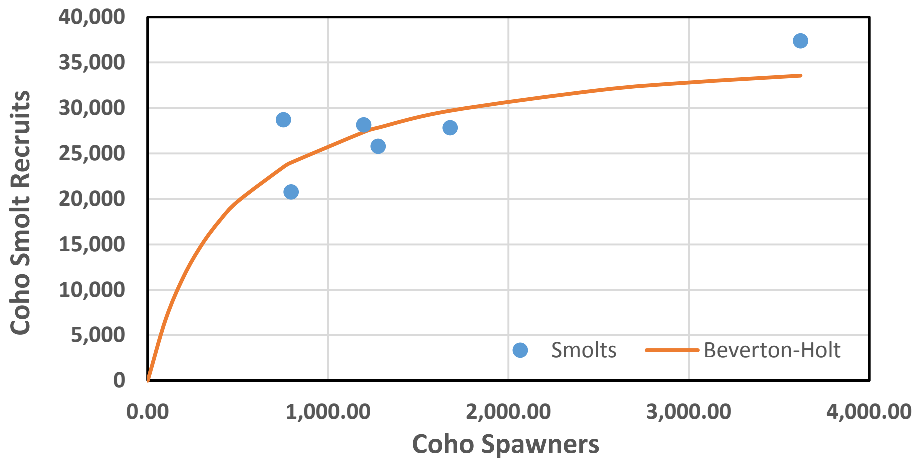


Figure 8. Coho spawners compared to resulting coho smolts in the Sandy River Basin Index Area, spawner years 2007–2012

4.1.4 Recolonization of the Little Sandy River

Recolonization of the Little Sandy River by steelhead after the removal of Little Sandy Dam in 2008 appears to have been immediate and sustained. Steelhead production increased to its highest level yet in 2014 (Figure 16), and by 2011 was comparable in terms of smolts per unit length and area of stream to other streams of similar size that were never blocked to steelhead, like Gordon Creek or Still Creek. 2011 was the first year that steelhead smolts were expected to result from the first steelhead adults spawning in the newly reopened portion of the stream. The steelhead smolts observed emigrating from the Little Sandy in 2009 and 2010—with estimated populations of 160 and 416 fish, respectively—were evidently primarily fish that had migrated upstream from the lower river past the site of the dam after its removal.

Although the Little Sandy River produced fewer coho smolts in 2014 than in 2013, the coho smolt estimate was still relatively large. This was the fifth year that coho smolts could be expected in the Little Sandy trap, originating from adults that spawned upstream of the trap site after dam removal in 2008. Thus far, the number of coho fry caught in the Little Sandy trap in a given year has served as an effective predictor of the coho smolt estimate the following year. By extrapolation, 2015 is predicted to result in a relatively low coho smolt estimate.

Spawning by Chinook salmon adults has also been documented to varying degrees in the Little Sandy River since the dam was removed in 2008. This is reflected in the variable presence of Chinook fry in the Little Sandy smolt trap.

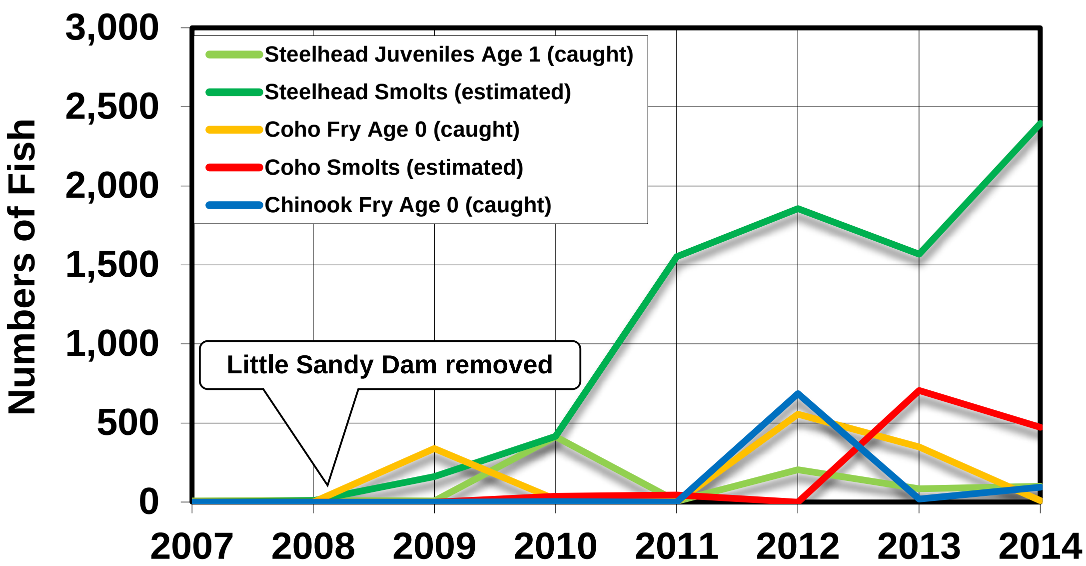


Figure 16. Recolonization of the Little Sandy River by steelhead, coho, and Chinook after the removal of the Little Sandy Dam

4.2 Fork Lengths

Steelhead and coho average fork lengths followed different patterns across monitored streams in 2014, as summarized in Tables 14 and 15, respectively. There were significant differences between the mean fork lengths of both steelhead and coho smolts among monitored streams (ANOVA, α=0.05, p<<0.001 for both tests). Steelhead smolts emigrating from the Bull Run River were larger than those emigrating from other monitored streams, except for the Zigzag River, but they were not significantly larger than steelhead smolts from Still or Clear creeks. Only 13 steelhead smolts were caught in the Zigzag trap in 2014 and there were no recaptures, so a weighted mean average fork length could not be calculated. The 13 steelhead smolts from the Zigzag River were also excluded from the ANOVA because of the small sample size and large variance. Beaver Creek coho smolts were the largest, on average, but were not significantly larger than Bull Run coho.

Table 14. Steelhead weighted mean fork lengths, weighted standard deviation, and range of fork lengths of steelhead smolts captured in Sandy River Basin smolt traps in 2014

Streams[a]	n[b]	Wtd. Mean Fork Length (mm)	Wtd. St. Dev. (mm)	Minimum (mm)	Maximum (mm)
Clear Creek	58	170	18	130	215
Zigzag River	13[c]	185	45	143	316
Still Creek	171	168	22	70	214
Cedar Creek	84	158	19	100	220
Little Sandy	237	155	12	125	198
Bull Run (without Little Sandy)	834	174	20	102	232
Beaver Creek	82	146	27	104	210

[a]Streams are presented in order from highest-elevation Clear Creek to lowest-elevation Beaver Creek.
[b]n= Number of fish for which fork lengths were determined
[c]No weighted mean fork length could be calculated for the Zigzag River. Mean fork length of measured fish is shown.

Figure 9 shows frequency distributions for steelhead smolt fork lengths. The results of the pair-wise comparisons are summarized below Figure 9.

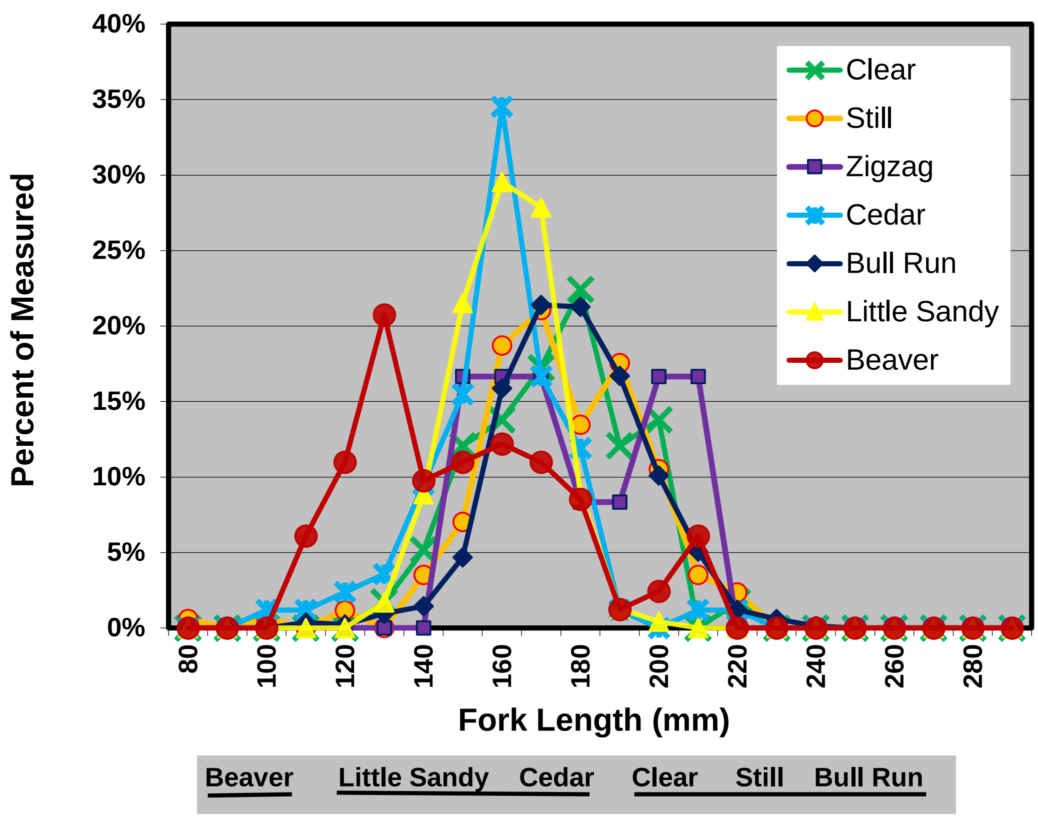


Figure 9. Steelhead smolt fork length frequency distributions for Sandy River Basin traps in 2014[a]
[a]Results of pair-wise statistical comparisons are presented from left to right, shortest to longest.

In Figure 9, streams that are grouped together by being mutually underlined are not statistically distinguishable from one another at a 95 percent level of significance (e.g., Cedar Creek and Little Sandy steelhead are not significantly different from each other in fork length, but are significantly longer than Beaver Creek steelhead).

Smolt age information reveals that different age distributions between streams obscure differences in steelhead growth. Figure 10 compares the weighted mean fork length of age 2 steelhead in all basins and for all years for which adequate age distribution data exists, with 95% confidence intervals. Upper basin steelhead have comparable average fork lengths to steelhead from lower in the basin. Little Sandy steelhead have been relatively small consistently (see Table 14). These patterns have been partly due to the fact that a higher proportion of the steelhead emigrating from upper-basin streams are age 3 than the steelhead emigrating from lower-basin streams. Age 3 fish are larger because they have had more time to grow.

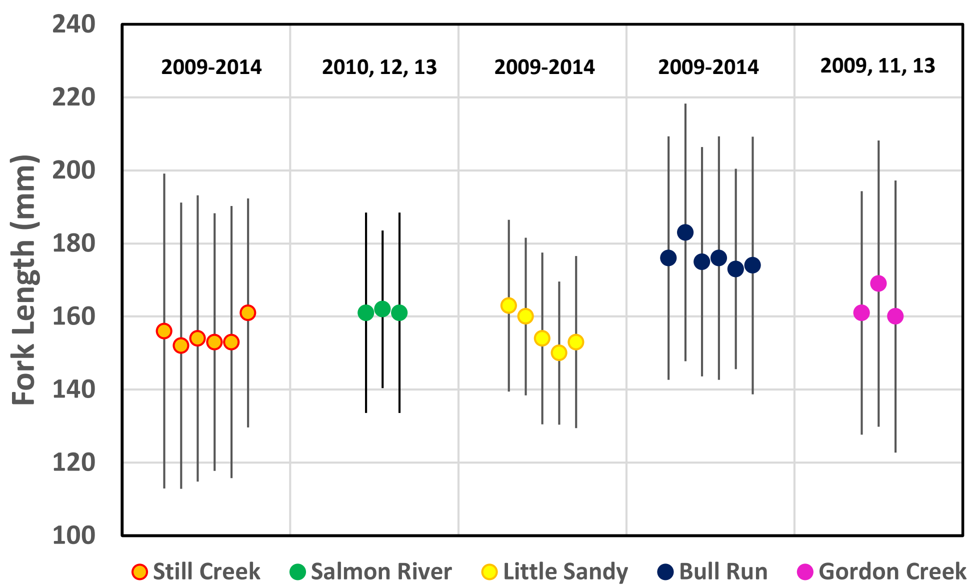


Figure 10. Weighted mean fork lengths of age 2 steelhead smolts for all Sandy River Basin streams and years for which age distribution data and fork length data exist.

Table 15. Coho weighted mean fork lengths, weighted standard deviation, and range of fork lengths of coho smolts captured in Sandy River Basin smolt traps in 2014

Streams[a]	n[b]	Wtd. Mean Fork Length (mm)	Wtd. St. Dev. (mm)	Minimum (mm)	Maximum (mm)
Clear Creek	257	111	14	73	194
Still Creek	999	105	13	72	215
Cedar Creek	343	114	9	80	160
Little Sandy	57	102	11	67	120
Bull Run (without Little Sandy)	78	114	18	80	194
Beaver Creek	235	118	19	72	185

[a]Streams are presented in order from highest-elevation Clear Creek to lowest-elevation Beaver Creek.
[b]n= Number of fish for which fork lengths were determined

Figure 11 shows frequency distributions for coho smolt fork lengths. The results of the pair-wise comparisons are summarized below Figure 11.

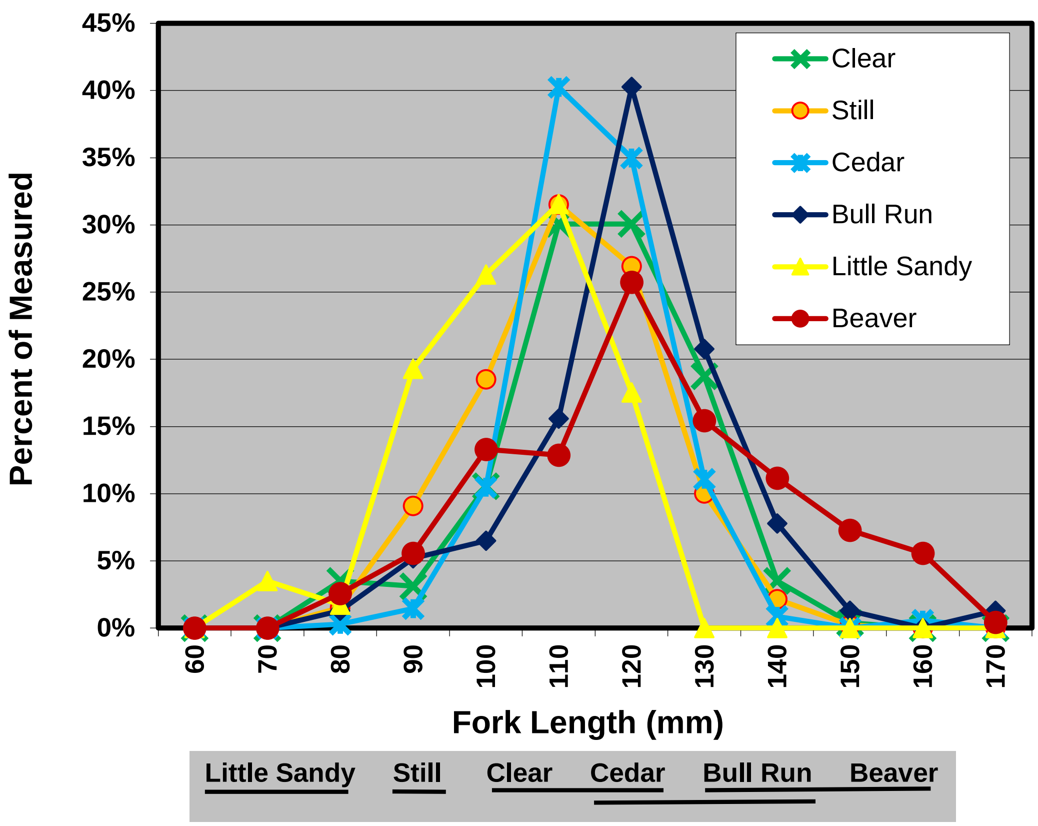


Figure 11. Coho smolt fork length frequency distributions for Sandy River Basin traps in 2014[a]
[a]Results of pair-wise statistical comparisons are presented from left to right, shortest to longest.

In Figure 11, streams that are grouped together by being mutually underlined are not statistically distinguishable from one another at a 95 percent level of significance (e.g., Beaver Creek coho are significantly larger than coho from Cedar Creek, but not statistically distinguishable from Bull Run coho. Bull Run coho are not statistically distinguishable from either Cedar Creek or Beaver Creek coho).

Smolt age information reveals that very few emigrating coho smolts in the Sandy River Basin are older than age 2, though most of those appear to emigrate from upper basin streams. The proportion of age 2 coho is too small to effect a substantial change to the overall weighted mean fork length of all emigrating coho.

4.3 Condition Factors

There were significant differences (ANOVA, $\alpha=0.05$, $p<<0.001$ for both tests) among the condition factors of steelhead and coho among streams monitored in 2014 (Figures 12 and 13). Clear Creek steelhead had the lowest condition factors (were thinnest) of steelhead from streams monitored in 2014, but they were not statistically distinguishable from those of any other stream except Beaver Creek. Beaver Creek steelhead had significantly higher condition factors (were fatter) than all other streams at a 95 percent level of confidence. Clear Creek coho had significantly lower condition factors than all other streams monitored in 2014. Beaver Creek, Little Sandy and Bull Run coho condition factors were statistically indistinguishable from one another, but were all significantly higher (the coho were fatter) than Still Creek and Clear Creek at a 95 percent level of confidence. Figures 11 and 12 show the results of Tukey test multiple comparisons of condition factors for these two species across monitored streams. The weights of Cedar Creek steelhead and coho were not measured, so their condition factors were not evaluated relative to the other streams.

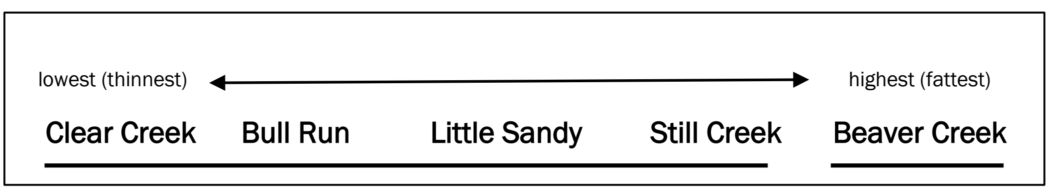


Figure 12. Steelhead smolt results of Tukey test multiple comparisons of condition factors for Sandy River streams monitored in 2014

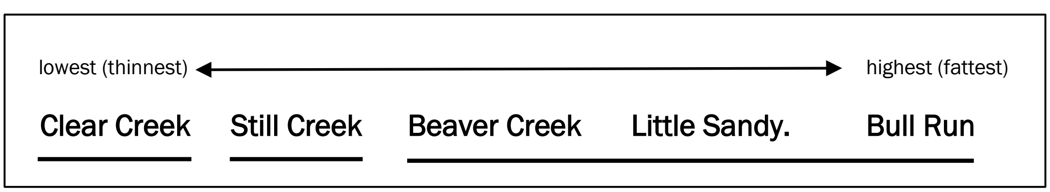


Figure 13. Coho smolt results of Tukey test multiple comparisons of coho smolt condition factors for Sandy River streams monitored in 2014

4.4 Emigration Dates

The weighted mean and peak dates of emigration were earlier in lower-elevation streams for coho, but were similar for steelhead throughout the Sandy River Basin. Beaver Creek coho emigrated earlier than coho from other streams, but not markedly so. The bulk of Beaver Creek steelhead, on the other hand, emigrated much earlier than was observed in all other streams. Still Creek and Clear Creek coho emigrated much later than coho from lower-basin streams. The weighted mean and median emigration dates for the trapping period are summarized, along with the estimated peak emigration date for the population and the dates of first and last capture, in Tables 16 and 17 for steelhead and coho, respectively.

The Zigzag River trap captured only 13 steelhead smolts and no coho. The associated emigration statistics are not weighted and are not considered representative of a steelhead population emigrating from this stream.

Table 16. Steelhead smolt weighted mean date of emigration, associated standard deviation, weighted median date of emigration, estimated peak emigration date, and earliest and latest capture dates in Sandy River streams monitored in 2014

Streams[a]	Wtd. Mean Emigration[b]	Wtd. St. Dev.	Wtd. Median Emigration[b]	Peak Emigration	Earliest Date[c]	Latest Date
Clear Creek	5-May	18 days	3-May	24-Apr	2-Apr	7-Jun
Zigzag River[b]	2-May	15 days	8-May	9-May	10-Apr	23-May
Still Creek	1-May	13 days	2-May	1-May	1-Apr	8-Jun
Cedar Creek	30-Apr	13 days	2-May	29-Apr	26-Mar	18-May
Little Sandy	27-Apr	14 days	1-May	9-May	17-Mar	26-May
Bull Run River	27-Apr	13 days	29-Apr	23-Apr	16-Mar	3-Jun
Beaver Creek	9-Apr	12 days	9-Apr	9-Apr	16-Mar	12-May

[a]Streams are presented in order from highest-elevation Clear Creek to lowest-elevation Beaver Creek.

[b]Zigzag River emigration date statistics are not weighted and not considered representative of what a larger population would show because of the small sample size (n=13).

Table 17. Coho smolt weighted mean date of emigration for the trapping period, associated standard deviation, weighted median date of emigration for the trapping period, estimated median emigration date for the population, and earliest and latest capture dates in Sandy River streams monitored in 2014

Streams[a]	Wtd. Mean Emigration[b] (Trapping)	Wtd. St. Dev.	Wtd. Median Emigration[b] (Trapping)	Median Emigration (Population)	Earliest Date[c]	Latest Date
Clear Creek	16-May	20 days	22-May	29-May	2-Apr	22-Jun
Still Creek	20-May	20 days	26-May	31-May	1-Apr	27-Jun
Cedar Creek	28-Apr	14 days	1-May	29-Apr	19-Mar	20-May
Little Sandy	26-Apr	18 days	1-May	9-May	14-Mar	28-May
Bull Run River	30-Apr	18 days	5-May	9-May	18-Mar	5-Jun
Beaver Creek	17-Apr	17 days	23-Apr	2-May	7-Mar	29-May

[a]Streams are presented in order from highest-elevation Clear Creek to lowest-elevation Beaver Creek.

[c]Earliest date reflects the initiation of trapping, not the earliest date of emigration. Emigration was already underway in some streams.

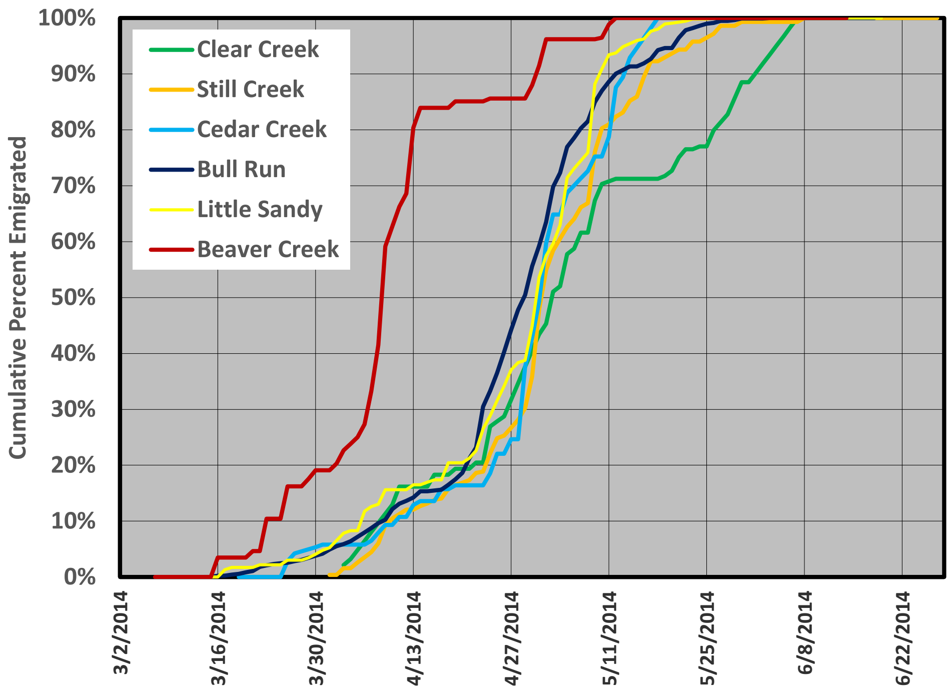


Figure 14. Steelhead smolt cumulative percentage of total emigration from Sandy River streams monitored in 2014. Steepest portions of each curve indicate peak capture periods.

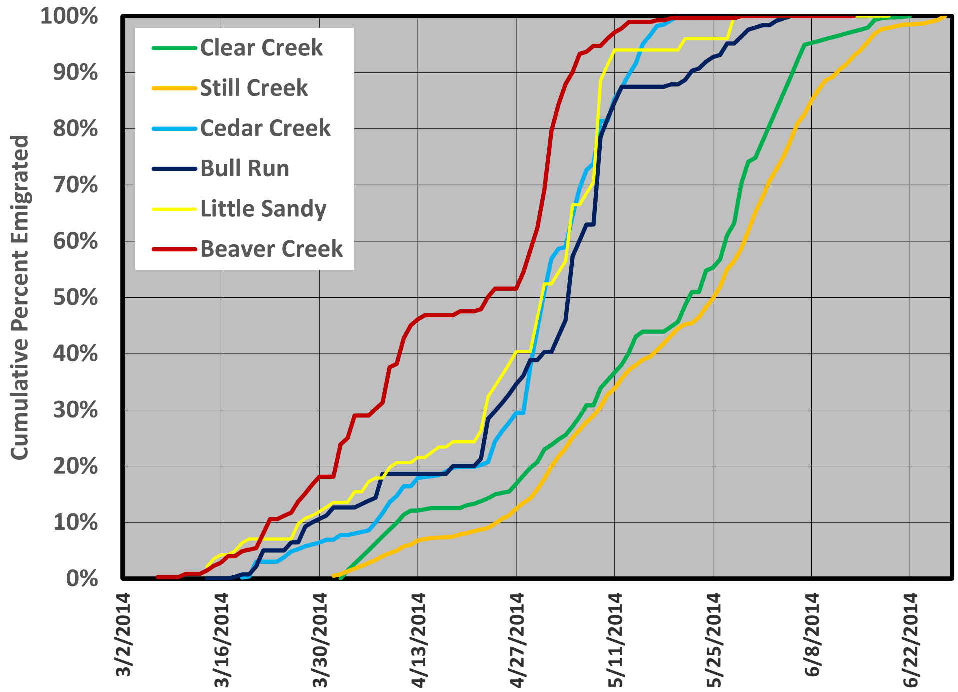


Figure 15. Coho smolt cumulative percentage of total emigration from Sandy River streams monitored in 2014. Steepest portions of each curve indicate peak capture periods.

4.5 Age Distribution

Both steelhead and coho smolts are, on average, slightly older at time of emigration from upper-basin streams than smolts from lower-basin streams. Tables 18 and 19 summarize the weighted mean age and age distribution for each stream for which adequate age data exist. Age data are averaged across all years.

Table 18. Steelhead smolt weighted mean age and age distribution for Sandy River streams

Stream	Weighted Average Age	Age 1	Age 2	Age 3	Age 4
Still Creek	2.42	1.1%	57.5%	39.3%	2.1%
Salmon River	2.21	1.8%	75.9%	21.5%	0.8%
Little Sandy	2.23	2.3%	72.6%	25.1%	0.0%
Bull Run	2.11	4.9%	79.3%	15.7%	0.1%
Gordon Creek	2.00	19.9%	59.7%	20.4%	0.0%

Table 19. Coho smolt weighted mean age and age distribution for Sandy River streams

Stream	Weighted Average Age	Age 1	Age 2	Age 3	Age 4
Still Creek	2.42	1.1%	57.5%	39.3%	2.1%
Salmon River	2.21	1.8%	75.9%	21.5%	0.8%
Little Sandy	2.23	2.3%	72.6%	25.1%	0.0%
Bull Run	2.11	4.9%	79.3%	15.7%	0.1%
Gordon Creek	2.00	19.9%	59.7%	20.4%	0.0%

5. Discussion

5.1 Smolt Population Estimation

Steelhead and coho smolt population estimates were within the range of the previous five years of the Sandy River Basin Smolt Monitoring Program. The steelhead estimates were relatively high in the Bull Run and Little Sandy rivers, as was the coho estimate in Still Creek. Clear Creek estimates were considerably lower than numbers observed in 2009. 2014 was the first year that smolt population estimates could be generated for Beaver Creek, and the number of coho observed to be emigrating was unexpectedly high.

The low estimates of steelhead and coho emigrating from Clear Creek could be due to chronically turbid water conditions. A landslide in a headwater tributary stream occurred during the winter of 2013-2014. At the time of smolt monitoring in 2014, mud and debris were still choking Clear Creek (Kathryn Arendt, USFS, pers. comm.).

The description of smolt production by various streams in the Sandy River Basin could be complicated to an unknown degree by movement of fish between subbasins either before or during the time of smolt emigration. A total of 55 hatchery (adipose-clipped) steelhead smolts were captured in the Bull Run trap from late April through May 2014. These fish would have entered the Bull Run after being released from the Cedar Creek hatchery, swimming upstream beyond the Bull Run trap and then being captured on their way back downstream. Although these fish were not included in the Bull Run steelhead population estimate, their presence highlights the possibility of similar behavior in wild fish. When making inferences about the effect of fish habitat conditions on smolt production, studies generally assume that the majority of fish emigrating from monitored streams had their origin in those streams. This is, in part, borne out by observed significant differences in characteristics such as fork lengths and condition factors. A large degree of movement among all streams would tend to equalize these characteristics between streams. Without further study, however, it cannot be discounted that such movement could occur and that the differences between the physical characteristics observed between smolts from different streams would have been even larger without it. Large numbers of hatchery steelhead have not been observed straying into the Bull Run River in the past.

Movement between streams probably explains some of the observations made in Beaver Creek. Some smolts probably originating in the upper Sandy River Basin appear to move into Beaver Creek during the fall or winter to overwinter. Yearling spring chinook smolts have been captured emigrating from Beaver Creek in the past (Strobel 2010). These fish would most likely have been spring Chinook, which do not spawn in Beaver Creek. Spring Chinook smolts are not generally captured in smolt traps in upper-basin streams where they are observed to spawn, despite being observed in large numbers as juveniles during the summer months. These fish must emigrate during the fall or winter and at least a few appear to have moved into Beaver Creek in the past.

The fork length distribution of steelhead emigrating from Beaver Creek in 2014 also suggests a complexity of life histories represented. Beaver Creek steelhead smolts showed a distinct tri-modal distribution that contrasted with the unimodal distribution of steelhead smolts from all other streams, except for Zigzag, which reflected a very small sample size. This tri-modal fork length distribution suggests the existence of groups of steelhead that experienced different rearing conditions, are of different ages, or a combination of both. One likely scenario leading to the co-occurrence of steelhead with different rearing histories is recent immigration from other streams.

Unequal trap avoidance by different groups of fish is a perennial concern with studies such as this that rely on mark-recapture methodologies. Trap avoidance could have affected the estimation of smolt population sizes in the Sandy River in 2014. If marked individuals become “trap-shy” (i.e., are caught a second time at a rate lower than fish passing the trap for the first time), this results in an inflated population estimate. Trap avoidance was suspected in 2010 when the Bull Run steelhead population estimate, 11,701 fish, seemed unreasonably large. The more precise results from 2011, 2012, 2013, and 2014, however, support the idea that the Bull Run River and the Little Sandy downstream of the Little Sandy trap site constitute a consistently productive system for steelhead and that the large population estimates obtained in 2014 and in previous years are, in fact, reasonable.

Large fish of a given species are probably also stronger swimmers than small fish and may have a greater ability to avoid capture when they recognize a trap in their downstream path. Were this effect to occur equally during the initial capture and subsequent recapture of fish, the result would be an underestimated population size. Were it to happen during both phases of capture, but more strongly during the recapture phase, the result would vary depending on the strength of the effect. Consequences of this effect are discussed more fully in Strobel (2010). Biases in the fork lengths of recaptured coho and steelhead towards smaller fish were not apparent in 2014.

The low numbers of steelhead and absence of coho emigrating from the Zigzag River in 2014 could be due to low productivity in the portions of the basin upstream of the trap site due to low water temperatures or chronically turbid water from glacial runoff. Cold water can slow metabolic rates and subsequently slow growth in fish. Very cold water could possibly limit productivity. Turbid glacial water can make finding prey difficult for salmonids. There are several streams, however, that are tributary to the Zigzag River upstream of the trapsite that have clear water. It is unknown why these tributaries apparently did not produce many steelhead or any coho smolts. A large number of Chinook fry, however, were caught in the Zigzag smolt trap, suggesting the river or its tributaries are used for spawning by this species.

The initial estimate of steelhead productivity (smolts per adult) was hampered in 2014 by difficulties encountered generating adult steelhead spawner estimates in previous years.

No estimates of the number of steelhead spawners in the Sandy River basin was generated in 2008 or 2009. The steelhead spawner estimate in 2011 was probably biased low, due to poor survey conditions (Eric Brown, ODFW, pers. comm). Steelhead productivity estimates are also complicated by the fact that an unknown proportion of steelhead smolts may be summer steelhead. Although there is some likelihood that summer steelhead redds are being counted during winter steelhead spawner surveys, the extent to which this is happening is unclear.

Steelhead and coho smolt populations for the final Sandy River Basin Index Area, the trends in smolt numbers over time, and Sandy River Basin freshwater productivity (smolts per adult) will be calculated after 20 years of annual smolt monitoring. The preliminary calculations made in 2014 and those to be made in future years will improve with the collection of additional data.

5.2 Fork Lengths

The observed differences in fork length distribution for steelhead and coho smolts among Sandy River Basin streams monitored in 2014 mirror differences observed in other years and may be due to one or both of two factors: (1) how rapidly fish are able to grow in each stream, relating to stream productivity, and (2) how long they have had to grow. Steelhead and coho weighted mean fork lengths have shown a correlation with water temperature (Strobel 2012). Steelhead smolts also vary in age from 1 to 4 years (Table 17). Their fork lengths, therefore, can reflect varying growth conditions over multiple years, as well as variations from stream to stream in the average length of time spent growing. Coho smolts also vary in age, though to a much lesser degree (Table 18). Scale samples are collected annually from steelhead and coho smolts for determining the proportions of emigrating smolts of various ages. The continued determination of ages from these scale samples will provide an improved ability to discern between the effects of growth and age.

5.3 Condition Factors

In 2014, condition factors showed no discernible relationship to fork length or natal stream location within the Sandy River Basin. Fish from Clear Creek had the lowest condition factors of any stream monitored in 2014, which may be related to high sediment and debris loading caused by a landslide in a headwater tributary. It is unlikely, however, that lower condition factors in fish reflect, in general, poor rearing conditions throughout the year in those same streams or low condition factors would tend to correlate with low fork lengths overall, which is not the case.

5.4 Emigration Dates

Coho smolts emigrated earlier from low-elevation streams than from higher-elevation streams. Steelhead smolts showed a similar pattern that was much less pronounced.

Similar patterns have been observed in most previous years. These differences in emigration timing could simply be contingent on environmental conditions (that is, water temperature) or could reflect life-history differences contributing to life-history diversity in the Sandy River Basin.

6. Findings, Conclusions, and Recommendations

- Population estimates or approximations could be generated for steelhead and coho smolts in seven streams in 2014.
- Steelhead and coho smolt estimates were generally relatively high in 2014, though within the range of the previous year's estimates. Exceptions were Clear Creek, which had relatively low estimates, and the Little Sandy, which had a record high steelhead smolt estimate.
- Estimates of steelhead and coho smolt production were generated for the entire Sandy River Basin Index Area for years 2009–2014. More precise estimates will be generated once additional years of smolt monitoring data are available.
- Estimates of freshwater productivity (smolts per adult) were generated for steelhead for parental years 2010 and 2011 and for coho for parental years 2007-2012.
- Steelhead and coho smolt fork lengths showed significant differences among monitored streams in the Sandy River Basin in 2014. High-elevation streams produced shorter fish of a given age than low-elevation streams, similar to what has been observed in previous years.
- Steelhead and coho smolts from different streams in the Sandy River Basin showed significant differences in the average condition factor in 2014. Clear Creek steelhead and coho had the lowest condition factors, but the remaining streams showed no correlation of condition factors between species from the same streams, with fork length, or with geographic location.
- Steelhead and coho smolts emigrated earlier from low-elevation streams than from high-elevation streams in 2014. Steelhead emigrated, on average, earlier than coho.
- A larger proportion of both steelhead and coho smolts emigrating from upper basin streams were of older ages than smolts emigrating from lower basin streams.
- These data represent the sixth installment of a long-term data set that will help both evaluate the viability of Sandy River steelhead and coho and guide the restoration efforts that seek to ensure their continued existence.

7. Acknowledgments

The Sandy River Partners would like to acknowledge the efforts and financial support that made the Sandy River Basin Smolt Monitoring Project possible. In addition to the funds provided by the involved agencies (the Portland Water Bureau, U.S. Forest Service, and Oregon Department of Fish and Wildlife) smolt monitoring efforts were also supported by a grant from Portland General Electric. Special thanks to the dedicated field crews that installed, maintained, and removed the numerous traps and checked them on a daily basis in all forms of weather. Crew personnel included Steve Schaaf, Jon Mueller, and Trevor Diemer from PWB; Joshua Haslitt and Kevin Perkins from USFS; and Matt Lackey, Todd Alsbury, Charles Baker, Jen Krajcik, Dave VanAmburgh, and Tim Foulk from ODFW. Additionally Don Mensch, Christy Slovacek, and Bob and Carla Heade (citizen volunteers) and Kelsey Jones and Aris Herrera (student volunteers) contributed countless invaluable volunteer hours to help out with the USFS smolt traps.

Five years' worth of smolt scale samples were aged by the ODFW Fish Life History Analysis Project in Corvallis, Oregon for this project. For their effort and the discussions with lab leader Ben Clemens of what the results mean, we are extremely grateful. Thanks also to Eric Brown and Jonathon Nott of the ODFW Oregon Adult Salmonid Inventory and Sampling Project (OASIS) for supplying adult steelhead and coho spawner estimates and to Luke Whitman of the ODFW Willamette Spring Chinook Project for providing adult spring Chinook spawner estimates.

8. Works Cited

Bjorkstedt, Erik P. 2005. DARR 2.0: Updated Software for Estimating Abundance from Stratified Mark-Recapture Data. NOAA/NMFS technical memorandum.NOAA-TM-NMFS-SWFSC-368. January.

Bjorkstedt, ErikP. 2010. DARR 2.0.2: DARR for R code. National Oceanic and Atmospheric Administration. http://swfsc.noaa.gov/textblock.aspx?Division=FED&id=3346

Hutchinson, Matthew W., Jessica L. Vogt, and Alex Neerman. Winter Steelhead of the Clackamas and Sandy Rivers: Spawning Ground Surveys 2006-2007. Oregon Department of Fish and Wildlife, Salem, Oregon. 2007.

Portland Water Bureau. Bull Run Water Supply Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species. Final Draft. City of Portland Water Bureau, Portland Oregon. 2008.

Scace, Justin G., Benjamin H. Letcher, and John Noreika. "An Efficient Smolt Trap for Sandy and Debris-Laden Streams." *North American Journal of Fisheries Management,* no. 27 (2007): 1276-86. doi: 10.1577/M07-036.1.

Strobel, Burke. Ecosystem Responses to a Large-Scale Salmon Carcass Enrichment Project. Interim report. Mt. Hood National Forest. Clackamas River Ranger District. Estacada, Oregon. 2004.

Strobel, Burke. 2014. Sandy River Basin Smolt Monitoring, 2013. Portland Water Bureau. Portland, Oregon.

Strobel, Burke. 2010. Sandy River Basin Smolt Monitoring, 2009. Portland Water Bureau. Portland, Oregon.

Suring, Erik J., Eric T. Brown, and Kelly M.S. Moore. 2006. Lower Columbia River Coho Status Report 2002 – 2004: Population Abundance, Distribution, Run Timing, and Hatchery Influence; Report Number OPSW-ODFW-2006-6. Oregon Department of Fish and Wildlife. Salem, Oregon.

Volkhardt, Gregory C., Steven L. Johnson, Bruce A. Miller, Thomas E. Nickelson, and Davd E. Seiler. 2007. Rotary Screw Traps and Inclined Plane Screen Traps. Pages 235-66 in D. H. Johnson et al. *Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations.* American Fisheries Society. Bethesda, Maryland.

Exhibit A. All Species and Life Stages Captured at Smolt Traps in the Sandy River Basin in 2014

	Clear Fork	Zigzag River	Still Creek	Cedar Creek	Little Sandy	Bull Run River	Beaver Creek
Orange Minnow-like fish	0	0	0	0	0	0	1
Bluegill	0	0	0	0	0	0	20
Catfish	0	0	0	0	0	0	1
Chinook Fry[a]	147	1,859	126	0	94	513	662
Chinook Smolt (Wild)	0	0	0	0	0	1	1
Chinook Smolt (Hatchery)	0	0	0	0	0	26	0
Chiselmouth	0	0	0	0	0	0	1
Coho Fry[a]	7	0	4	219	9	23	229
Coho Smolt	285	0	1,926	387	56	78	486
Cutthroat Fry	0	0	0	44	0	0	0
Cutthroat Juvenile	0	0	1	7	4	1	2
Cutthroat Smolt	8	1	10	3	2	6	1
Cutthroat Adult	2	0	2	22	0	2	0
Longnose Dace	7	0	8	0	50	519	6
Speckled Dace	0	0	0	0	0	5	289
Northern Pikeminnow	0	0	0	0	0	4	82
Pacific Lamprey Adult	4	0	1	1	0	0	1
Lamprey Amocete	14	0	1	0	1	0	11
Pumpkinseed	0	0	0	292	0	0	237
Peamouth	0	0	0	0	0	0	316
Rainbow Trout	3	2	4	0	9	5	1
Three-Spine Stickleback	0	0	0	0	0	0	1
Redside Shiner	0	0	0	0	0	0	43
Sucker	0	0	0	0	0	19	29
Sculpin	1	2	6	0	0	26	144
Steelhead Fry	0	403	0	39	287	146	2

	Clear Fork	Zigzag River	Still Creek	Cedar Creek	Little Sandy	Bull Run River	Beaver Creek
Steelhead Juvenile	66	16	80	0	100	157	89
Steelhead Smolt (Wild)	67	14	177	84	237	829	82
Steelhead Smolt (Hatchery)	0	0	0	0	0	55	1
Steelhead Adult	3	0	3	0	0	0	0
Whitefish Adult	0	0	0	0	3	0	0

[a]Chinook, coho, and steelhead fry were too numerous to identify individually in the Zigzag River, Still Creek, Bull Run, Little Sandy, and Beaver Creek. Fry were subsampled and the ratios applied to the unidentified fry.

Appendix G

Bull Run HCP Monitoring Report

Lower Bull Run River Shading Monitoring 2014

April 2015

Burke Strobel
City of Portland Water Bureau

PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

Contents

1. Introduction

In the Bull Run Water Supply Habitat Conservation Plan (HCP), Appendix G, Temperature Management Plan for the Bull Run River, the Portland Water Bureau committed to managing City-owned land along the lower Bull Run River "to protect riparian shade conditions so that their value to protecting instream water temperatures will be maintained." Accompanying this commitment is a requirement to monitor shading of the river channel through time:

> "The Water Bureau will survey and measure shading along the lower Bull Run River with a solar pathfinder once every five years. Results will be reported in an annual report."

The year 2014 is Year 5 of the HCP compliance period. PWB staff established 12 permanent stations for making consistent solar pathfinder measurements in the lower Bull Run River channel and performed initial measurements in 2014.

The objective of the Bull Run River shading monitoring is to measure the amount of shading for the lower Bull Run River channel and to determine whether it changes over time.

2. Methods

Shading was quantified using a device called a solar pathfinder. A solar pathfinder uses a convex, semitransparent reflective surface to allow an observer (in the northern hemisphere) to trace the southern skyline over plots of the sun's path, averaged for each month of the year (Figure 1). The combination of a plotted sun path and sketch of where skyline elements (such as trees, ridges, and buildings) intersect that path provides a means of estimating the degree of shading at any time of year. The resulting measure is

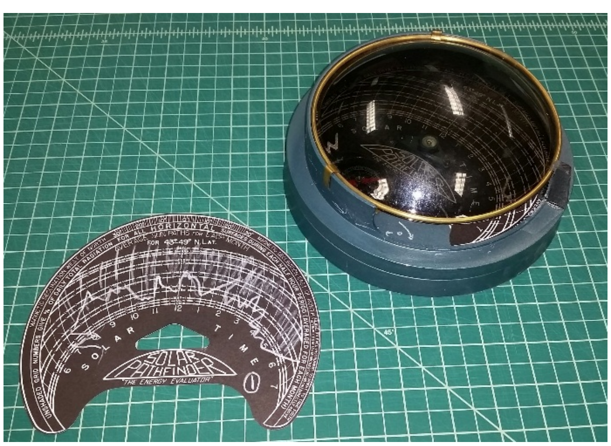


Figure 1. Sun Plot Paper with Skyline (Left) and Solar Pathfinder (Right)

termed the "percentage of total insolation." A site located in an area without shading of any sort, for example, would receive 100 percent of total insolation.

PWB established 12 permanent stations in the lower Bull Run River channel for taking consistent solar pathfinder measurements. Stations were located every half mile, starting at river mile (RM) 0.25, between the mouth of the Bull Run River and ending at the Dam 2 spillway, approximately RM 5.8 (Figure 2). Table 1 summarizes the active channel width and channel orientation for each station.

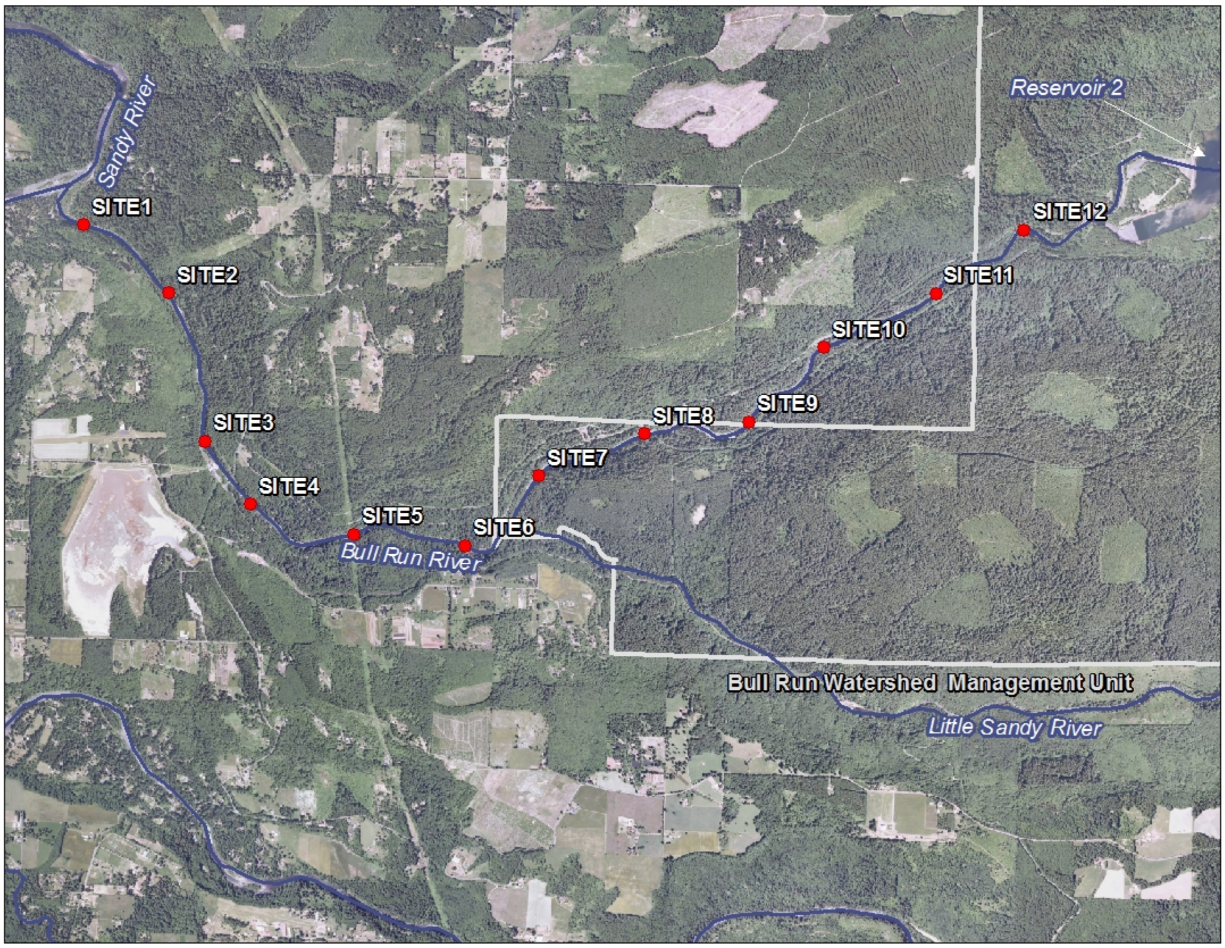


Figure 2. Permanent Solar Pathfinder Measurement Stations, Lower Bull Run River

Stations were marked by placing bolts with a stainless steel washers into the tops of selected rocks (Figure 3). Criteria for the selections of rocks included size and durability. Rocks chosen were large enough to endure extreme high flows without moving and near the middle of the river channel and were of a material that is not easily eroded, such as basalt. A two-inch deep hole was drilled into each rock and a concrete wedge anchor bolt was set into the hole with a stainless steel washer. The location of each station rock was documented by collecting a Global Positioning System (GPS) waypoint, photographing it in relation to its surroundings, and describing its location.

The time of day is not a factor when collecting solar pathfinder measurements, because it only involves tracing the portion of the skyline that potentially intercepts the sun's path. The time of year, however, is important. Measurements should be made during the late spring through early fall months, when deciduous trees are fully in leaf. The solar pathfinder measurements in 2014 were made between September 11 and September 19.

Solar pathfinder measurements were taken at each location after establishing the respective station. The solar pathfinder was placed directly onto the rock over the marker bolt and leveled. The skyline was sketched onto the plot paper. The plot paper was examined afterwards in the office to quantify the average percentage of total insolation for the spring and summer months, March through September.

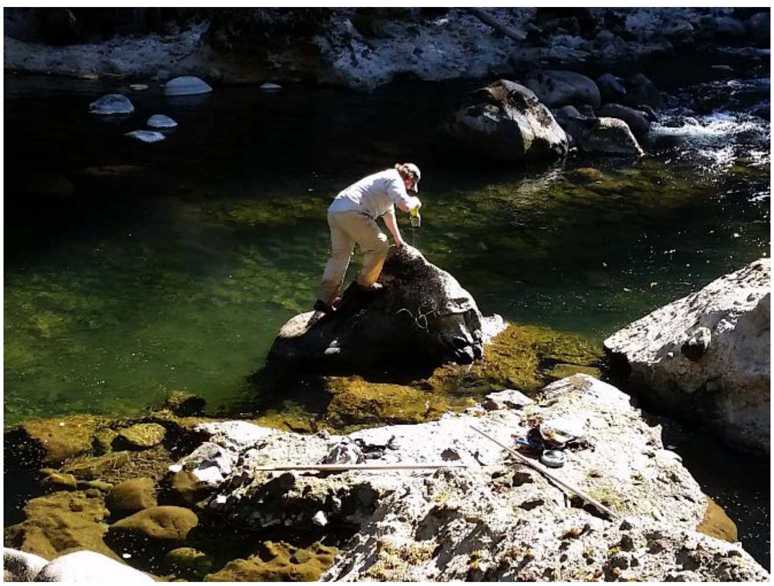


Figure 3. Setting a Solar Pathfinder Station

Solar pathfinder measurements will be repeated over time and analyzed for trends. Measurements made in 2014 will be repeated in 2019 and every five years after that for the duration of the HCP term, ending in 2059. The trend analysis will focus on June measurements, since that month has a high sun angle and the least amount of shading. The trend analysis will also focus on specific stations in the lower Bull Run River channel, where the amount of shading is most likely to be affected by riparian forest changes: Sites 1, 5, 8, and 11. Stations where the majority of shading is provided by valley slopes and cliffs will not be analyzed for trends.

3. Results

The percentage of insolation resulting from solar pathfinder measurements taken in 2014 for each site and each month under study are summarized in Table 1 and Figure 4. These measurements are the first in a long-term set. Solar pathfinder measurements will be retaken at each of the 12 stations every five years. The next year that measurements will be taken is 2019.

Table 1. Monthly Solar Pathfinder Measurements, Lower Bull Run River Channel, March–September

				Percentage of Total Insolation by Month						
Station	River Mile	Active Channel Width (feet)	Channel Orientation	March	April	May	June	July	August	September
Site #1	0.25	149	East>West	4.8%	50.3%	84.0%	79.9%	83.0%	62.3%	13.5%
Site #2	0.75	110	Southeast>Northwest	61.3%	53.5%	62.0%	63.7%	63.3%	56.5%	60.0%
Site #3	1.25	84	East>West	30.3%	31.5%	31.8%	33.8%	34.3%	28.5%	30.3%
Site #4	1.75	95	Southeast>Northwest	9.0%	24.8%	38.5%	45.6%	42.0%	24.5%	9.0%
Site #5	2.25	152	East>West	54.8%	65.0%	66.8%	66.7%	68.0%	64.5%	60.0%
Site #6	2.75	147	East>West	14.5%	39.3%	45.3%	54.2%	48.8%	41.5%	26.3%
Site #7	3.25	103	Northeast>Southwest	29.5%	36.5%	49.8%	51.2%	49.8%	38.0%	33.0%
Site #8	3.75	130	East>West	13.0%	64.3%	81.0%	81.6%	82.8%	72.0%	23.5%
Site #9	4.25	139	Northeast>Southwest	41.3%	42.8%	51.5%	49.8%	51.5%	43.0%	42.5%
Site #10	4.75	107	Northeast>Southwest	12.5%	19.5%	42.0%	53.2%	48.0%	23.3%	18.0%
Site #11	5.25	78	Northeast>Southwest	45.3%	53.3%	68.8%	73.5%	73.5%	55.0%	47.0%
Site #12	5.75	122	East>West	19.5%	30.8%	53.8%	63.0%	56.0%	33.0%	20.5%

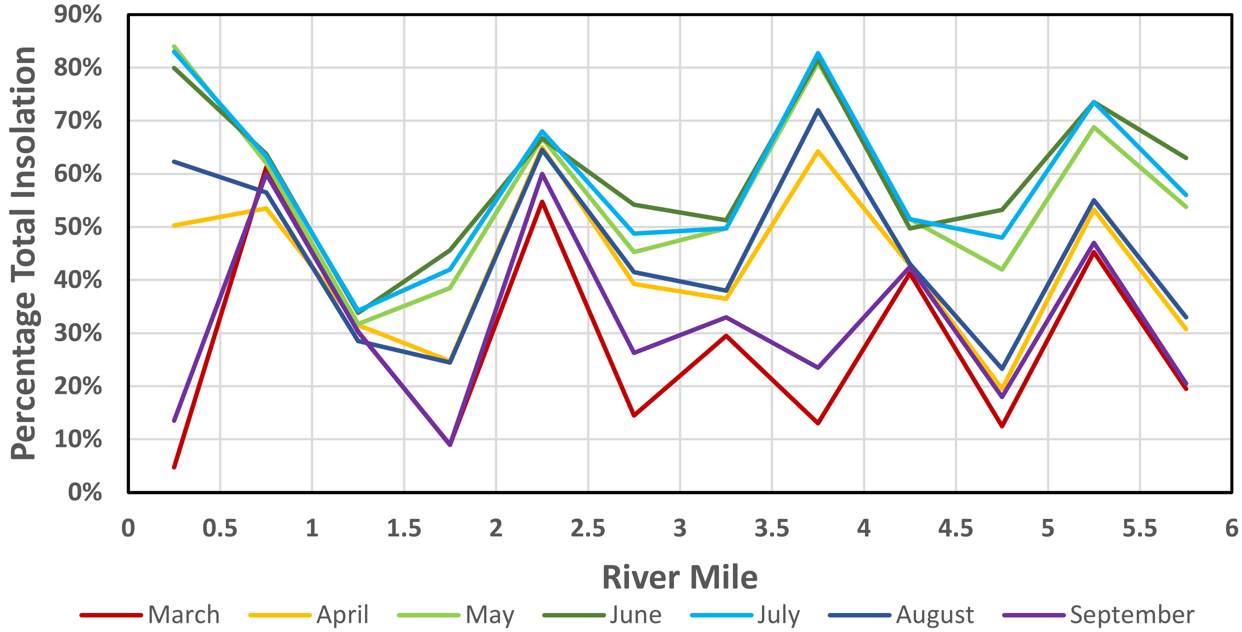


Figure 4. Monthly Solar Pathfinder Measurements, Lower Bull Run River Channel, March–September 2014.

Appendix H. Correspondence on Measures

Note: Each item includes two pieces of correspondence: a letter from the Portland Water Bureau (PWB) to the National Marine Fisheries Service (NMFS) and the NMFS response. Letters appearing in previous reports are summarized and appear in gray. Letters relevant to the current compliance year are summarized and presented in full following the summaries.

Correspondence Summaries from Compliance Reports 2010–2013

Item 1. April 26, 2011, letter from Steve Kucas, PWB, to Ben Meyer, NMFS, proposing to create conservation easements in another subbasin of the Sandy River watershed to replace the benefits of Measure H-22, Boulder 1 Riparian Easement

May 11, 2011, letter from Michael Tehan, NMFS, to Steve Kucas, PWB, authorizing the City to implement conservation easements in Gordon Creek to compensate for Measure H-22

Item 2. July 22, 2011, letter from Steve Kucas, PWB, to Ben Meyer, NMFS, proposing to place large wood pieces in another subbasin of the Sandy River tributary to replace the benefits of Measure H-26, Boulder 0 and 1 LW Placement

August 16, 2011, letter from Ben Meyer for Michael Tehan, NMFS, to Steve Kucas, PWB, authorizing the City to place large wood in Gordon Creek to compensate for Measure H-26

Item 3. August 22, 2011, letter from Steve Kucas, PWB, to Ben Meyer, NMFS, requesting authorization to use riparian easements on lower Bull Run or Sandy River parcels in fulfillment of HCP riparian easement targets

September 16, 2011, letter from Michael Tehan, NMFS, to Steve Kucas, PWB, authorizing the City to purchase some parcels of land on the lower Bull Run or Sandy River and create riparian easements to fulfill HCP easement targets

Item 4. February 14, 2012, letter from Steve Kucas, PWB, to Ben Meyer, NMFS, requesting authorization to increase the number of large wood structures in Trout Creek reach 1A in lieu of adding wood in Trout Creek reach 2A for Measure H-7

March 15, 2012, letter from Michael Tehan, NMFS, to Steve Kucas, PWB, authorizing the City to place additional large wood structures in Trout Creek reach 1A in lieu of placing them in Trout Creek 2A

Item 5. December 9, 2011 letter from Steve Kucas, PWB, to Ben Meyer, NMFS, requesting authorization to obtain conservation easements in the Sandy River reach 2 instead of reach 1, establish easements wider than 100 feet wide in the lower Sandy River, and establish conservation easements on lands owned by The Nature Conservancy

January 5, 2012, letter from Michael Tehan, NMFS, to Steve Kucas, PWB, authorizing the City obtain conservation easements in the Sandy River reach 2 in lieu of reach 1, obtain conservation easements in sites wider than 100 feet pending NMFS review and giving priority to parcels on side-channels, and establish conservation easements on lands owned by The Nature Conservancy

Item 6. September 18, 2012, letter from Steve Kucas, PWB, to Ben Meyer, NMFS, requesting authorization to obtain conservation easements along the main stem of the Sandy River in lieu of Gordon Creek and establish a long-term 200-foot-wide easement on the Camp Collins property

September 25, 2012, letter from Michael Tehan, NMFS, to Steve Kucas, PWB, authorizing the City to obtain conservation easements along the main stem of the Sandy River in lieu of Gordon Creek and establish a long-term 200-foot-wide easement on the Camp Collins property

Item 7. April 2, 2013, letter from Steve Kucas, PWB, to Ben Meyer, NMFS, requesting authorization to discontinue implementation of Measure R-2, Cutthroat Trout Rescue

April 26, 2013, letter from Michael Tehan, NMFS, to Steve Kucas, PWB, authorizing the City to discontinue implementation of Measure R-2, Cutthroat Trout Rescue

Item 8. August 6, 2013, letter from Steve Kucas, PWB, to Marc Liverman, NMFS, requesting authorization to fund fish carcass placement in reaches other than those specified in the Habitat Conservation Plan (HCP) for Measures H-25 and H-29

December 3, 2013, letter from Kim W. Kratz, NMFS, to Steve Kucas, PWB, authorizing the City to fund fish carcass placement in reaches other than those specified in the Habitat Conservation Plan (HCP) for Measures H-25 and H-29

Correspondence for the 2014 Compliance Year

Item 9. November 18, 2014, letter from David G. Shaff, PWB, to Kim Kratz, NMFS, requesting confirmation that the Habitat Conservation Plan (HCP) Implementing Agreement documents the City's commitment to forgo consumptive use of the Little Sandy River and serves as the Little Sandy Flow Agreement for Measure F-4

December 4, 2014, letter from Kim W. Kratz, NMFS, to David G. Shaff, PWB, confirming that the City has documented its commitment to forgo exercise of its rights and claims to the Little Sandy River and that no additional flow agreement is required for Measure F-4

PORTLAND WATER BUREAU

FROM FOREST TO FAUCET

Nick Fish, Commissioner
David G. Shaff, Administrator

1120 SW 5th Avenue, Room 600
Portland, Oregon 97204-1926
Information: 503-823-7404
www.portlandoregon.gov/water

November 18, 2014

Kim Kratz
Assistant Regional Administrator
Oregon/Washington Coastal Area Office
1201 NE Lloyd Blvd., Suite 1100
Portland, OR 97232

Dear Mr. Kratz:

Measure F-4 of the Bull Run Water Supply Habitat Conservation Plan (HCP) anticipated that the City of Portland (City) would develop a "flow agreement documenting the City's commitment to forgo exercise" of its Little Sandy water rights and claims to the Little Sandy River for the term of the HCP. Pursuant to Section 7.2.2 of the HCP, the City must "forgo consumptive use of Little Sandy water under [its] . . . 1892 [water rights] claim and the 1909 [statutory water] right for the term of the HCP." That limitation, along with all other HCP obligations, is incorporated by reference in the related Implementing Agreement (Implementing Agreement §3.0) between the City and NMFS. In authorizing execution of the Implementing Agreement, the City Council directed the Portland Water Bureau to "implement the measures" of the HCP.

As Administrator of the Water Bureau, I am ultimately responsible for HCP implementation. The City interprets the Implementing Agreement to bind it to the commitments made in the HCP. That means that the City must forego consumptive use of the Little Sandy during the term of the HCP. The City intends to honor that commitment; to do otherwise would breach the Implementing Agreement.

Given this, the City suggests that there is no need to enter into an additional instrument to constrain the City's actions regarding the Little Sandy. Any additional agreement would merely affirm what the City is already obligated to do—not to use the Little Sandy River for consumptive purposes. The City believes that the Implementing Agreement already serves as the Measure F-4 flow agreement and the City has already met its obligations under Measure F-4.

If you agree with the City's interpretation, I request that you respond with a letter confirming that by entering into the Implementation Agreement, the City is achieving its obligations under Measure F-4 to create a Little Sandy flow agreement.

If you wish to discuss this further or have any questions, please contact the Water Bureau's Environmental Compliance Manager, Steve Kucas at (503) 823-6976.

Sincerely,

David G. Shaff
Administrator

C: Steve Kucas, Portland Water Bureau

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

Refer to NMFS No.:
NWR-2008-3771

December 4, 2014

David G. Shaff
Administrator
Portland Water Bureau
1120 SW 5th Avenue, Room 600
Portland, Oregon 97204-1926

Dear Mr. Shaff:

The National Marine and Fisheries Service (NMFS) received a letter from you dated November 18, 2014 requesting our confirmation that by entering into the Implementing Agreement between the City and NMFS the City has met its obligations to create a Little Sandy Flow Agreement, measure F-4 of the Bull Run Water Supply Habitat Conservation Plan (HCP).

The NMFS has reviewed your request and believe it fits within the parameters of the HCP. Specifically, NMFS agrees with the City's interpretation that:

- The Implementing Agreement to binds the City to the commitments made in the HCP.
- Pursuant to Section 7.2.2 of the HCP the City must forgo consumptive use of the Little Sandy for the term of the HCP.
- By entering into the Implementation Agreement the City has documented its commitment to forgo exercise of its rights and claims to the Little Sandy River for the terms of the HCP and no additional flow agreement is required.

I therefore affirm that the City has met its obligations under Measure F-4 to create a Little Sandy flow agreement.

Please include an update on whether or not the City has exercised any of its water rights in the Little Sandy River in the annual compliance report.

Please direct questions regarding this letter to Christy Fellas of the Willamette Branch of the Oregon Washington Coastal Area Office at 503.231.2307 or christina.fellas@noaa.gov.

Sincerely,

Marc Liverman /for

Kim W. Kratz, Ph.D
Assistant Regional Administrator
Oregon Washington Coastal Area Office

cc: Steve Kucas, Portland Water Bureau