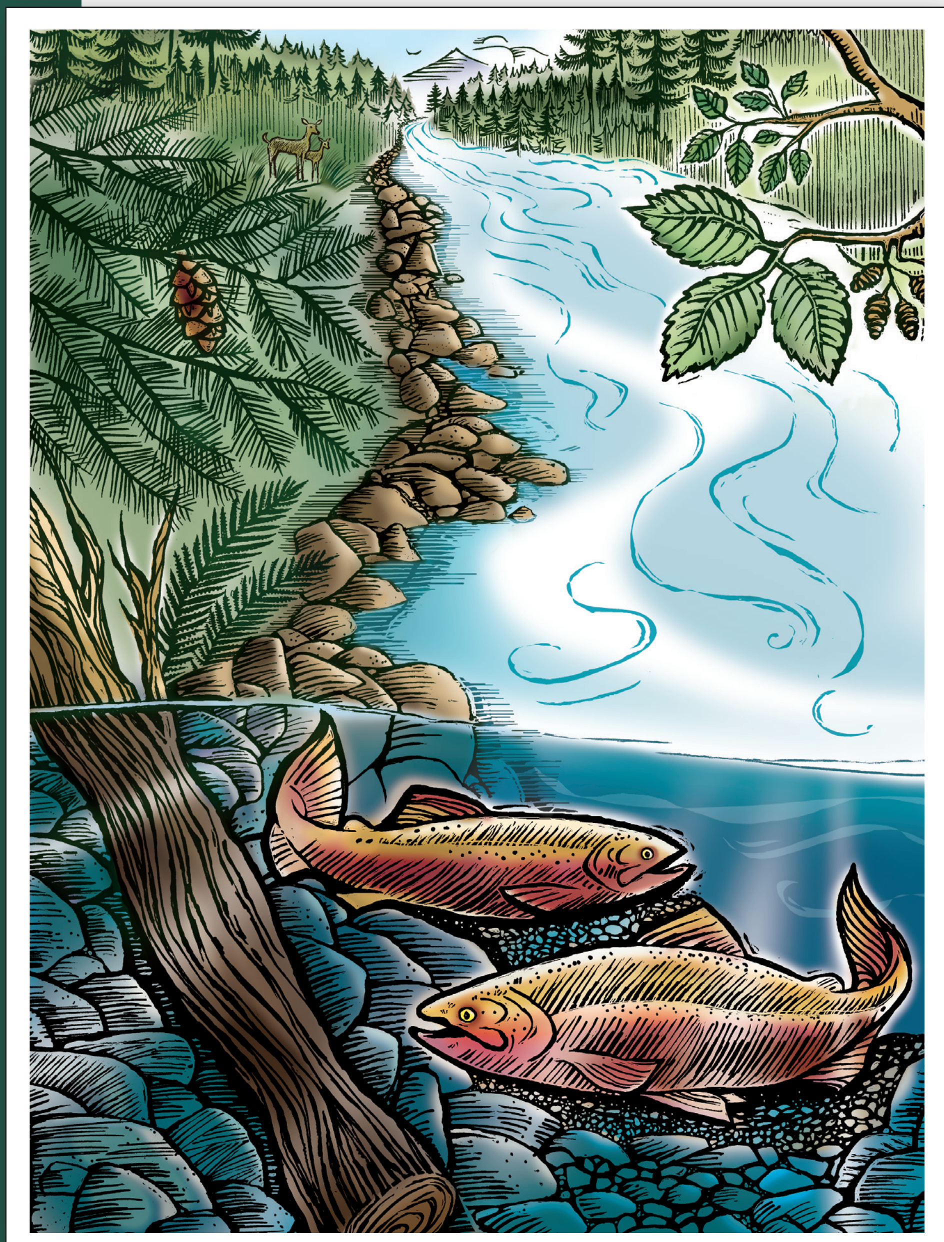
# Bull Run Water Supply
## Habitat Conservation Plan

### Annual Compliance Report 2013 – Year 4



**Final · May 2014**

Portland Water Bureau
From Forest to Faucet

City of Portland, Oregon 1851

# Contents

## Tables



## Figures

# Acronyms and Abbreviations

| | |
|---|---|
| cfs | cubic feet per second |
| EDT | Ecosystem Diagnosis and Treatment |
| ESA | Endangered Species Act |
| HCP | Habitat Conservation Plan |
| JOM | juvenile outmigrants |
| LCR | Lower Columbia River |
| MEPS | Middle of Eye to Posterior Scale |
| 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

**The City was in full compliance with the terms and conditions of the HCP for 2013. The City was also in full compliance with the Clean Water Act by adherence to the HCP Temperature Management Plan for the Lower Bull Run River and the Sandy River Basin Total Maximum Daily Load requirements.**

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 fourth year of the HCP was 2013, referred to as Year 4 throughout this document. This is the fourth 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 was in full compliance with the terms and conditions of the HCP for 2013. The City was also in full compliance with the Clean Water Act by adherence to the HCP Temperature Management Plan for the Lower Bull Run River and the Sandy River Basin TMDL requirements.

# 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 third 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 9, 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 9 also indicates where the effectiveness monitoring reports, Appendixes A and B, and the research reports, Appendixes C through G, are relevant to measures in this annual report. Measures that are not relevant to the 2012 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. A new report, introduced in the third year, provides results of water quality monitoring in Bull Run Reservoir 2 before and after the modifications to the water intake towers at Bull Run Dam 2 (see Appendix B). This monitoring is required as part of a Clean Water Act 401 Certification.

## 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 will study 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 will collaborate 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 will use 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.

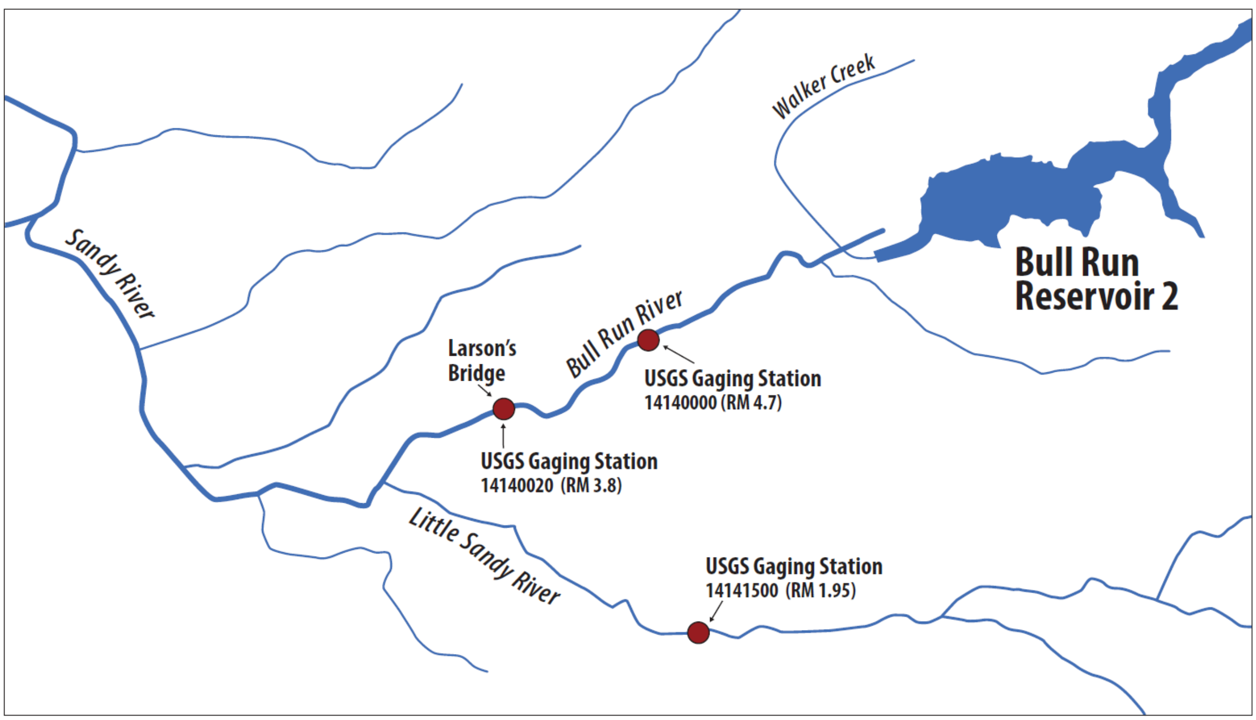



**Figure 1. USGS Gaging Stations for Compliance Monitoring**

### 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 2013**

The City met the minimum instream flow requirements of HCP Measure F-1 in 2013. Guaranteed minimum flows for normal water years were used as the flow targets in 2013. Lower Bull Run River flows at USGS Gage No. 14140000 are depicted in Figure 2.

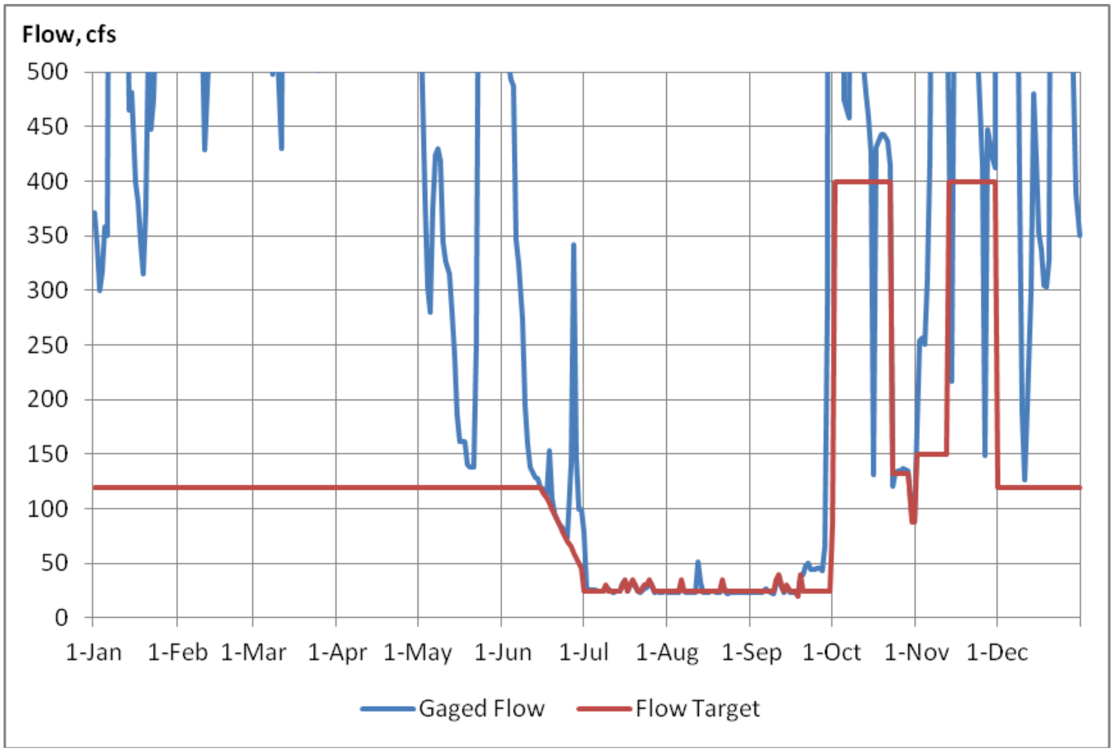



**Figure 2. Lower Bull Run River Minimum Flows and Actual Flows[a] in 2013**
[a]Flows exceeding 500 cfs are not shown.

Releases from Bull Run Reservoir 2 were reduced on four days in October-November 2013 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.

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 2 summarizes the dates and flows used to derive these calculations.

**Table 2. Dates, Inflow, and Flow Targets for October and November 2013**

| Flow Target Period | | Index Period | | Average Inflow (cfs) During Index Period | Flow Target (cfs) |
|---|---|---|---|---|---|
| From | To | From | To | | |
| 1-Oct | 1-Oct | 17-Sep | 23-Sep | 171 | 86 |
| 2-Oct | 8-Oct | 24-Sep | 30-Sep | 1703 | 400 |
| 9-Oct | 15-Oct | 1-Oct | 7-Oct | 1215 | 400 |
| 16-Oct | 22-Oct | 8-Oct | 14-Oct | 843 | 400 |
| 23-Oct | 29-Oct | 15-Oct | 21-Oct | 263 | 132 |
| 30-Oct | 31-Oct | 22-Oct | 28-Oct | 175 | 88 |
| 1-Nov | 5-Nov | 22-Oct | 28-Oct | 175 | 150 |
| 6-Nov | 12-Nov | 29-Oct | 4-Nov | 340 | 150 |
| 13-Nov | 19-Nov | 5-Nov | 11-Nov | 1303 | 400 |
| 20-Nov | 26-Nov | 12-Nov | 18-Nov | 1045 | 400 |
| 27-Nov | 30-Nov | 19-Nov | 25-Nov | 1248 | 400 |

### Planned Accomplishments for Calendar Year 2014

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 2014 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 4 and 5 (in mean daily flow in cfs). Fall flows in Table 5 will not be implemented more frequently than two years in a row and will not be implemented 4 years after a previous season of critical fall flows has been implemented (to avoid affecting the same age cohort twice). If a year does not have a critical spring or fall season, all flows will be the normal water year flows described in Measure F-1.

The triggers for a critical spring or fall season are defined in Table 3.

**Table 3. Critical Spring and Fall Season Triggers**

| Critical Season | Trigger |
|---|---|
| Spring | Drawdown occurs prior to June 15 |
| Fall | August and September inflows within lowest 10% of historical record (1940 to current HCP Year) |

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

**Table 4. Flow Commitments for the Lower Bull Run River During Water Years with Critical Spring Seasons**

| Time Period | Guaranteed Minimum Flow[a] (cfs) | |
|---|---|---|
| June 1–June 30 | 30 | If critical spring season trigger is met, decrease flow after drawdown begins but no earlier than June 1. Maintain downramping rate described in Measure F-3, from 120 cfs to 30 cfs. |

[a] Measured at USGS 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 5.

**Table 5. Flow Commitments for the Lower Bull Run River During Water Years with Critical Fall Seasons[a]**

| Time Period | Guaranteed Minimum Flow[a] (cfs) | Required Percent of Inflow (cfs) | Maximum Required Flow (cfs) |
|---|---|---|---|
| October 1–October 15 | 20 | If critical fall season trigger is met, continue to vary flow from 20–40 cfs to manage downstream water temperature | |
| October 16–October 31 | 30 | 50% | 250 |
| November 1–November 15 | 30 | 40% | 250 |
| November 16–November 30 | 70 | 40% | 350 |
| December 1–May 31 | 120 | n/a | n/a |

[a]Measured at USGS 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 2013

The critical spring trigger was not met in 2013; therefore, critical spring flows were not implemented. Reservoir drawdown began on July 3, 2013.

The lowest 10 percent of total reservoir inflow during August and September from 1940 through 2012 was 3.707 billion gallons. Total reservoir inflow during August and September 2013 was 11.63 billion gallons.

### Planned Accomplishments for Calendar Year 2014

Critical spring and fall triggers will be assessed in 2014. 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 lower 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 2013

The City was in full 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 94.61 percent of the time in 2013. Downramping exceedences occurred during 472 hours, or 5.39 percent of total operating hours during the monitoring year. Of those 472 hours, all 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. That left the City's operating record with no reportable exceedences during 2013.

Even though the downramping exceedences were excluded from the fluctuation limit, the City analyzed the flow data to determine why they occurred. All of the downramping exceedences (472 hours) were attributed to either naturally occurring drops in the upstream tributary flows, or a period when the North Tunnel at Dam 2 was out of service, all of which are covered by specific exclusion language in the HCP Measure F-3 description. Accounting for each hour of the allowed downramping exceedences follows:

- 458 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. From January 1 through November 19, the City's Bull Run Dam 2 Tower project precluded use of the Dam 2 North Tunnel, and hence PHP Powerhouse 2, for use in dampening the fluctuations of downstream river flows. During that ten-and-a-half-month period, PHP Powerhouse 1 was started and stopped 361 times resulting in 138 exceedence events.
- 14 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.

### Planned Accomplishments for Calendar Year 2014

Flow downramping will continue to be monitored in 2014.

### 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 will forgo 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), will be significantly higher than flows that occurred during PGE's Marmot/Little Sandy hydropower operation (when most Little Sandy River flows were diverted to Roslyn Lake).

#### Measure 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 2013

No work was done on this measure in calendar year 2013.

#### Planned Accomplishments for Calendar Year 2014

The City has until 2014 to complete this measure.

### 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 will alter its water supply infrastructure and its water supply operations to reduce water temperatures in the lower Bull Run River. The City's strategy relies on sharing the available cold water in the Bull Run reservoirs. The City 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 2013

The daily maximum temperature requirement outlined in HCP Measure T-1 was met. The 7-day moving averages of the daily maximum water temperature at Larson's Bridge are shown in Figure 3. All 7-day averages were less than 21.0 °C. The maximum value for the 7-day moving average was 20.7 °C.

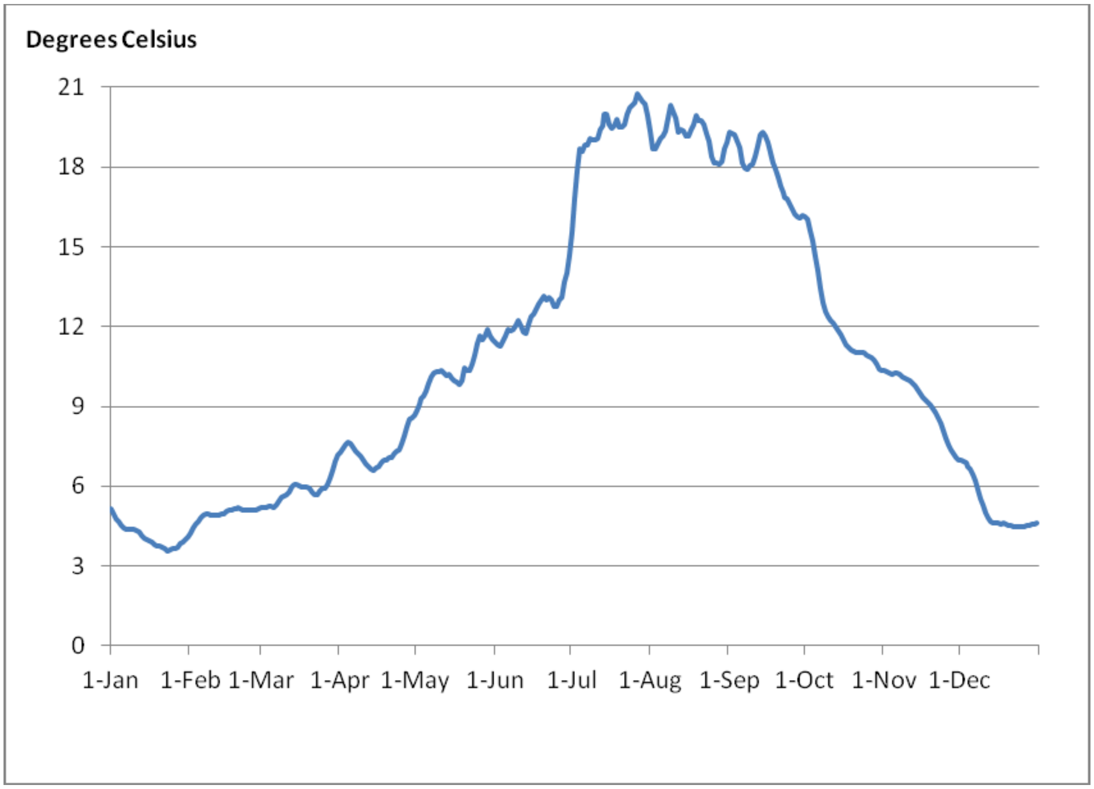



**Figure 3. 7-Day Moving Average of Daily Maximum Water Temperature in the Lower Bull Run River at Larson's Bridge (USGS Gage No. 14140020) for 2013**

### Planned Accomplishments for Calendar Year 2014

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. 2014 will be the first year operating the new multi-level intakes at Bull Run Dam 2.

### 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 will continue 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 2013

The Bull Run reservoirs were operated to meet the requirements of Measure R-1 in 2013. 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 May 2, and Reservoir 1 was operated about halfway up the gates (1,038–1,042 feet) from May 2–May 21. Once Measure R-3 (Reed Canarygrass Removal) was completed on May 10, Reservoir 1 was filled to the top of the spillway gates and held there (1,044–1,045 feet) until July 4. Reservoir 1 reached its minimum elevation for 2013 of 1000.69 feet on September 21, then refilled to spillway elevation (1,036 feet) on September 30. Another shorter period of drawdown started on October 17 due to a combination of high fish flow releases and dry weather. Reservoir 1 level went down to 1020.14 feet on November 1 and refilled again to spillway elevation on November 16. Reservoir 1 remained within 2 feet of spillway elevation after November 16 except for the periods of November 27–December 2, when the reservoir was drawn down again to meet fish flow demands and then immediately thereafter surcharged by a storm to the 1,043-foot range.

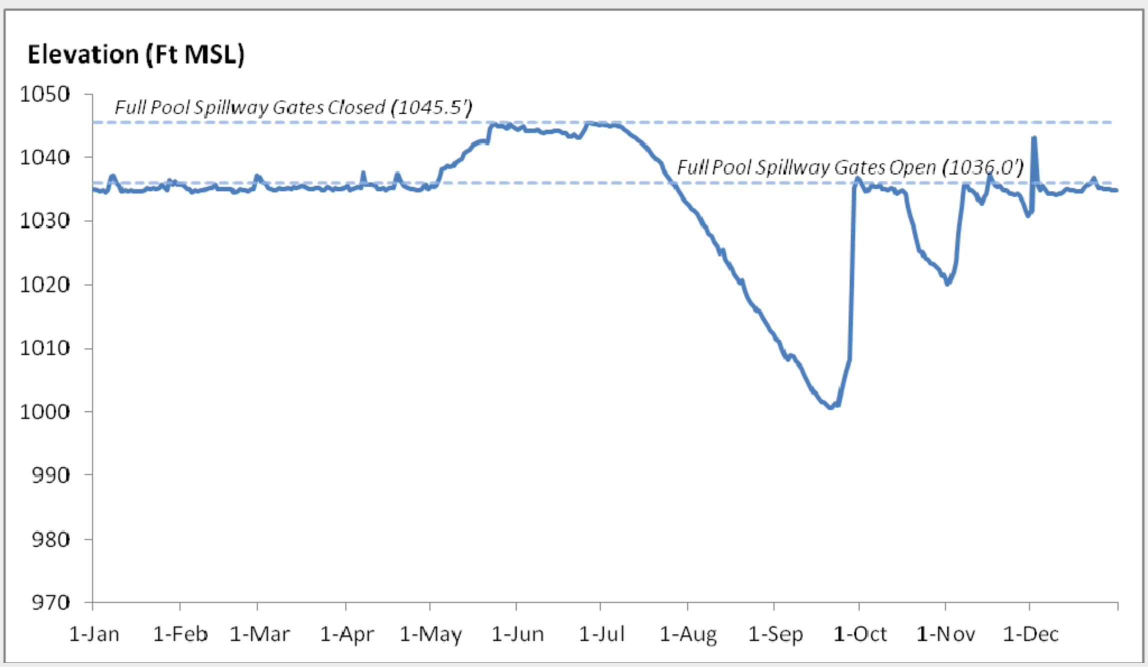



**Figure 4. Reservoir 1 Elevations[a] During 2013**

[a]Reservoir elevations were recorded at midnight at USGS Gage No. 14139000 in feet above mean sea level (MSL). Data from Portland Water Bureau SCADA system were used to fill in small gaps of missing data.

Reservoir 2 was operated within 2 feet of spillway elevation for all of 2013 except for November 15, when the level reached 857.88 feet. A fallen tree struck a transmission line on this date, causing the powerhouses at both dams to be offline for day, thus reducing the ability to manage water levels during this outage.

The amount of water that can be passed through the intakes of Reservoir 2 was limited during construction of the new intake on the north tower. As a result, most of the water leaving Reservoir 2 that was not diverted for water supply passed over the spillway, causing Reservoir 2 elevation to be in the 860–862-foot range for portions of the year. Inflows from the watershed exceeded the capacity of the active intake January 1 – May 9, May 23 – June 5, and then again periodically in the fall from September 29 to the end of 2013. During the summer season from June 5 to September 29, Reservoir 2 elevations were between 858 and 860 feet.

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

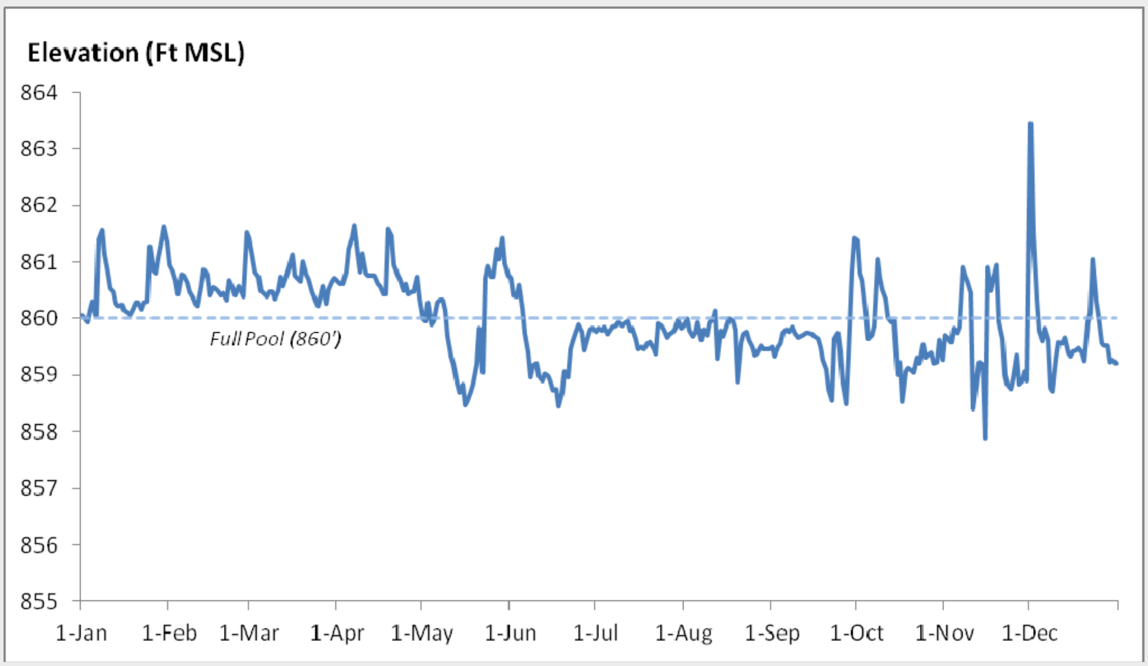



**Figure 5. Reservoir 2 Elevations[a] During 2013**

[a]Reservoir elevations were recorded at midnight at USGS Gage No. 14139900 in mean feet above sea level (MSL).

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

### Planned Accomplishments for Calendar Year 2014

Reservoir elevations will be managed in 2014 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-2—Cutthroat Trout Rescue

**Location:** Bull Run watershed

**Benefits:** Prevent mortality of cutthroat trout in spillway canal

**Contact:** Burke Strobel, Fish Biologist, PWB Resource Protection

#### Primary Objective

The City will implement Measure R-3 to prevent cutthroat mortality due to elevated summer water temperatures.

#### Measure Commitments

**Measure R-2—Cutthroat Trout Rescue**: For HCP Years 1–50, the City will remove cutthroat trout from the Dam 2 spillway approach canal annually to prevent mortality due to elevated summer water temperatures.

The City will use several approaches to implement this measure and will determine which one is most effective.

In HCP Year 1, the City will install a fyke net and place salmon eggs in a basket in the trap box to attract cutthroat trout. The fyke net will be placed in the spillway approach canal in early June when water temperatures are cool and will be checked two to three times per week through the end of the month. After June, and when drawdown first starts to isolate the water in the spillway approach canal, the City will drain the canal to determine whether the fyke net was effective for capturing fish.

If at least two-thirds of the cutthroat found in the approach canal are trapped by the fyke net and successfully returned to Reservoir 2, the City will continue that approach for HCP Years 2–50. If less than two-thirds of the cutthroat trout are successfully returned to Reservoir 2, the City will consider a new orientation and location for the fyke net.

After HCP Year 2, if the City determines that fyke netting does not effectively capture the cutthroat in the canal, the City will drain the canal in Reservoir 2 as soon as reservoir elevations allow.

If the City determines that draining the canal sends warm water down the Bull Run River, and interferes with the objectives for Measures T-1 and T-2, the City will not continue this conservation measure. Funding would be allocated to other habitat conservation measures according to the adaptive management process described in Chapter 9 of the HCP.

If the City's methods for the spillway approach canal fish rescue are ineffective—defined as having more than one-third mortality associated with the trapping of fish or leaving fish in the spillway to experience high water temperatures—the City will not continue the measure. In that case, the funding will be allocated to other habitat conservation measures according to the adaptive management process described in Chapter 9 of the HCP.

### Status of Work for Calendar Year 2013

Implementation of Measure R-2 was cancelled in 2013 due to the low number of cutthroat captured in the previous three years of implementation and its insignificant benefit to the Reservoir 2 cutthroat trout population. With the assistance of Oregon Department of Fish and Wildlife (ODFW) boat electrofishing crews, the City removed fish from the Dam 2 spillway approach canal in 2010, 2011, and 2012. Despite effective removal techniques, only 11, 16, and 1 fish were removed in those years, respectively. For those same years, the City observed 0, 2, and 0 cutthroat still in the canal after fish removal. The City has received authorization from NMFS to discontinue the implementation of Measure R-2 (see Appendix H, Item 7).

### Planned Accomplishments for Calendar Year 2014

This measure will not be implemented in the future.

### 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 2013

The City met the requirements of Measure R-3. On May 10, 2013, City staff and wildlife biologist Char Corkran worked at the north bank of the upper end of Bull Run Reservoir 1 (Figure 7). All parties participated in cutting reed canarygrass in three areas within the western toad and red-legged frog breeding areas. Once the three areas were cut, the grass was removed from breeding locations with rakes and pitchforks. The three sites were left with grass stubble approximately 2–4 inches in height and exposed mineral soil.

#### Planned Accomplishments for Calendar Year 2014

City staff will return to the three sites and cut reed canarygrass within the western toad and red-legged frog breeding areas.

**Figure 7. Reed Canarygrass Removal**

### 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 will replenish 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 2013

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 2013, 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 14 and 15, 2013. The gravel was obtained from a gravel quarry located near Estacada, Oregon, on an old alluvial terrace above the Clackamas River. The material complied 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 306 cfs to approximately 759 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 (3,560 cfs) on January 31, 2013, redistributed most of the placed gravel.

### Planned Accomplishments for Calendar Year 2014

Spawning gravel will be placed in the lower Bull Run River in January 2014. The placement methods will be similar to those used in previous years.

## 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 2013

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 2013. The City also managed invasive species on lower Bull Run River riparian land.

### Planned Accomplishments for Calendar Year 2014

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 2013

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

#### Planned Accomplishments for Calendar Year 2014

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 2013

The City has complied with all of the commitments in Measure O&M-2 in 2013. In 2010, the City moved the fuel tanks and pumps out of the Sandy River floodplain.

#### Planned Accomplishments for Calendar Year 2014

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

### 4.1.2 Offsite Measures

The City will implement 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 6). 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 6. Easement Acre Targets and Acres Obtained for HCP Implementation, Year 4 (2013)[a]**

| Measure Code | Reaches | HCP Years | Easement Acre Targets[b] | Acres Obtained by Year | | Total Acres Obtained |
|---|---|---|---|---|---|---|
| | | | | 2010–2012 | 2013 | |
| **Lower Sandy** | | | | | | |
| H-11 | Sandy 1 | 2010-2014 | 0 | — | — | — |
| H-12 | Sandy 2 | 2010-2014 | 143 | 0 | 54 | 54 |
| H-13 | Gordon 1A, 1B | 2010-2014 | 23 | 23 | — | 23 |
| | | Subtotal | 166 | | | 77 |
| **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 |
| —[c] | Lower Bull Run River | 2012 | 0 | 0 | 34 | 34 |
| | | Subtotal | 99 | | | 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 | | | |
| | Grand Total | | **373** | **42** | **88** | **130** |

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

[b]Targets documented in previous compliance reports.

[c]No associated HCP measure. The City of Portland acquired land around the lower Bull Run River, as authorized by NMFS (see Appendix H, Item 3).

### Measures H-12, H-13, H-16, and H-22–Riparian Easements and Improvements

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

**Benefits:** Improve riparian and instream habitat

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

#### 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 will be 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 2013

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.

Currently, the City has finalized easements for 130 acres (Table 6). The City was successful in working with willing landowners and finalized one easement and one land acquisition in 2013. The easement was finalized for 54 acres in reach Sandy 2 (Camp Collins). The City also purchased property in the lower Bull Run watershed and is counting the acquired acreage within a 100-foot buffer towards the overall easement target for the middle Sandy River, as expressed in the HCP. Authorization for this adaptive management change was granted via letter (NMFS letter to Steve Kucas dated September 16, 2011), summarized in Appendix H, Item 3. The City acquired 34 acres of riparian buffer along the lower Bull Run River.

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 Figure 8). PWB is currently evaluating the use of remote sensing to collect canopy data on larger parcels.

Table 7 summarizes the location, acreage total, and condition of the canopy cover for the easements that the City has obtained to-date.

**Table 7. Location, Amount, and Estimate of Canopy Cover for Easements, HCP Year 4 (2013)**

| 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[b] | 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]Monitoring data are collected every 5 years after the initial data collection; results will be available the fifth year after the easement was acquired. 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.

[b]The City of Portland obtained acreage in the lower Bull Run watershed in 2013.

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 $\geq$70 percent criterion stated in the HCP. The City will continue to track the canopy cover for all easements.

### Planned Accomplishments for Calendar Year 2014

The City anticipates finalizing a large easement in 2014 in the lower Sandy watershed. The City will also be negotiating easements with other willing landowners.

**Figure 8. The Rayne Easement After Planting, the Middle Sandy Gorge on the 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 2013**

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 can pursue acquiring water rights on Cedar Creek through 2019.

**Planned Accomplishments for Calendar Year 2014**

The City will start approaching willing landowners to discuss the acquisition of their surface water rights in 2014.

#### 4.1.2.3 Fish Passage

**Measures P-2, 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 will provide 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, will provide 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-2—Alder 1 Fish Passage: Within HCP Years 1-5, the City will modify the fish ladder under the Highway 26 bridge in reach Alder 1 to provide upstream and downstream volitional passage for steelhead and coho salmon. Passage design will be reviewed and approved in advance by NMFS.

Measure P-3—Alder 1A Fish Passage: Within HCP Years 1-5, the City will modify the City of Sandy water diversion weir at RM 1.7 of reach Alder 1A to provide upstream and downstream volitional passage for steelhead and coho. Passage design will be reviewed and approved in advance by NMFS.

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 2013

The City has complied with all of the commitments for fish passage measures P-2, P-3, and P-4.

Measure P-2 was completed in 2013. The fish ladder at the waterfall on Alder Creek was completed in the summer and is currently operating (Figure 9). The City continues to monitor the new fish ladder.

For Measure P-3, the design has been completed and all permits/permissions have been obtained.

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 9. Final Fish Ladder on Alder Creek**

#### Planned Accomplishments for Calendar Year 2014

For Measure P-3, the City plans to build the fish ladder on Alder Creek at the City of Sandy's water diversion structure in the summer.

#### 4.1.2.4 Large Wood Placement

**Measures H-3, H-5, H-6, H-7, H-17, and H-26—Large Wood Placement**

**Location:** Little Sandy River, Gordon, Trout, Cedar and Boulder creeks

**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 10 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, Gordon Creek, reaches 1A and 1B; Trout Creek, reaches 1A and 2A, and in Cedar Creek, reaches 2 and 3. Benefits were also anticipated in Boulder Creek, reaches 0 and 1, but this measure was cancelled in 2011 due to insufficient landowner permissions. Instead, the large wood intended for Boulder Creek was placed in Gordon Creek (see Appendix H, Item 2 for a summary of supporting documentation).

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 2013

Under the terms of HCP measures H-2, 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 placed logs in Gordon and Trout creeks in 2012. The City is obligated to conduct compliance monitoring of these placements and their functional integrity.

#### H-3 Little Sandy 1 and 2 LW Placement

Preparations for Measure H-3 began in 2013.

#### H-5 Gordon 1A and 1B LW Placement

Measure H-5 was implemented in 2013. Compliance monitoring in the summer of 2013 confirmed that all structures were in place and functioning as designed.

#### H-6 Trout 1A LW Placement

Measure H-6 was implemented in 2013. Compliance monitoring in the summer of 2013 confirmed that all structures were in place and functioning as designed.

#### H-17 Cedar 2 and 3 LW Placement

Initial preparations for H-17 were begun in 2013. This project is anticipated to be implemented in 2015.

#### Planned Accomplishments for Calendar Year 2014

#### H-3 Little Sandy 1 and 2 LW Placement

In 2014, the City plans to complete designs, obtain necessary permits to implement the project, and select a contractor. The City intends to implement this measure in 2014.

#### H-5 Gordon 1A and 1B LW Placement

In 2014, the City plans to conduct compliance monitoring of all large wood placements in Gordon 1A and 1B. All structures built in 2012 will be revisited and any changes to structures will be documented.

### H-6 Trout 1A LW Placement

In 2014, the City plans to conduct compliance monitoring of all large wood placements in Trout 1A. All structures built in 2012 will be revisited and any changes to structures will be documented.

**Figure 10. A Typical Large Wood Structure**

### H-17 Cedar 2 and 3 LW Placement

In 2014, 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 2015.

#### 4.1.2.5 Channel Restoration

**Measure H-8—Sandy 1 Reestablishment of River Mouth**

**Location:** Sandy River Basin

**Benefits:** Increase and enhance species habitat

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

**Primary Objectives**

The objective for Measure H-8 is to re-establish the historic mouth of the Sandy River. Approximately one mile of channel habitat will be opened that will improve habitat diversity, provide cover, and increase refuge areas for migrating fish.

**Measure H-8 Commitments**

Measure H–8—Sandy 1 Reestablishment of River Mouth: Within HCP Years 6–10, the City will contribute up to a maximum of $1.1 million for the removal of a 1930s–era dike in the Sandy River delta area in coordination with the Columbia River Gorge National Scenic Area. All project designs will be submitted to USFS and NMFS for review.

**Status of Work for Calendar Year 2013**

The City, in cooperation with the U. S. Army Corps of Engineers and the U. S. Forest Service, provided funding that allowed the successful removal of the Sandy River delta dam at the mouth of the Sandy River. The historical mouth of the Sandy River is now open and approximately 1 mile of riverine habitat is now usable for fish and wildlife.

The City has now completed Measure H-8.

**Planned Accomplishments for Calendar Year 2014**

The City has completed Measure H-8 and there are no other planned activities for this measure.

## Measure H-10 Sandy 1 Turtle Survey and Relocation

**Location:** Sandy River Basin

**Benefits:** Avoid impacts to species

**Contact:** John Deshler, Wildlife Biologist, PWB Resource Protection

### Primary Objectives

The objective for Measure H-10 is to avoid impacts to western painted or northwestern pond turtles that may be in the Sandy River delta.

### Measure H-10 Commitments

**Measure H–10—Turtle Survey and Relocation**: The City will survey areas downstream of the I–84 bridge in the Sandy River delta for the presence of western painted and northwestern pond turtles if there will be any ground disturbance associated with implementation of the City's habitat conservation measures in the Sandy River delta (e.g., H–8 and H–9). Any of the two species of turtles that would be directly affected will be relocated. Relocations will be coordinated with ODFW.

### Status of Work for Calendar Year 2013

Measure H-10, Sandy 1 Turtle Survey and Relocation, was successfully completed in 2013. The City coordinated with the U.S. Army Corps of Engineers, the U.S. Forest Service and ODFW and partnered with staff from ODFW, the City of Gresham, and the Port of Portland to conduct field surveys and relocation efforts (see Figure 11). PWB conducted basking surveys in early July 2013 and located three western painted turtles at the historical channel of the Sandy River, the area of ground disturbance from Measure H-8. In July and August 2013, a total of 24 western painted turtles were captured and relocated to Company Lake, a Port of Portland restoration site one mile east of the historic mouth of the Sandy River. No turtle nests were found during nest surveys. No northwestern pond turtles were observed, captured, or relocated. See Appendix G for details of the work completed on Measure H-10 in 2013.

### Planned Accomplishments for Calendar Year 2014

The measure has been completed.

**Figure 11. Turtle Survey and Relocation in the Sandy River**

#### 4.1.2.6 Carcass Placement

**Measure H-25 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-25 is to enhance in-stream productivity and benefit fish.

**Measure H-25 Commitments**

**Measure H–25—Salmon 2 Carcass Placement**: Within HCP Years 6–10, the City will provide funding, for one season, to place at least 1,800 salmon carcasses (approximately 300 carcasses per mile) in reach 2 of the Salmon River. The carcass placement will be implemented as part of a basin–wide partnership project by ODFW, USFS, and the Sandy River Basin Watershed Council. This measure will 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 2013**

In the HCP under the conditions of Measure H-25, the City agreed to a one-time payment to place 1,800 salmon carcasses in reach Salmon 2. The Sandy River Basin Partners, including NMFS, identified 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 created an agreement with the Sandy River Basin Watershed Council (SRBWC) to place salmon carcasses in the Sandy River watershed. The carcass placements will be implemented as part of a basin-wide partnership project by ODFW, USFS, and the SRBWC.

In 2013, the City paid the SRBWC to place 1,870 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-25 has been completed early.

**Planned Accomplishments for Calendar Year 2014**

This measure has been completed. The City intends to fund the SRBWC to place salmon carcasses to meet its obligations for another HCP measures (H-29 Zigzag 1A, 1B, and 1C Carcass Placements).

#### 4.1.2.7 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 2013**

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 2013.

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 2014**

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 is completing 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 completed 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 8 with the Oregon Administrative Rule language that describes the standard.

**Table 8. 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. |

Starting in 2012 and through 2013, PWB gathered monitoring data to provide baseline results (prior to the intake tower improvements). Monitoring in subsequent years will provide results that can be compared to the baseline data. Appendix B of this report describes the monitoring efforts.

## 4.2 Effectiveness Monitoring

The City will conduct 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 will be 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 will use 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 is conducting 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, H-5, H-6, H-7, and H-26—Large Wood Placement

**Location:** Little Sandy River, Gordon Creek, Trout Creek, Boulder 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, Gordon Creek reaches 1A and 1B, Trout Creek reach 1A, and Salmon River reach 2. Large wood measures were also planned for Boulder Creek reaches 0 and 1 and Trout Creek reach 2A, but were cancelled in 2011 and 2012, respectively. See the measure descriptions and explanations for the cancellations starting on page 39 for more information.

#### Measure Commitments

The measure commitments for HCP Measures H-3, H-5, H-6, H-7, and H-26 are described in Section 4.1.2.4, which starts on page 39 of this report.

---

[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.

### 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 1A and 1B of Gordon Creek are to achieve 80 percent of the predicted increase in backwater pools, pools, and pool-tail habitat 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 (e.g., 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 2013

The City fully complied with the effectiveness monitoring as required by the HCP for Measures H-3, H-5 , H-6, and H-24. Measure H-7 (Trout 2A) was cancelled in 2012, but a habitat survey of Trout 2A was still conducted as part of effectiveness monitoring for Measure H-6. 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., Gordon 1A and 1B LW Placement) in Appendix A of this report.

### Planned Accomplishments for Calendar Year 2014

The collection of baseline data for effectiveness monitoring will be conducted in 2014 in the Little Sandy River for Measure H-3, to be implemented in 2014, and in the Salmon River. Baseline habitat surveys will follow protocols and geographic extents identical to those used in 2013.

## 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 2013. 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

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). Additional TDG data were collected on one occasion in 2013.

The City has measured TDG levels in excess of 110 percent below the 10-year, 7-day average flood (7Q10) flow on five occasions in the past but not in 2013. On 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. On the other two occasions, however, no flow was present from Powerhouse 2 because of the implementation of other HCP-related infrastructure projects designed to improve downstream water temperatures for fish, Flows in the lower Bull Run River at the time of TDG monitoring in 2013 exceeded the 7Q10 flow.

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. It will conduct an annual survey 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. Instream flows are normally managed by Pacific General Electric (PGE, the operator of the hydroelectric facilities) in communication with the City to make these surveys possible. However, the installation of a multi-level intake at the main Dam 2 Tower has required that flows through Powerhouse 2 be curtailed during construction, affecting the City's ability to prepare for and conduct weekly surveys. 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 2013, but the effort was significantly hampered by the inability to control flows in the lower river due to the Dam 2 Tower project described above. The detailed description of the Bull Run Adult Chinook Population Research protocol is available in Appendix F of the HCP. Protocols followed in late August and September 2013 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 2013 and the U.S. Forest Service (USFS) monitored JOM production in one additional stream. 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 2013

The City was in full compliance with Measure H-30—Habitat Fund. The City has committed $373,280 of Habitat Fund dollars through 2013 to Sandy River Basin Partners projects. The City did not distribute Habitat Fund money to Sandy River Basin Partners in 2013. Instead, the City partially funded the removal of the Sandy River delta dam. 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 through 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, working with the Habitat Fund Subcommittee of the Sandy River Basin Partners, agreed to fund the Freshwater Trust to fund 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 2014

The City will create an agreement to fund the Freshwater Trust to fund design and construction of habitat restoration projects on the Salmon River and Still Creek.

## Table 9. 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 and the Status column shows that the measure has been completed or removed from the HCP, or the Status column is blank. 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 | Measure is in full compliance. |
| **F-2** | **Minimum Instream Flows, Water Years with Critical Seasons** | Provide instream flows | Record hourly flows at USGS Gage No. 1414000 | 2010–59 | Measure is in full compliance. |
| **F-3** | **Flow Downramping** | Maintain downramping rate at or below 2”/hour | Record hourly flows at USGS Gage No. 14140000 | 2010–59 | Measure is in full compliance. |
| **F-4** | **Little Sandy Flow Agreement** | Avoid conflicts with natural instream flows | Document completion of flow agreement | 2010–14 | Measure is in process—PWB anticipates full compliance by 2014. |
| **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 is in full compliance. |

## 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<br>Document implementation and completion of Dam 2 tower and spillway rock weir improvements (tower improvements will be complete and operational by 2014) | 2014–59 | Measure is in process—Compliance commitments start 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 has been completed. |
| **R-1** | **Reservoir Operations** | Avoid or minimize mortality of cutthroat and rainbow trout | Document reservoir surface elevations | 2010–59 | Measure is in full compliance. |
| **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 will no longer be implemented. Benefits to cutthroat trout are insignificant. Change authorized by NMFS in April 26, 2013 letter (see Appendix H, Item 7) |
| **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 | Measure is in full compliance. |

## 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<br>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 | Measure is in full compliance. |
| **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 | Measure is in full compliance. |
| **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<br>Document changes in stormwater facilities at Sandy River Station, if needed<br>Document tree planting and success of revegetation efforts | 2010–59 | Measure is in full compliance. |
| **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 | Measure is in full compliance. |

## 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<br>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<br>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 H, Item 5). |
| **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 is in process—PWB anticipates acquiring conservation easement acreage by 2014. |
| **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<br><br>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<br>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<br>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 H, Item 6). |

## Offsite Measures–Compliance

| # | Measure | Measurable Habitat Objective | Compliance Monitoring | HCP Years | Status |
|---|---|---|---|---|---|
| **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 has been completed. |
| **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 full compliance by 2019. |
| **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 | Measure is in process. |
| **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 | |

| Offsite Measures–Compliance | | | | | |
|---|---|---|---|---|---|
| **#** | **Measure** | **Measurable Habitat Objective** | **Compliance Monitoring** | **HCP Years** | **Status** |
| **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 | |
| **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 will obtain 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 in May 11, 2011 letter (see Appendix H, Item 1). |
| **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 | |

## Offsite Measures–Compliance

| # | Measure | Measurable Habitat Objective | Compliance Monitoring | HCP Years | Status |
|---|---|---|---|---|---|
| **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<br>Complete an aerial photograph analysis or site survey to determine whether planting is needed<br>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<br>Document date riparian easement is completed and when site potential forest is established | 2015–19 | |
| **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 has been completed. |
| **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 is in process—PWB anticipates full compliance by 2014. |

## Offsite Measures–Compliance

| # | Measure | Measurable Habitat Objective | Compliance Monitoring | HCP Years | Status |
|---|---|---|---|---|---|
| **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 has been completed. |
| **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 has been completed in the Zigzag and upper Sandy Rivers. Change authorized by NMFS in December 3, 2013 letter (see Appendix H, Item 8). |
| **H-29** | **Zigzag 1A, 1B, and 1C Carcass Placement** | Place 1,800 salmon carcasses in one season | Same as above | 2020–24 | |
| **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 is in process—PWB anticipates full compliance by 2015. |
| **H-4** | **Sandy 1 and 2 Log Jams** | Place 10 engineered log jams in reaches Sandy 1 and 2 | Same as above | 2015–19 | |
| **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<br>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 has been completed. |

## Offsite Measures–Compliance

| # | Measure | Measurable Habitat Objective | Compliance Monitoring | HCP Years | Status |
|---|---|---|---|---|---|
| **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 has been completed |
| **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 in August 16, 2011 and March 15, 2012 letters (see Appendix H, Items 2 and 4). |
| **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 | |
| **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 in August 16, 2011 letter (see Appendix H, Item 2). |

## Offsite Measures–Compliance

| # | Measure | Measurable Habitat Objective | Compliance Monitoring | HCP Years | Status |
|---|---|---|---|---|---|
| **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 has been completed. |
| **H-9** | **Sandy 1 Channel Reconstruction** | Open one-third river miles of side-channel habitat<br>Place 25 logs in side channel | Tag all side-channel logs at the time of placement for later identification<br>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)<br>Note: Measure H-10 is only necessary for projects conducted in the Sandy River delta. | 2015–19 | Measure has been completed. |
| **H-27** | **Zigzag 1A Channel Redesign** | Maintain one-third mile of floodplain habitat for steelhead, coho, and spring Chinook<br>Place 25 pieces of LW in reaches Zigzag 1A and 1B | Tag all pieces of LW at the time of placement for later identification<br>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<br>Protocols will be available within six months of the start of the HCP term | 2010–59 | Measure is in full compliance. |

## Offsite Measures–Compliance

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

## 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 is August 2012–December 2013.<br>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 has been completed. 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 has been completed. Effectiveness monitoring will continue through 2025. See Appendix A. |
| **H-7** | **Trout 2A LW Placement** | | | 2010–14 | Measure will not be implemented and associated effectiveness monitoring has been cancelled. (See Appendix H, Item 2.) |
| **H-3** | **Little Sandy 1 and 2 LW Placement** | Achieve 80% of predicted increase in pieces of LW within 15 years of implementation<br>Achieve 80% of predicted increase in backwater pools, pools, and pool-tail habitat within 15 years of implementation<br>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 is in full compliance. 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. |
| **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 | |
| **H-17** | **Cedar 2 and 3 LW Placement** | Achieve 80% of predicted increase in pieces of LW within 15 years of implementation<br>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 | |
| **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 | |
| **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 | |

## Offsite Measures—Effectiveness

| # | Measure | Measurable Habitat Objective | Effectiveness Monitoring | HCP Years | Status |
|---|---|---|---|---|---|
| **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 | Measure is in full compliance. |

## 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 is in full compliance. 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 | Reporting in Year 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 is in full compliance. See Appendix D. |
| **BR Adult Chinook Population** | Survey, sampling, linear regression | Include with annual compliance report | 2010–59 | Measure is in full compliance. See Appendix E. |
| **Sandy River Basin Smolt Monitoring** | Mark recapture study, various analyses methods | Include with annual compliance report | 2010–59 | Measure is in full compliance. 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. Sandy River Delta Turtle Survey and Relocation

H. Correspondence on Measure Adjustment

## Appendix A

# Bull Run HCP Effectiveness Monitoring Report

# Effectiveness Monitoring for Offsite In-Channel Conservation Measures

April 2014
Burke Strobel
City of Portland Water Bureau

# Contents



## Tables

# 1. Summary

The City of Portland Water Bureau (PWB) is in full compliance with its Habitat Conservation Plan obligations in 2013 with regard to effectiveness monitoring for offsite in-channel conservation measures. Fish habitat surveys were conducted for three offsite measures—H-3, Little Sandy 1 and 2 Large Wood Placement; H-5, Gordon 1A/1B Large Wood Placement; H-6, Trout 1A 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. A fourth measure for which fish habitat surveys were conducted, H-7, Trout 2A Large Wood Placement, was originally planned in Trout Creek, but was cancelled in 2012 because of the lack of landowner permission. The large wood pieces intended for placement in Trout 2A were added to Measure H-6, Trout 1A Large Wood Placement, instead.

This appendix summarizes the results of the 2013 surveys. The data collected in 2013 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. The data collected for H-5, Gordon 1A/1B Large Wood Placement and H-6, Trout 1A Large Wood Placement represent the first year of post-treatment measurements.

# 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 2013, baseline data and post-treatment data were collected in streams. Baseline data were collected in the Little Sandy River. Baseline effectiveness monitoring was also continued in 2013 in the Salmon River, where the City expects to implement habitat enhancement measures in the near future. Post-treatment data were collected in Gordon Creek and Trout Creek. The five HCP measures associated with this monitoring are H-3, Little Sandy 1 and 2 Large Wood Placement; H-5, Gordon 1A/1B Large Wood Placement; H-6, Trout 1A Large Wood Placement; H-7; H-23, Salmon 2 Miller Quarry Acquisition; and H-24, Salmon 2 Miller Quarry Restoration. A sixth measure for which fish habitat monitoring was conducted, H-7, Trout 2A Large Wood Placement, was originally planned in Trout Creek, but was cancelled in 2012 because of the lack of landowner permission. The large wood pieces intended for placement in Trout 2A were added to Measure H-6, Trout 1A Large Wood Placement.

This appendix describes the effectiveness monitoring protocols and results to-date for the in-channel measures to be conducted in the Little Sandy River and the Salmon River, and the in-channel measures already completed in Gordon and Trout creeks. 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 the effectiveness of the offsite in-channel measures at accomplishing the 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 from year-to-year and from 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 2011[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 | 567% | Gordon 1A |
| Backwater Pools | Percentage of reach (by surface area) that comprises backwater pools | Increase from 0% to 5% | Gordon 1A |
| Pool Habitat | Percentage of reach (by surface area) that comprises pool habitat | 115% | Gordon 1A |
| Pool-Tail Habitat | Percentage of reach (by surface area) that comprises pool tail-outs | 46% | Gordon 1A |
| Small-Cobble Riffles | Percentage of reach (by surface area) that comprises small cobble riffles | -33% | Gordon 1A |
| Large-Cobble Riffles | Percentage of reach (by surface area) that comprises large cobble riffles | -17% | Gordon 1A |
| Fine Sediment | Percentage of gravel patches (by surface area) that is fine sediment | -25% | Gordon 1A |
| Large Woody Debris | Number of pieces per channel width | 567% | Gordon 1B |
| Backwater Pools | Percentage of reach (by surface area) that comprises backwater pools | Increase from 0% to 5% | Gordon 1B |
| Pool Habitat | Percentage of reach (by surface area) that comprises pool habitat | 212% | Gordon 1B |
| Pool-Tail Habitat | Percentage of reach (by surface area) that comprises pool tail-outs | 326% | Gordon 1B |
| Small-Cobble Riffles | Percentage of reach (by surface area) that comprises small cobble riffles | -40% | Gordon 1B |
| Large Woody Debris | Number of pieces per channel width | 7% | Trout 1A |
| Large Woody Debris | Number of pieces per channel width | 13% | Trout 2A |
| 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 2013**

| Watershed | Treated Reaches | Control Reaches |
|---|---|---|
| Bull Run River | Little Sandy 1 | Little Sandy 2 |
| Lower Sandy River | Trout 1A | Trout 3A |
| | Trout 2A | Trout 3A |
| | Gordon 1A | Gordon 2A |
| | Gordon 1B | Gordon 2A |
| 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)
  - 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,

[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.

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, or 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):

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

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 lessthan 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. 2013 Results

Tables 3, 4, 5, and 6 summarize the results for offsite in-stream measure effectiveness monitoring surveys conducted in 2013 in the Little Sandy River, Gordon Creek, Trout 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 2013 Survey Results**

| | Treatment Reach | | Control Reach | |
|---|---|---|---|---|
| | Little Sandy 1 Reach | | Little Sandy 2 Reach | |
| **Attribute** | **EDT Current** | **2013 Survey** | **EDT Current** | **2013 Survey** |
| Large Wood (pieces/CW)[b] | 1.5 | 2.6 | 5.0 | 1.3 |
| Backwater Pools | 0.0% | 0.0% | 2.0% | 0.0% |
| Beaver Ponds | 0.0% | 0.0% | 0.0% | 0.0% |
| Pools | 27% | 35.1% | 20.0% | 38.6% |
| Pool Tails | 0.0% | 1.6% | 0.0% | 0.5% |
| Small-Cobble Riffles | 5.0% | 0.0% | 0.0% | 0.0% |
| Large-Cobble Riffles | 63.0% | 61.7% | 74.0% | 60.9% |
| Glides | 0.0% | 0.0% | 0.0% | 0.0% |
| Off-Channel Habitat | 0.0% | 0.1% | 0.0% | 0.0% |

**Table 3. Comparison of Values for Various Habitat Attributes[a] in the Little Sandy River Derived from the EDT Database and 2013 Survey Results**

| | Treatment Reach | | Control Reach | |
|---|---|---|---|---|
| | Little Sandy 1 Reach | | Little Sandy 2 Reach | |
| Attribute | EDT Current | 2013 Survey | EDT Current | 2013 Survey |
| Percent Fines | 8.5% | 4.0% | 14.5% | 7.1% |
| Embeddedness | 0.0% | 6.0% | 0.0% | 11.4% |

[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 Gordon Creek Derived from the EDT Database and 2013 Survey Results**

| | Treatment Reaches | | | | Control Reach | |
|---|---|---|---|---|---|---|
| | Gordon 1A Reach | | Gordon 1B Reach | | Gordon 2A Reach | |
| Attribute | EDT Current | 2013 Survey | EDT Current | 2013 Survey | EDT Current | 2013 Survey |
| Large Wood (pieces/CW)[b] | 1.5 | 3.0 | 1.5 | 5.5 | 1.5 | 3.8 |
| Backwater Pools | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Beaver Ponds | 0.0% | 0.0% | 0.0% | 4.8% | 0.0% | 0.0% |
| Pools | 14.0% | 33.5% | 6.5% | 16.6% | 3.2% | 16.8% |
| Pool Tails | 3.5% | 1.8% | 1.3% | 0.9% | 3.2% | 0.8% |
| Small-Cobble Riffles | 52.3% | 11.1% | 58.4% | 4.2% | 40.6% | 2.0% |
| Large-Cobble Riffles | 30.2% | 40.0% | 33.8% | 73.5% | 52.9% | 80.3% |
| Glides | 0.0% | 13.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| Off-Channel Habitat | 0.0% | 0.0% | 0.0% | 0.3% | 0.0% | 0.0% |
| Percent Fines | 24.0% | 19.1% | 8.5% | 22.2% | 8.5% | 11.2% |
| Embeddedness | 0.0% | 38.5% | 0.0% | 41.5% | 0.0% | 34.4% |

[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 Trout Creek Derived from the EDT Database and 2013 Survey Results**

| | Treatment Reaches | | | | Control Reach | |
|---|---|---|---|---|---|---|
| | Trout 1A Reach | | Trout 2A Reach | | Trout 3A Reach | |
| Attribute | EDT Current | 2013 Survey | EDT Current | 2013 Survey | EDT Current | 2013 Survey |
| Large Wood (pieces/CW)[b] | 1.5 | 2.5 | 1.5 | 7.1 | 1.5 | 5.1 |
| Backwater Pools | 10.3% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| Beaver Ponds | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Pools | 4.1% | 22.5% | 0.0% | 13.6% | 3.9% | 15.9% |
| Pool Tails | 1.0% | 0.0% | 0.0% | 0.8% | 0.0% | 0.4% |
| Small-Cobble Riffles | 41.2% | 11.7% | 58.0% | 9.4% | 54.9% | 0.0% |
| Large-Cobble Riffles | 43.3% | 1.6% | 42.0% | 75.1% | 41.2% | 83.7% |
| Glides | 0.0% | 64.1% | 0.0% | 1.0% | 0.0% | 0.0% |
| Off-Channel Habitat | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Percent Fines | 14.5% | 75.7% | 8.5% | 27.7% | 8.5% | 10.7% |
| Embeddedness | 0.0% | 56.7% | 0.0% | 38.8% | 0.0% | 16.7% |

[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 6. Comparison of Values for Various Habitat Attributes[a] in the Salmon River Derived from the EDT Database and 2013 Survey Results**

| | Treatment Reach | | Control Reach | |
|---|---|---|---|---|
| | Salmon 2 Reach | | Salmon 3 Reach | |
| Attribute | EDT Current | 2013 Survey | EDT Current | 2013 Survey |
| Large Wood (pieces/CW)[b] | 2.0 | 10.3 | 2.0 | 5.1 |
| Backwater Pools | 3.1% | 0.0% | 0.0% | 0.0% |
| Beaver Ponds | 0.0% | 3.4% | 0.0% | 3.9% |
| Pools | 3.1% | 26.5% | 15.7% | 26.0% |
| Pool Tails | 1.2% | 1.4% | 2.8% | 0.7% |
| Small-Cobble Riffles | 3.1% | 6.5% | 2.8% | 0.1% |

**Table 6. Comparison of Values for Various Habitat Attributes[a] in the Salmon River Derived from the EDT Database and 2013 Survey Results**

| | Treatment Reach | | Control Reach | |
|---|---|---|---|---|
| | Salmon 2 Reach | | Salmon 3 Reach | |
| Attribute | EDT Current | 2013 Survey | EDT Current | 2013 Survey |
| Large-Cobble Riffles | 89.4% | 61.5% | 78.7% | 69.3% |
| Glides | 0.0% | 0.6% | 0.0% | 0.0% |
| Off-Channel Habitat | 2.6% | 0.6% | 2.6% | 0.0% |
| Percent Fines | 8.5% | 29.6% | 8.5% | 14.2% |
| Embeddedness | 0.0% | 49.3% | 0.0% | 40.9% |

[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 7 summarizes the averages of baseline values, standard deviations, and post-treatment targets for the habitat attributes that have measurable habitat objectives in each treatment reach. Control reaches are not included because they do not have measurable habitat objectives. The number of baseline survey years that are incorporated into each baseline average is given in parentheses in the Reach column.

**Table 7. Baseline Averages, Post-Treatment Targets, and Post-Treatment Averages for Habitat Attributes with Measurable Habitat Objectives in Streams Surveyed in 2013[a,b]**

| Attribute | Baseline Average | Standard Deviation | Post-Treatment Target | Post-Treatment Average | Reach |
|---|---|---|---|---|---|
| Large Woody Debris (pieces/CW) | 2.6 | NA | NA | NA | Little Sandy 1 (n=1) |
| Large Woody Debris (pieces/CW) | 2.3 | 0.4 | 10 | 3.0 | Gordon 1A (n=4) |
| Backwater Pools | 0.5% | 0.8% | 5.1% | 0.0% | |
| Pool Habitat | 36.3% | 7.4% | 30.0% | 33.5% | |
| Pool-Tail Habitat | 1.0% | 0.6% | 5.1% | 1.8% | |
| Small-Cobble Riffles | 8.2% | 4.96% | 34.8% | 11.1% | |
| Large-Cobble Riffles | 43.6% | 7.7% | 25.0% | 40.0% | |
| Fine Sediment | 12.6% | 4.6% | 18.0% | 19.1% | |
| Large Woody Debris (pieces/CW) | 3.7 | 0.5 | 10 | 5.5 | Gordon 1B (n=4) |
| Backwater Pools | 0.0 | 0.1% | 4.7% | 0.0% | |

**Table 7. Baseline Averages, Post-Treatment Targets, and Post-Treatment Averages for Habitat Attributes with Measurable Habitat Objectives in Streams Surveyed in 2013[a,b]**

| Attribute | Baseline Average | Standard Deviation | Post-Treatment Target | Post-Treatment Average | Reach |
|---|---|---|---|---|---|
| Pool Habitat | 0.3 | 8.51% | 20.2% | 16.6% | |
| Pool-Tail Habitat | 0.0 | 0.32% | 5.5% | 0.9% | |
| Small-Cobble Riffles | 0.0 | 1.76% | 35.0% | 4.2% | |
| Large Woody Debris (pieces/CW) | 1.1 | 1.0 | 1.6 | 2.5 | Trout 1A (n=3) |
| Large Woody Debris (pieces/CW) | 5.5 | 1.2 | 1.7 | 7.1 | Trout 2A (n=3) |
| Large Woody Debris (pieces/CW) | 12.9 | 3.6 | 2.2 | NA | Salmon 2 (n=2) |
| Artificial confinement | 25% | NA | 22% | NA | |

[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.

# 9. Discussion

The results presented in Tables 3, 4, 5, and 6 of this report contribute to the baseline average of values and begins a record of post-treatment values for the respective monitored habitat attributes. Measures H-5, Gordon 1A/1B Large Wood Placement and H-6, Trout 1A Large Wood Placement, were implemented in 2012, so the habitat attribute data collected in these streams in 2013 represent the first post-treatment measurements. Additional post-treatment data will be collected in Gordon Creek and Trout Creek in 2016, 2019, 2022, and 2025. At least one more year of baseline data will be collected on the Little Sandy River and 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, D.G., and G.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, P., A.H. Fayram, and M.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 2014

Kristin Anderson
City of Portland Water Bureau

# Contents

# 1. Summary

The City is modifying its Bull Run Dam 2 water intake towers for the Bull Run Water Supply Habitat Conservation Plan (CHP) 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 describes 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 continued through calendar year 2013 and this report includes results from that sampling effort (see Exhibit A). Starting in 2014, the City will collect monitoring data after the completion of the Dam 2 Tower project and those data will be compared to pre-construction and operation conditions (baseline conditions).

# 2. Introduction

As part of the HCP, the City of Portland is implementing a 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 draws 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 water-quality standard.

**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 through 2013 will provide baseline results; monitoring in subsequent years will provide results that can be 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 2013, the City completed monthly sampling of nutrient concentrations in Bull Run Reservoir No. 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 two parameters.

### 3.1.2 Dissolved Oxygen

Dissolved oxygen was monitored upstream and downstream of Bull Run Dam 2 in 2013. This monitoring will fulfill 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 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 will fulfill 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 the compliance with HCP Measure T-1 Pre-Infrastructure Temperature Management and (in the future) HCP Measure T-2, Post-Infrastructure Temperature Management, the bureau already reports on (or is planning to report on) temperatures in the lower Bull Run River at Larson's Bridge. The bureau will continue to gather and report these data here for the period required for 401 certification.

## 3.2 Sampling

Reservoir 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. Samples at the Headworks Bridge for downstream dissolved oxygen measurements were collected by a multiparameter probe lowered from the bridge into the river.[1]

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.

[1] The probe used to measure dissolved oxygen concentration and saturation contains two DO sensors: a membrane-based probe and an optical probe. The optical probe is the primary sensor. Data from the membrane probe are reported if the optical probe malfunctions.

**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

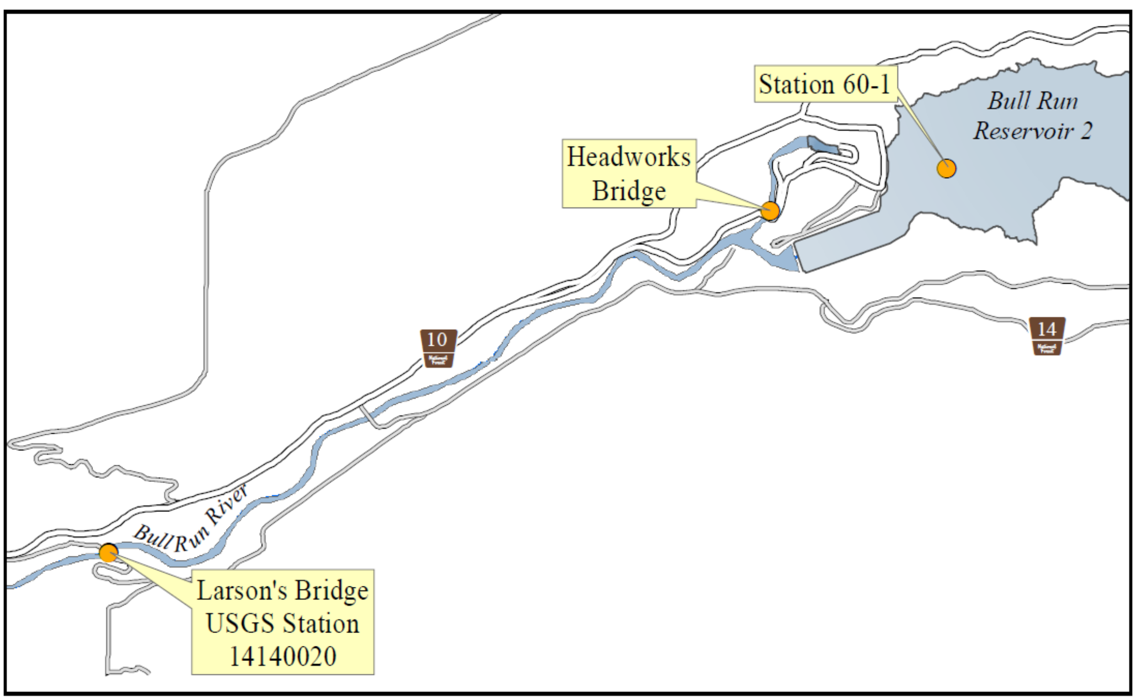



**Figure 1. Sampling Sites for Monitoring**

# 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 each sample depth were shown. In the lower Bull Run River, dissolved oxygen concentration and saturation levels and temperatures were shown 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

The data from this first monitoring period was part of the baseline results; baseline data collection continued through 2013 (see Table 2 for the baseline sampling periods). Exhibit A includes raw data from the 2013 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 2013. Samples were often collected and analyzed at a frequency greater than the frequency that will be required in 2014. However, January samples were not collected due to staff unavailability, and that sampling event was rescheduled for early February. In 2014, sampling will be rescheduled within the same month if cancelled for similar reasons.

In 2013, nutrient results were within expected ranges. Reactive phosphorus ranged from <0.003 – 0.004 milligrams per liter (mg/L), and total phosphorus ranged from <0.01 – 0.023 mg/L. Nitrite ranged from <0.005 – 0.005 mg/L, nitrate from <0.01 – 0.047 mg/L, and total nitrogen from <0.05 – 0.25 mg/L.

### 5.1.2 Dissolved Oxygen

Table A-2 shows results of dissolved oxygen (DO) monitoring at the Headworks Bridge. No data for January 2013 are included due to staff unavailability. Baseline sampling in 2013 showed DO saturation values of 94.5% – 103% at the Headworks Bridge.

Table A-3 includes DO results from Reservoir 2. The baseline monitoring results from 2013 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. Any sediment stirred up, either naturally or with disturbance, can result in lower DO values in the deepest depths. In some cases, when sediment is stirred up by sampling activities, a steep decline in observed DO occurs at the base of the reservoir. In these cases, the very low DO values are not considered representative.

### 5.1.3 pH Levels

Table A-3 includes results for pH observed in Reservoir 2 in 2013 baseline monitoring. Results ranged from pH 6.3 – 7.3. It is notable that many instances of pH less than 6.5 were observed. This is indicative of natural conditions in the Bull Run watershed.

### 5.1.4 Temperature

Table A-3 also includes temperature measurements during profiling of Reservoir 2 in 2013 baseline monitoring. As expected, temperature stratification was observed to change seasonally.

## 6. Conclusions

Now that baseline data have been collected, 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.

Once the new Reservoir No. 2 water intake goes into service, monitoring in Reservoir 2 and at Headworks Bridge will continue for at least five years, 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.

[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.

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]**

| ***2/5/2013*** | | | | | | |
|---|---|---|---|---|---|---|
| **Sample Depth** | **Elevation** | **$PO_4$** | **Total P** | **$NO_2$** | **$NO_3$** | **Total N** |
| **M** | **ft MSL** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** |
| 1 | 856.7 | <0.0030 | <0.010 | <0.005 | 0.04 | 0.07 |
| 4 | 846.9 | <0.0030 | <0.010 | <0.005 | 0.04 | 0.07 |
| 13 | 817.4 | <0.0030 | <0.010 | <0.005 | 0.04 | 0.07 |
| 22 | 787.8 | <0.0030 | <0.010 | <0.005 | 0.03 | 0.09 |
| 31 | 758.3 | <0.0030 | 0.012 | <0.005 | 0.04 | 0.09 |

| ***3/5/2013*** | | | | | | |
|---|---|---|---|---|---|---|
| **Sample Depth** | **Elevation** | **$PO_4$** | **Total P** | **$NO_2$** | **$NO_3$** | **Total N** |
| **M** | **ft MSL** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** |
| 1 | 856.7 | <0.003 | <0.010 | <0.005 | 0.02 | 0.06 |
| 10 | 827.2 | <0.003 | 0.012 | <0.005 | 0.02 | 0.07 |
| 18 | 801 | <0.003 | <0.010 | <0.005 | 0.02 | 0.08 |
| 27 | 771.4 | <0.003 | <0.010 | <0.005 | 0.02 | 0.07 |

| ***3/26/2013*** | | | | | | |
|---|---|---|---|---|---|---|
| **Sample Depth** | **Elevation** | **$PO_4$** | **Total P** | **$NO_2$** | **$NO_3$** | **Total N** |
| **M** | **ft MSL** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** |
| 1 | 856.7 | <0.003 | <0.010 | <0.005 | 0.02 | 0.05 |
| 10 | 827.2 | <0.003 | <0.010 | <0.005 | 0.021 | 0.05 |
| 19 | 797.7 | <0.003 | <0.010 | <0.005 | 0.021 | 0.05 |
| 28 | 768.2 | <0.003 | <0.010 | <0.005 | 0.021 | 0.05 |

| ***4/23/2013*** | | | | | | |
|---|---|---|---|---|---|---|
| **Sample Depth** | **Elevation** | **$PO_4$** | **Total P** | **$NO_2$** | **$NO_3$** | **Total N** |
| **M** | **ft MSL** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** |
| 1 | 856.7 | <0.003 | <0.010 | <0.005 | <0.01 | 0.07 |
| 2 | 853.4 | <0.003 | <0.010 | <0.005 | <0.01 | 0.08 |
| 11 | 823.9 | <0.003 | <0.010 | <0.005 | <0.01 | 0.07 |
| 20 | 794.4 | <0.003 | <0.010 | <0.005 | <0.01 | 0.09 |
| 29 | 764.9 | <0.003 | <0.010 | <0.005 | 0.01 | 0.06 |

| ***5/21/2013*** | | | | | | |
|---|---|---|---|---|---|---|
| **Sample Depth** | **Elevation** | **$PO_4$** | **Total P** | **$NO_2$** | **$NO_3$** | **Total N** |
| **M** | **ft MSL** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** |
| 1 | 857 | <0.003 | <0.01 | <0.005 | <0.01 | 0.19 |
| 6 | 852 | <0.003 | <0.01 | <0.005 | <0.01 | 0.18 |
| 14 | 844 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |
| 22 | 836 | <0.003 | <0.01 | <0.005 | <0.01 | 0.15 |
| 31 | 827 | <0.003 | <0.01 | <0.005 | <0.01 | 0.17 |

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

***6/4/2013***

| 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 | 855.7 | <0.003 | <0.01 | <0.005 | <0.01 | <0.05 |
| 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 | 0.06 |
| 28 | 767.2 | <0.003 | <0.01 | <0.005 | <0.01 | <0.05 |

***6/18/2013***

| 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 | 854.7 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |
| 6 | 838.3 | <0.003 | <0.01 | <0.005 | <0.01 | 0.07 |
| 14 | 812.1 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |
| 22 | 785.8 | <0.003 | <0.01 | <0.005 | <0.01 | 0.07 |
| 28 | 766.2 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |

***7/2/2013***

| 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 | 855.7 | <0.003 | <0.010 | <0.0050 | <0.01 | 0.06 |
| 6 | 839.3 | <0.003 | <0.010 | <0.0050 | <0.01 | 0.07 |
| 15 | 809.8 | <0.003 | <0.010 | <0.0050 | <0.01 | 0.06 |
| 22 | 786.8 | <0.003 | <0.010 | <0.0050 | <0.01 | 0.06 |
| 31 | 757.3 | <0.003 | 0.023 | <0.0050 | 0.015 | 0.13 |

***7/16/2013***

| 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 | 855.7 | <0.003 | <0.01 | <0.005 | <0.010 | 0.10 |
| 6 | 839.3 | <0.003 | <0.01 | <0.005 | <0.010 | 0.06 |
| 15 | 809.8 | <0.003 | <0.01 | <0.005 | <0.010 | 0.07 |
| 22 | 786.8 | <0.003 | <0.01 | <0.005 | <0.010 | 0.06 |
| 32 | 755 | <0.003 | <0.01 | <0.005 | 0.014 | 0.08 |

***7/30/2013***

| 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 | 855.7 | <0.003 | <0.01 | <0.005 | <0.01 | 0.08 |
| 6 | 839.3 | <0.003 | 0.015 | <0.005 | <0.01 | 0.14 |
| 15 | 809.8 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |
| 22 | 786.8 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |
| 29 | 763.9 | <0.003 | <0.01 | <0.005 | 0.019 | 0.07 |

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

***8/13/2013***

| 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 | 855.7 | <0.003 | <0.01 | < 0.005 | < 0.01 | <0.05 |
| 6 | 839.3 | <0.003 | <0.01 | < 0.005 | < 0.01 | 0.25 |
| 15 | 809.8 | <0.003 | <0.01 | < 0.005 | < 0.01 | <0.05 |
| 22 | 786.8 | <0.003 | <0.01 | < 0.005 | < 0.01 | 0.07 |
| 29 | 763.9 | 0.003 | <0.01 | < 0.005 | < 0.01 | 0.05 |

***8/27/2013***

| 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 | 855.7 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |
| 6 | 839.3 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |
| 15 | 809.8 | <0.003 | 0.01 | <0.005 | <0.01 | 0.05 |
| 22 | 786.8 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |
| 29 | 763.9 | <0.003 | <0.01 | <0.005 | <0.01 | 0.07 |

***9/10/2013***

| 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 | 855.7 | <0.003 | <0.01 | <0.0050 | <0.010 | 0.08 |
| 6 | 839.3 | <0.003 | <0.01 | <0.0050 | <0.010 | 0.14 |
| 15 | 809.8 | 0.003 | <0.01 | <0.0050 | <0.010 | 0.07 |
| 22 | 786.8 | <0.003 | <0.01 | <0.0050 | <0.010 | 0.06 |
| 30 | 760.6 | <0.003 | <0.01 | <0.0050 | 0.014 | 0.10 |

***9/24/2013***

| 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 | 855.7 | <0.003 | <0.01 | <0.005 | <0.01 | 0.06 |
| 6 | 839.3 | <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 | 0.07 |
| 29 | 763.9 | <0.003 | <0.01 | <0.005 | 0.016 | 0.09 |

***10/8/2013***

| 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 | 855.7 | <0.003 | <0.01 | <0.005 | 0.042 | 0.12 |
| 6 | 839.3 | <0.003 | <0.01 | 0.005 | 0.039 | 0.11 |
| 15 | 809.8 | <0.003 | <0.01 | <0.005 | 0.040 | 0.11 |
| 22 | 786.8 | <0.003 | <0.01 | <0.005 | 0.044 | 0.11 |
| 29 | 763.9 | <0.003 | <0.01 | <0.005 | 0.047 | 0.11 |

**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 |
|---|---|---|---|---|---|---|
| ***10/22/2013*** | | | | | | |
| 1 | 854.7 | <0.003 | <0.01 | <0.005 | 0.027 | 0.10 |
| 6 | 838.3 | <0.003 | <0.01 | <0.005 | 0.027 | 0.10 |
| 14 | 812.1 | <0.003 | <0.01 | <0.005 | 0.036 | 0.10 |
| 22 | 785.8 | <0.003 | <0.01 | <0.005 | 0.037 | 0.12 |
| 29 | 762.9 | <0.003 | <0.01 | <0.005 | 0.038 | 0.10 |
| ***11/5/2013*** | | | | | | |
| 1 | 855.7 | <0.003 | <0.01 | <0.005 | 0.033 | 0.11 |
| 6 | 839.3 | <0.003 | <0.01 | <0.005 | 0.032 | 0.10 |
| 15 | 809.8 | <0.003 | <0.01 | <0.005 | 0.034 | 0.10 |
| 22 | 786.8 | <0.003 | <0.01 | <0.005 | 0.039 | 0.10 |
| 29 | 763.9 | <0.003 | <0.01 | <0.005 | 0.040 | 0.11 |
| ***11/19/2013*** | | | | | | |
| 1 | 856.7 | <0.003 | <0.01 | <0.005 | 0.041 | 0.11 |
| 6 | 840.3 | <0.003 | <0.01 | <0.005 | 0.042 | 0.10 |
| 15 | 810.8 | <0.003 | <0.01 | <0.005 | 0.041 | 0.10 |
| 22 | 787.8 | <0.003 | <0.01 | <0.005 | 0.041 | 0.10 |
| 31 | 758.3 | <0.003 | <0.01 | <0.005 | 0.041 | 0.09 |
| ***12/5/2013*** | | | | | | |
| 1 | 849.7 | <0.003 | 0.011 | <0.005 | 0.043 | 0.13 |
| 4 | 839.9 | 0.004 | 0.011 | <0.005 | 0.042 | 0.13 |
| 13 | 810.4 | 0.003 | 0.012 | <0.005 | 0.047 | 0.15 |
| 20 | 787.4 | 0.003 | 0.012 | <0.005 | 0.042 | 0.15 |
| 29 | 757.9 | <0.003 | 0.013 | <0.005 | 0.040 | 0.14 |
| ***12/17/2013*** | | | | | | |
| 1 | 849.7 | <0.003 | 0.011 | <0.005 | 0.042 | 0.13 |
| 4 | 839.9 | <0.003 | 0.010 | <0.005 | 0.041 | 0.12 |
| 13 | 810.4 | <0.003 | 0.011 | <0.005 | 0.047 | 0.12 |
| 20 | 787.4 | <0.003 | 0.011 | <0.005 | 0.045 | 0.12 |
| 29 | 757.9 | <0.003 | 0.011 | <0.005 | 0.044 | 0.13 |

[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 |
|---|---|---|---|---|
| 2/5/2013 | 0.6 | 12.7 | 97.9 | 4.4 |
| 2/12/2013 | FE [b] | 12.8 | 98.7 | 4.4 |
| 2/26/2013 | 0.9 | 12.8 | 99.0 | 4.5 |
| 3/12/2013 | 0.6 | 12.7 | 99.0 | 4.8 |
| 3/26/2013 | 0.5 | 12.5 | 98.3 | 5.3 |
| 4/9/2013 | 0.2 | 11.8 | 94.5 | 5.8 |
| 4/23/2013 | 1.4 | 12.4 | 102 | 6.6 |
| 5/7/2013 | 0.8 | 12.0 | 100 | 7.4 |
| 5/21/2013 | 1.5 | 11.2 | 97.7 | 9.2 |
| 6/4/2013 | 0.3 | 11.4 | 99.6 | 9.5 |
| 6/18/2013 | 1.2 | 11.2 | 100 | 10.2 |
| 7/5/2013 | 0.7 | 10.4 | 97.2 | 12.2 |
| 7/16/2013 | 0.3 | 10.6 | 102 | 13.5 |
| 7/30/2013 | 0.3 | 10.1 | 99.3 | 14.5 |
| 8/13/2013 | 0.6 | 10.1 | 100 | 14.9 |
| 8/27/2013 | 0.5 | 10.0 | 100 | 15.5 |
| 9/10/2013 | 0.5 | 10.1 | 103 | 16.3 |
| 9/24/2013 | 0.6 | 9.6 | 98.6 | 16.5 |
| 10/8/2013 | 0.2 | 11.0 | 100 | 11.2 |
| 10/22/2013 | 0.2 | 11.2 | 99.5 | 10.2 |
| 11/5/2013 | 0.6 | 11.2 | 98.6 | 9.7 |
| 11/19/2013 | 0.0 | 11.6 | 97.6 | 7.9 |
| 12/3/2013 | 0.0 | 12.5 | 101 | 6.2 |
| 12/17/2013 | 0.1 | 12.9 | 98.1 | 4.0 |
| 12/31/2013 | 0.1 | 12.9 | 98.7 | 4.1 |

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

[b]FE denotes field exception, in which an accurate field measurement was not available

**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 |
|---|---|---|---|---|---|
| ***1/15/2013*** | | | | | |
| 1 | 856.7 | 12.4 | 92.8 | 3.2 | 6.96 |
| 2 | 853.4 | 12.4 | 92.7 | 3.2 | 6.95 |
| 3 | 850.2 | 12.4 | 92.6 | 3.2 | 6.94 |
| 4 | 846.9 | 12.4 | 92.5 | 3.21 | 6.92 |
| 5 | 843.6 | 12.4 | 92.3 | 3.23 | 6.92 |
| 6 | 840.3 | 12.3 | 92.2 | 3.25 | 6.91 |
| 7 | 837.0 | 12.3 | 92.2 | 3.3 | 6.9 |
| 8 | 833.8 | 12.3 | 92 | 3.32 | 6.91 |
| 9 | 830.4 | 12.3 | 91.9 | 3.32 | 6.91 |
| 10 | 827.2 | 12.2 | 91.9 | 3.34 | 6.9 |
| 11 | 823.9 | 12.2 | 91.7 | 3.36 | 6.9 |
| 12 | 820.6 | 12.2 | 91.6 | 3.36 | 6.9 |
| 13 | 817.3 | 12.2 | 91.6 | 3.35 | 6.9 |
| 14 | 814.1 | 12.2 | 91.5 | 3.37 | 6.9 |
| 15 | 810.8 | 12.2 | 91.5 | 3.38 | 6.9 |
| 16 | 807.5 | 12.2 | 91.5 | 3.43 | 6.9 |
| 17 | 804.2 | 12.1 | 91.3 | 3.47 | 6.89 |
| 18 | 800.9 | 12.1 | 91.3 | 3.52 | 6.89 |
| 19 | 797.7 | 12.1 | 91.1 | 3.54 | 6.9 |
| 20 | 794.4 | 12.1 | 91 | 3.59 | 6.89 |
| 21 | 791.1 | 12 | 90.7 | 3.63 | 6.89 |
| 22 | 787.8 | 12 | 90.5 | 3.64 | 6.88 |
| 23 | 784.5 | 12 | 90.4 | 3.65 | 6.88 |
| 24 | 781.3 | 11.9 | 90.2 | 3.66 | 6.88 |
| 25 | 778.0 | 11.9 | 90 | 3.66 | 6.88 |
| 26 | 774.7 | 11.9 | 90 | 3.66 | 6.87 |
| 27 | 771.4 | 11.9 | 89.9 | 3.66 | 6.88 |
| 28 | 768.1 | 11.9 | 89.9 | 3.66 | 6.87 |
| ***2/5/2013*** | | | | | |
| 1 | 856.7 | 12.7 | 96.9 | 4.11 | 6.98 |
| 2 | 853.4 | 12.7 | 97.3 | 4.11 | 6.91 |
| 3 | 850.1 | 12.7 | 97.3 | 4.1 | 6.89 |
| 4 | 846.9 | 12.7 | 97.3 | 4.11 | 6.88 |
| 5 | 843.6 | 12.7 | 97.3 | 4.1 | 6.85 |
| 6 | 840.3 | 12.7 | 97.2 | 4.09 | 6.84 |
| 7 | 837.0 | 12.7 | 97.1 | 4.08 | 6.83 |
| 8 | 833.8 | 12.7 | 97 | 4.07 | 6.83 |
| 9 | 830.5 | 12.7 | 97 | 4.06 | 6.83 |
| 10 | 827.2 | 12.7 | 96.9 | 4.05 | 6.81 |
| 11 | 823.9 | 12.7 | 96.8 | 4.05 | 6.81 |
| 12 | 820.6 | 12.7 | 96.7 | 4.04 | 6.8 |
| 13 | 817.3 | 12.7 | 96.7 | 4.04 | 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 | 814.1 | 12.6 | 96.6 | 4.04 | 6.79 |
| 15 | 810.8 | 12.6 | 96.6 | 4.03 | 6.79 |
| 16 | 807.5 | 12.6 | 96.3 | 4.03 | 6.78 |
| 17 | 804.2 | 12.6 | 96.3 | 4.02 | 6.78 |
| 18 | 800.9 | 12.6 | 96.3 | 4.02 | 6.78 |
| 19 | 797.7 | 12.6 | 96.1 | 4 | 6.78 |
| 20 | 794.4 | 12.6 | 96 | 3.99 | 6.77 |
| 21 | 791.1 | 12.6 | 96 | 3.99 | 6.77 |
| 22 | 787.8 | 12.6 | 95.9 | 3.98 | 6.79 |
| 23 | 784.5 | 12.6 | 95.8 | 3.97 | 6.76 |
| 24 | 781.3 | 12.6 | 95.7 | 3.97 | 6.77 |
| 25 | 778.0 | 12.5 | 95.6 | 3.96 | 6.75 |
| 26 | 774.7 | 12.5 | 95.5 | 3.95 | 6.75 |
| 27 | 771.4 | 12.5 | 95.4 | 3.96 | 6.75 |
| 28 | 768.1 | 12.5 | 95.4 | 3.95 | 6.75 |
| 29 | 764.9 | 12.5 | 95.3 | 3.93 | 6.75 |
| 30 | 761.6 | 12.5 | 95.3 | 3.93 | 6.74 |
| 31 | 758.3 | 12.5 | 95.1 | 3.94 | 6.75 |
| ***2/12/2013*** | | | | | |
| 1 | 856.7 | 12.8 | 97.7 | 4.14 | 6.77 |
| 2 | 853.4 | 12.8 | 97.7 | 4.12 | 6.76 |
| 3 | 850.2 | 12.8 | 97.7 | 4.13 | 6.76 |
| 4 | 846.9 | 12.7 | 97.5 | 4.12 | 6.76 |
| 5 | 843.6 | 12.7 | 97.4 | 4.11 | 6.74 |
| 6 | 840.3 | 12.7 | 97.4 | 4.11 | 6.77 |
| 7 | 837.0 | 12.7 | 97.2 | 4.11 | 6.75 |
| 8 | 833.8 | 12.7 | 97.2 | 4.11 | 6.75 |
| 9 | 830.4 | 12.7 | 97 | 4.11 | 6.74 |
| 10 | 827.2 | 12.7 | 97 | 4.11 | 6.74 |
| 11 | 823.9 | 12.7 | 96.9 | 4.11 | 6.75 |
| 12 | 820.6 | 12.6 | 96.7 | 4.1 | 6.74 |
| 13 | 817.3 | 12.6 | 96.7 | 4.1 | 6.74 |
| 14 | 814.1 | 12.6 | 96.6 | 4.09 | 6.74 |
| 15 | 810.8 | 12.6 | 96.4 | 4.09 | 6.75 |
| 16 | 807.5 | 12.6 | 96.2 | 4.06 | 6.74 |
| 17 | 804.2 | 12.6 | 96.1 | 4.06 | 6.75 |
| 18 | 800.9 | 12.6 | 96 | 4.06 | 6.74 |
| 19 | 797.7 | 12.6 | 95.8 | 4.05 | 6.74 |
| 20 | 794.4 | 12.5 | 95.6 | 4.05 | 6.74 |
| 21 | 791.1 | 12.5 | 95.5 | 4.05 | 6.74 |
| 22 | 787.8 | 12.5 | 95.3 | 4.05 | 6.73 |
| 23 | 784.5 | 12.4 | 95 | 4.08 | 6.73 |
| 24 | 781.3 | 12.4 | 94.9 | 4.09 | 6.73 |

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

| Sample Depth<br>m | Elevation<br>ft MSL | DO concentration<br>mg/L | DO saturation<br>% | Temperature<br>°C | pH |
|---|---|---|---|---|---|
| 25 | 778.0 | 12.4 | 94.6 | 4.09 | 6.74 |
| 26 | 774.7 | 12.4 | 94.5 | 4.08 | 6.72 |
| 27 | 771.4 | 12.4 | 94.4 | 4.07 | 6.72 |
| 28 | 768.1 | 12.3 | 94.2 | 4.05 | 6.72 |
| ***3/5/2013*** | | | | | |
| 1 | 856.7 | 12.8 | 99.2 | 4.51 | 7.25 |
| 2 | 853.6 | 12.9 | 99.5 | 4.5 | 7.16 |
| 3 | 850.2 | 12.9 | 99.7 | 4.49 | 7.07 |
| 4 | 846.9 | 12.9 | 99.6 | 4.49 | 7.01 |
| 5 | 843.5 | 12.9 | 99.6 | 4.5 | 6.96 |
| 6 | 840.2 | 12.9 | 99.5 | 4.49 | 6.93 |
| 7 | 837.0 | 12.8 | 99.2 | 4.49 | 6.91 |
| 8 | 833.8 | 12.8 | 99.3 | 4.49 | 6.91 |
| 9 | 830.4 | 12.8 | 99.2 | 4.47 | 6.88 |
| 10 | 827.2 | 12.8 | 99.1 | 4.47 | 6.87 |
| 11 | 823.9 | 12.8 | 99.1 | 4.46 | 6.86 |
| 12 | 820.6 | 12.8 | 98.9 | 4.46 | 6.85 |
| 13 | 817.3 | 12.8 | 98.9 | 4.47 | 6.83 |
| 14 | 814.1 | 12.8 | 98.6 | 4.46 | 6.82 |
| 15 | 810.8 | 12.8 | 98.6 | 4.45 | 6.82 |
| 16 | 807.5 | 12.8 | 98.6 | 4.46 | 6.81 |
| 17 | 804.2 | 12.8 | 98.5 | 4.46 | 6.81 |
| 18 | 800.9 | 12.8 | 98.5 | 4.46 | 6.79 |
| 19 | 797.7 | 12.7 | 98.3 | 4.45 | 6.79 |
| 20 | 794.4 | 12.7 | 97.9 | 4.45 | 6.79 |
| 21 | 791.1 | 12.7 | 98 | 4.44 | 6.79 |
| 22 | 787.8 | 12.7 | 97.9 | 4.43 | 6.77 |
| 23 | 784.5 | 12.7 | 97.9 | 4.44 | 6.78 |
| 24 | 781.3 | 12.7 | 97.8 | 4.43 | 6.78 |
| 25 | 778.0 | 12.7 | 97.7 | 4.43 | 6.78 |
| 26 | 774.7 | 12.7 | 97.6 | 4.42 | 6.78 |
| 27 | 771.4 | 12.6 | 97.3 | 4.43 | 6.76 |
| ***3/12/2013*** | | | | | |
| 1 | 856.7 | 12.7 | 100 | 5.12 | 6.99 |
| 2 | 853.4 | 12.7 | 100 | 5.12 | 6.94 |
| 3 | 850.2 | 12.7 | 99.3 | 5.04 | 6.92 |
| 4 | 846.9 | 12.7 | 99.4 | 4.93 | 6.89 |
| 5 | 843.6 | 12.7 | 99.3 | 4.85 | 6.89 |
| 6 | 840.3 | 12.7 | 98.8 | 4.78 | 6.88 |
| 7 | 837.0 | 12.7 | 98.7 | 4.72 | 6.87 |
| 8 | 833.8 | 12.7 | 98.4 | 4.63 | 6.87 |
| 9 | 830.4 | 12.7 | 98.1 | 4.61 | 6.87 |
| 10 | 827.2 | 12.6 | 97.9 | 4.57 | 6.86 |

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

| Sample Depth<br>m | Elevation<br>ft MSL | DO concentration<br>mg/L | DO saturation<br>% | Temperature<br>°C | pH |
|---|---|---|---|---|---|
| 11 | 823.9 | 12.6 | 97.8 | 4.57 | 6.85 |
| 12 | 820.6 | 12.6 | 97.7 | 4.57 | 6.85 |
| 13 | 817.3 | 12.6 | 97.5 | 4.56 | 6.85 |
| 14 | 814.1 | 12.6 | 97.5 | 4.55 | 6.86 |
| 15 | 810.8 | 12.6 | 97.4 | 4.54 | 6.85 |
| 16 | 807.5 | 12.6 | 97.3 | 4.53 | 6.85 |
| 17 | 804.2 | 12.6 | 97.1 | 4.52 | 6.85 |
| 18 | 800.9 | 12.6 | 97 | 4.49 | 6.86 |
| 19 | 797.7 | 12.5 | 96.8 | 4.49 | 6.86 |
| 20 | 794.4 | 12.5 | 96.5 | 4.36 | 6.86 |
| 21 | 791.1 | 12.5 | 96.4 | 4.4 | 6.86 |
| 22 | 787.8 | 12.5 | 95.9 | 4.23 | 6.85 |
| 23 | 784.5 | 12.4 | 95.5 | 4.21 | 6.85 |
| 24 | 781.3 | 12.5 | 95.5 | 4.2 | 6.85 |
| 25 | 778.0 | 12.4 | 95.4 | 4.19 | 6.85 |
| 26 | 774.7 | 12.4 | 95.3 | 4.2 | 6.85 |
| 27 | 771.4 | 12.4 | 95 | 4.2 | 6.85 |
| 28 | 768.1 | 12.4 | 94.8 | 4.19 | 6.86 |
| ***3/26/2013*** | | | | | |
| 1 | 856.7 | 12.5 | 98.3 | 5.14 | 6.81 |
| 2 | 853.4 | 12.5 | 98.2 | 5.13 | 6.8 |
| 3 | 850.2 | 12.5 | 98.1 | 5.13 | 6.8 |
| 4 | 846.9 | 12.5 | 97.9 | 5.1 | 6.8 |
| 5 | 843.6 | 12.5 | 97.8 | 5.09 | 6.8 |
| 6 | 840.3 | 12.4 | 97.7 | 5.09 | 6.8 |
| 7 | 837.0 | 12.4 | 97.6 | 5.08 | 6.8 |
| 8 | 833.8 | 12.4 | 97.6 | 5.08 | 6.8 |
| 9 | 830.5 | 12.4 | 97.3 | 5.08 | 6.8 |
| 10 | 827.2 | 12.4 | 97.3 | 5.07 | 6.8 |
| 11 | 823.9 | 12.4 | 97.3 | 5.07 | 6.8 |
| 12 | 820.6 | 12.4 | 97.2 | 5.07 | 6.8 |
| 13 | 817.3 | 12.4 | 97.1 | 5.07 | 6.8 |
| 14 | 814.1 | 12.4 | 97 | 5.07 | 6.81 |
| 15 | 810.8 | 12.3 | 96.7 | 5.07 | 6.8 |
| 16 | 807.5 | 12.3 | 96.8 | 5.07 | 6.81 |
| 17 | 804.2 | 12.3 | 96.7 | 5.06 | 6.8 |
| 18 | 800.9 | 12.3 | 96.6 | 5.04 | 6.8 |
| 19 | 797.7 | 12.3 | 96.6 | 5.03 | 6.8 |
| 20 | 794.4 | 12.3 | 96.2 | 5.04 | 6.81 |
| 21 | 791.1 | 12.3 | 96.3 | 5.02 | 6.81 |
| 22 | 787.8 | 12.3 | 96.2 | 5.02 | 6.81 |
| 23 | 784.5 | 12.3 | 96.2 | 5 | 6.81 |
| 24 | 781.3 | 12.3 | 96.1 | 4.99 | 6.8 |

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

| Sample Depth<br>m | Elevation<br>ft MSL | DO concentration<br>mg/L | DO saturation<br>% | Temperature<br>°C | pH |
|---|---|---|---|---|---|
| 25 | 778.0 | 12.3 | 96 | 4.99 | 6.8 |
| 26 | 774.7 | 12.2 | 95.8 | 4.98 | 6.81 |
| 27 | 771.4 | 12.2 | 95.8 | 4.95 | 6.81 |
| 28 | 768.1 | 12.2 | 95.6 | 4.92 | 6.81 |
| 29 | 764.9 | 12.2 | 95.4 | 4.9 | 6.81 |
| ***4/9/2013*** | | | | | |
| 1 | 857.7 | 11.8 | 95.2 | 6.16 | 6.94 |
| 2 | 854.4 | 11.8 | 95.1 | 6.14 | 6.93 |
| 3 | 851.1 | 11.8 | 95 | 6.12 | 6.92 |
| 4 | 847.8 | 11.8 | 94.9 | 6.09 | 6.92 |
| 5 | 844.6 | 11.8 | 94.7 | 6.08 | 6.94 |
| 6 | 841.2 | 11.7 | 94.3 | 6.04 | 6.94 |
| 7 | 838.0 | 11.7 | 94.1 | 5.96 | 6.93 |
| 8 | 834.7 | 11.7 | 93.9 | 5.92 | 6.93 |
| 9 | 831.4 | 11.7 | 93.8 | 5.89 | 6.92 |
| 10 | 828.2 | 11.7 | 93.6 | 5.85 | 6.92 |
| 11 | 824.9 | 11.7 | 93.5 | 5.79 | 6.92 |
| 12 | 821.6 | 11.7 | 92.9 | 5.58 | 6.93 |
| 13 | 818.3 | 11.7 | 93 | 5.55 | 6.92 |
| 14 | 815.1 | 11.7 | 92.9 | 5.52 | 6.91 |
| 15 | 811.8 | 11.7 | 92.8 | 5.51 | 6.91 |
| 16 | 808.5 | 11.7 | 92.7 | 5.51 | 6.91 |
| 17 | 805.2 | 11.6 | 92.4 | 5.5 | 6.91 |
| 18 | 801.9 | 11.6 | 92.2 | 5.48 | 6.9 |
| 19 | 798.7 | 11.6 | 92 | 5.46 | 6.9 |
| 20 | 795.4 | 11.6 | 91.9 | 5.44 | 6.89 |
| 21 | 792.1 | 11.6 | 91.6 | 5.42 | 6.89 |
| 22 | 788.8 | 11.6 | 91.5 | 5.4 | 6.89 |
| 23 | 785.5 | 11.5 | 91.1 | 5.37 | 6.88 |
| 24 | 782.3 | 11.5 | 90.9 | 5.3 | 6.88 |
| 25 | 779.0 | 11.5 | 90.8 | 5.28 | 6.87 |
| 26 | 775.7 | 11.5 | 90.8 | 5.27 | 6.87 |
| 27 | 772.4 | 11.5 | 90.7 | 5.27 | 6.88 |
| 28 | 769.1 | 11.5 | 90.6 | 5.26 | 6.88 |
| 29 | 765.9 | 11.5 | 90.8 | 5.25 | 6.88 |
| 30 | 762.6 | 11.6 | 91.2 | 5.22 | 6.89 |
| 31 | 759.0 | 11.6 | 91.3 | 5.19 | 6.9 |
| ***4/23/2013*** | | | | | |
| 1 | 856.7 | 12.8 | 104 | 6.82 | 6.87 |
| 2 | 853.4 | 12.8 | 104 | 6.76 | 6.78 |
| 3 | 850.2 | 12.8 | 104 | 6.67 | 6.76 |
| 4 | 846.9 | 12.7 | 104 | 6.53 | 6.74 |
| 5 | 843.6 | 12.7 | 103 | 6.36 | 6.73 |

**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 |
|---|---|---|---|---|---|
| 6 | 840.3 | 12.7 | 103 | 6.35 | 6.72 |
| 7 | 837.0 | 12.7 | 103 | 6.34 | 6.71 |
| 8 | 833.8 | 12.7 | 103 | 6.34 | 6.72 |
| 9 | 830.5 | 12.7 | 103 | 6.34 | 6.71 |
| 10 | 827.2 | 12.7 | 103 | 6.35 | 6.71 |
| 11 | 823.9 | 12.7 | 103 | 6.34 | 6.71 |
| 12 | 820.6 | 12.6 | 102 | 6.34 | 6.7 |
| 13 | 817.3 | 12.6 | 102 | 6.34 | 6.7 |
| 14 | 814.1 | 12.6 | 102 | 6.32 | 6.69 |
| 15 | 810.8 | 12.6 | 102 | 6.09 | 6.7 |
| 16 | 807.5 | 12.6 | 102 | 6.07 | 6.69 |
| 17 | 804.2 | 12.6 | 101 | 6.01 | 6.68 |
| 18 | 800.9 | 12.6 | 101 | 6 | 6.68 |
| 19 | 797.7 | 12.6 | 101 | 6 | 6.68 |
| 20 | 794.4 | 12.5 | 101 | 5.98 | 6.67 |
| 21 | 791.1 | 12.5 | 101 | 5.94 | 6.68 |
| 22 | 787.8 | 12.5 | 100 | 5.75 | 6.67 |
| 23 | 784.5 | 12.5 | 99.7 | 5.7 | 6.66 |
| 24 | 781.3 | 12.5 | 99.4 | 5.65 | 6.65 |
| 25 | 778.0 | 12.5 | 99.3 | 5.65 | 6.64 |
| 26 | 774.7 | 12.4 | 99.1 | 5.62 | 6.64 |
| 27 | 771.4 | 12.4 | 98.8 | 5.6 | 6.63 |
| 28 | 768.1 | 12.4 | 98.7 | 5.6 | 6.63 |
| 29 | 764.9 | 12.4 | 98.2 | 5.51 | 6.64 |
| ***5/7/2013*** | | | | | |
| 1 | 855.7 | 11.5 | 107 | 12.3 | 7.02 |
| 2 | 852.4 | 11.6 | 107 | 11.7 | 6.96 |
| 3 | 849.2 | 11.8 | 107 | 11.1 | 6.96 |
| 4 | 845.9 | 11.9 | 107 | 10.6 | 6.93 |
| 5 | 842.6 | 11.9 | 106 | 10.5 | 6.94 |
| 6 | 839.3 | 11.9 | 106 | 10.3 | 6.93 |
| 7 | 836.0 | 11.9 | 105 | 10 | 6.93 |
| 8 | 832.8 | 11.9 | 104 | 9.76 | 6.91 |
| 9 | 829.5 | 11.9 | 104 | 9.45 | 6.91 |
| 10 | 826.2 | 11.9 | 104 | 9.32 | 6.91 |
| 11 | 822.9 | 12.1 | 104 | 8.71 | 6.91 |
| 12 | 819.6 | 12.2 | 102 | 7.9 | 6.9 |
| 13 | 816.3 | 12.2 | 102 | 7.6 | 6.89 |
| 14 | 813.1 | 12.2 | 102 | 7.33 | 6.88 |
| 15 | 809.8 | 12.2 | 102 | 7.26 | 6.88 |
| 16 | 806.5 | 12.2 | 101 | 7.15 | 6.88 |
| 17 | 803.2 | 12.2 | 101 | 6.88 | 6.88 |
| 18 | 799.9 | 12.2 | 100 | 6.82 | 6.87 |

**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 | 796.7 | 12.2 | 100 | 6.76 | 6.86 |
| 20 | 793.4 | 12.2 | 99.9 | 6.71 | 6.86 |
| 21 | 790.1 | 12.2 | 99.3 | 6.6 | 6.85 |
| 22 | 786.8 | 12.1 | 99 | 6.58 | 6.85 |
| 23 | 783.5 | 12.1 | 98.7 | 6.53 | 6.84 |
| 24 | 780.3 | 12.1 | 98.5 | 6.42 | 6.84 |
| 25 | 777.0 | 12.1 | 97.9 | 6.35 | 6.83 |
| 26 | 773.7 | 12.1 | 97.5 | 6.26 | 6.82 |
| 27 | 770.4 | 12 | 96.9 | 6.16 | 6.81 |
| 28 | 767.1 | 12 | 96.2 | 6.08 | 6.81 |
| 29 | 763.9 | 11.8 | 95.1 | 6.04 | 6.78 |
| 30 | 760.6 | 11.8 | 94.4 | 5.99 | 6.78 |
| ***5/21/2013*** | | | | | |
| 1 | 854.7 | 10.2 | 101 | 15 | 6.91 |
| 2 | 851.4 | 10.2 | 101 | 15 | 6.88 |
| 3 | 848.2 | 10.6 | 103 | 14.3 | 6.87 |
| 4 | 844.9 | 10.9 | 103 | 12.8 | 6.86 |
| 5 | 841.6 | 11 | 103 | 12.5 | 6.84 |
| 6 | 838.3 | 11.2 | 104 | 12.2 | 6.83 |
| 7 | 835.0 | 11.1 | 102 | 11.7 | 6.82 |
| 8 | 831.8 | 11.4 | 104 | 11.6 | 6.83 |
| 9 | 828.5 | 11.4 | 104 | 11.2 | 6.83 |
| 10 | 825.2 | 11.6 | 105 | 11 | 6.83 |
| 11 | 821.9 | 11.6 | 105 | 10.8 | 6.83 |
| 12 | 818.6 | 11.6 | 104 | 10.6 | 6.82 |
| 13 | 815.3 | 11.6 | 103 | 10.4 | 6.81 |
| 14 | 812.1 | 11.4 | 101 | 10.2 | 6.78 |
| 15 | 808.8 | 11.3 | 100 | 10 | 6.76 |
| 16 | 805.5 | 11.2 | 99.1 | 9.81 | 6.75 |
| 17 | 802.2 | 11.2 | 98.5 | 9.65 | 6.73 |
| 18 | 798.9 | 11.2 | 97.9 | 9.49 | 6.71 |
| 19 | 795.7 | 11.2 | 97.7 | 9.42 | 6.71 |
| 20 | 792.4 | 11.2 | 97.3 | 9.29 | 6.7 |
| 21 | 789.1 | 11.2 | 96.9 | 9.17 | 6.7 |
| 22 | 785.8 | 11.2 | 96.6 | 9.05 | 6.68 |
| 23 | 782.5 | 11.1 | 96.3 | 8.96 | 6.69 |
| 24 | 779.3 | 11.1 | 95.9 | 8.8 | 6.68 |
| 25 | 776.0 | 11 | 94.8 | 8.65 | 6.67 |
| 26 | 772.7 | 10.9 | 93.2 | 8.4 | 6.66 |
| 27 | 769.4 | 10.8 | 91.5 | 8.17 | 6.64 |
| 28 | 766.1 | 10.7 | 90.1 | 7.94 | 6.61 |
| 29 | 762.9 | 10.6 | 88.3 | 7.46 | 6.59 |
| 30 | 759.6 | 10.4 | 86.5 | 7.22 | 6.58 |

**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 |
|---|---|---|---|---|---|
| 31 | 756.3 | 10.1 | 82.8 | 6.94 | 6.53 |
| ***6/4/2013*** | | | | | |
| 1 | 855.7 | 11 | 105 | 13.1 | 7.02 |
| 2 | 852.4 | 11.1 | 105 | 12.8 | 7 |
| 3 | 849.2 | 11.2 | 103 | 11.8 | 6.99 |
| 4 | 845.9 | 11.4 | 102 | 10.8 | 6.98 |
| 5 | 842.6 | 11.5 | 102 | 9.98 | 6.96 |
| 6 | 839.3 | 11.4 | 100 | 9.65 | 6.93 |
| 7 | 836.0 | 11.5 | 101 | 9.56 | 6.92 |
| 8 | 832.8 | 11.4 | 99.1 | 9.33 | 6.9 |
| 9 | 829.5 | 11.3 | 98.8 | 9.3 | 6.9 |
| 10 | 826.2 | 11.3 | 98.2 | 9.16 | 6.88 |
| 11 | 822.9 | 11.3 | 97.7 | 9.06 | 6.89 |
| 12 | 819.6 | 11.2 | 97.4 | 9 | 6.88 |
| 13 | 816.3 | 11.2 | 97.2 | 8.97 | 6.89 |
| 14 | 813.1 | 11.3 | 97.4 | 8.93 | 6.88 |
| 15 | 809.8 | 11.3 | 97.2 | 8.9 | 6.88 |
| 16 | 806.5 | 11.2 | 97 | 8.89 | 6.88 |
| 17 | 803.2 | 11.2 | 96.8 | 8.87 | 6.88 |
| 18 | 799.9 | 11.2 | 96.9 | 8.83 | 6.87 |
| 19 | 796.7 | 11.3 | 96.8 | 8.77 | 6.88 |
| 20 | 793.4 | 11.2 | 96.7 | 8.75 | 6.87 |
| 21 | 790.1 | 11.2 | 96.7 | 8.71 | 6.88 |
| 22 | 786.8 | 11.2 | 96.2 | 8.64 | 6.87 |
| 23 | 783.5 | 11.2 | 96.1 | 8.61 | 6.87 |
| 24 | 780.3 | 11.2 | 95.9 | 8.59 | 6.87 |
| 25 | 777.0 | 11.2 | 95.9 | 8.57 | 6.87 |
| 26 | 773.7 | 11.2 | 95.7 | 8.57 | 6.86 |
| 27 | 770.4 | 11.1 | 95.2 | 8.54 | 6.86 |
| 28 | 767.1 | 11.1 | 95.1 | 8.53 | 6.86 |
| 29 | 763.9 | 11.1 | 94.8 | 8.52 | 6.86 |
| 30 | 760.6 | 11 | 94.1 | 8.5 | 6.85 |
| 31 | 757.3 | 11 | 93.7 | 8.48 | 6.84 |
| ***6/18/2013*** | | | | | |
| 1 | 854.7 | 9.73 | 103 | 17.9 | 6.74 |
| 2 | 851.4 | 9.82 | 103 | 17.5 | 6.72 |
| 3 | 848.2 | 10.2 | 103 | 16 | 6.69 |
| 4 | 844.9 | 10.4 | 104 | 15.3 | 6.69 |
| 5 | 841.6 | 10.7 | 105 | 14.4 | 6.68 |
| 6 | 838.3 | 10.8 | 104 | 13.8 | 6.66 |
| 7 | 835.0 | 11 | 105 | 13.3 | 6.67 |
| 8 | 831.8 | 11.1 | 105 | 12.6 | 6.67 |
| 9 | 828.5 | 11.2 | 104 | 12.3 | 6.66 |

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

| Sample Depth<br>m | Elevation<br>ft MSL | DO concentration<br>mg/L | DO saturation<br>% | Temperature<br>°C | pH |
|---|---|---|---|---|---|
| 10 | 825.2 | 11.2 | 104 | 12 | 6.64 |
| 11 | 821.9 | 11.2 | 104 | 11.8 | 6.65 |
| 12 | 818.6 | 11.3 | 104 | 11.6 | 6.64 |
| 13 | 815.3 | 11.3 | 103 | 11.3 | 6.64 |
| 14 | 812.1 | 11.3 | 103 | 11.1 | 6.63 |
| 15 | 808.8 | 11.2 | 101 | 10.8 | 6.62 |
| 16 | 805.5 | 11.2 | 101 | 10.6 | 6.63 |
| 17 | 802.2 | 11.2 | 100 | 10.4 | 6.6 |
| 18 | 798.9 | 11.2 | 99.9 | 10.1 | 6.61 |
| 19 | 795.7 | 11.2 | 99.3 | 9.97 | 6.61 |
| 20 | 792.4 | 11.2 | 98.2 | 9.71 | 6.6 |
| 21 | 789.1 | 11 | 96.5 | 9.53 | 6.57 |
| 22 | 785.8 | 10.9 | 95.6 | 9.47 | 6.56 |
| 23 | 782.5 | 10.9 | 94.9 | 9.39 | 6.57 |
| 24 | 779.3 | 10.8 | 93.7 | 9.2 | 6.55 |
| 25 | 776.0 | 10.6 | 91.5 | 9.09 | 6.51 |
| 26 | 772.7 | 10.4 | 89.8 | 9 | 6.5 |
| 27 | 769.4 | 10.2 | 88.3 | 8.87 | 6.48 |
| 28 | 766.1 | 10.1 | 86.9 | 8.8 | 6.47 |
| 29 | 762.9 | 10 | 86.1 | 8.7 | 6.45 |
| 30 | 759.6 | 9.81 | 84.1 | 8.63 | 6.44 |
| 31 | 756.3 | 2.52[b] | 21.6[b] | 8.55 | 6.3 |
| ***7/2/2013*** | | | | | |
| 1 | 855.7 | 9.36 | 107 | 22.2 | 7.1 |
| 2 | 852.4 | 9.76 | 108 | 20.1 | 7.03 |
| 3 | 849.2 | 10.3 | 109 | 18.2 | 7 |
| 4 | 845.9 | 10.8 | 111 | 16.8 | 6.98 |
| 5 | 842.6 | 10.9 | 110 | 15.7 | 6.95 |
| 6 | 839.3 | 10.9 | 108 | 15.1 | 6.93 |
| 7 | 836.0 | 11.1 | 109 | 14.7 | 6.93 |
| 8 | 832.7 | 11 | 107 | 14.2 | 6.92 |
| 9 | 829.3 | 10.8 | 104 | 13.8 | 6.9 |
| 10 | 826.2 | 10.6 | 102 | 13.5 | 6.9 |
| 11 | 822.9 | 10.7 | 102 | 13.4 | 6.9 |
| 12 | 819.6 | 10.6 | 101 | 13.3 | 6.88 |
| 13 | 816.3 | 10.6 | 101 | 13.1 | 6.9 |
| 14 | 813.1 | 10.6 | 100 | 13 | 6.9 |
| 15 | 809.8 | 10.7 | 102 | 12.9 | 6.9 |
| 16 | 806.5 | 10.6 | 101 | 12.8 | 6.89 |
| 17 | 803.2 | 10.6 | 99.8 | 12.7 | 6.9 |
| 18 | 799.9 | 10.6 | 99.8 | 12.6 | 6.89 |
| 19 | 796.3 | 10.6 | 99.5 | 12.5 | 6.89 |
| 20 | 793.4 | 10.7 | 100 | 12.4 | 6.9 |

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

| Sample Depth<br>m | Elevation<br>ft MSL | DO concentration<br>mg/L | DO saturation<br>% | Temperature<br>°C | pH |
|---|---|---|---|---|---|
| 21 | 790.1 | 10.6 | 98.9 | 12.2 | 6.89 |
| 22 | 786.8 | 10.6 | 98.5 | 12 | 6.88 |
| 23 | 783.5 | 10.4 | 96.7 | 11.9 | 6.87 |
| 24 | 779.9 | 10.4 | 95.8 | 11.7 | 6.84 |
| 25 | 777.0 | 10.2 | 93.4 | 11.5 | 6.84 |
| 26 | 773.7 | 10.1 | 92.5 | 11.3 | 6.83 |
| 27 | 770.4 | 10 | 91.3 | 11.2 | 6.8 |
| 28 | 766.8 | 9.73 | 87.8 | 10.8 | 6.77 |
| 29 | 763.9 | 9.6 | 85.9 | 10.4 | 6.76 |
| 30 | 760.6 | 9.35 | 83.1 | 10.2 | 6.73 |
| 31 | 757.3 | 8.72 | 76.7 | 9.72 | 6.67 |
| ***7/16/2013*** | | | | | |
| 1 | 855.7 | 9.22 | 104 | 21.3 | 6.7 |
| 2 | 852.4 | 9.16 | 103 | 21.2 | 6.6 |
| 3 | 849.2 | 9.19 | 103 | 21.1 | 6.6 |
| 4 | 845.9 | 9.69 | 106 | 19.8 | 6.57 |
| 5 | 842.6 | 9.99 | 108 | 18.9 | 6.54 |
| 6 | 839.3 | 10.2 | 107 | 17.7 | 6.53 |
| 7 | 836.0 | 10.3 | 106 | 16.8 | 6.53 |
| 8 | 832.7 | 10.7 | 108 | 16.2 | 6.55 |
| 9 | 829.3 | 10.8 | 108 | 15.6 | 6.54 |
| 10 | 826.2 | 10.7 | 107 | 15.3 | 6.53 |
| 11 | 822.9 | 10.7 | 106 | 14.9 | 6.53 |
| 12 | 819.6 | 10.6 | 104 | 14.4 | 6.52 |
| 13 | 816.3 | 10.5 | 103 | 14.2 | 6.52 |
| 14 | 813.1 | 10.4 | 101 | 13.9 | 6.53 |
| 15 | 809.8 | 10.3 | 99.4 | 13.6 | 6.52 |
| 16 | 806.5 | 10.2 | 98.2 | 13.5 | 6.51 |
| 17 | 803.2 | 10.2 | 97.4 | 13.3 | 6.5 |
| 18 | 799.9 | 10.1 | 96.5 | 13.2 | 6.5 |
| 19 | 796.7 | 10.2 | 96.6 | 13 | 6.5 |
| 20 | 793.4 | 10.2 | 96.2 | 12.9 | 6.5 |
| 21 | 790.1 | 10.1 | 95.6 | 12.8 | 6.49 |
| 22 | 786.8 | 9.96 | 93.8 | 12.7 | 6.48 |
| 23 | 783.5 | 9.93 | 93.4 | 12.6 | 6.47 |
| 24 | 780.3 | 9.89 | 92.8 | 12.5 | 6.46 |
| 25 | 777.0 | 9.85 | 92.1 | 12.4 | 6.46 |
| 26 | 773.7 | 9.77 | 91 | 12.1 | 6.45 |
| 27 | 770.4 | 9.78 | 90.8 | 12 | 6.45 |
| 28 | 767.1 | 9.63 | 89 | 11.8 | 6.45 |
| 29 | 763.5 | 9.56 | 87.6 | 11.5 | 6.44 |
| 30 | 760.6 | 9.43 | 86.2 | 11.3 | 6.43 |
| 31 | 757.3 | 8.79 | 79.8 | 11 | 6.4 |

**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 |
|---|---|---|---|---|---|
| 32 | 755.0 | 5.22[b] | 46.8[b] | 10.5 | 6.27 |
| ***7/30/2013*** | | | | | |
| 1 | 855.7 | 8.85 | 100 | 21.5 | 7.06 |
| 2 | 852.4 | 8.85 | 100 | 21.5 | 7.05 |
| 3 | 849.1 | 9.49 | 105 | 20.5 | 7.01 |
| 4 | 845.8 | 9.84 | 107 | 19.6 | 7 |
| 5 | 842.6 | 10.2 | 109 | 18.7 | 6.98 |
| 6 | 839.3 | 10.3 | 108 | 17.9 | 6.97 |
| 7 | 836.0 | 10.4 | 108 | 17.1 | 6.94 |
| 8 | 832.7 | 10.3 | 106 | 16.5 | 6.91 |
| 9 | 829.5 | 10.3 | 105 | 16.2 | 6.91 |
| 10 | 826.2 | 10.3 | 104 | 16 | 6.9 |
| 11 | 822.9 | 10.2 | 103 | 15.5 | 6.88 |
| 12 | 819.6 | 10.2 | 102 | 15.2 | 6.87 |
| 13 | 816.3 | 10.2 | 101 | 14.9 | 6.86 |
| 14 | 813.1 | 10.1 | 99.2 | 14.7 | 6.85 |
| 15 | 809.8 | 10.1 | 98.7 | 14.5 | 6.85 |
| 16 | 806.5 | 9.85 | 96.3 | 14.4 | 6.82 |
| 17 | 803.2 | 9.81 | 95.6 | 14.2 | 6.81 |
| 18 | 799.9 | 9.79 | 95.1 | 14.1 | 6.82 |
| 19 | 796.7 | 9.72 | 94.2 | 14 | 6.8 |
| 20 | 793.4 | 9.59 | 92.7 | 13.8 | 6.79 |
| 21 | 790.1 | 9.58 | 92.2 | 13.6 | 6.79 |
| 22 | 786.8 | 9.54 | 91.7 | 13.6 | 6.78 |
| 23 | 783.5 | 9.43 | 90.3 | 13.4 | 6.76 |
| 24 | 780.3 | 9.51 | 90.9 | 13.3 | 6.77 |
| 25 | 777.0 | 9.51 | 90.6 | 13.2 | 6.76 |
| 26 | 773.7 | 9.49 | 90.2 | 13 | 6.77 |
| 27 | 770.4 | 9.32 | 88.4 | 13 | 6.75 |
| 28 | 767.1 | 9.16 | 86.5 | 12.8 | 6.73 |
| 29 | 763.9 | 8.93 | 83.9 | 12.6 | 6.7 |
| ***8/13/2013*** | | | | | |
| 1 | 855.7 | 8.92 | 102 | 22 | 7.19 |
| 2 | 852.4 | 8.9 | 102 | 21.9 | 7.18 |
| 3 | 849.1 | 9.3 | 105 | 21.2 | 7.12 |
| 4 | 845.9 | 9.59 | 105 | 19.8 | 7.1 |
| 5 | 842.6 | 9.93 | 107 | 19.2 | 7.1 |
| 6 | 839.3 | 9.98 | 106 | 18.1 | 7.07 |
| 7 | 836.0 | 10.4 | 108 | 17.3 | 7.06 |
| 8 | 832.8 | 10.2 | 105 | 16.9 | 7.02 |
| 9 | 829.4 | 10 | 102 | 16.3 | 6.98 |
| 10 | 826.2 | 9.94 | 101 | 16 | 6.96 |
| 11 | 822.9 | 9.8 | 98.9 | 15.8 | 6.93 |

**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 |
|---|---|---|---|---|---|
| 12 | 819.6 | 9.77 | 98 | 15.5 | 6.92 |
| 13 | 816.3 | 9.74 | 97.1 | 15.2 | 6.92 |
| 14 | 813.1 | 9.68 | 96.1 | 15 | 6.91 |
| 15 | 809.8 | 9.65 | 95.3 | 14.8 | 6.9 |
| 16 | 806.5 | 9.61 | 94.7 | 14.7 | 6.9 |
| 17 | 803.2 | 9.41 | 92.5 | 14.6 | 6.88 |
| 18 | 799.9 | 9.44 | 92.5 | 14.4 | 6.88 |
| 19 | 796.7 | 9.32 | 91.1 | 14.3 | 6.86 |
| 20 | 793.4 | 9.2 | 89.6 | 14.2 | 6.83 |
| 21 | 790.1 | 9.2 | 89.5 | 14.1 | 6.83 |
| 22 | 786.8 | 9.24 | 89.7 | 14 | 6.83 |
| 23 | 783.5 | 9.3 | 89.9 | 13.8 | 6.82 |
| 24 | 780.3 | 9.3 | 89.7 | 13.7 | 6.82 |
| 25 | 777.0 | 9.26 | 89.1 | 13.6 | 6.81 |
| 26 | 773.7 | 9.21 | 88.5 | 13.5 | 6.8 |
| 27 | 770.4 | 9.14 | 87.5 | 13.4 | 6.79 |
| 28 | 767.1 | 8.97 | 85.7 | 13.3 | 6.77 |
| 29 | 763.9 | 8.77 | 83.3 | 13.1 | 6.76 |
| 30 | 760.6 | 8.67 | 82.2 | 13 | 6.74 |
| 31 | 757.3 | 7.81 | 73.5 | 12.6 | 6.69 |
| ***8/27/2013*** | | | | | |
| 1 | 855.7 | 9.1 | 102 | 21 | 7 |
| 2 | 852.4 | 9.15 | 102 | 20.7 | 6.99 |
| 3 | 849.1 | 9.15 | 102 | 20.7 | 7 |
| 4 | 845.8 | 9.14 | 102 | 20.6 | 7 |
| 5 | 842.6 | 9.85 | 108 | 19.7 | 6.98 |
| 6 | 839.3 | 10.1 | 109 | 19 | 6.93 |
| 7 | 836.0 | 9.38 | 99.7 | 18.3 | 6.86 |
| 8 | 832.8 | 9.9 | 104 | 17.7 | 6.87 |
| 9 | 829.4 | 10.1 | 105 | 17.3 | 6.85 |
| 10 | 826.2 | 9.82 | 102 | 17 | 6.81 |
| 11 | 822.9 | 9.62 | 98.7 | 16.6 | 6.78 |
| 12 | 819.6 | 9.76 | 99.6 | 16.3 | 6.78 |
| 13 | 816.3 | 9.83 | 100 | 16.2 | 6.78 |
| 14 | 813.1 | 9.69 | 98 | 15.9 | 6.76 |
| 15 | 809.8 | 9.45 | 95.2 | 15.7 | 6.73 |
| 16 | 806.5 | 9.12 | 91.7 | 15.6 | 6.7 |
| 17 | 803.2 | 9.3 | 93.4 | 15.6 | 6.72 |
| 18 | 799.9 | 9.35 | 93.6 | 15.4 | 6.72 |
| 19 | 796.7 | 9.26 | 92.5 | 15.3 | 6.7 |
| 20 | 793.4 | 9.26 | 92.3 | 15.2 | 6.71 |
| 21 | 790.1 | 9.01 | 89.6 | 15.1 | 6.68 |
| 22 | 786.8 | 8.85 | 87.7 | 15 | 6.67 |

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

| Sample Depth<br>m | Elevation<br>ft MSL | DO concentration<br>mg/L | DO saturation<br>% | Temperature<br>°C | pH |
|---|---|---|---|---|---|
| 23 | 783.5 | 8.9 | 87.9 | 14.8 | 6.67 |
| 24 | 780.3 | 8.82 | 86.9 | 14.7 | 6.66 |
| 25 | 777.0 | 8.67 | 85.3 | 14.6 | 6.65 |
| 26 | 773.7 | 8.6 | 84.4 | 14.5 | 6.64 |
| 27 | 770.4 | 8.38 | 81.9 | 14.4 | 6.63 |
| 28 | 767.1 | 8.24 | 80.4 | 14.2 | 6.61 |
| 29 | 763.9 | 7.84 | 76.1 | 14 | 6.58 |
| 30 | 760.6 | 7.59 | 73.2 | 13.7 | 6.56 |
| 31 | 757.3 | 6.79 | 64.8 | 13.2 | 6.53 |
| ***9/10/2013*** | | | | | |
| 1 | 855.7 | 9.42 | 105 | 20.9 | 7.03 |
| 2 | 852.4 | 9.41 | 105 | 20.8 | 7 |
| 3 | 849.2 | 9.41 | 105 | 20.8 | 7 |
| 4 | 845.9 | 9.42 | 105 | 20.7 | 7 |
| 5 | 842.6 | 9.63 | 106 | 20.3 | 6.99 |
| 6 | 839.3 | 9.56 | 104 | 19.6 | 6.94 |
| 7 | 836.0 | 9.57 | 103 | 18.8 | 6.89 |
| 8 | 832.7 | 9.56 | 102 | 18.5 | 6.87 |
| 9 | 829.5 | 9.55 | 101 | 18.2 | 6.83 |
| 10 | 826.2 | 9.63 | 102 | 17.9 | 6.83 |
| 11 | 822.9 | 9.87 | 103 | 17.6 | 6.83 |
| 12 | 819.6 | 9.99 | 104 | 17.4 | 6.84 |
| 13 | 816.3 | 9.03 | 93.9 | 17.3 | 6.75 |
| 14 | 813.1 | 8.98 | 93.2 | 17.2 | 6.73 |
| 15 | 809.8 | 9.69 | 100 | 17.1 | 6.79 |
| 16 | 806.5 | 9.5 | 98.1 | 16.9 | 6.77 |
| 17 | 803.2 | 8.98 | 92.3 | 16.7 | 6.73 |
| 18 | 799.9 | 9.22 | 94.6 | 16.6 | 6.75 |
| 19 | 796.7 | 8.9 | 91 | 16.4 | 6.72 |
| 20 | 793.4 | 8.72 | 89 | 16.3 | 6.71 |
| 21 | 790.1 | 8.66 | 88.1 | 16.2 | 6.7 |
| 22 | 786.8 | 8.72 | 88.4 | 16 | 6.71 |
| 23 | 783.5 | 8.46 | 85.5 | 15.9 | 6.69 |
| 24 | 780.3 | 8.32 | 84 | 15.8 | 6.67 |
| 25 | 777.0 | 8.15 | 82 | 15.7 | 6.66 |
| 26 | 773.7 | 7.92 | 79.5 | 15.6 | 6.64 |
| 27 | 770.4 | 7.64 | 76.4 | 15.4 | 6.62 |
| 28 | 767.1 | 7.32 | 73 | 15.3 | 6.61 |
| 29 | 763.9 | 6.88 | 68.2 | 15 | 6.57 |
| 30 | 760.6 | 6.52 | 64.2 | 14.7 | 6.55 |
| ***9/24/2013*** | | | | | |
| 1 | 855.7 | 8.73 | 93.2 | 18.5 | 6.95 |
| 2 | 852.4 | 8.72 | 93 | 18.5 | 6.96 |

**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 |
|---|---|---|---|---|---|
| 3 | 849.2 | 8.7 | 92.9 | 18.5 | 6.96 |
| 4 | 845.9 | 8.69 | 92.8 | 18.5 | 6.96 |
| 5 | 842.6 | 8.68 | 92.6 | 18.5 | 6.96 |
| 6 | 839.3 | 8.55 | 91.3 | 18.5 | 6.97 |
| 7 | 836.0 | 8.65 | 92.3 | 18.5 | 6.97 |
| 8 | 832.8 | 8.19 | 87.2 | 18.4 | 6.89 |
| 9 | 829.5 | 8.12 | 86.2 | 18.2 | 6.86 |
| 10 | 826.2 | 8 | 84.7 | 18.1 | 6.84 |
| 11 | 822.9 | 8.1 | 85.5 | 18 | 6.82 |
| 12 | 819.6 | 8.26 | 86.9 | 17.8 | 6.83 |
| 13 | 816.3 | 8.23 | 86.3 | 17.7 | 6.81 |
| 14 | 813.1 | 7.98 | 83.6 | 17.6 | 6.78 |
| 15 | 809.8 | 7.81 | 81.8 | 17.6 | 6.78 |
| 16 | 806.5 | 7.89 | 82.5 | 17.5 | 6.78 |
| 17 | 803.2 | 7.64 | 79.8 | 17.4 | 6.75 |
| 18 | 799.9 | 7.63 | 79.5 | 17.4 | 6.75 |
| 19 | 796.7 | 7.49 | 78 | 17.3 | 6.74 |
| 20 | 793.4 | 7.07 | 73.5 | 17.3 | 6.71 |
| 21 | 790.1 | 7.05 | 73.3 | 17.2 | 6.7 |
| 22 | 786.8 | 7.11 | 73.8 | 17.1 | 6.71 |
| 23 | 783.5 | 6.91 | 71.6 | 17.1 | 6.69 |
| 24 | 780.3 | 6.75 | 69.8 | 17 | 6.68 |
| 25 | 777.0 | 6.71 | 69.3 | 16.9 | 6.66 |
| 26 | 773.7 | 6.58 | 67.8 | 16.8 | 6.65 |
| 27 | 770.4 | 6.23 | 64 | 16.6 | 6.63 |
| 28 | 767.1 | 5.62[b] | 61.2[b] | 16.4 | 6.62 |
| 29 | 763.9 | 5.99[b] | 57.2[b] | 16.2 | 6.6 |
| ***10/8/2013*** | | | | | |
| 1 | 855.7 | 9.94 | 93.4 | 12.6 | 6.8 |
| 2 | 852.4 | 9.96 | 93.1 | 12.3 | 6.8 |
| 3 | 849.2 | 9.96 | 93.2 | 12.3 | 6.79 |
| 4 | 845.9 | 9.92 | 92.4 | 12.2 | 6.79 |
| 5 | 842.6 | 9.97 | 92.6 | 12 | 6.79 |
| 6 | 839.3 | 10.1 | 93.1 | 11.8 | 6.8 |
| 7 | 836.0 | 10 | 92.8 | 11.8 | 6.79 |
| 8 | 832.8 | 10.1 | 92.8 | 11.7 | 6.79 |
| 9 | 829.5 | 10.1 | 92.7 | 11.6 | 6.79 |
| 10 | 826.2 | 10.1 | 92.5 | 11.6 | 6.79 |
| 11 | 822.9 | 10.1 | 92.9 | 11.5 | 6.8 |
| 12 | 819.6 | 10.1 | 92.9 | 11.5 | 6.8 |
| 13 | 816.3 | 10.2 | 92.8 | 11.4 | 6.8 |
| 14 | 813.1 | 10.1 | 92.3 | 11.3 | 6.8 |
| 15 | 809.8 | 10.2 | 92.7 | 11.2 | 6.81 |

**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 |
|---|---|---|---|---|---|
| 16 | 806.5 | 10.2 | 92.7 | 11.1 | 6.81 |
| 17 | 803.2 | 10.2 | 92.6 | 11.1 | 6.81 |
| 18 | 799.9 | 10.2 | 92.6 | 11.1 | 6.81 |
| 19 | 796.7 | 10.2 | 92.3 | 11 | 6.8 |
| 20 | 793.4 | 10.2 | 92.6 | 11 | 6.8 |
| 21 | 790.1 | 10.2 | 92.3 | 11 | 6.8 |
| 22 | 786.8 | 10.2 | 92 | 11 | 6.79 |
| 23 | 783.5 | 10.1 | 91.6 | 10.9 | 6.8 |
| 24 | 780.3 | 10.1 | 91.6 | 10.9 | 6.8 |
| 25 | 777.0 | 10.2 | 91.8 | 10.9 | 6.8 |
| 26 | 773.7 | 10.1 | 91.8 | 10.9 | 6.79 |
| 27 | 770.4 | 10.1 | 91.3 | 10.9 | 6.8 |
| 28 | 767.1 | 10.2 | 91.7 | 10.9 | 6.8 |
| 29 | 763.9 | 10.2 | 91.7 | 10.8 | 6.79 |
| ***10/22/2013*** | | | | | |
| 1 | 854.7 | 10.5 | 96.6 | 11.6 | 6.93 |
| 2 | 851.4 | 10.5 | 96 | 11.5 | 6.92 |
| 3 | 848.0 | 10.4 | 95.5 | 11.4 | 6.92 |
| 4 | 844.8 | 10.4 | 95.2 | 11.4 | 6.92 |
| 5 | 841.5 | 10.4 | 95 | 11.3 | 6.92 |
| 6 | 838.3 | 10.4 | 94.8 | 11.3 | 6.92 |
| 7 | 835.0 | 10.3 | 94.2 | 11.3 | 6.91 |
| 8 | 831.7 | 10.3 | 94.1 | 11.2 | 6.91 |
| 9 | 828.4 | 10.3 | 93.6 | 11.1 | 6.91 |
| 10 | 825.2 | 10.3 | 93.3 | 10.9 | 6.9 |
| 11 | 821.9 | 10.3 | 91.9 | 10.3 | 6.89 |
| 12 | 818.6 | 10.3 | 91.6 | 10.2 | 6.87 |
| 13 | 815.3 | 10.3 | 91.4 | 10.1 | 6.87 |
| 14 | 812.1 | 10.3 | 91.1 | 10 | 6.86 |
| 15 | 808.8 | 10.3 | 90.9 | 9.95 | 6.86 |
| 16 | 805.5 | 10.3 | 90.8 | 9.94 | 6.86 |
| 17 | 802.2 | 10.3 | 91 | 9.9 | 6.86 |
| 18 | 798.9 | 10.3 | 91 | 9.89 | 6.86 |
| 19 | 795.7 | 10.3 | 91.1 | 9.83 | 6.86 |
| 20 | 792.4 | 10.3 | 91.2 | 9.81 | 6.86 |
| 21 | 789.1 | 10.4 | 91.2 | 9.79 | 6.86 |
| 22 | 785.8 | 10.3 | 91.1 | 9.79 | 6.86 |
| 23 | 782.5 | 10.3 | 91 | 9.79 | 6.86 |
| 24 | 779.3 | 10.3 | 91 | 9.78 | 6.86 |
| 25 | 776.0 | 10.3 | 90.9 | 9.76 | 6.86 |
| 26 | 772.7 | 10.3 | 90.7 | 9.76 | 6.87 |
| 27 | 769.4 | 10.3 | 90.8 | 9.76 | 6.87 |
| 28 | 766.1 | 10.3 | 90.7 | 9.75 | 6.86 |

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

| Sample Depth<br>m | Elevation<br>ft MSL | DO concentration<br>mg/L | DO saturation<br>% | Temperature<br>°C | pH |
|---|---|---|---|---|---|
| 29 | 762.9 | 10.3 | 90.6 | 9.75 | 6.87 |
| ***11/5/2013*** | | | | | |
| 1 | 855.7 | 10.4 | 92 | 9.95 | 6.79 |
| 2 | 852.4 | 10.4 | 91.8 | 9.94 | 6.77 |
| 3 | 849.1 | 10.4 | 91.6 | 9.93 | 6.76 |
| 4 | 845.9 | 10.3 | 91.4 | 9.92 | 6.76 |
| 5 | 842.6 | 10.3 | 91.2 | 9.92 | 6.75 |
| 6 | 839.3 | 10.3 | 91.1 | 9.91 | 6.75 |
| 7 | 836.0 | 10.3 | 91 | 9.91 | 6.75 |
| 8 | 832.8 | 10.3 | 90.8 | 9.91 | 6.76 |
| 9 | 829.5 | 10.3 | 90.7 | 9.9 | 6.75 |
| 10 | 826.2 | 10.2 | 90.6 | 9.9 | 6.75 |
| 11 | 822.9 | 10.2 | 90.5 | 9.9 | 6.75 |
| 12 | 819.6 | 10.2 | 90.4 | 9.9 | 6.75 |
| 13 | 816.3 | 10.2 | 90.1 | 9.88 | 6.74 |
| 14 | 813.1 | 10.1 | 89 | 9.72 | 6.73 |
| 15 | 809.8 | 10.1 | 88.7 | 9.67 | 6.73 |
| 16 | 806.5 | 10.1 | 88.5 | 9.67 | 6.72 |
| 17 | 803.2 | 10.1 | 88.4 | 9.66 | 6.72 |
| 18 | 799.9 | 10 | 88.3 | 9.64 | 6.71 |
| 19 | 796.7 | 10 | 88 | 9.62 | 6.71 |
| 20 | 793.4 | 10.1 | 88.8 | 9.57 | 6.72 |
| 21 | 790.1 | 10.2 | 89.2 | 9.52 | 6.73 |
| 22 | 786.8 | 10.2 | 89.3 | 9.5 | 6.74 |
| 23 | 783.5 | 10.2 | 89.3 | 9.44 | 6.75 |
| 24 | 780.3 | 10.2 | 89.4 | 9.44 | 6.75 |
| 25 | 777.0 | 10.2 | 89.4 | 9.39 | 6.75 |
| 26 | 773.7 | 10.3 | 89.5 | 9.35 | 6.75 |
| 27 | 770.4 | 10.3 | 89.5 | 9.33 | 6.76 |
| 28 | 767.1 | 10.3 | 89.5 | 9.3 | 6.76 |
| 29 | 763.9 | 10.3 | 89.4 | 9.27 | 6.76 |
| ***11/19/2013*** | | | | | |
| 1 | 856.7 | 10.9 | 92.7 | 8.47 | 6.7 |
| 2 | 853.4 | 10.8 | 92.5 | 8.46 | 6.7 |
| 3 | 850.2 | 10.8 | 92.3 | 8.45 | 6.7 |
| 4 | 846.8 | 10.8 | 92.2 | 8.37 | 6.7 |
| 5 | 843.6 | 10.8 | 92.2 | 8.33 | 6.7 |
| 6 | 840.3 | 10.8 | 91.6 | 8.31 | 6.7 |
| 7 | 837.0 | 10.9 | 92.1 | 8.09 | 6.71 |
| 8 | 833.8 | 10.9 | 92.5 | 8.07 | 6.71 |
| 9 | 830.5 | 11 | 92.4 | 8 | 6.71 |
| 10 | 827.2 | 11 | 92.4 | 7.92 | 6.71 |
| 11 | 823.9 | 11 | 92.4 | 7.89 | 6.71 |

**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 |
|---|---|---|---|---|---|
| 12 | 820.6 | 11 | 92.4 | 7.83 | 6.71 |
| 13 | 817.3 | 10.9 | 92 | 7.83 | 6.71 |
| 14 | 814.1 | 11 | 92.1 | 7.82 | 6.72 |
| 15 | 810.8 | 11 | 92.1 | 7.82 | 6.72 |
| 16 | 807.5 | 10.9 | 92.1 | 7.87 | 6.72 |
| 17 | 804.2 | 10.9 | 92 | 7.86 | 6.72 |
| 18 | 800.9 | 10.9 | 91.9 | 7.86 | 6.72 |
| 19 | 797.7 | 10.9 | 91.8 | 7.84 | 6.73 |
| 20 | 794.4 | 10.9 | 91.7 | 7.83 | 6.73 |
| 21 | 791.1 | 10.9 | 91.7 | 7.83 | 6.73 |
| 22 | 787.8 | 10.9 | 91.4 | 7.79 | 6.73 |
| 23 | 784.5 | 10.9 | 91.4 | 7.74 | 6.73 |
| 24 | 781.3 | 10.9 | 91.4 | 7.73 | 6.73 |
| 25 | 778.0 | 10.9 | 91.4 | 7.72 | 6.73 |
| 26 | 774.7 | 10.9 | 91.2 | 7.7 | 6.73 |
| 27 | 771.4 | 10.9 | 91.2 | 7.71 | 6.73 |
| 28 | 768.1 | 10.9 | 91 | 7.71 | 6.73 |
| 29 | 764.9 | 10.9 | 91 | 7.69 | 6.73 |
| 30 | 761.6 | 10.8 | 90.8 | 7.69 | 6.73 |
| 31 | 758.3 | 10.8 | 90.9 | 7.69 | 6.73 |
| ***12/5/2013*** | | | | | |
| 1 | 849.7 | 12.3 | 98.3 | 5.81 | 6.96 |
| 2 | 846.4 | 12.1 | 96.5 | 5.8 | 6.95 |
| 3 | 843.1 | 12 | 96 | 5.8 | 6.95 |
| 4 | 839.9 | 12 | 95.7 | 5.8 | 6.95 |
| 5 | 836.6 | 12 | 95.5 | 5.79 | 6.94 |
| 6 | 833.3 | 11.9 | 95.3 | 5.78 | 6.94 |
| 7 | 830.0 | 11.9 | 95 | 5.78 | 6.94 |
| 8 | 826.7 | 11.9 | 94.9 | 5.78 | 6.94 |
| 9 | 823.5 | 11.9 | 94.8 | 5.77 | 6.94 |
| 10 | 820.2 | 11.9 | 94.7 | 5.77 | 6.94 |
| 11 | 816.9 | 11.8 | 94.6 | 5.78 | 6.93 |
| 12 | 813.6 | 11.8 | 94.5 | 5.77 | 6.93 |
| 13 | 810.3 | 11.8 | 94.4 | 5.77 | 6.93 |
| 14 | 807.1 | 11.8 | 94.3 | 5.77 | 6.93 |
| 15 | 803.8 | 11.8 | 94.1 | 5.77 | 6.93 |
| 16 | 800.5 | 11.8 | 94 | 5.76 | 6.92 |
| 17 | 797.2 | 11.8 | 93.9 | 5.76 | 6.92 |
| 18 | 793.9 | 11.8 | 93.9 | 5.76 | 6.92 |
| 19 | 790.7 | 11.7 | 93.7 | 5.75 | 6.92 |
| 20 | 787.4 | 11.7 | 93.7 | 5.75 | 6.92 |
| 21 | 784.1 | 11.7 | 93.6 | 5.75 | 6.92 |
| 22 | 780.8 | 11.7 | 93.4 | 5.75 | 6.92 |

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

| Sample Depth<br>m | Elevation<br>ft MSL | DO concentration<br>mg/L | DO saturation<br>% | Temperature<br>°C | pH |
|---|---|---|---|---|---|
| 23 | 777.5 | 11.7 | 93.4 | 5.75 | 6.92 |
| 24 | 774.3 | 11.7 | 93.3 | 5.75 | 6.92 |
| 25 | 771.0 | 11.7 | 93.1 | 5.71 | 6.92 |
| 26 | 767.7 | 11.6 | 92.9 | 5.71 | 6.92 |
| 27 | 764.4 | 11.6 | 92.8 | 5.67 | 6.91 |
| 28 | 761.1 | 11.6 | 92.6 | 5.66 | 6.91 |
| 29 | 757.9 | 11.6 | 92.5 | 5.66 | 6.91 |
| ***12/17/2013*** | | | | | |
| 1 | 849.7 | 12.2 | 93.2 | 3.9 | 6.74 |
| 2 | 846.4 | 12.2 | 92.3 | 3.83 | 6.72 |
| 3 | 843.1 | 12.1 | 92.2 | 3.84 | 6.72 |
| 4 | 839.9 | 12.1 | 92 | 3.8 | 6.71 |
| 5 | 836.6 | 12.1 | 91.8 | 3.79 | 6.71 |
| 6 | 833.3 | 12.1 | 91.7 | 3.78 | 6.71 |
| 7 | 830.0 | 12.1 | 91.6 | 3.82 | 6.71 |
| 8 | 826.6 | 12 | 91.4 | 3.84 | 6.71 |
| 9 | 823.5 | 12 | 91.4 | 3.84 | 6.72 |
| 10 | 820.2 | 12 | 91.2 | 3.84 | 6.72 |
| 11 | 816.9 | 12 | 91.1 | 3.83 | 6.72 |
| 12 | 813.6 | 12 | 91.1 | 3.84 | 6.72 |
| 13 | 810.3 | 12 | 91 | 3.83 | 6.72 |
| 14 | 807.1 | 12 | 90.9 | 3.84 | 6.72 |
| 15 | 803.8 | 12 | 90.8 | 3.83 | 6.73 |
| 16 | 800.5 | 12 | 90.7 | 3.84 | 6.73 |
| 17 | 797.2 | 11.9 | 90.7 | 3.86 | 6.73 |
| 18 | 793.9 | 11.9 | 90.6 | 3.86 | 6.73 |
| 19 | 790.7 | 11.9 | 90.6 | 3.86 | 6.73 |
| 20 | 787.4 | 11.9 | 90.4 | 3.86 | 6.73 |
| 21 | 784.1 | 11.9 | 90.4 | 3.84 | 6.73 |
| 22 | 780.8 | 11.9 | 90.2 | 3.83 | 6.73 |
| 23 | 777.5 | 11.9 | 90.2 | 3.84 | 6.73 |
| 24 | 774.3 | 11.9 | 90.1 | 3.83 | 6.73 |
| 25 | 771.0 | 11.8 | 90 | 3.84 | 6.74 |
| 26 | 767.7 | 11.8 | 90 | 3.84 | 6.74 |
| 27 | 764.4 | 11.8 | 89.9 | 3.87 | 6.74 |
| 28 | 761.1 | 11.8 | 89.8 | 3.86 | 6.74 |
| 29 | 757.9 | 11.8 | 89.7 | 3.85 | 6.75 |
| 30 | 754.6 | 11.8 | 89.7 | 3.87 | 6.74 |
| 31 | 751.3 | 11.8 | 89.6 | 3.86 | 6.75 |
| ***12/31/2013*** | | | | | |
| 1 | 854.2 | 12.4 | 94.3 | 3.96 | 6.6 |
| 2 | 850.9 | 12.4 | 94.5 | 3.95 | 6.59 |
| 3 | 847.7 | 12.4 | 94.6 | 3.95 | 6.59 |

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

| Sample Depth<br>m | Elevation<br>ft MSL | DO concentration<br>mg/L | DO saturation<br>% | Temperature<br>°C | pH |
|---|---|---|---|---|---|
| 4 | 844.4 | 12.4 | 94.6 | 3.95 | 6.58 |
| 5 | 841.1 | 12.4 | 94.5 | 3.95 | 6.58 |
| 6 | 837.8 | 12.4 | 94.5 | 3.96 | 6.58 |
| 7 | 834.5 | 12.4 | 94.4 | 3.95 | 6.58 |
| 8 | 831.3 | 12.4 | 94.4 | 3.95 | 6.57 |
| 9 | 828.0 | 12.4 | 94.3 | 3.96 | 6.57 |
| 10 | 824.7 | 12.4 | 94.2 | 3.96 | 6.58 |
| 11 | 821.4 | 12.4 | 94.2 | 3.96 | 6.58 |
| 12 | 818.1 | 12.4 | 94.1 | 3.96 | 6.58 |
| 13 | 814.8 | 12.3 | 94 | 3.96 | 6.58 |
| 14 | 811.6 | 12.3 | 93.9 | 3.96 | 6.58 |
| 15 | 808.3 | 12.3 | 93.8 | 3.96 | 6.58 |
| 16 | 805.0 | 12.3 | 93.8 | 3.96 | 6.58 |
| 17 | 801.7 | 12.3 | 93.5 | 3.95 | 6.58 |
| 18 | 798.4 | 12.3 | 93.5 | 3.95 | 6.59 |
| 19 | 795.2 | 12.3 | 93.4 | 3.95 | 6.58 |
| 20 | 791.9 | 12.2 | 93.2 | 3.94 | 6.59 |
| 21 | 788.6 | 12.2 | 93.1 | 3.94 | 6.59 |
| 22 | 785.3 | 12.2 | 93 | 3.94 | 6.59 |
| 23 | 782.0 | 12.2 | 92.9 | 3.94 | 6.59 |
| 24 | 778.8 | 12.2 | 92.8 | 3.94 | 6.59 |
| 25 | 775.5 | 12.2 | 92.6 | 3.94 | 6.6 |
| 26 | 772.2 | 12.2 | 92.5 | 3.94 | 6.59 |
| 27 | 768.9 | 12.1 | 92.4 | 3.94 | 6.59 |
| 28 | 765.6 | 12.1 | 92.1 | 3.95 | 6.59 |
| 29 | 762.4 | 12.1 | 92 | 3.95 | 6.59 |
| 30 | 759.1 | 12 | 91.8 | 3.96 | 6.6 |

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

[b]DO measurements at the very bottom of the reservoir can be affected by sediment that has been stirred up; these low measurements are not considered representative of typical water quality

## Appendix C

# Bull Run HCP Research Report

# Lower Bull Run River Spawning Gravel Research

April 2014
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 2013 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 Dam 2 spillway plunge pool rock weir (river mile [RM] 5.8) to the mouth of the Bull Run River (RM 0).

The combined surface area of adequately sized spawning gravel patches was significantly higher than the baseline average for steelhead for most flows, and significantly higher than the baseline average for Chinook at all flows. The surface area of spawning gravel in 2013 was higher than what had been observed in all previous years (2010-2012) at most locations and flows. Large accumulations of gravel were associated with the gravel-addition sites and more gravel had moved downstream into the lowest section of the river between the mouth and the Bull Run Powerhouse (RM 0-1.5) than has been observed in the past. 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 2013 to benefit spawning salmonids. This was the fourth treatment year. 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 2013.

[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 is augmenting 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 the HCP implementation. This roughly doubles the estimated natural recruitment rate of gravel in the absence of reservoirs (calculations and estimates summarized in CH2M HILL 2003) and is intended to accelerate the accumulation of gravel in the lower Bull Run River.

After five years, the rate of gravel supplementation 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 the areal extent of spawning gravel in the lower Bull Run prior to 1923, which is when the first Bull Run dam was constructed.

The objective of the Bull Run River spawning gravel research is to measure the surface area of patches of gravel suitable for spawning steelhead and Chinook salmon in 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 salmon. 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, $\alpha$=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 ($\alpha$=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 ($\alpha$=0.05).

This question was not evaluated in 2012, because a trend requires multiple years of post-treatment data.

## 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, $\alpha$ =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 salmon (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 Engineer 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 flows:

- **1,405 cfs:** 10 percent average exceedence flow for March, April, and May (peak steelhead spawning months)
- **614 cfs:** 50 percent average exceedence flow for March, April, and May
- **120 cfs:** The lowest allowed flow during March, April, and May under the HCP measure for minimum flows (actual flows may be higher)

### 5.1.2 Spring Chinook Spawning Gravel

The amount of **spring Chinook spawning gravel** was estimated for the following flows:

- **358 cfs:** 10 percent average exceedence flow for September and October (the peak spring Chinook spawning months)
- **77 cfs** : 50 percent average exceedence flow for September and October
- **30 cfs**: The lowest allowed flow during September and October under the HCP measure for minimum flows (actual flows may be higher)

### 5.1.3 Fall Chinook Spawning Gravel

The amount of **fall Chinook spawning gravel** was estimated for the following flows:

- **1,480 cfs:** 10 percent average exceedence flow for October and November (the peak fall Chinook spawning months)
- **77 cfs** : 50 percent average exceedence flow for October and November
- **30 cfs**: The lowest allowed flow during October and November under the HCP measure for minimum flows (actual flows may be higher)

Calculating the amount of spawning gravel at the 10 percent and 50 percent exceedence flows, as well as the minimum allowable flow for each species' peak spawning period, allows for comparisons in the amount of spawning gravel across flows and across years. The amount of gravel wetted at the minimum allowable flow represents the minimum amount of gravel that would be available to each species. The amount of gravel wetted at the 10 percent and 50 percent exceedence flows indicates how far up the margins of the channel gravel accumulates and how much gravel remains available for spawning. This combined information 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 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 will be conducted each year during HCP Years 2–6, while the maximum amount of gravel supplementation (1,200 cubic yards) occurs. This represents the period of time when gravel is expected to accumulate most rapidly in the lower Bull Run River.

After gravel supplementation is reduced in Year 6 of the HCP (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 10$^{th}$ Percentile of Substrate Size.** The sizes of particles corresponding to the upper and lower 10$^{th}$ 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. The 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 2013 survey was conducted at a discharge flow that varied between 20 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 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.

[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.

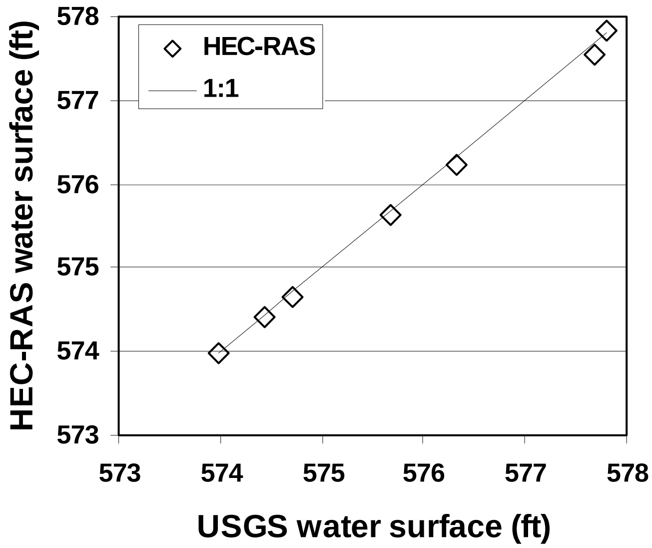



**Figure 1. Comparison of HEC-RAS Model River Stage Results with USGS Stage/Discharge Curve Values**

# 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 ($\alpha$=0.05).

# 7. Results

A total of 684 gravel patches with substrate sizes suitable for spawning Chinook were identified within the active channel in 2013, with a total of 56,340 square feet of combined surface area. Of these, 514 patches also had substrate sizes suitable for spawning steelhead, with a total of 39,665 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 2013 than the baseline average at all flows. This difference was statistically significant at the lowest flow (120 cfs), but not at the other, higher 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, 2013**

| | 120 cfs | 614 cfs | 1,405 cfs |
|---|---|---|---|
| 2013 Survey Results | 16,077 $ft^2$ | 21,757 $ft^2$ | 27,121 $ft^2$ |
| 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 | No | No |

### 7.1.2 Spring Chinook

In 2013, 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, 2013**

| | 30 cfs | 77 cfs | 358 cfs |
|---|---|---|---|
| 2013 Survey Results | 14,947 $ft^2$ | 16,217 $ft^2$ | 23,544 $ft^2$ |
| 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 2013, 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, 2013**

| | 30 cfs | 77 cfs | 1,480 cfs |
|---|---|---|---|
| 2013 Survey Results | 14,947 $ft^2$ | 16,217 $ft^2$ | 32,538 $ft^2$ |
| 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

There has been no statistically significant trend in gravel surface area over time in post-supplementation years. Four 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, it has not steadily increased or decreased 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).

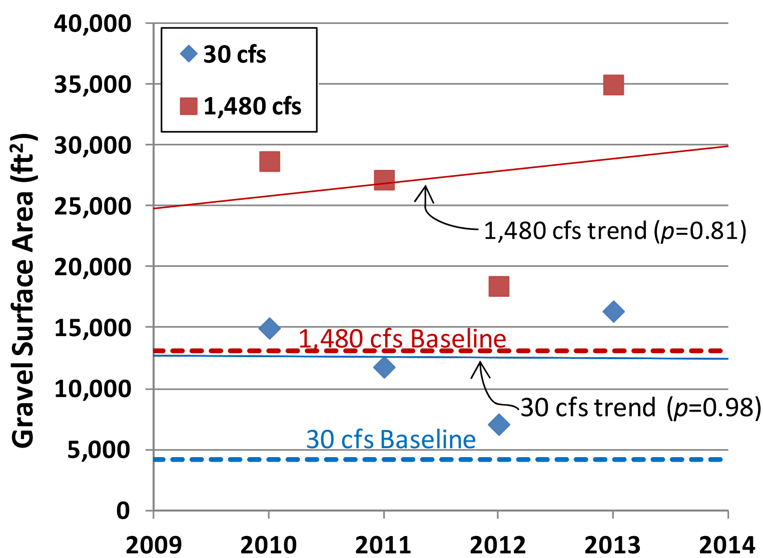



**Figure 2. Trends in the Surface Area of Steelhead Spawning Gravel Wetted at 30 cfs and 1,480 cfs in Post-Treatment Years. Baseline Surface Areas are Indicated**

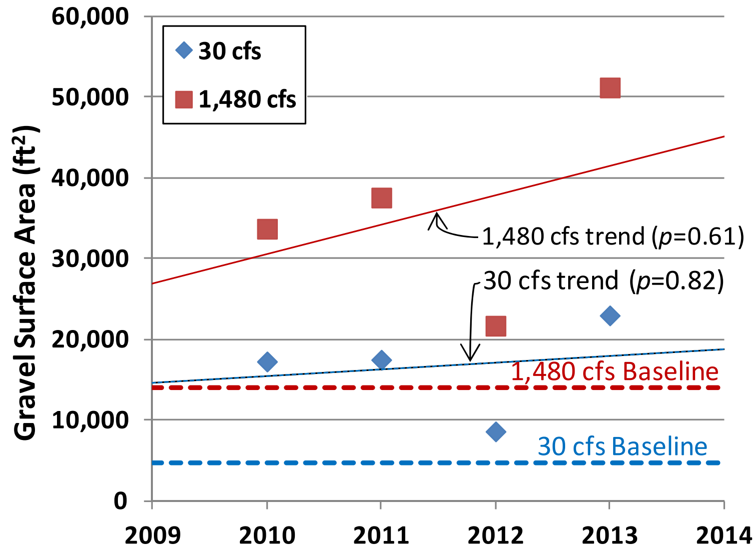



**Figure 3. Trends in the Surface Area of Chinook Spawning Gravel Wetted at 30 cfs and 1,480 cfs in Post-Treatment Years. Baseline Surface Areas are Indicated**

## 7.3 Distribution of Spawning Gravel

### 7.3.1 Steelhead

In 2013, 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. More gravel had moved downstream into the lower 1.5 miles of the river channel (mouth to the Bull Run Powerhouse) than has been observed in the past. Figures 5 and 6 compare the longitudinal distribution of steelhead spawning gravel in 2013 with previous post-treatment years and the baseline at flows that bracket the range of flows being evaluated.

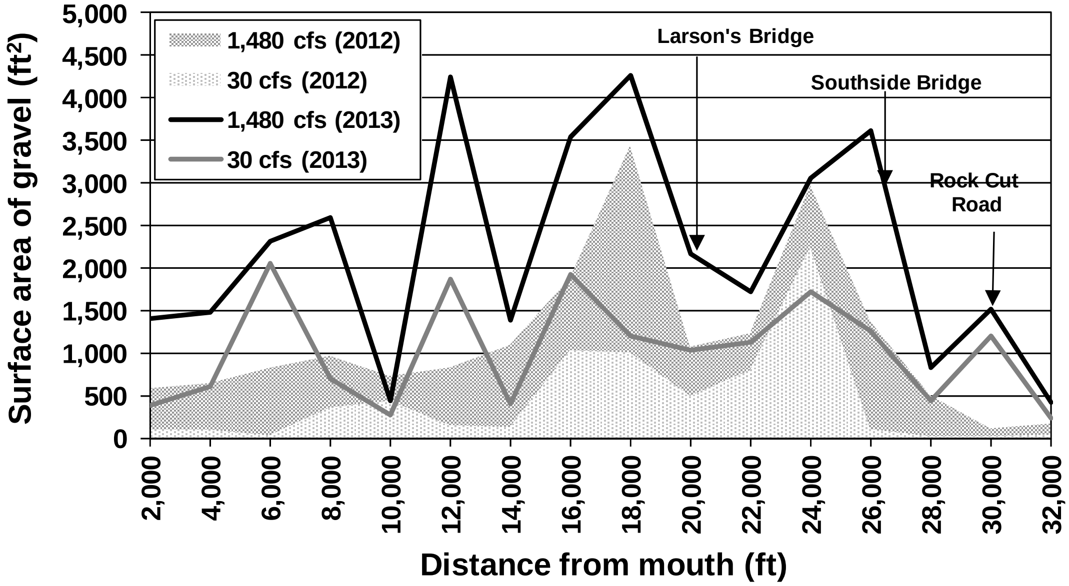



**Figure 4. Longitudinal Distribution of Steelhead Spawning-Size Gravel Patches in the Lower Bull Run River in 2012 at 30 cfs and 1,480 cfs Compared to 2012**

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 2013 than what was observed in previous years at all flows greater than 77 cfs.

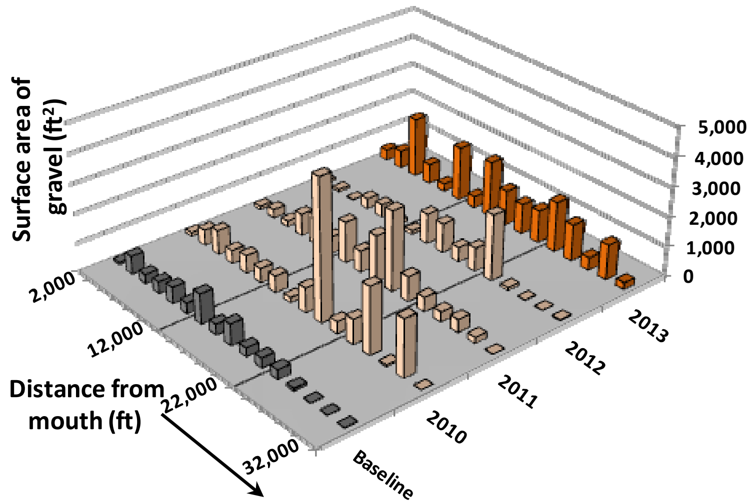



**Figure 5. Longitudinal Distribution of Steelhead Spawning-Size Gravel Patches in the Lower Bull Run River in 2010-2013 Compared to the Baseline Average at 30 cfs**

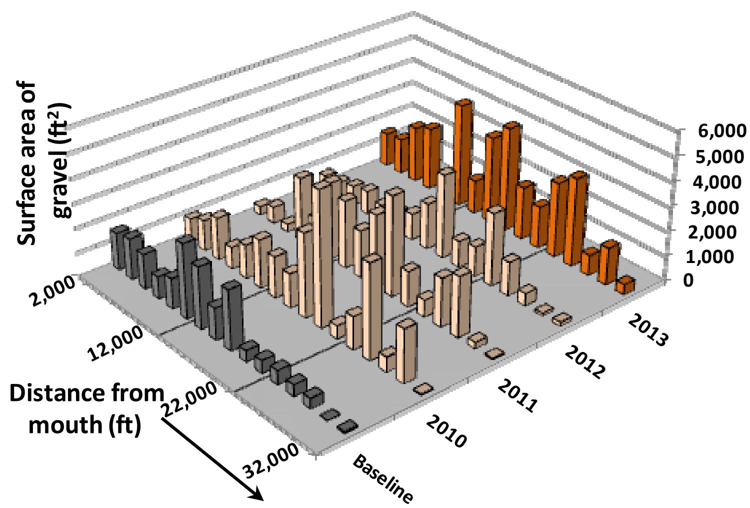



**Figure 6. Longitudinal Distribution of Steelhead Spawning-Size Gravel Patches in the Lower Bull Run River in 2010-2013 Compared to the Baseline Average at 1,480 cfs**

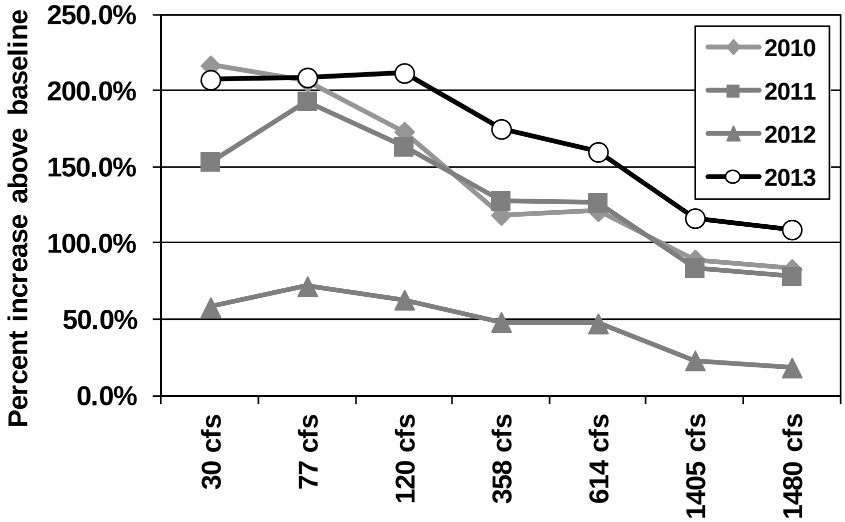



**Figure 7. Increase in the Surface Area of Steelhead Spawning-Size Gravel Patches in 2013 above the Baseline Average for Various Flows Compared to 2010, 2011, and 2012**

## 7.3.2 Chinook

In 2013, 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. More gravel had moved downstream into the lower 1.5 miles of the river channel (mouth to the Bull Run Powerhouse) than has been observed in the past. Figures 9 and 10 compare the longitudinal distribution of Chinook spawning gravel in 2013 with previous post-treatment years and the baseline at flows that bracket the range of flows being evaluated.

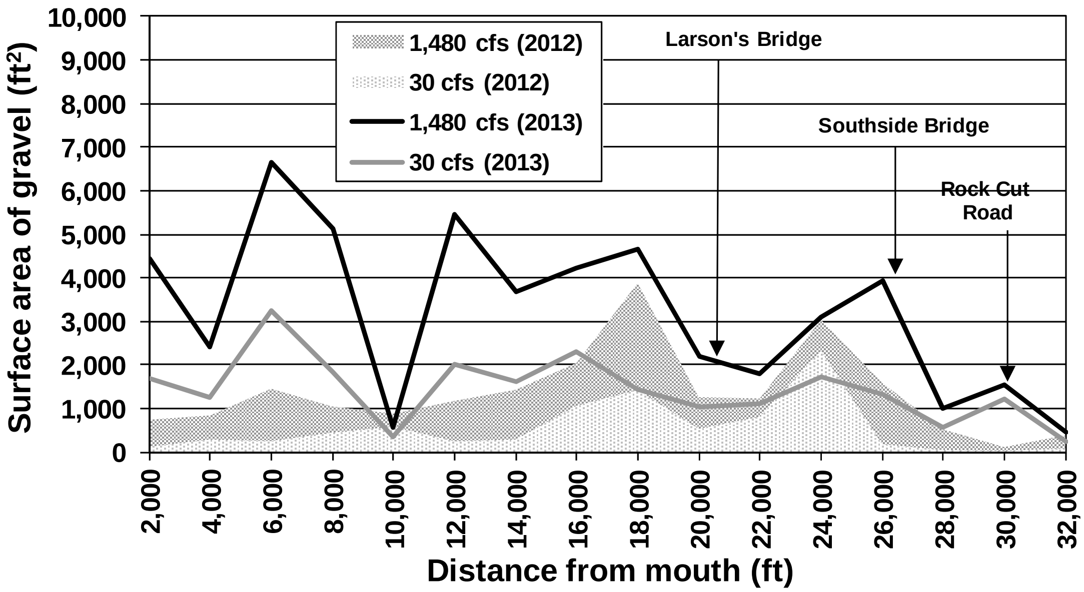



**Figure 8. Longitudinal Distribution of Chinook Spawning-Size Gravel Patches in the Lower Bull Run River in 2013 at 30 cfs and 1,480 cfs Compared to 2012**

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 2013 than what was observed in previous years at all flows except 77 cfs.

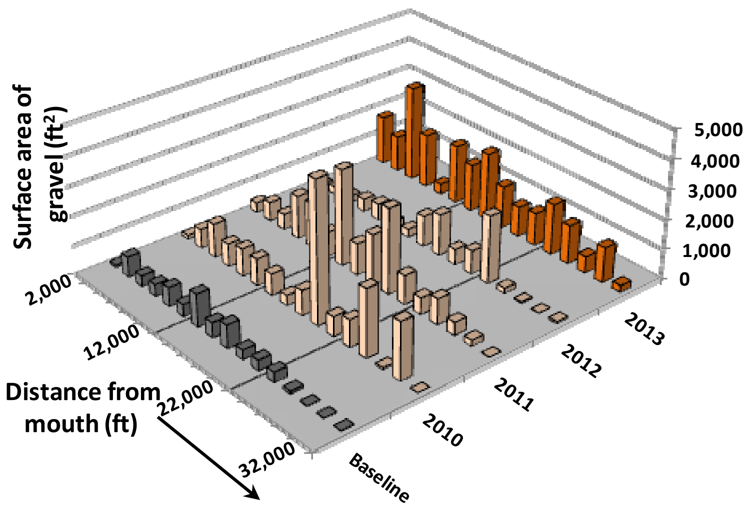



**Figure 9. Longitudinal Distribution of Chinook Spawning-Size Gravel Patches in the Lower Bull Run River in 2010-2013 Compared to the Baseline Average at 30 cfs**

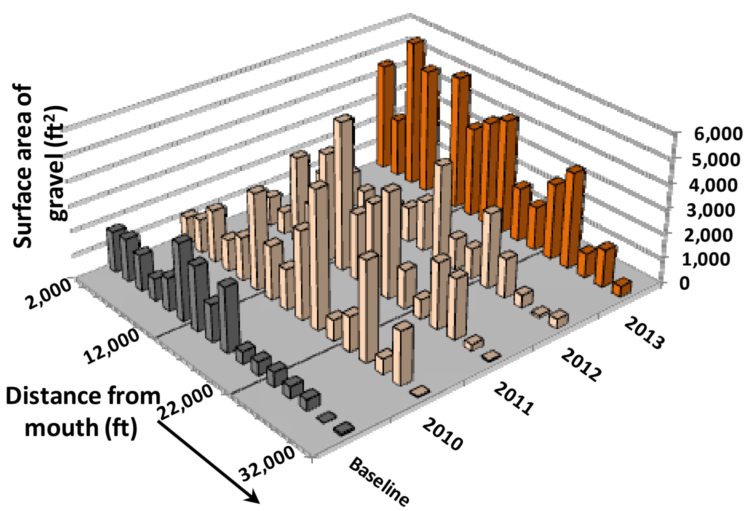



**Figure 10. Longitudinal Distribution of Chinook Spawning-Size Gravel Patches in the Lower Bull Run River in 2010-2013 Compared to the Baseline Average at 1,480 cfs**

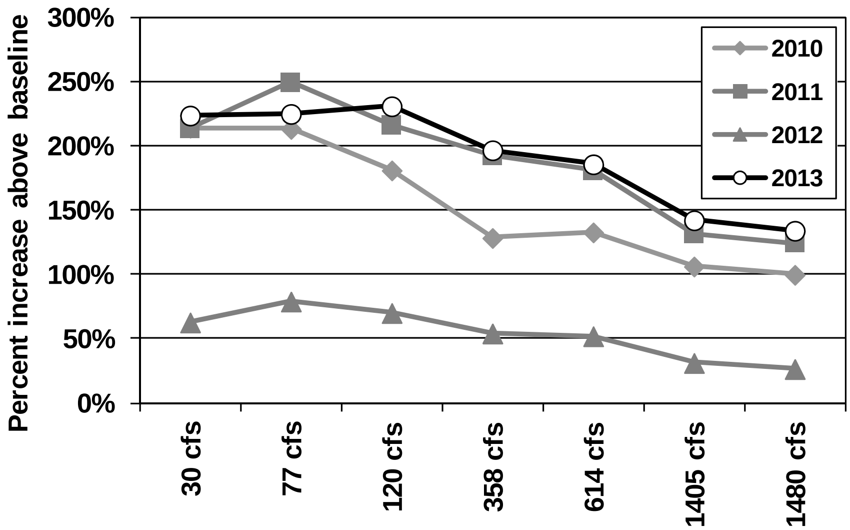



**Figure 11. Increase in the Surface Area of Chinook Spawning-Size Gravel Patches in 2013 above the Baseline Average for Various Flows Compared to 2010, 2011, and 2012**

# 8. Summary and Discussion

The total surface area of spawning-sized gravel was significantly greater in 2013 than in baseline years at all flows for steelhead and most flows for Chinook at a 95% level of statistical confidence. Gravel was distributed relatively evenly throughout the length of the river channel downstream of the gravel placement sites, with greater accumulations in the lowest 1.5 miles of the river than has been observed in previous years. This is evidence that the pulses of gravel first introduced into the river in 2010 have finally worked their way to the furthest downstream portions of the Bull Run River.

Gravel that appeared to be absent in 2012 was evident in the channel again in 2013. Observed gravel accumulations were noticeably smaller in 2012 than in the previous two years. Much of the spawning gravel observed in 2010 and 2011 was believed to have been mobilized into the bottoms of deep pools by moderate winter flows. The lower Bull Run River has a number of very large pools formed by flood flows constrained by bedrock canyon walls so deep that gravel patches cannot be observed. At relatively low flows that are still high enough to mobilize gravel, these slow, deep pools represent likely places for deposition. At very high flows, however, deep pools become the sites of the most turbulent, scouring currents, which would remove deposited gravel. Some of this sequestered gravel appears to have been remobilized, despite relatively low winter flows, to locations where it could be observed in 2013. The fact that gravel that was observed in 2010 and 2011, but apparently missing in 2012, rematerialized in 2013 in the downstream-most portions of the river supports the idea that there are places in the river channel where large quantities of gravel can be deposited without being observed during annual surveys.

Additional large gravel accumulations observed in 2013 can be attributed to the very low winter flows having left considerable quantities of gravel in the immediate downstream vicinity of the three gravel placement sites. Flows in the Bull Run River never exceeded 5,220 cfs during the previous winter. It was apparent that these relatively low winter flows were unable to move much of the gravel placed in January 2013 very far downstream (see Figures 4 and 8).

# 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, T.C., and C. Fishenich. 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 2014
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 2013. TDG data were collected on only one occasion in 2013 when the correct target flow occurred.

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 three occasions at one of the sites. The measurements, however, were made in water from a spillway and represented only a portion of the total flow in the river at the time. 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 in 2012, initiated in 2012 and to be 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 River 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 elevated 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, or turbines in which air bubbles could be brought under sufficient pressure to cause their dissolution in water beyond the level of saturation.

Monitoring locations were established to monitor the effects of each specific structure on TDG levels, or to provide information on the persistence of TDG downstream. 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.

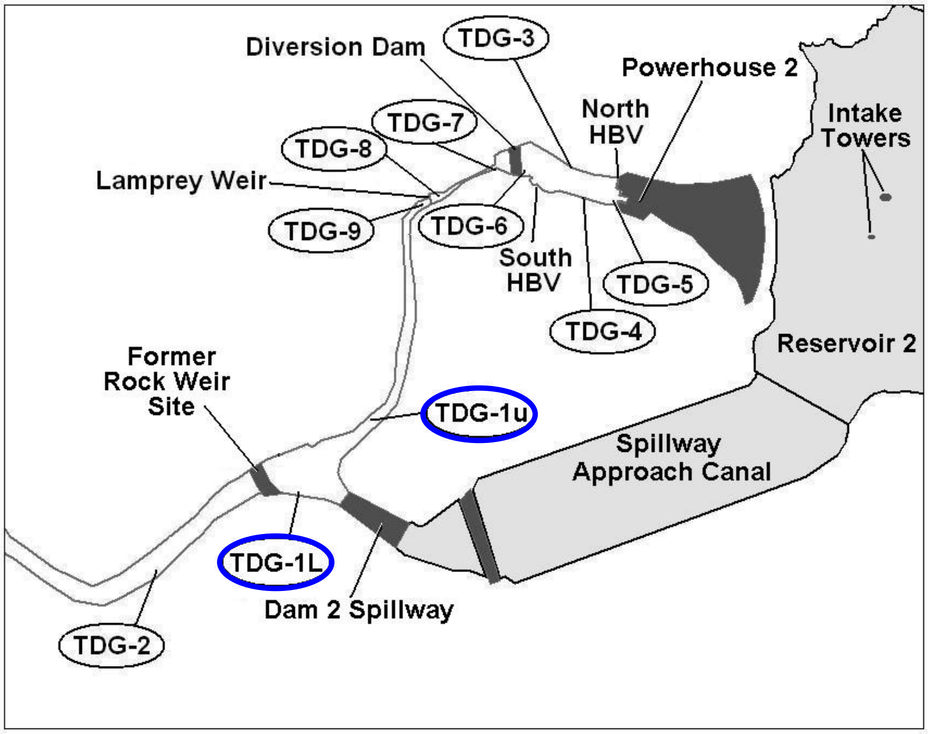



**Figure 1. Locations of TDG Monitoring Sites Associated with Dam 2**[a]

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

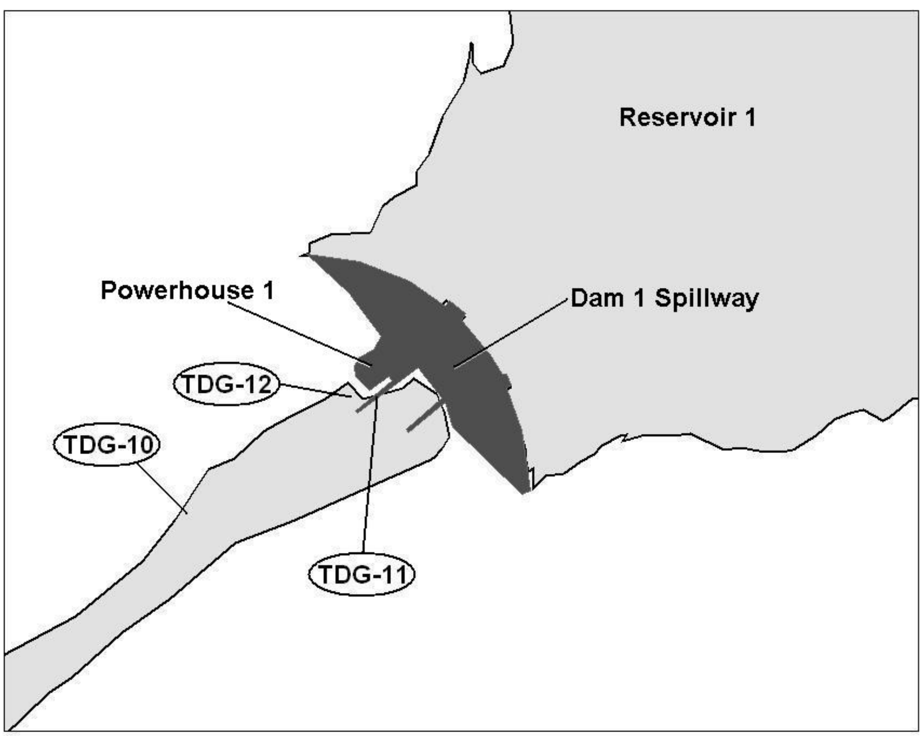



**Figure 2. Locations of TDG Monitoring Sites Associated with Dam 1**

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 were 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, TDG data were only collected on one occasion in 2013. 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.

TDG levels greater than 110 percent saturation was measured at two monitoring sites on one occasion in the lower Bull Run River in 2013 , but the total river flow was greater than the 7Q10 flow. TDG levels exceeded 110% at TDG-1L and TDG-2 during a high flow event in December, 2013. Total flow in the river, and flow over the Dam 2 spillway were both in excess of the 7Q10 flow for the lower Bull Run River.

**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 |
| 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). The highest TDG level observed among these sites was 120 percent saturation at TDG-1L at a spillway flow of 10,611 cfs.

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.

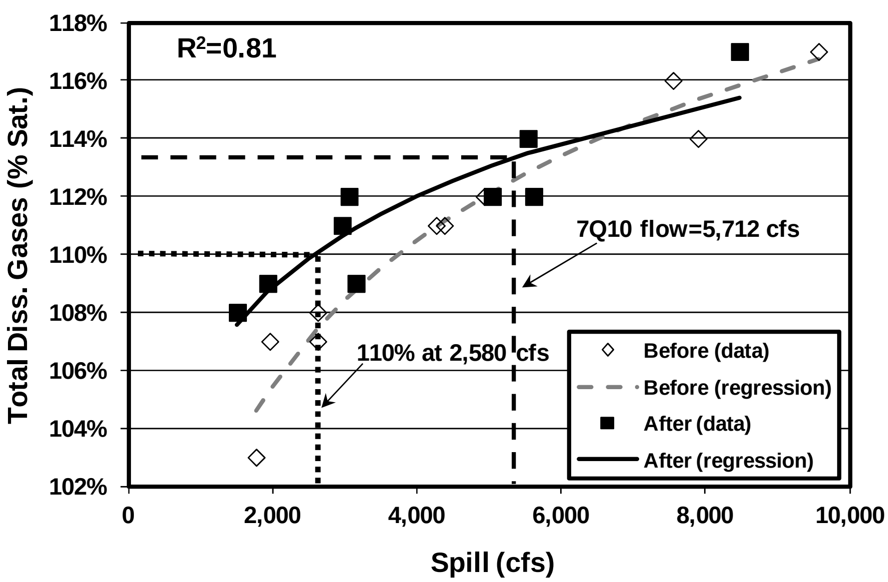



**Figure 3. Relationship of TDG Percent Saturation to Flow over the Dam 2 Spillway (TDG-1L) Post-Rock Weir Removal Compared to Pre-Rock Weir Removal Relationship**

TDG data were collected at the Dam 1 spillway on one occasion in 2013. 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 were 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.

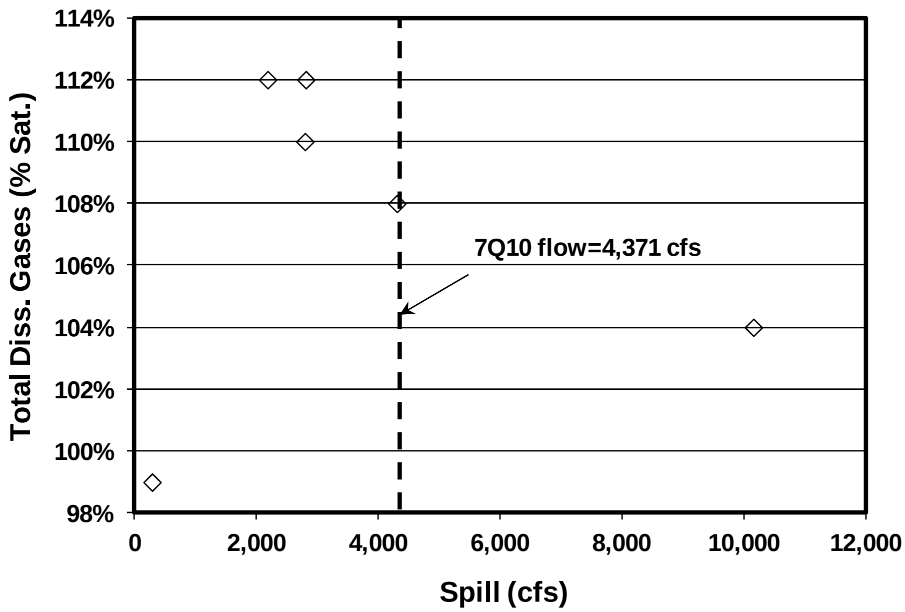



**Figure 4. Relationship of TDG Percent Saturation to Flow over the Dam 1 Spillway (TDG-11)**

## 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. The one measurement in 2013 is the only time TDG has been measured at TDG-1u after the modification of the intake tower. It is insufficient to determine if 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.

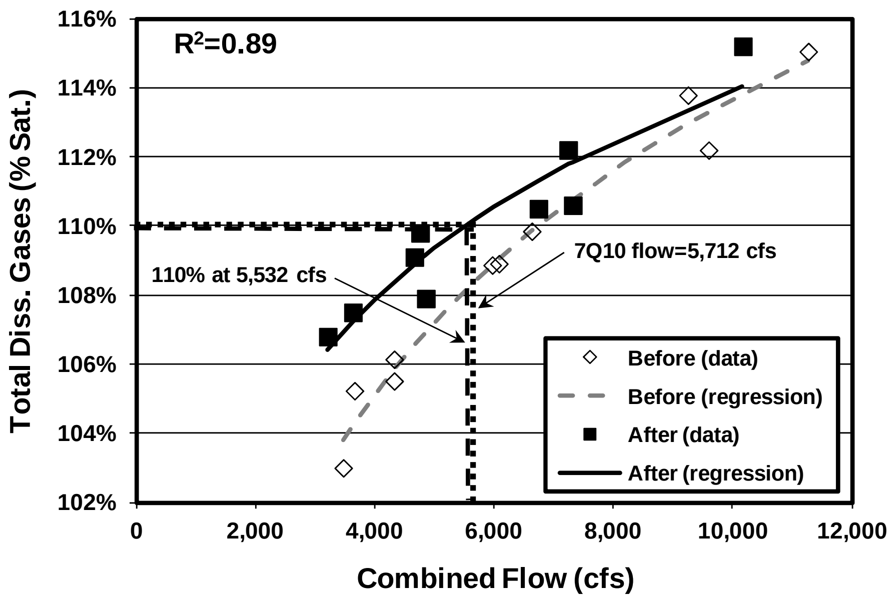



**Figure 5. Relationship of TDG Percent Saturation to the Combined Flow of the Dam 2 Spillway and Powerhouse 2 Pre-Rock Weir Removal Compared to Post-Rock Weir Removal**

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.

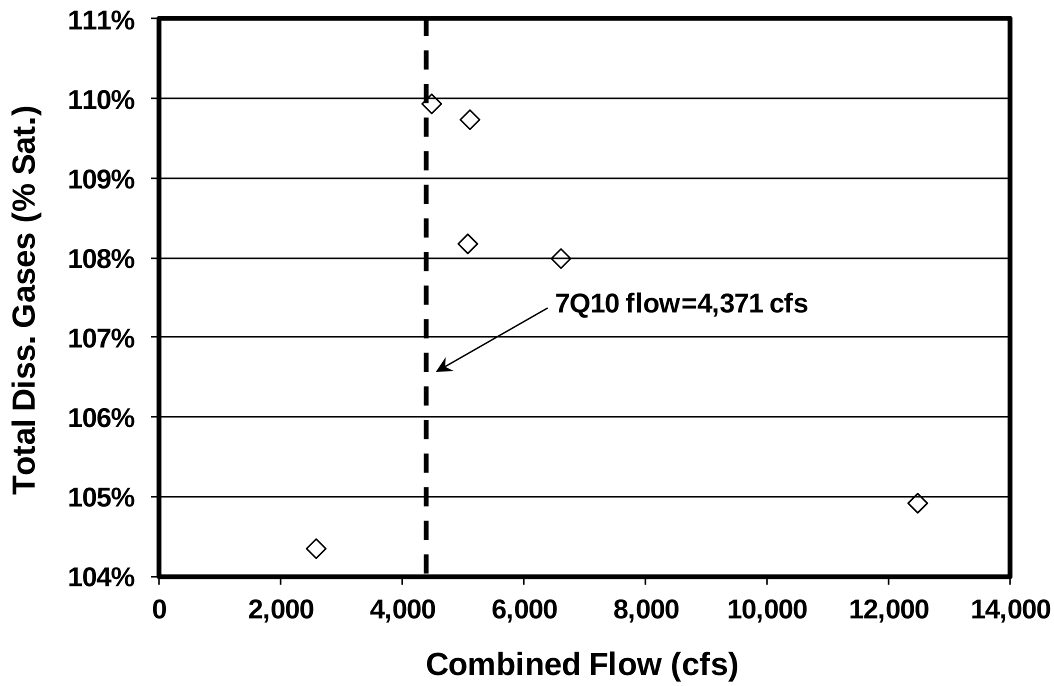



**Figure 6. Relationship of TDG Percent Saturation to Combined Flow of the Dam 1 Spillway and Powerhouse 1**

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 have 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.

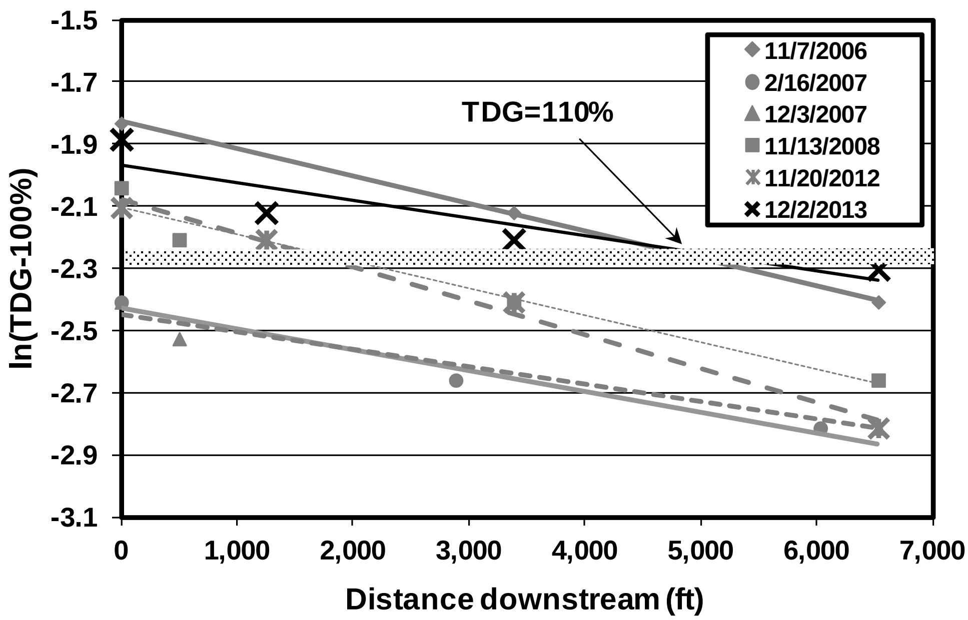



**Figure 7. Dissipation of TDG Downstream of the Site of the Rock Weir at the Dam 2 Spillway Plunge Pool on Four Dates**

**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 hich 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 observed exceedences of the ODEQ standard of 110 percent saturation of TDG at monitoring sites in 2013 when the Bull Run River flows were below the 7Q10 flow for the respective sites. TDG levels exceeded 110 percent at two sites on one occasion, but the flow over the spillway and in the river were above the 7Q10 flow,

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 at the base of the Dam 2 spillway are now calculated to exceed 110 percent at a spillway 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. 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. How quickly do elevated levels of TDG dissipate downstream when they are observed?

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 has not exceeded 110 percent below the Dam 2 spillway plunge pool at total river flows below the 7Q10 flow for the site as of the end of 2013.

# 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 2014

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 2013 regarding lower Bull Run River adult Chinook salmon population research. Weekly surveys of spawning and holding Chinook adults and redds were conducted in the lower Bull Run River from early July 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 2013, no spawning surveys could be conducted on five occasions because of high flows. The peak adult Chinook count and minimum escapement estimate[1] in 2013 were in the middle of the range of what has been observed in past years after Marmot Dam was removed. The cumulative redd count, however, was the highest ever observed in the lower Bull Run, suggesting that poor visibility during several surveys resulted in relative undercounts of live adults and carcasses. The missed surveys may have also contributed to a lower peak adult Chinook count.

In addition to the survey protocol used from 2010-2012, weekly surveys began earlier in 2013. That was necessary to evaluate efforts by the Oregon Department of Fish and Wildlife 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. Survey protocols were altered between early July and late September to include 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 while in operation.

# 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 may 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. The Oregon Department of Fish and Wildlife (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 and redds in the lower Bull

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

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 abundance for the Bull Run. The Bull Run data could then be used with information gathered by other agencies to determine the status of listed Sandy River Chinook populations.

An additional monitoring consideration was added in 2013 to those that underlie the Chinook population research protocols described in the HCP. ODFW began acclimating and releasing hatchery Chinook smolts in the lower Bull Run River in 2011. 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 return in 2013. 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) and a large return of hatchery fish could quickly exceed that threshold in the Bull Run River, undermining the City's restoration efforts. ODFW installed a river channel-spanning weir near the mouth of the Bull Run River in early July,2013, to remove hatchery Chinook adults while allowing wild Chinook adults to enter the river. Spawning survey timing and protocols were adjusted in 2013 to support ODFW's efforts to prevent adult hatchery Chinook from entering the Bull Run River.

# 3. Research Objectives

In 2013 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, $\alpha$=0.05, $\beta$=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 added in 2013:

- 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 ($\alpha$=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 the 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 a fish growth rate through time. ODFW thermally "marks" otoliths in hatchery Chinook by exposing juvenile fish to varying water temperatures over time. As fish growth increases in warm water or decreases in cold water, characteristic banding patterns are created, which provide an indication of the fish origin (Schroeder et al. 2005).

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 the cooperation of the operators at the City's Headworks facility and the Portland General Electric (PGE) powerhouses at Bull Run Dam 1 and Dam 2 to maintain flows of 150 cubic feet per second (cfs) or less above the Little Sandy confluence for the duration of each survey. This is the level of flow necessary for safety and for accurate counts. 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)

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

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 and 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 will be conducted.

Weekly surveys in 2013 were conducted from early June through mid-December. Five weeks were missed because of high flows. 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

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

- Number of adults and number of jacks
- Species
- 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]

[5] Substrate sizes are discussed in the HCP, Appendix F. The HCP is available on the PWB web site at www.portlandonline.com/water/index.cfm?c=46157.

- 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

- 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, then surveys were cancelled.

Live adults and jacks were counted and their location 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. Carcasses with adipose fins were sampled for otoliths, tissue, and scales 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. After October 31, only tissue samples were collected from Chinook carcasses with adipose fins.

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 2013 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 that 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. Modified surveys were conducted between July 2 and September 24.

# 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 ($\alpha$=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 the ODFW cutoff date of October 31 plus one week for distinguishing between carcasses that were considered to be spring Chinook (previous to and including the first survey after October 31, i.e., the first survey in November) or fall Chinook (after the first survey in November).

# 7. Results and Discussion

## 7.1 Surveys

In 2013, weekly surveys were influenced by high stream flows and the construction work associated with the Bull Run Dam 2 tower improvement project. Because of the construction work, the City was not able to regulate the flows in the lower Bull Run River in the first half of the season as in past years.

A total of 19 weekly surveys were conducted in 2013 between July 2 and December 11, 13 following modified protocols which included snorkeling, and six following standard protocols. Surveys were cancelled due to high flows on five dates, October 2, October 8, November 7, November 21, and December 4. The survey conducted on December 11 was a partial survey, from Larson's Bridge to the PGE Bull Run Powerhouse. Only part of the river was surveyed on December 11 because of staffing issues.

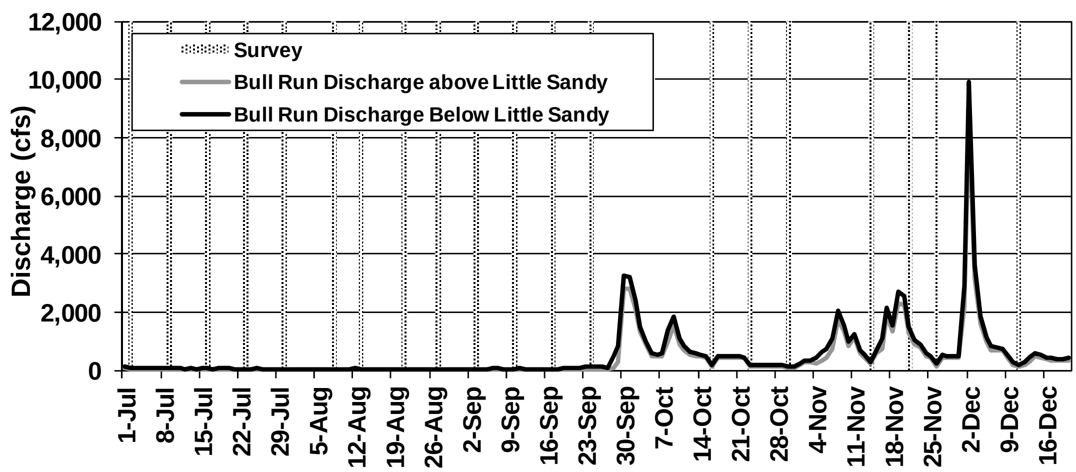



**Figure 1. Bull Run River Discharge Above and Below the Little Sandy Confluence and Dates of Chinook Spawning Surveys**

## 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 2013 were in the middle of the range of previous survey years, whereas cumulative redd count was the highest ever observed, as indicated in Table 1.

**Table 1. Summary Statistics for Chinook Spawning Runs in the Lower Bull Run River, 2007—2013[a]**

| Year | Peak Count | Minimum Escapement | Cumulative Redd Count | % Hatchery (n)[b] | % Female (n) |
|---|---|---|---|---|---|
| 2013 | 54 | 69 | 124 | 16.3% (48) | 64.6% (47) |
| 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.

Peak adult counts continue to be lower, on average, than they had been prior to the Marmot Dam removal in 2007 ($\text{t-test}_{\text{one-tailed}}$, $p$=0.01, df=9), 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 52 (±41). The increasing trend observed between 2007 and 2011 stopped with the lower counts in 2012 and 2013 ($p$=0.52).

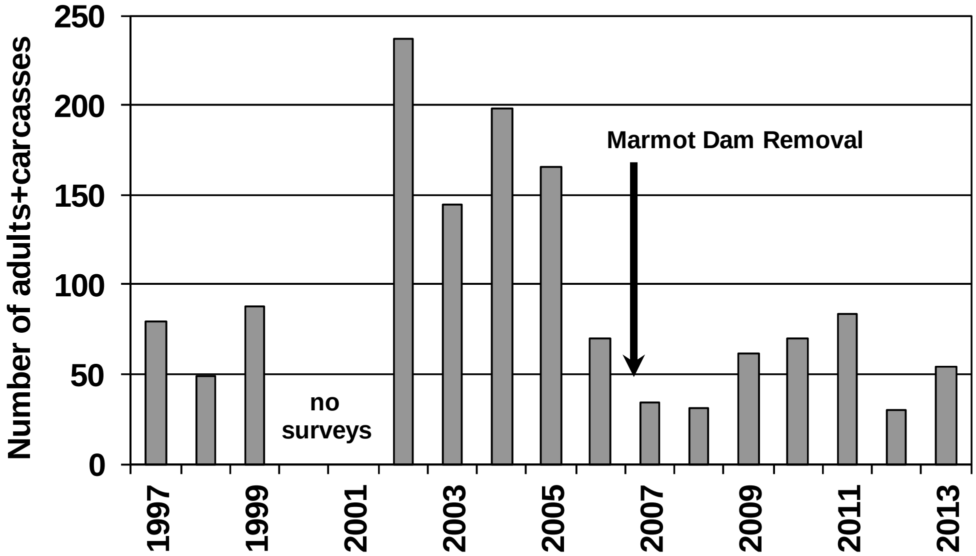



**Figure 2. Chinook Salmon Peak Counts for All Years when Surveys Were Conducted**

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 date cut-off 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. Genetic analysis may help to separate these combined statistics in the future.

The peak count of spring Chinook in the Bull Run River in 2013 does not reflect the spring Chinook escapement to the Sandy River in general. The mid-range count in the Bull Run contrasted with a relatively low count in the greater Sandy River Basin. 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 Roselyn 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; see Figures 2 and 3).

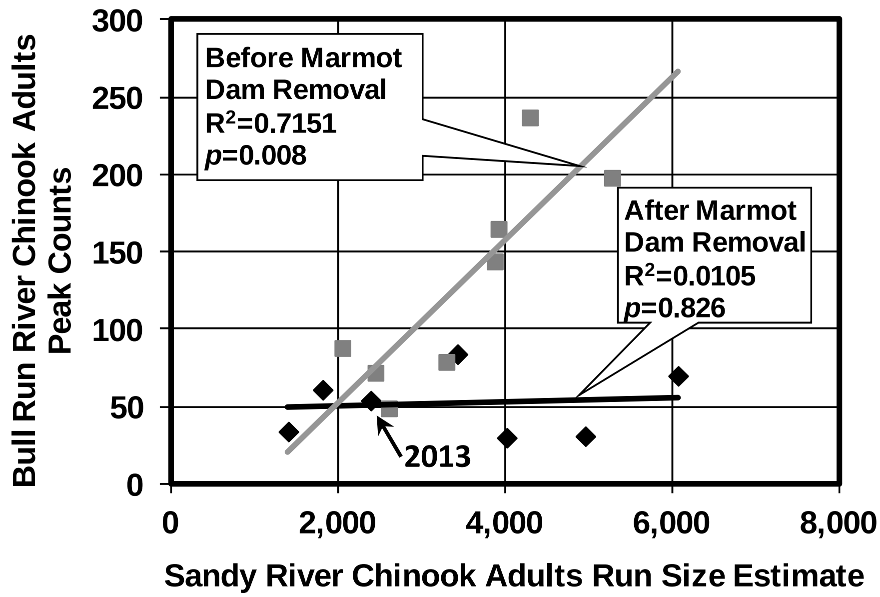



**Figure 3. Relationship of Peak Counts of Adult Chinook in the Lower Bull Run River with Estimated Run Size of Spring Chinook in the Upper Sandy River Basin, Before and After the Removal of Marmot Dam**

## 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 date of the peak fish count and peak redd count occurred in mid-October. The date of the minimum escapement estimate was in November rather than October, because it included cumulative counts of both spring and fall Chinook carcasses.

**Table 2. Timing of Adult Chinook Peak Counts, Highest Minimum Escapement Estimate, and Peak Redd Count, 2007–2013**

| Year | Peak Count | Minimum Escapement | Peak Redd Count |
|---|---|---|---|
| 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. 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 were 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 October 2013 appears to correspond with both an increase in flow and 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).

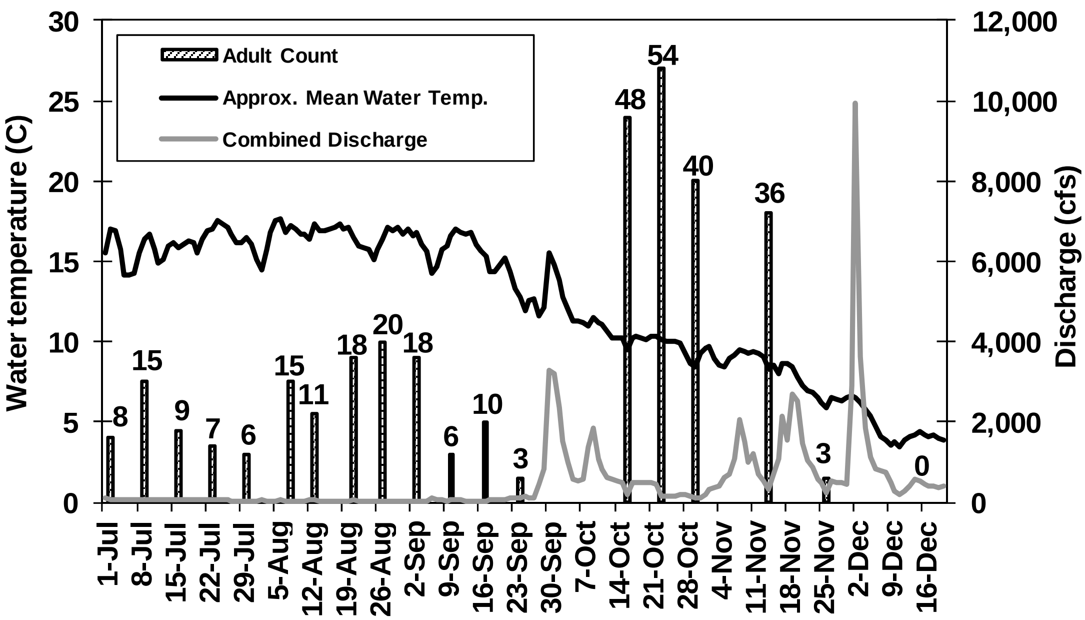



**Figure 4. Environmental Variables[a] that May Be Useful in Explaining Chinook Salmon Run Timing in the Lower Bull Run River in 2013**

[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 during the period of time the weir was in operation. At least 15 hatchery adult Chinook moved into the lower Bull Run River before the weir starting operating on July 7. 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 upward trend ($p$=0.77). The percentage of adipose-clipped adults among fish for which the status of the adipose fin could be determined began at 100 percent and decreased to 50 percent as wild fish were passed above the weir and joined the hatchery fish that had entered the river before the installation of the weir in early July. Only hatchery adult Chinook were observed in the river until August 8. Sample sizes of adult Chinook salmon for which the status of the adipose fin could be determined were very small at both the beginning and the end of the period when the ODFW weir was in operation. A high-flow event on September 29, 2013 damaged the ODFW weir, ending its period of operation and ending weekly snorkel surveys. The results of the snorkel surveys conducted between early July and late 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 the highest that it has been since Marmot Dam was removed in 2007 (Table 1). This contrasts with the mid-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 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 October 16 and November 26. The date of the peak Chinook redd count was October 16, which was one week before the date of the peak fish count. No surveys were conducted the two weeks prior to the date of the peak redd count, so the redd count on that day could be elevated because it reflects more than one week of spawning activity. The date of the next-highest redd count corresponds to that of the peak adult 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.

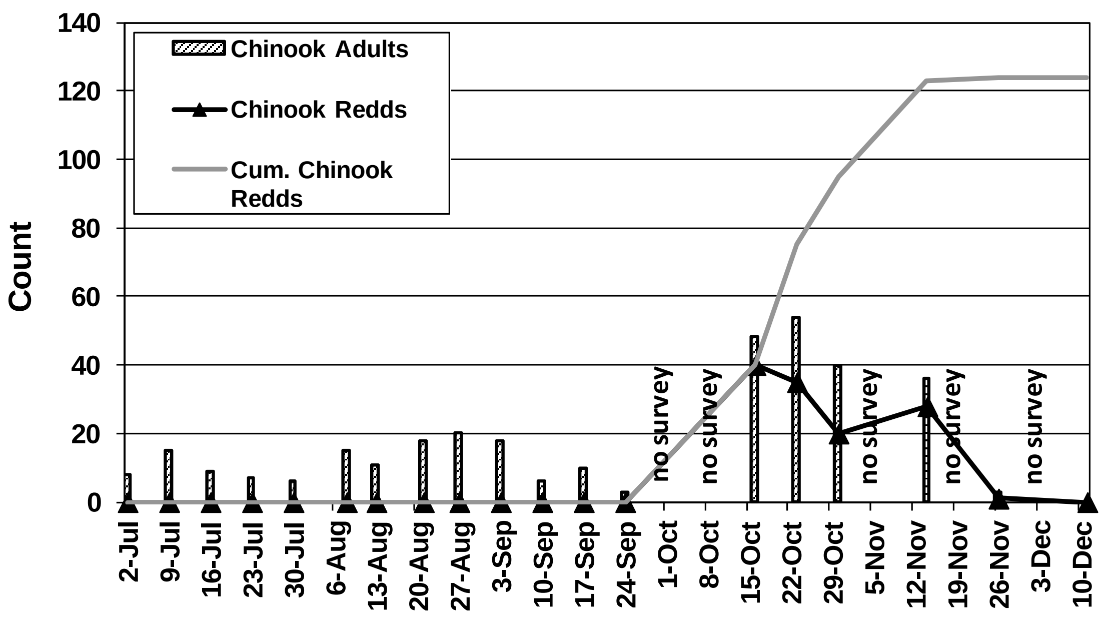



**Figure 5. Comparison of the Timing of the Presence of Adult Chinook Salmon and the Construction of Redds in 2013**

Chinook that first entered the Bull Run River in July held in the river in deep pools until October, when they began spawning. Apparently they were joined at that time by additional spring Chinook. 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; however—77 percent—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 2013 based on a relatively large sample size of carcasses for which the status of the adipose fin could be determined (48). The actual percentage of hatchery fish may have been higher than 16.3 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 Chinook carcasses considered spring Chinook carcasses that were of hatchery origin was 16.7 percent based on a sample size of 47 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. No survey could be conducted on the date of the potential first survey in November, however, because of high flows. Any carcasses found during the subsequent survey (November 14) could be a combination of spring Chinook that might have been observed as carcasses on November 7 and fall Chinook that might have been observed as living fish on November 7. If the cutoff date of October 31 were applied to carcasses to distinguish between spring Chinook and fall Chinook, then the percentage of hatchery fish would be 26 percent, with a sample size of 31 carcasses.

### 7.4.2 Sex Ratio

Over half of the Chinook carcasses recovered in 2013 were female. Of the 52 carcasses observed in the Bull Run River in 2013, 47 were intact enough to determine their sex. Of these 47, 30 (64.6 percent) were female.

Females tend 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 seven survey years. One year, 2012, males made up a larger percentage of recovered carcasses, but the total sample size was extremely low (5). The reason for this observed asymmetry is unknown. It 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 they 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 2013, however. Both male and female carcasses had an average length of 65.3 centimeters.

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, though this is increasingly unlikely.

# 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 69 adult Chinook salmon returned to the Bull Run River to spawn in 2013. The peak daily count of live adults plus carcasses was 54.

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

  A total of 124 Chinook redds were identified in the Bull Run River in 2013.

- **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 2 and November 26, 2013. The peak date was October 23, 2013. Chinook redds were observed between October 16 and November 26, 2013. The peak date for redd observation was October 16.

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

  In 2013, 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 16.3 percent.

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

  In 2013, 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?**

  Between July 2, 2013, and September 24, 2013, the percentage of spring Chinook observed while snorkeling decreased from 100% to 50%, though with small sample sizes at the beginning and end of the period when the ODFW weir was in operation.

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

  In 2013, 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 on or before the first survey in November were spring Chinook, was 16.7 percent.

# 9. Works Cited

Olsen, J.B., S.J. Miller, K. Harper, K. Van Hatten, K. Whitton, J.J. Nagler, and J.K. Wenburg. 2004. Sex ratios of juvenile and adult Chinook salmon in the Kuskokwim and Yukon Rivers. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program, Final Report for Study 02-097. Anchorage, Alaska.

Oregon Department of Fish and Wildlife (ODFW). 2011. Final Hatchery and Genetic Management Plan (HGMP): Spring Chinook. Salem, 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.

Schroeder, R.K., K.R. Kenaston, and L.K. Krentz. 2005. Spring Chinook salmon in the Willamette and Sandy Rivers. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-10, Annual Progress Report. Portland, Oregon.

# Exhibit A

**Table A-1. Lower Bull Run River adult Chinook snorkel survey results, July 2-September 24, 2013.**

| Date | Hatchery (no adipose) | Wild (adipose) | Undetermined | Total | Percent hatchery | Visibility | Comments |
|---|---|---|---|---|---|---|---|
| July 2, 2013 | 4 | 0 | 2 | 6 | 100% | Excellent | 2 Chinook jacks, 1 wild and 1 hatchery |
| July 9, 2013 | 8 | 0 | 5 | 13 | 100% | Excellent | 2 Chinook jacks, both hatchery. |
| July 16, 2013 | 8 | 0 | 0 | 8 | 100% | Excellent | 2 adult steelhead also seen, both wild |
| July 23, 2013 | 4 | 0 | 3 | 7 | 100% | Good | 1 adult steelhead seen, ad status? |
| July 30, 2013 | 4 | 0 | 2 | 6 | 100% | Excellent | 7 adult steelhead seen with ad fins |
| August 8, 2013 | 13 | 1 | 1 | 15 | 93% | Excellent | 6 adult steelhead seen with ad fins |
| August 13, 2013 | 6 | 1 | 4 | 11 | 86% | Moderate | 3 adult steelhead with ad fins. |
| August 21, 2013 | 6 | 2 | 9 | 17 | 75% | Excellent | 3 adult steelhead with ad fins. |
| August 27, 2013 | 15 | 3 | 2 | 20 | 83% | Excellent | 4 adult steelhead with ad fins. |
| Sept. 3, 2013 | 11 | 5 | 2 | 18 | 69% | Excellent | 5 adult steelhead with ad fins. |
| Sept. 10, 2013 | 5 | 1 | 0 | 6 | 83% | Moderate | 1 hatchery Chinook jack and 2 adults of unidentified species. |
| Sept. 17, 2013 | 3 | 1 | 5 | 9 | 75% | Good | 2 Chinook jacks, 1 wild and 1 hatchery. |
| Sept. 24, 2013 | 1 | 1 | 0 | 2 | 50% | Poor | 1 Chinook jack, ad fin status? |

# Appendix F. Sandy River Basin Smolt Monitoring

## 2013

April 2014

Burke Strobel, Portland Water Bureau

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

*Photo (right) of rotary smolt trap 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 2013 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 complicated in 2013 by both natural and human-induced factors. High flows were encountered in several streams on multiple occasions and low flows hampered trap operations in one stream. Two releases of hatchery Chinook smolts from an acclimation pond interrupted monitoring efforts in one stream. One trap was stripped of its major parts.

Smolt numbers, fork length, condition factors, and emigration timing were monitored using rotary smolt traps in eight streams; Clear Fork, Lost Creek, Still Creek, Salmon River, Cedar Creek, Bull Run River, Little Sandy River, and Gordon Creek. Provisional population estimates were calculated for steelhead and coho smolts in all eight streams, but no fork length analysis was conducted on Lost Creek and no condition factor analysis was conducted on Lost Creek or Cedar Creek.

Preliminary Sandy River Basin-level population estimates were calculated for each year from 2009 to 2013. Freshwater productivity (smolts per adult) was also estimated for coho for each year from 2009 to 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. The streams with smolts having the longest and shortest weighted mean fork lengths generally had the lowest and highest condition factors, respectively.

Steelhead smolts emigrated earlier than coho smolts, on average, in all streams. Neither species exhibited any geographic pattern in emigration.

# 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 2013 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 2007 and assumed the management of the Little Sandy 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; PWB 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 (e.g., enumerating smolts at the mouths of large rivers) and collecting smolt information at a scale that is most meaningful to individual restoration efforts (e.g., enumerating smolts in tributaries). The

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

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, and is summarized in the HCP Appendix F (PWB 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)

## 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 1. 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. Smolt monitoring was initiated on Cedar Creek in 2013.**

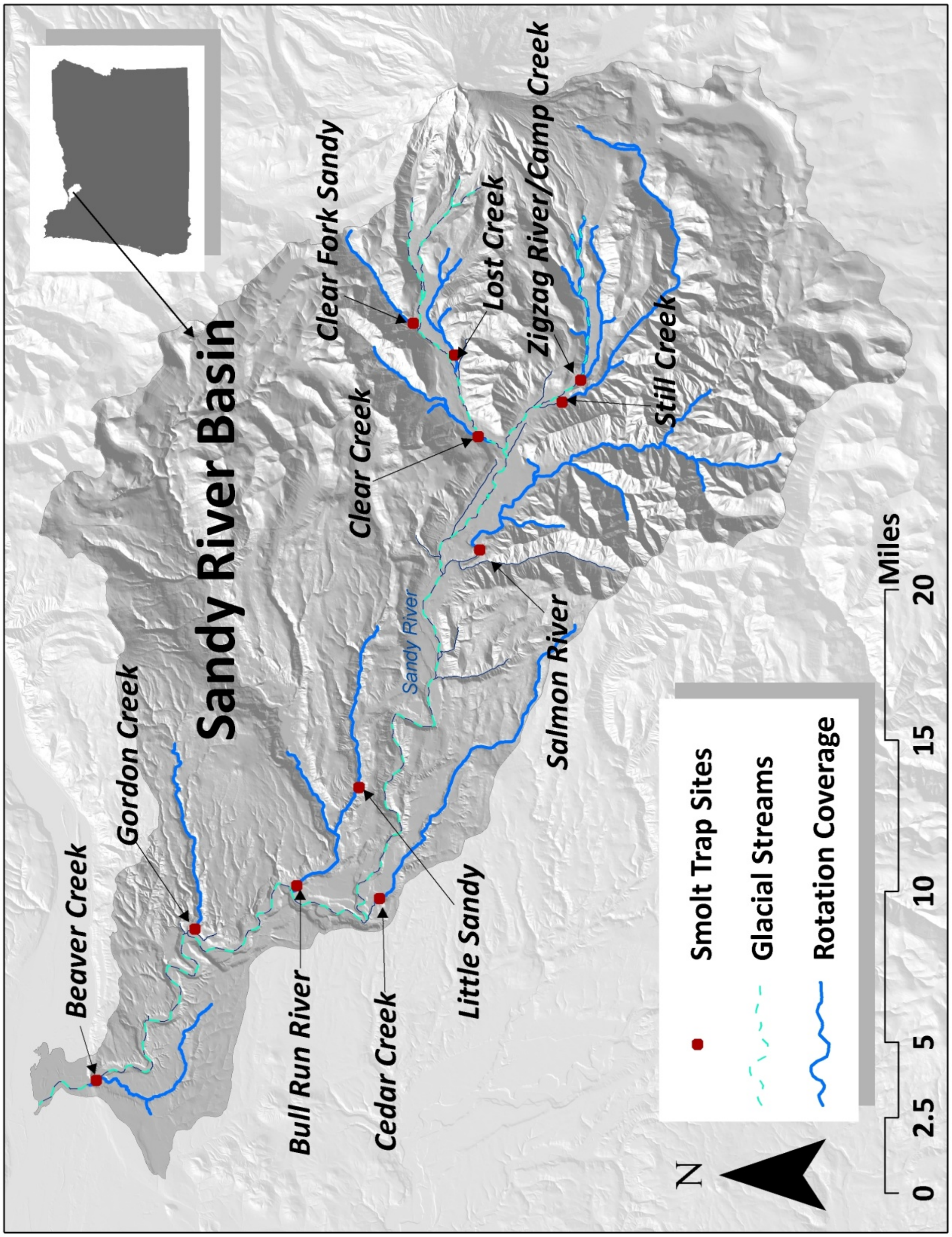



**Figure 2. Sandy River Basin—Smolt trap sites, streams covered by rotating smolt trap study, and streams receiving glacial runoff**

# 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 2013

Smolt production was monitored in Clear Fork Sandy River (Clear Fork), Lost Creek, Still Creek, the Salmon River, Cedar Creek, the Little Sandy River, the Bull Run River, and Gordon Creek in 2013. Eight-foot-diameter rotary traps were used on the Salmon River and the Bull Run River. Five-foot-diameter rotary screw traps were used on all other streams. The Clear Fork, Lost Creek, Still Creek, and Salmon River traps were checked and maintained by the USFS Zigzag Ranger District. ODFW checked and maintained the Cedar Creek trap. PWB checked and maintained the Little Sandy River, Bull Run River, and Gordon 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 when 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 2013. Traps were not operated because of high flows on multiple days in all streams but Cedar Creek. Four days were missed on the Bull Run River to avoid capturing acclimated hatchery Chinook smolts released on two occasions upstream of the trap. Sixteen days were missed on Gordon Creek because major parts of the trap were stolen and eventually replaced with a wooden structure. Trap efficiency on Cedar Creek was hampered by low flows, but the trap functioned for at least a portion of each day throughout the study period.

**Figure 3. After trap parts were stolen, Gordon Creek was monitored by mounting a rotary screw and livewell to a wooden frame standing on the streambed.**

**Table 3. Dates of operation and the number of days traps did not operate in the Sandy River Basin in 2013**

| Stream[a] | Trap In | Trap Out | Down Time (days) |
|---|---|---|---|
| Clear Fork | April 11 | June 14 | 9 |
| Lost Creek | April 17 | June 15 | 8 |
| Still Creek | April 2 | June 28 | 2 |
| Salmon River | April 15 | June 26 | 12 |
| Cedar Creek | April 7 | June 14 | 0 |
| Little Sandy | March 11 | June 25 | 11 |
| Bull Run River (without the Little Sandy River) | March 11 | June 18 | 18 |
| Gordon Creek | March 11 | June 24 | 17 |

[a]Streams are presented in order from highest-elevation Clear Fork to lowest-elevation Gordon 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 according to a separate sampling protocol to support other monitoring efforts.[2]

### 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. Measuring fish at the Little Sandy trap**

## 3.2 Assumptions

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

- 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).

---

[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 the PWB or USFS. Some tissue samples have been analyzed by the National Oceanic and Atmospheric Administration (NOAA).

- 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 (e.g., they do not suffer mortality between marking and potential recapture).
- Marked and unmarked fish traveling together have an equal probability of recapture (e.g., 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):

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

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,

---

[3] NMFS: http://swfsc.noaa.gov/textblock.aspx?Division=FED&id=3346.

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 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 to illustrate the process of filling gaps in each time series of subbasin estimates and 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 2013, 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 2013, 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 coho spawners in the Sandy River Basin for each parent generation that produced the coho smolts monitored in 2009 through 2013 were used to tentatively calculate freshwater productivity (smolts per adult). Adult coho spawner estimates were obtained from the ODFW Oregon Adult Salmonid Inventory & Sampling (OASIS) Program. The adult 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 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 2013**

| | | Period | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Site[a] | Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Clear Fork | Steelhead | 0.037 | 0.037 | 0.037 | 0.500 | 0.500 | | |
| | Coho | 0.220 | 0.220 | 0.220 | 0.453 | 0.160 | | |
| Lost Creek | Steelhead | 0.500 | 0.500 | 0.500 | | | | |
| | Coho | NA | NA | NA | | | | |
| Still Creek | Steelhead | 0.114 | 0.114 | 0.202 | 0.119 | 0.119 | 0.119 | |
| | Coho | 0.135 | 0.225 | 0.223 | 0.242 | 0.241 | 0.384 | |
| Salmon River | Steelhead | 0.290 | 0.026 | 0.071 | 0.045 | 0.045 | | |
| | Coho | 0.147 | 0.160 | 0.291 | 0.195 | 0.195 | | |
| Cedar Creek | Steelhead | 0.077 | 0.077 | 0.077 | 0.077 | | | |
| | Coho | 0.370 | 0.235 | 0.076 | 0.076 | | | |
| Little Sandy River | Steelhead | 0.092 | 0.092 | 0.092 | 0.092 | 0.195 | 0.357 | 0.357 |
| | Coho | 0.429 | 0.214 | 0.214 | 0.357 | 0.154 | 0.321 | 0.321 |
| Bull Run (without Little Sandy River) | Steelhead | 0.051 | 0.051 | 0.051 | 0.063 | 0.082 | 0.021 | 0.021 |
| | Coho | 0.067 | 0.067 | 0.067 | 0.114 | 0.098 | 0.098 | 0.098 |
| Gordon Creek | Steelhead | 0.139 | 0.139 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 |
| | Coho | 0.130 | 0.333 | 0.208 | 0.208 | 0.109 | 0.159 | 0.159 |

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

### 4.1.2 Subbasin Population Estimates

Monitored smolt production was particularly high and concentrated in certain streams in 2013. More steelhead smolts were produced by the Bull Run River than all other monitored streams combined. The majority of coho smolts from monitored streams emigrated from the Salmon River, as is summarized in Table 5. The estimated smolt population size in 2013 was the largest ever observed for steelhead in the Bull Run and Clear Fork, for steelhead and coho in the Salmon River, and for coho in the Little Sandy and Gordon Creek. Lost Creek had no observed coho smolt production. Exhibit A summarizes the total captures at all trap sites.

The Gordon Creek steelhead and coho smolt populations were likely significantly larger than their calculated estimates. Smolt monitoring on Gordon Creek was interrupted for 16 days when major parts of the trap were stripped, during what appeared to be a time of heavy emigration. Captures were much lower, on average, when the trap was replaced, despite comparable trap efficiency. The downtime estimate reflects a conservative assumption that smolt emigration declined throughout the downtime period. Smolt emigration also appeared to already be underway when monitoring began in early March and an unknown portion of it was missed. Past experience with emigration timing in Gordon Creek suggests, however, that the portion that was missed at the beginning of the season was not large.

The variances associated with estimates in several streams were large relative to the estimates themselves in 2013. Steelhead estimates tended to be less precise than coho estimates because of lower trap efficiencies for steelhead than for coho (see Table 4). The Gordon Creek estimates had particularly wide confidence intervals due to uncertainty associated with the downtime estimate.

**Table 5. Steelhead and coho smolt population estimates and 95% confidence intervals[a]**

| | Steelhead | | Coho | |
|---|---|---|---|---|
| **Stream[b]** | **Estimate** | **95% CI** | **Estimate** | **95% CI** |
| Clear Fork | 967 | 51% | 853 | 29% |
| Lost Creek | 12 | 57% | 0 | NA |
| Still Creek | 1,293 | 38% | 5,435 | 12% |
| Salmon River | 12,755 | 47% | 21,721 | 18% |
| Cedar Creek | 169 | 56% | 2,589 | 44% |
| Little Sandy | 1,569 | 40% | 706 | 35% |
| Bull Run (without Little Sandy) | 25,399 | 36% | 2,010 | 57% |
| Gordon Creek | 1,210 | 122% | 1,080 | 50% |

[a]Confidence intervals are expressed as percentages of the associated estimates.

[b]Streams are presented in order from highest-elevation Clear Fork to lowest-elevation Gordon Creek.

Of all streams monitored in 2013, 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. Lost Creek had the lowest steelhead smolt production per unit of length and surface area.

**Table 6. Steelhead and coho smolts per mile and smolts per 1,000 ft²**

| | Steelhead | | Coho | |
|---|---|---|---|---|
| Streams[a] | Smolts/mile | Smolts/1,000 ft² | Smolts/mile | Smolts/1,000 ft² |
| Clear Fork | 1.63 | 197.35 | 1.44 | 174.08 |
| Lost Creek | 0.01 | 1.76 | 0.00 | 0.00 |
| Still Creek | 0.49 | 86.78 | 3.06 | 744.52 |
| Salmon River | 1.16 | 458.81 | 2.00 | 829.05 |
| Cedar Creek | 0.06 | 11.50 | 0.91 | 176.12 |
| Little Sandy | 0.80 | 265.93 | 0.36 | 119.66 |
| Bull Run (without Little Sandy) | 6.57 | 3,060.12 | 0.52 | 242.17 |
| Gordon Creek | 0.78 | 163.51 | 0.71 | 150.00 |

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

Of all streams monitored in 2013, coho smolt production per unit of stream length was highest in Still Creek and coho smolt production per unit of surface area was highest in the Salmon River. Lost Creek 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**

| | Clear Fork Sandy | Lost Creek | Clear Creek[a] | Zigzag River | Still Creek | Salmon River | Cedar Creek[a] | Little Sandy | Bull Run | Gordon Creek | Beaver Creek[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **n** | 3 | 4 | 1 | 3 | 17 | 3 | 1 | 5 | 5 | 3 | 2 |
| **Average** | 634 | 15 | 2,514 | 6 | 1,590 | 7,331 | 169 | 1,111 | 12,796 | 1,511 | 6 |
| **Variance[b]** | 298,296 | 327 | 1,133,378 | 37 | 2,260,378 | 23,504,832 | 2,366 | 586,674 | 55,880,158 | 743,484 | na |

[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.

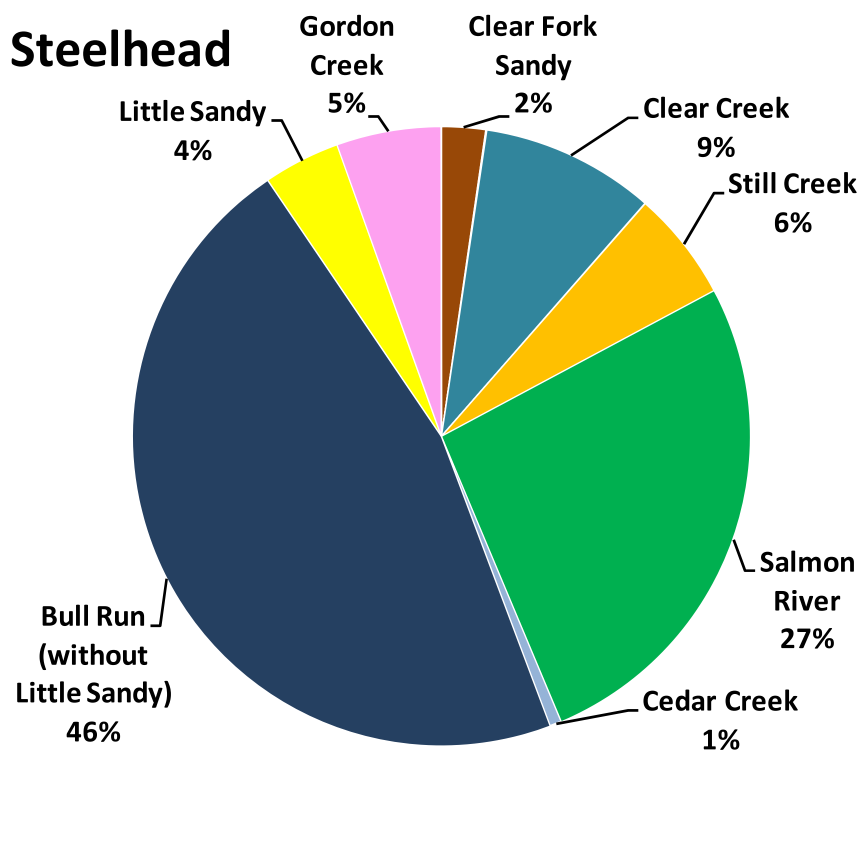



**Figure 5. Average relative contributions of monitored streams to steelhead smolt production in the Sandy River Basin Index Area**

**Table 8. Statistics for coho subbasin smolt trap population estimates compiled from the Sandy River Basin**

| | Clear Fork Sandy | Lost Creek | Clear Creek[a] | Zigzag River | Still Creek | Salmon River | Cedar Creek[a] | Little Sandy | Bull Run | Gordon Creek | Beaver Creek[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **n** | 5 | 4 | 1 | 3 | 20 | 3 | 1 | 5 | 5 | 3 | 2 |
| **Average** | 1,020 | 0 | 3,838 | 0 | 3,453 | 13,879 | 2,589 | 156 | 1,235 | 877 | 1 |
| **Variance[b]** | 402,899 | 0 | 220,862 | 0 | 3,802,287 | 47,379,924 | 332,190 | 94,755 | 1,128,394 | 78,649 | 1 |

[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.

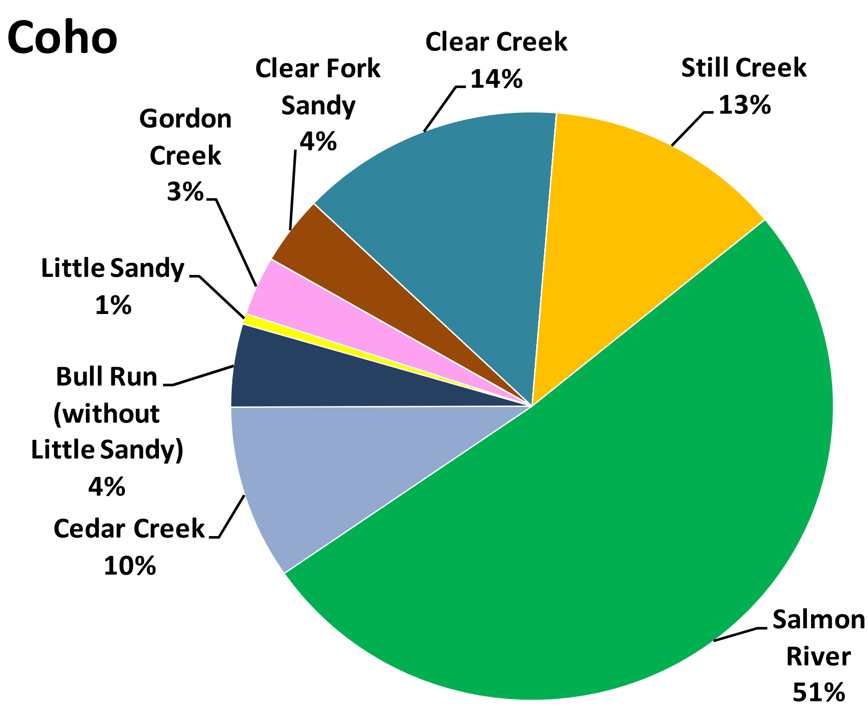



**Figure 6. Average relative contributions of monitored streams to coho smolt production in the Sandy River Basin Index Area**

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 five years of the Sandy River Basin Smolt Monitoring Plan period (2009-2013). 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 Clear 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[b] | Zigzag River | Still Creek | Salmon River | Cedar Creek | Little Sandy | Bull Run | Gordon Creek | Beaver Creek |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2009** | 634 | 5 | 2,514 | 6 | 3,709 | 7,331 | | 160 | 6,637 | 2,483 | 6 |
| | 169% | na | 83% | na | 87% | 130% | | 153% | 96% | 97% | na |
| **2010** | 4 | 15 | 2,514 | 5 | 138 | 3,419 | | 416 | 11,701 | 1,511 | 11 |
| | na | 240% | 83% | na | 102% | 77% | | 56% | 149% | 112% | na |
| **2011** | 634 | 1 | 2,514 | 1 | 4,958 | 7,331 | | 1,552 | 7,750 | 839 | 6 |
| | 169% | na | 83% | na | 15% | 130% | | 51% | 33% | 63% | na |
| **2012** | 634 | 15 | 2,514 | 13 | 1,174 | 5,819 | | 1,856 | 12,495 | 1,511 | 0 |
| | 169% | 240% | 83% | na | 41% | 20% | | 67% | 59% | 112% | na |
| **2013** | 967 | 12 | 2,514 | 6 | 1,293 | 12,755 | 169 | 1,569 | 25,399 | 1,210 | 6 |
| | 51% | 55% | 83% | na | 38% | 47% | 56% | 40% | 36% | 122% | na |

[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[b] | Zigzag River | Still Creek | Salmon River | Cedar Creek | Little Sandy | Bull Run | Gordon Creek | Beaver Creek |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2009** | 1,020 | 0 | 3,838 | 0 | 5,528 | 13,879 | 0 | 0 | 661 | 994 | 1 |
| | 122% | 0% | 24% | 0% | 21% | 97% | | 0% | 109% | 41% | na |
| **2010** | 1,646 | 0 | 3,838 | 0 | 3,911 | 11,077 | 0 | 37 | 2,708 | 877 | 1 |
| | 51% | 0% | 24% | 0% | 12% | 53% | | 50% | 68% | 63% | na |
| **2011** | 1,020 | 0 | 3,838 | 0 | 6,325 | 13,879 | 0 | 39 | 483 | 557 | 1 |
| | 122% | 0% | 24% | 0% | 9% | 97% | | 166% | 61% | 70% | na |
| **2012** | 1,020 | 0 | 3,838 | 0 | 3,890 | 8,838 | 0 | 0 | 314 | 877 | 0 |
| | 122% | 0% | 24% | 0% | 30% | 14% | | 0% | 141% | 63% | na |
| **2013** | 853 | 0 | 3,838 | 0 | 5,435 | 21,721 | 2,589 | 706 | 2,010 | 1,080 | 1 |
| | 29% | 0% | 24% | 0% | 12% | 18% | 44% | 35% | 57% | 50% | na |

[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** | 23,485 | 52.6% | 25,920 | 52.7% |
| **2010** | 19,733 | 90.4% | 24,095 | 26.2% |
| **2011** | 25,586 | 39.8% | 26,141 | 52.0% |
| **2012** | 26,031 | 31.3% | 18,777 | 12.8% |
| **2013** | 45,900 | 24.4% | 38,233 | 11.5% |

[a]Confidence intervals are expressed as percentages of the associated estimates.

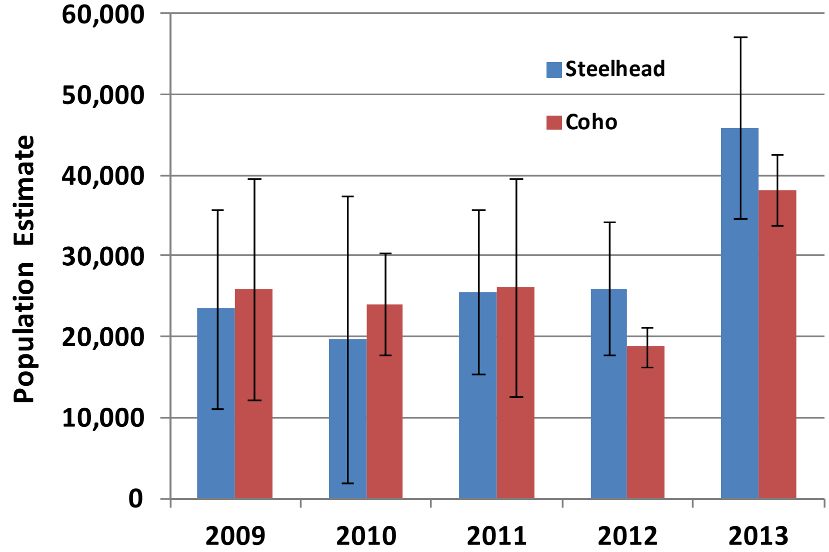



**Figure 7. Sandy River basin Index Area steelhead and coho smolt population estimates and 95% confidence intervals**

Estimates of freshwater productivity (smolts per adult) for coho are presented in Table 12 and the number of coho smolts are plotted against the number of coho spawners in the parent generation in Figure 5. Estimates of freshwater productivity for steelhead could not be calculated because adult steelhead spawner estimates are not yet available for the years corresponding to the parent generations of the steelhead smolts observed between 2009 and 2012, and steelhead smolts have not yet been aged to assign proportions of each subbasin steelhead smolt population estimate to parent cohorts.

**Table 12. Estimates of freshwater productivity for coho salmon in the Sandy River Basin Index Area**

| Coho Spawners | | Coho Smolts | | Freshwater Productivity |
|---|---|---|---|---|
| Year | Estimate | Year | Estimate | Smolts Per Adult |
| **2007** | 753 | **2009** | 25,920 | 34 |
| **2008** | 1,277 | **2010** | 24,095 | 19 |
| **2009** | 1,677 | **2011** | 26,141 | 16 |
| **2010** | 795 | **2012** | 18,777 | 24 |
| **2011** | 3,619 | **2013** | 38,233 | 11 |

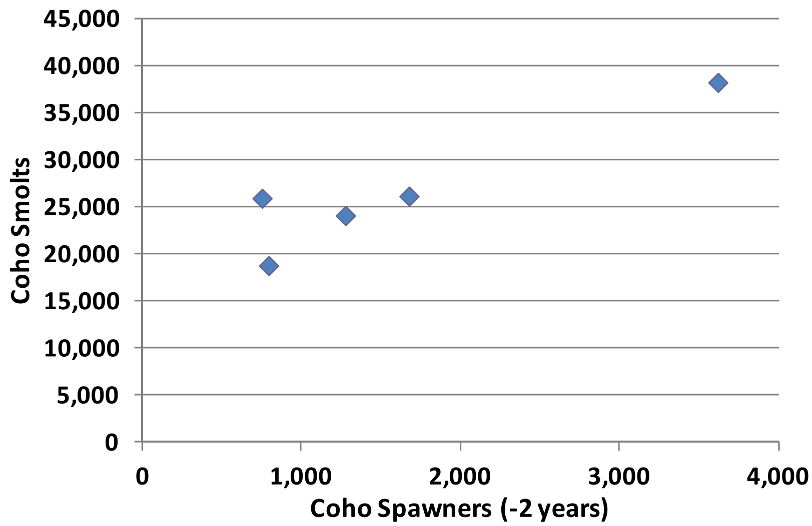



**Figure 8. Coho spawners vs. resulting coho smolts in the Sandy River Basin Index Area**

## 4.2 Fork Lengths

Steelhead and coho average fork lengths followed different patterns across monitored streams in 2013, as summarized in Tables 13 and 14, respectively. There were significant differences between the weighted mean fork lengths of both steelhead and coho smolts among monitored streams (ANOVA, $\alpha$=0.05, $p$<<0.001 for both tests). Both steelhead and coho smolts emigrating from the Bull Run River were significantly larger than those emigrating from other monitored streams.

**Table 13. Steelhead weighted mean fork lengths, weighted standard deviation, and range of fork lengths of steelhead smolts captured in Sandy River Basin smolt traps in 2013**

| Streams[a] | n[b] | Wtd. Mean Fork Length (mm) | Wtd. St. Dev. (mm) | Minimum (mm) | Maximum (mm) |
|---|---|---|---|---|---|
| Clear Fork | 32 | 155 | 28 | 95 | 208 |
| Still Creek | 179 | 160 | 18 | 109 | 202 |
| Salmon River | 451 | 165 | 20 | 90 | 216 |
| Cedar Creek | 13 | 125 | 36 | 89 | 180 |
| Little Sandy | 214 | 152 | 16 | 126 | 265 |
| Bull Run (without Little Sandy) | 1221 | 174 | 18 | 107 | 280 |
| Gordon Creek | 65 | 154 | 21 | 119 | 195 |

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

[b]n= Number of fish for which fork lengths were determined

Figure 9 shows frequency distributions for steelhead smolt fork lengths. The results of the pair-wise comparisons are summarized below Figure 9.

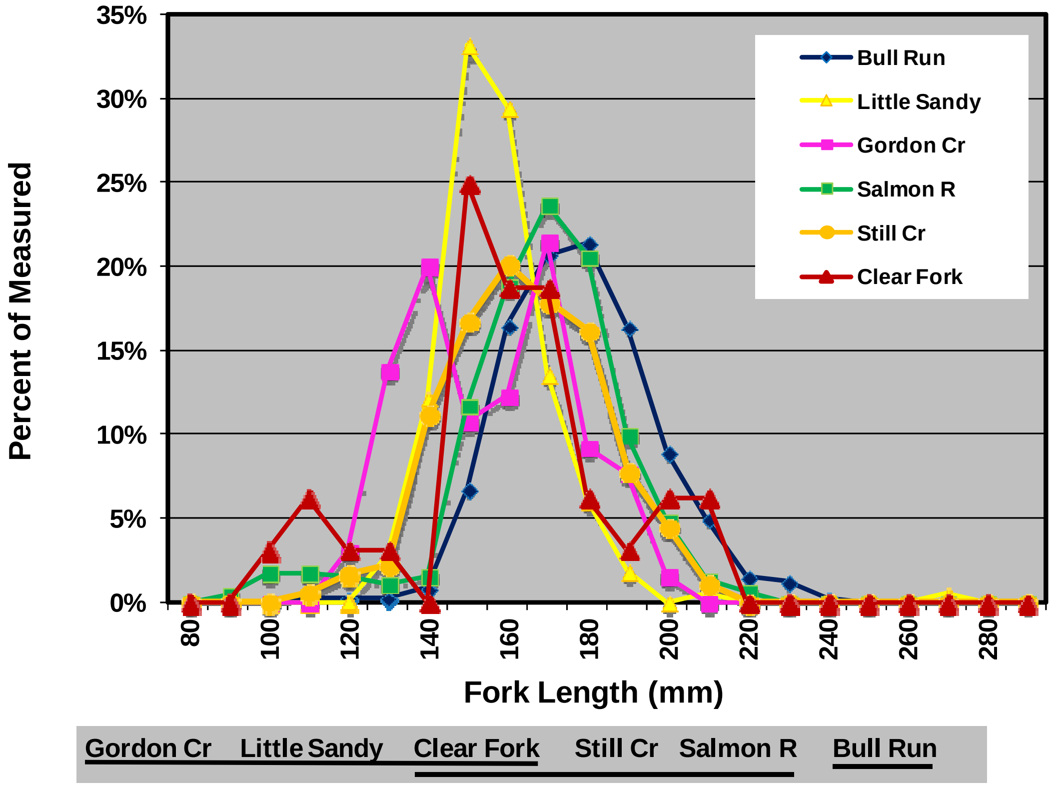



**Figure 9. Steelhead smolt fork length frequency distributions for Sandy River Basin traps in 2013[a,b]**

[a]Results of pairwise statistical comparisons are presented from left to right, shortest to longest.

[b]Cedar Creek had too few steelhead to include in the fork length frequency distribution or pairwise comparisons.

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., Gordon Creek and Little Sandy steelhead are not significantly different from each other or from Clear Fork steelhead in fork length, but are significantly shorter than Still Creek steelhead. Still Creek steelhead are statistically indistinguishable from Clear Fork and Salmon River steelhead in fork length, but significantly shorter than steelhead from the Bull Run).

**Table 14. Coho weighted mean fork lengths, weighted standard deviation, and range of fork lengths of coho smolts captured in Sandy River Basin smolt traps in 2013**

| Streams[a] | n[b] | Wtd. Mean Fork Length (mm) | Wtd. St. Dev. (mm) | Minimum (mm) | Maximum (mm) |
|---|---|---|---|---|---|
| Clear Fork | 163 | 94 | 10 | 70 | 122 |
| Still Creek | 918 | 99 | 12 | 69 | 156 |
| Salmon River | 1125 | 103 | 13 | 70 | 164 |
| Cedar Creek | 321 | 108 | 8 | 80 | 134 |
| Little Sandy | 138 | 101 | 10 | 75 | 123 |
| Bull Run (without Little Sandy) | 191 | 112 | 13 | 70 | 139 |
| Gordon Creek | 141 | 96 | 13 | 58 | 123 |

[a]Streams are presented in order from highest-elevation Still Creek to lowest-elevation Bull Run River.
[b]n= Number of fish for which fork lengths were determined

Figure 10 shows frequency distributions for coho smolt fork lengths. The results of the pair-wise comparisons are summarized below Figure 10.

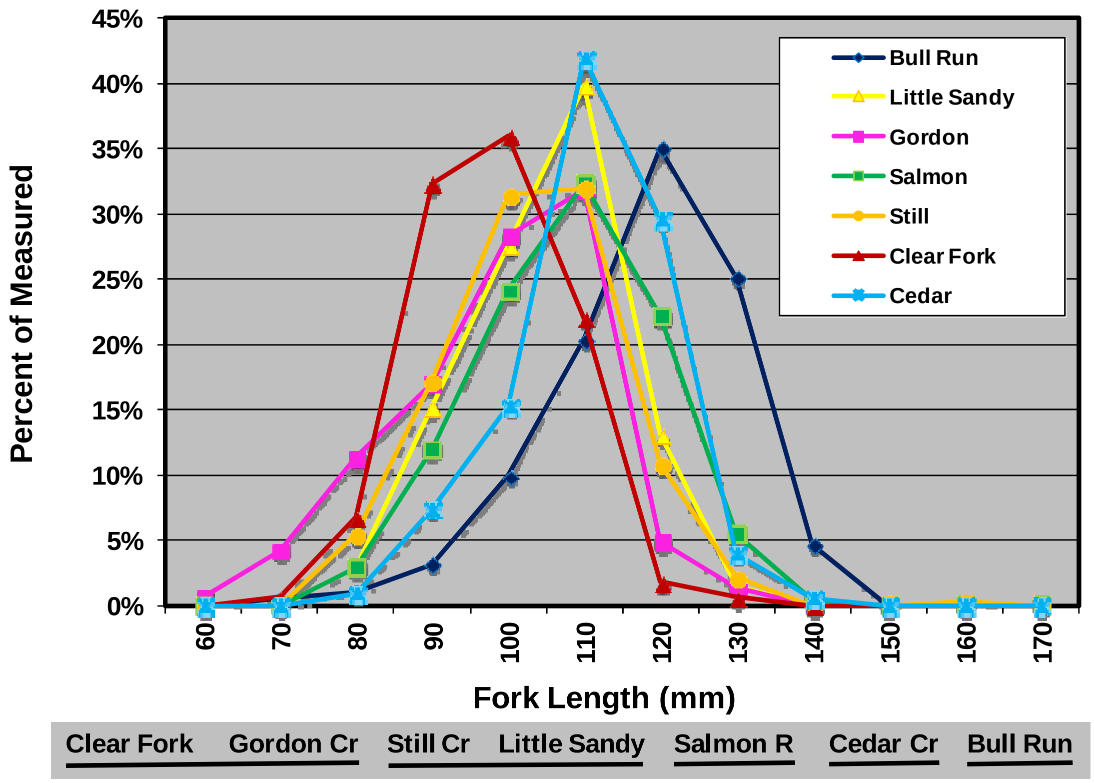



**Figure 10. Coho smolt fork length frequency distributions for Sandy River Basin traps in 2013[a]**
[a]Results of pairwise statistical comparisons are presented from left to right, shortest to longest.

In Figure 10, 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., Little Sandy coho are significantly smaller than coho from the Salmon River, but are not statistically distinguishable from Still Creek coho).

## 4.3 Condition Factors

There were significant differences (ANOVA, α=0.05, $p<<0.001$ for both tests) among the condition factors of steelhead and coho among streams monitored in 2013 (Figures 8 and 9). Bull Run steelhead had significantly lower condition factors (were thinner) than steelhead from all other streams. Salmon River steelhead had the highest condition factors (were the fattest, but were statistically indistinguishable from Still Creek steelhead at a 95 percent level of confidence. Bull Run and Little Sandy coho had the lowest condition factors of all monitored streams but were statistically indistinguishable from one another. Clear Fork coho had the highest condition factors but were not distinguishable from coho from the Salmon River or Gordon or Still creeks 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. Weights of Cedar Creek steelhead and coho were not measured, so their condition factors were not evaluated relative to the other streams.

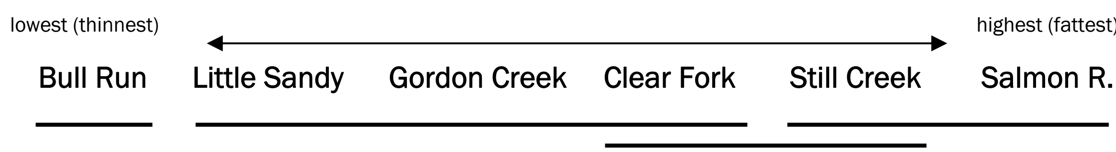



**Figure 11. Steelhead smolt results of Tukey test multiple comparisons of condition factors for Sandy River streams monitored in 2013**


**Figure 12. Coho smolt results of Tukey test multiple comparisons of coho smolt condition factors for Sandy River streams monitored in 2013**

## 4.4 Emigration Dates

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. Gordon Creek had the earliest median population emigration dates for steelhead and coho, respectively. The Salmon River and Clear Fork Sandy had the latest median population emigration dates for steelhead and coho smolts, respectively. 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 15 and 16 for steelhead and coho, respectively.

The Lost Creek trap captured only five steelhead smolts. The associated emigration statistics are not considered representative of a steelhead population emigrating from this stream. Statistics are presented for the trapping period, but no attempt was made to calculate a median emigration date that would be representative of the population.

**Table 15. 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 2013**

| Streams[a] | Wtd. Mean Emigration[b] | Wtd. St. Dev. | Wtd. Median Emigration[b] | Peak Emigration | Earliest Date[c] | Latest Date |
|---|---|---|---|---|---|---|
| Clear Fork | 27-Apr | 11 days | 28-Apr | 5-May | 12-Apr | 2-Jun |
| Lost Creek[d] | 12-May | — | — | — | 19-Apr | 27-May |
| Still Creek | 2-May | 16 days | 4-May | 5-May | 4-Apr | 8-Jun |
| Salmon River | 12-May | 13 days | 8-May | 4-May | 16-Apr | 14-Jun |
| Cedar Creek | 28-Apr | 8 days | 30-Apr | 3-May | 15-Apr | 10-May |
| Little Sandy | 28-Apr | 15 days | 4-May | 5-May | 15-Mar | 12-Jun |
| Bull Run River | 7-May | 14 days | 7-May | 7-May | 16-Mar | 14-Jun |
| Gordon Creek | 18-Apr | 23 days | 1-May | 4-May | 12-Mar | 17-May |

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

[c]Earliest date reflects the initiation of trapping on Gordon Creek and Salmon River, not the earliest date of emigration. Emigration was already underway in both streams.

[d]Lost Creek emigration date statistics are not considered representative for what a larger population would show because of the small sample size (n=5).

**Table 16. 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 2013**

| Streams[a] | Wtd. Mean Emigration[b] (Trapping) | Wtd. St. Dev. | Wtd. Median Emigration[b] (Trapping) | Median Emigration (Population) | Earliest Date[c] | Latest Date |
|---|---|---|---|---|---|---|
| Clear Fork | 22-May | 15 days | 26-May | 28-May | 15-Apr | 14-Jun |
| Still Creek | 17-May | 16 days | 21-May | 27-May | 3-Apr | 28-Jun |
| Salmon River | 20-May | 14 days | 25-May | 28-May | 16-Apr | 24-Jun |

**Table 16. 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 2013**

| Streams[a] | Wtd. Mean Emigration[b] (Trapping) | Wtd. St. Dev. | Wtd. Median Emigration[b] (Trapping) | Median Emigration (Population) | Earliest Date[c] | Latest Date |
|---|---|---|---|---|---|---|
| Cedar Creek | 10-May | 12 days | 10-May | 10-May | 8-Apr | 31-May |
| Little Sandy | 3-May | 20 days | 8-May | 9-May | 12-Mar | 11-Jun |
| Bull Run River | 3-May | 19 days | 8-May | 7-May | 13-Mar | 13-Jun |
| Gordon Creek | 20-Apr | 26 days | 30-Apr | 14-Mar | 12-Mar | 8-Jun |

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

[c]Earliest date reflects the initiation of trapping on Gordon Creek and Salmon River, not the earliest date of emigration. Emigration was already underway in both streams.

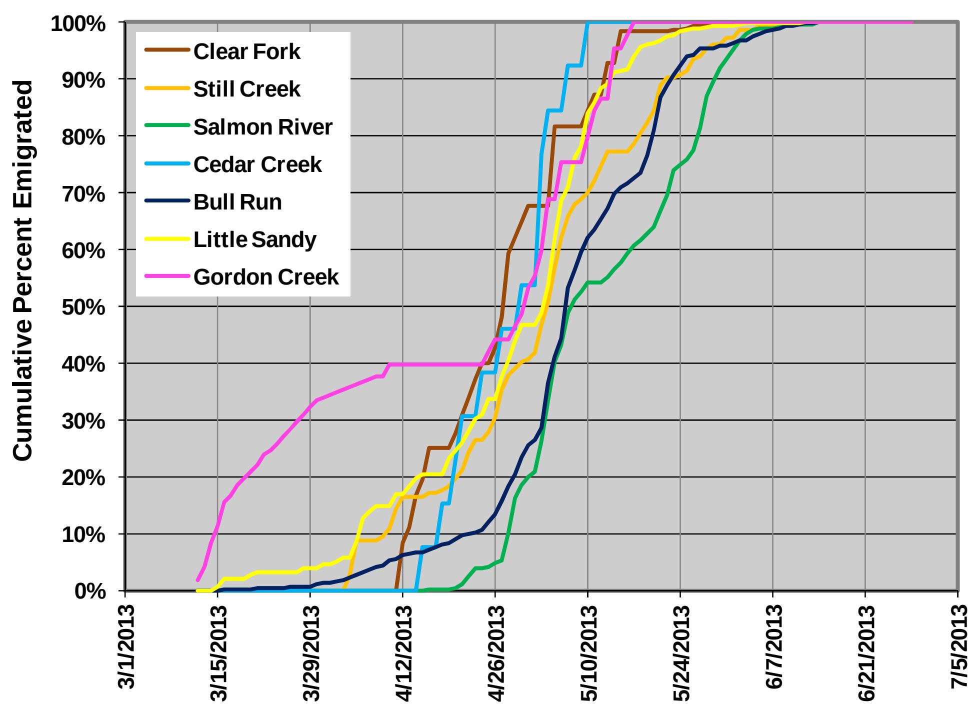



**Figure 13. Steelhead smolt cumulative percentage of total emigration from Sandy River streams monitored in 2013. Steepest portions of each curve indicate peak capture periods.**

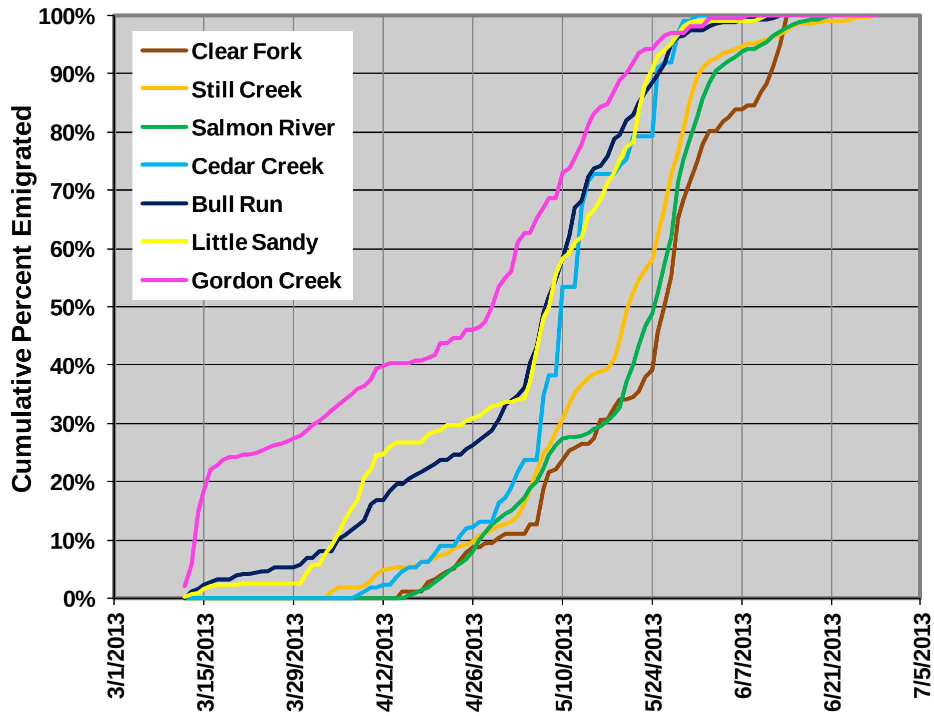



**Figure 14. Coho smolt cumulative percentage of total emigration from Sandy River streams monitored in 2013. Steepest portions of each curve indicate peak capture periods.**

# 5. Discussion

## 5.1 Smolt Population Estimation

Steelhead and coho smolt population estimates were generally large in 2013 relative to the previous four years of the Sandy River Basin Smolt Monitoring Program. The steelhead estimates in the Bull Run and Salmon rivers, and the coho estimate in the Salmon River were twice the previous record highs. Most of the remaining estimates were near their record high, except for steelhead in Still Creek and Gordon Creek and coho in the Clear Fork Sandy. The actual size of the population of coho and steelhead emigrating from Gordon Creek may have been significantly larger than estimated, because of the interruption of monitoring during a period of high emigration and because a portion of the beginning of the emigration period may have been missed.

The large smolt population estimates could be due to either relatively low winter flows, high numbers of spawning adults, a combination of those factors, or other, unknown influences. Winter flows in the Sandy River Basin were lower in 2013 than in previous years of the Sandy River Basin Smolt Monitoring Project.

There is an apparent negative relationship in the lower Bull Run River between the size of the peak flow in the river the preceding winter and the steelhead smolt population estimate, but a linear relationship is insignificant at a 95 percent level confidence (Figure 15). Large peak flows could decrease survival of over-wintering fish by displacing them from their refuges under rocks in the streambed, where steelhead tend to seek winter cover. Very high flows could also eliminate refuges by moving the rocks. Coho, which tend to seek refuge in woody debris jams and off-channel habitats, could suffer higher mortality during large peak flows if debris jams are washed away or if off-channel habitats are flooded by swift water. High numbers of spawning adults can contribute to large smolt populations by laying more eggs and more completely occupying available habitat. The estimated number of returning adult coho in 2011, the year-class that spawned the majority of coho smolts observed in 2013, was the largest in the Sandy River Basin since the beginning of the Sandy River Basin Smolt Monitoring Project (see Table 12 and Figure 5).

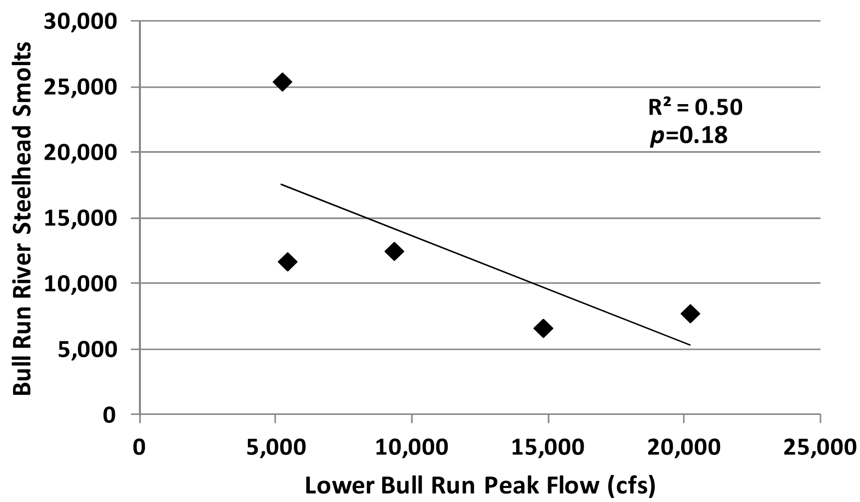



**Figure 15. Relationship between peak flow the preceding winter and steelhead smolt production in the Bull Run River, 2009-2013**

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 2013. 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, and 2013, however, support the idea that the Bull Run River and the Little Sandy downstream of the Little Sandy trap site constitute a productive system for steelhead and that the large population estimates obtained in 2013 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 2013.

The low numbers of steelhead and absence of coho emigrating from Lost Creek in 2013 could be due to low productivity in the portions of the basin upstream of the trap site due to low water temperatures. Cold water can slow metabolic rates and subsequently slow growth in fish. Very cold water could possibly limit productivity.

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 2013 and those to be made in future years will improve with the collection of additional data.

## 5.2 Recolonization of the Little Sandy

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 has declined slightly from 2011 (Figure 16), but remains comparable 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.

The Little Sandy River produced far more coho smolts in 2013 than in any previous year. This was the fourth 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. A marked increase in the number of coho fry caught in 2012 was evidence of an increase in coho spawning activity in the fall of 2011. This increased presence of juvenile coho translated into a nearly 20-fold increase in coho smolt production over the previous highest estimate (2011, see Table 11). The initial increase of coho fry caught in the Little Sandy trap in 2008—which was evidence of immediate recolonization by spawning coho just months after the removal of the dam—did not result in a similar increase in coho smolts the following spring. This is evidence that the particularly low winter flows preceding the 2013 smolt emigration resulted in higher survival rates than would probably be typical for this species—which prefers low-gradient, unconfined streams with a wealth of large wood—in the high-gradient, confined, low-wood Little Sandy channel.

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.

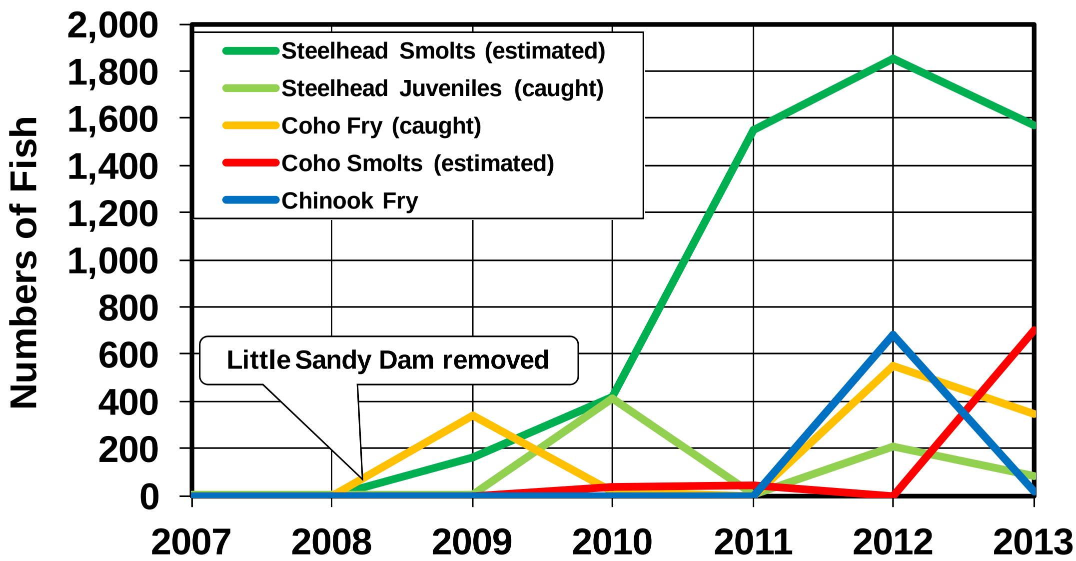



**Figure 16. Recolonization of the Little Sandy River by steelhead and coho after the removal of the Little Sandy Dam**

## 5.3 Fork Lengths

The observed differences in fork length distribution for steelhead and coho smolts among Sandy River Basin streams monitored in 2013 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 can also vary in age from 1 to 3 years (Hansen et al. 2001). 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 may also vary in age, though to a much lesser degree. Scale samples are collected annually from steelhead and coho smolts for determining the proportions of emigrating smolts of various ages. Once ages have been determined, this information will be used in the future to discern between the effects of growth and age.

## 5.4 Condition Factors

In 2013, streams that produced fish with relatively low fork lengths also produced fish with relatively high condition factors. Still Creek had relatively small, fat steelhead and coho whereas the Bull Run, on the other extreme, had large, relatively thin fish. A similar relationship has been observed in previous years, especially with coho. This pattern may reflect that relatively higher water temperatures in lower-elevation streams allow for some growth during the winter, using up more stored body fat. It is also possible that over-wintering conditions in the specific low-elevation streams are poor, requiring fish to expend more energy to survive. It is unlikely, however, that lower condition factors in fish reflect poor rearing conditions throughout the year in these streams or the observed patterns of fork length would be lower as well.

## 5.5 Emigration Dates

Coho smolts emigrated earlier from low-elevation streams than from higher-elevation streams, but steelhead smolts showed no such pattern. Similar patterns have been observed in most previous years. These differences in emigration timing could simply be contingent on environmental conditions (e.g. 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 eight streams in 2013.
- Steelhead and coho smolt estimates were higher in most streams in 2013 than in previous years of the Sandy River Basin smolt monitoring project.
- Estimates of steelhead and coho smolt production and coho freshwater productivity were generated for the entire Sandy River Basin Index Area for years 2009–2013. More precise estimates will be generated once additional years of smolt monitoring data are available.
- Steelhead and coho smolt fork lengths showed significant differences among monitored streams in the Sandy River Basin in 2013. High-elevation streams produced shorter fish 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 2013. The streams with smolts having the longest and shortest weighted mean fork lengths generally had fish with the lowest and highest condition factors, respectively. A similar pattern has been observed in previous years.
- Coho smolts emigrated earlier from low-elevation streams than from high-elevation streams in 2013. There was no apparent pattern in emigration dates of steelhead smolts among streams. Steelhead emigrated, on average, earlier than coho.
- These data represent the fifth 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 Den Fraser, Steve Schaaf, and Jon Mueller from PWB; Joshua Haslitt and Kevin Perkins from USFS; and Jonathan Paquette, Michael Hayworth, and Neal Berg from ODFW. Additionally Don and Kristy Mensch, Bob and Carla Heade, Kelsey Jones, and Nathan Haines contributed countless invaluable volunteer hours to help out with the USFS smolt traps.

# 8. Works Cited

Bjorkstedt, E.P. 2005. DARR 2.0: Updated software for estimating abundance from stratified mark-recapture data; NOAA/NMFS Technical Memorandum NOAA-TM-NMFS-SWFSC-368.

Bjorkstedt, E.P. 2010. DAR R 2.0.2: DAR R for R. http://swfsc.noaa.gov/textblock.aspx?Division=FED&id=3346

Hansen, B., L. Campbell, and B. Strobel. 2001. Steelhead Life History in the Upper Clackamas River Basin. Fisheries Partnerships in Action, 2000 Accomplishments Report for the Clackamas River Fisheries Working Group.

Hutchinson, M.W., J.L. Vogt, and A. Neerman. 2007. Winter Steelhead of the Clackamas and Sandy Rivers: Spawning Ground Surveys 2006-2007. Oregon Department of Fish and Wildlife. Clackamas, 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. Final Draft. Portland, Oregon.

Scace, J.G., B.H. Letcher, and J. Noreika. An Efficient Smolt Trap for Sandy and Debris-Laden Streams. *N Am J Fisheries Manage* 27 (2007):1276–1286.Strobel, Burke. 2004. Ecosystem Responses to a Large-Scale Salmon Carcass Enrichment Project. Interim report. Clackamas River Ranger District. Estacada, Oregon.

Strobel, Burke. 2012. Sandy River Basin Smolt Monitoring, 2011. Portland Water Bureau. Portland, Oregon.

Strobel, Burke. 2010. Sandy River Basin Smolt Monitoring, 2009. Portland Water Bureau. Portland, Oregon.

Suring, E.J., E.T. Brown, and K.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, G.C., S.L. Johnson, B.A. Miller, T.E. Nickelson, and D.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.

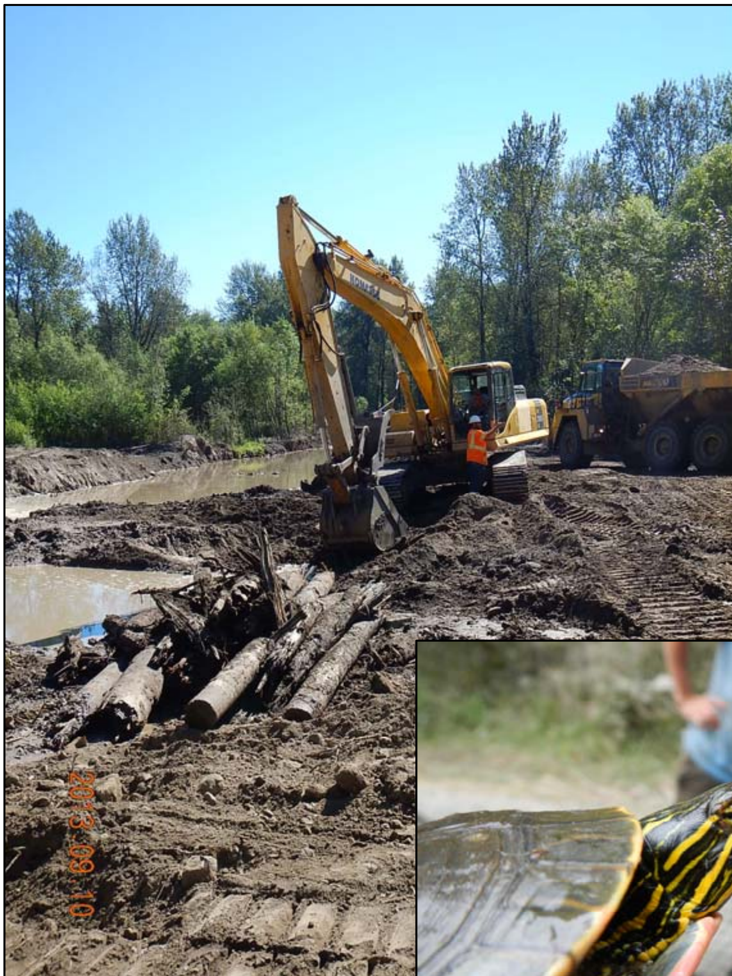
# Exhibit A

**Table A-1. All species and life stages captured at smolt traps in the Sandy River Basin in 2013**

| | Clear Fork | Lost Creek | Still Creek | Salmon River | Cedar Creek[a] | Bull Run River | Little Sandy | Gordon Creek |
|---|---|---|---|---|---|---|---|---|
| Chinook Fry[b] | 357 | 816 | 526 | 8,832 | 0 | 38 | 1,916 | 7,913 |
| Chinook Juveniles | 2 | 0 | 3 | 1 | 0 | 0 | 60 | 52 |
| Chinook Smolts Wild | 0 | 0 | 1 | 10 | 0 | 0 | 0 | 0 |
| Chinook Smolts Hatchery | 0 | 0 | 0 | 0 | 0 | 0 | 237 | 0 |
| Coho Fry[b] | 1 | 0 | 0 | 34 | 50 | 743 | 431 | 1,975 |
| Coho Juveniles | 29 | 0 | 26 | 435 | 312 | 4 | 10 | 102 |
| Coho Smolts | 209 | 0 | 1,283 | 3,517 | 14 | 139 | 193 | 141 |
| Cutthroat Juveniles | 3 | 2 | 2 | 1 | 1 | 12 | 2 | 2 |
| Cutthroat Smolts | 0 | 0 | 5 | 6 | 0 | 7 | 10 | 4 |
| Cutthroat Adults | 4 | 9 | 0 | 1 | 0 | 5 | 0 | 3 |
| Long Nose Dace | 0 | 0 | 2 | 822 | 0 | 4 | 961 | 437 |
| Speckled Dace | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Lamprey Ammocoetes | 0 | 0 | 0 | 74 | 0 | 1 | 1 | 797 |
| Pacific Lamprey Adults | 0 | 0 | 0 | 13 | 0 | 0 | 2 | 0 |
| Northern Pikeminnow | 0 | 16 | 0 | 0 | 0 | 0 | 2 | 0 |
| Rainbow Trout | 16 | 39 | 17 | 3 | 0 | 17 | 0 | 4 |
| Sucker | 0 | 0 | 0 | 0 | 0 | 0 | 41 | 4 |
| Sculpin | 9 | 0 | 3 | 6 | 0 | 3 | 51 | 183 |
| Steelhead Fry[b] | 0 | 2 | 0 | 20 | 5 | 242 | 97 | 470 |
| Steelhead Juvenile | 120 | 20 | 120 | 326 | 5 | 82 | 124 | 96 |
| Steelhead Smolt | 36 | 5 | 187 | 487 | 13 | 214 | 1,236 | 67 |
| Steelhead Adult | 1 | 0 | 1 | 1 | 0 | 1 | 2 | 1 |
| Whitefish | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

[a]A number of fry were noted in the Cedar Creek trap as "trout fry", but were not identified to species.

[b]Chinook, coho, and steelhead fry were too numerous to identify individually in the Salmon River, Bull Run, Little Sandy, and Gordon Creek. Fry were subsampled and the ratios applied to the unidentified fry.





## Appendix G

# Sandy River Delta Turtle Survey and Relocation

# 2013

April 2014

John Deshler, Portland Water Bureau

Photo (left) credits: John Deshler, PWB.

Photo (right) credits: John Deshler, PWB.

# Contents

# 1. Summary

In 2013, the U.S. Army Corps of Engineers, the U.S. Forest Service, and the Portland Water Bureau (PWB) cooperated in an ecosystem restoration project at the Sandy River Delta that included dam removal and the dredging of the historical river channel. PWB contributed funds for the removal of the dam as required in the Bull Run Water Supply Habitat Conservation Plan (HCP) Measure H-8—Sandy 1 Reestablishment of River Mouth (Portland Water Bureau 2008). As part of the HCP, PWB also committed to the capture and relocation of native turtles in order to reduce injury or mortality that might result from the removal of the dam or dredging activities. PWB also agreed to relocate native amphibians captured during fish and turtle salvage efforts (see HCP Measure H-10—Turtle Survey and Relocation).

In July and August 2013, turtles were trapped during a total of 41 trap nights. There were 45 captures and 9 recaptures. The western painted turtle, an Oregon sensitive species, was the only turtle species observed or captured. From 24 to 36 individual turtles were captured and relocated. The exact number of individual turtles captured and relocated could not be determined because not all turtles were marked prior to release and some marks were probably lost. In addition, 22 northern red-legged frogs and 13 Pacific tree frogs were relocated away from construction and dredging operations.

# 2. Introduction

## 2.1 Background

In the 1930s, a dam was constructed at the Sandy River delta in an attempt to provide a deeper channel for migrating salmonids and smelt entering the Sandy River on their way spawning grounds (U.S. Army Corps of Engineers [the Corps] 2013). In 2013 the Corps, the U.S. Forest Service, and the Portland Water Bureau (PWB) cooperated in an ecosystem restoration project at the Sandy River delta. For the project, the delta dam was removed and approximately one mile of the historical channel was dredged in order to improve habitat for salmonid fish species. As part of the restoration project, PWB agreed to capture and relocate native turtles in order to reduce instances of injury or mortality that might result from dam removal or dredging activities (see HCP Measure H-10).

Oregon's two native turtle species, the western painted turtle *(Chrysemys picta bellii)* and the northwestern pond turtle *(Emy [= Clemmys] marmorata marmorata)* are sensitive species in Oregon (Oregon Department of Fish and Wildlife [ODFW] 2008). Only western painted turtles were known to inhabit the site (Robin Dobson, U.S. Forest Service, and Laura Guderyahn, City of Gresham, personal communications).

The Sandy River delta historical channel has provided habitat for native threatened and endangered salmonid fish, at least in some seasons when flows and temperatures are conducive to their presence and survival (Portland Water Bureau 2008). The Oregon Department of Fish and Wildlife agreed to salvage native fish at the site prior to dam removal.

Native amphibians, including the northern red-legged frog *(Rana aurora)*—another Oregon sensitive species—also inhabit the Sandy River delta (Oregon Department of Fish and Wildlife 2008). As with the native turtles, native amphibians were at risk of injury and mortality from construction and dredging activities at the site. PWB agreed to relocate native amphibians when they were captured during fish salvage efforts that were conducted by ODFW and when they were captured during turtle relocation efforts.

## 2.2 Goals and Objectives

The goals of the turtle survey and relocation project were the following:

- Reduce injuries and mortalities among native turtles during construction and dredging
- Reduce injuries and mortalities among native amphibians when they were captured during fish and turtle salvage efforts

## 2.3 Site

The Sandy River delta lies at the confluence of the Sandy and Columbia Rivers, north of Interstate 84 near Troutdale, Oregon (Figure 1). The historical river channel is approximately one mile long, and is east of the main stem Sandy River. The project site included an on-site relocation pond south of the historical channel and a staging area for equipment and materials. As the project progressed, turtles were relocated to another site, Company Lake, west of the mouth of the Sandy River.

# 3. Methods

In April 2013, PWB held an on-site meeting with representatives of the cooperating agencies, regional experts in turtle ecology, and an ecologist who had in-depth knowledge of the geology, hydrology, flora, and prior restoration actions at the site. The meeting was held to determine the field methods for turtle and amphibian capture and relocation efforts. Steve Helm, Environmental Manager for the Corps attended. The regional turtle experts included Laura Guderyahn (Watershed Restoration Coordinator, City of Gresham), Susan Barnes (Conservation Biologist, Oregon Department of Fish and Wildlife), Liz Ruther (Habitat Conservation Biologist, ODFW), and Sarah Wilson (Mitigation Site Specialist, Port of Portland). Robin Dobson (Ecologist, U.S. Forest Service) provided in-depth information about the ecology of the site.

Several techniques were used for the turtle salvage and relocation efforts in July and August. In July, PWB coordinated a turtle nest survey and a basking survey. In July and August, turtles were captured and relocated using equipment and methods provided by Laura Guderyahn. PWB's Wildlife Biologist, John Deshler, coordinated the turtle surveys and the capture and relocation effort.

## 3.1 Turtle Nest Survey and Basking Survey

A survey for turtle nests was conducted on July 12, 2013 by John Deshler and Sarah Wilson. During the survey, areas were selected and explored that were within the zone of disturbance by construction and dredging activities and deemed suitable for turtle nesting. An area was deemed suitable for turtle nesting if it (1) was likely to receive adequate sunlight to warm a nest, (2) appeared to be above mean high water, (3) had at least one relatively unimpeded path to water, and (4) had soil that was suitable for excavation during the season of nest creation. During the nest survey, the ground was examined for evidence that a nest had been created and covered over by the nesting female, excavated and destroyed by a predator (i.e., egg shell remnants present), or opened by hatched turtles. The areas surveyed for turtle nests included the dam, the staging area, and the channel access for heavy equipment (see Figure 1).

A survey for basking turtles was conducted on July 24, 2013, prior to dredging and dam removal, to confirm the presence of native turtles at the site and determine the best locations to conduct trapping. PWB's wildlife biologist and regional turtle experts Laura Guderyahn, Susan Barnes, and Sarah Wilson participated in the survey. The entire length of the historical channel was surveyed from the shoreline using binoculars.

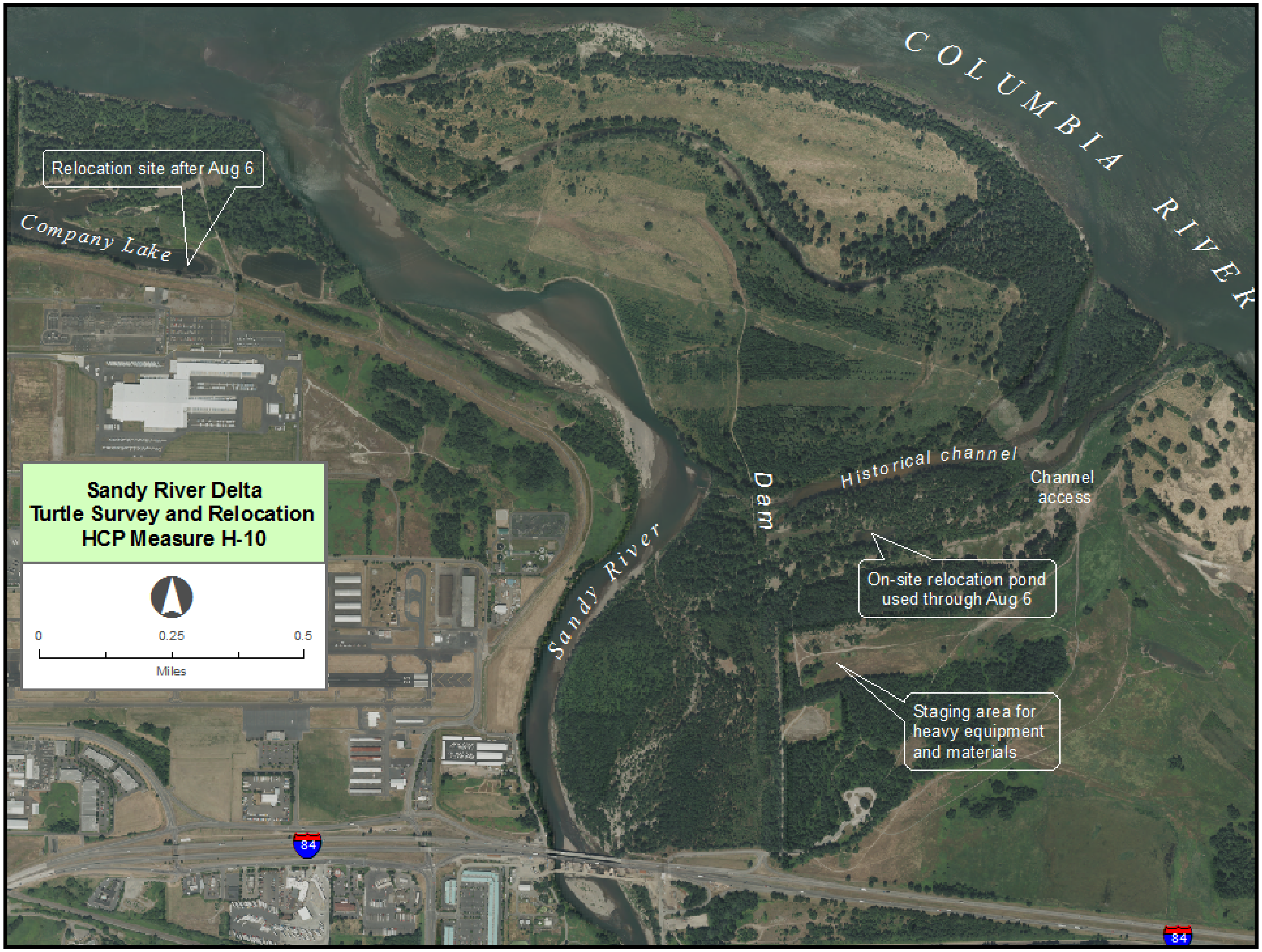



**Figure 1. The Sandy River delta site where western painted turtles were captured at the historical channel and relocated to an on-site relocation pond and Company Lake**

## 3.2 Relocation Site Selection

The goal of relocation was to move turtles to suitable habitat that was near the Sandy River buttt was far enough away to prevent rapid return to the historical channel. An on-site relocation pond was initially selected by regional turtle experts and the representatives of the cooperating agencies (see Figure 1). The relocation pond was approximately 0.1 mile south of the historical channel. The amount of water, sunlight, and forage at the pond appeared to be highly suitable for turtles. The distance and vegetative barriers between the pond and the historical channel were deemed sufficient to prevent rapid dispersal back to the historical channel.

During the course of the capture and relocation project it became apparent that turtles could quickly travel back to the construction area and an alternative relocation site was needed. All turtles captured after August 6th were relocated to Company Lake, a Port of Portland restoration site west of the Sandy River main channel (see Figures 1 and 2).

**Figure 2. PWB staff Maile Uchida releases a marked turtle at Company Lake.**

## 3.3 Turtle Capture and Relocation

Turtles were captured in the historical river channel and relocated either to the on-site relocation pond or to Company Lake.

Trapping was conducted using an adaptive approach that considered the schedule of construction and dredging activities for the ecosystem restoration project, previous trapping success, fluctuating water levels, and the recapture of marked turtles. Trapping was begun after the channel had been sufficiently dewatered to allow an excavator to move into the channel. The intent was to allow turtles to voluntarily leave the channel as water levels dropped and to seek out suitable habitat for themselves, rather than be trapped and relocated. Initially, dredging was started near the channel access point. Dredging progressed east to west toward the dam over many days, allowing trapping to occur away from construction activities. Once dredging and dam removal were started, water levels fluctuated and only about half of the pools held sufficient water to allow trapping. Dredging was then done from the channel access point toward the mouth of the historical channel

Turtles were captured using baited hoop traps (see Figure 3). Each trap was six feet long by three feet in diameter with one-inch nylon mesh netting. When set, each trap was baited with one freshly opened tin of sardines and one can of cat food and placed in water that was at least two feet deep. In one instance, turtles in a very shallow pond near the dam were captured by hand and with nets by the on-site construction crew.


**Figure 3. City of Gresham staff Laura Guderyahn and PWB staff John Deshler capture turtles at the historical channel of the Sandy River delta, August 2013.**

Once captured, turtles were placed in high-sided, heavy-duty, round plastic buckets with a small amount of water and no lid (see Figure 4).

Turtles that were captured on the first day of trapping were not marked. All turtles captured after the first day were marked with Wite-Out® that covered a circle approximately ¾ inch in diameter on the anterior half of the dorsal carapace. When previously marked turtles were recaptured, a fresh mark was applied.

The trapping effort was measured in terms of trap nights (e.g., 3 traps set for 1 calendar night = 3 trap nights).

Turtles were taken to the relocation site and released unharmed within 24 hours of capture, typically within 1 hour of being removed from a trap.

**Figure 4. Western painted turtles that have been marked and placed in a bucket prior to release**

## 3.4 Amphibian Capture and Relocation

PWB agreed to relocate native amphibians when they were captured in seine nets used during fish salvage efforts by ODFW and when they were captured in turtle nets. In addition, turtle capture field crews occasionally used their hands and hand nets to capture amphibians. Captured amphibians were placed in buckets with a small amount of water and relocated to the designated relocation site. The buckets had 18-inch-high sides and lids to prevent frogs from escaping.

# 4. Results

## 4.1 Turtle Nest Survey and Basking Survey

No turtle nests were located during the nest survey. During the basking survey, three western painted turtles were observed basking on logs in the historical channel, west of the channel access point.

## 4.2 Turtle Capture and Relocation

From July 29 through August 21, 2013, turtles were trapped for a total of 41 trap nights. There were 45 captures and 9 recaptures (see Table 1 for details of trapping effort and release locations). The number of turtles that were captured ranged from 24 to 36. The low value of the range is based on the 24 turtles that were taken to Company Lake. None of these were recaptured. The high value of the range (36) includes the 24 relocated to Company Lake, plus the maximum of 18 turtles released at the on-site relocation pond minus the 6 recaptures taken to Company Lake. The exact number of individual turtles captured could not be determined, because (1) not all turtles were marked upon release, and (2) the marks on some recaptured turtles were badly faded indicating that some other turtles may have completely lost their marks and been missed as recaptures. The western painted turtle was the only turtle species captured. The 18 western painted turtles (hereafter "turtles") captured in the historical channel from July 29 through August 6 were relocated to the on-site relocation pond. Because the first marked turtles that had been relocated to the on-site relocation pond returned to the channel that was under construction within just one week, a new relocation site was selected. All 24 turtles captured after August 6 were relocated to Company Lake (see Figure 1), which was much further away from the construction activities and the historical Sandy River channel.

Continued dewatering of the historical channel during late July and early August also caused the water level of the relocation pond to drop. In response to these changing water levels and turtles returning to the channel, trapping was conducted at the on-site relocation pond in an effort to move turtles from there to Company Lake.

**Table 1. Details from the Capture and Relocation of Western Painted Turtles at the Sandy River Delta, July 29 through August 21, 2013**

| | | | | TRAP INFORMATION | | | | TURTLE CAPTURE INFORMATION | | | | | | | | | | | RELEASE INFORMATION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | # Traps | | | | # Turtles | | | Age class | | | Sex | | | Capture | | # Turtles | | Release | |
| # | Date | Action | Surveyor[a] | Set | Checked | Removed | Location | Total | Previously marked | Mortalities | Adults | Subadults | Not recorded | Female | Male | Unspecified | Time | Location | Released Alive | Marked on release | Time | Location |
| 1 | 07-29 | Set traps | JD,LG,SB | 6 | | | Historical channel | | | | | | | | | | | | | | | |
| 2 | 07-30 | Check and set | JD,LG,SB | 6 | 6 | | Historical channel | 6 | | 0 | 6 | | | 1 | 1 | 4 | 9:00–10:00 | Historical channel | 6 | 0 | 10:45 | On-site relocation pond |
| 3 | 07-31 | Check, remove | LG,SB, SW | | 6 | 6 | Historical channel | 10 | | 0 | 9 | 1 | | 7 | 2 | 1 | 8:00–10:00 | Historical channel | 10 | 10 | 10:30 | On-site relocation pond |
| 4 | 08-05 | Set traps | JD,LG | 5 | | | Historical channel | | | | | | | | | | | | | | | |
| 5 | 08-06 | Check and set | JD,LG,AK, SB | 5 | 5 | | Historical channel | 5 | 3 | 0 | 5 | | | 3 | 2 | | 10:00–11:00 | Historical channel | 5 | 5 | 11:30 | On-site relocation pond |
| 6 | 08-07 | Check and set | LG,SB | 5 | 5 | | Historical channel | 3 | 1 | 0 | 3 | | | 3 | | | 9:00–10:00 | Historical channel | 3 | 3 | 10:30 | Company Lake |
| 7 | 08-08 | Check and set | JD,MU | 2 | 5 | 1 | Historical channel | 5 | 2 | 0 | 5 | | | 3 | 2 | | 9:30–10:30 | Historical channel | 5 | 5 | 11:00 | Company Lake |
| | | | | 2 | | | On-site relocation pond | | | | | | | | | | | | | | | |
| 8 | 08-09 | Check, remove | JD,MU | | 2 | 2 | Historical channel | 1 | | 0 | 1 | | | | | 1 | 9:30–10:00 | Historical channel | 1 | 1 | 10:30 | Company Lake |
| | | | | | 2 | 2 | On-site relocation pond | 0 | | | | | | | | | | | | | | |
| 9 | 08-13 | Set traps | JD,MU | 2 | | | Historical channel | | | | | | | | | | | | | | | |

**Table 1. Details from the Capture and Relocation of Western Painted Turtles at the Sandy River Delta, July 29 through August 21, 2013**

| | | | | TRAP INFORMATION | | | | TURTLE CAPTURE INFORMATION | | | | | | | | | | | RELEASE INFORMATION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | # Traps | | | | # Turtles | | | Age class | | | Sex | | | Capture | | # Turtles | | Release | |
| # | Date | Action | Surveyor[a] | Set | Checked | Removed | Location | Total | Previously marked | Mortalities | Adults | Subadults | Not recorded | Female | Male | Unspecified | Time | Location | Released Alive | Marked on release | Time | Location |
| | | | | 2 | | | On-site relocation pond | | | | | | | | | | | | | | | |
| 10 | 08-14 | Check, remove | JD,SW | | 2 | 2 | Historical channel | 4 | 3 | 0 | 4 | | | | | 4 | 9:00–9:30 | Historical channel | 4 | 4 | | Company Lake |
| | | | | | 2 | 2 | On-site relocation pond | 6 | | 0 | 3 | 3 | 0 | | 1 | 5 | 9:30–10:00 | On-site relocation pond | 6 | 6 | | Company Lake |
| 11 | 08-15 | Set traps | JD | 2 | | | On-site relocation pond | | | | | | | | | | | | | | | |
| 12 | 08-16 | Check, remove | JD | | 2 | 2 | On-site relocation pond | 0 | | | | | | | | | | | | | | |
| 13 | 08-19 | Net capture, release | LKE staff, JD | 0 | 0 | 0 | | 5 | | 0 | 2 | 3 | 0 | | | 5 | 9:00 & 15:00 | Near the dam | 4 | 4 | 16:00 | Company Lake |
| 14 | 08-20 | Release and set | JD | 4 | | | Historical channel | | | | | | | | | | 17:00 on 8/19 | Historical channel | 1 | 1 | 10:00 | Company Lake |
| 15 | 08-21 | Check, remove | JD | | 4 | 4 | Historical channel | 0 | | | | | | | | | | | | | | |
| | | | **Totals** | **41** | | | | **45** | **9** | **0** | **38** | **7** | **0** | **17** | **8** | **20** | | | **45** | **39** | | |

[a]Surveyor: JD=John Deshler (Wildlife Biologist, City of Portland), LG=Laura Guderyahn (Watershed Restoration Coordinator, City of Gresham), SB=Susan Barnes (Conservation Biologist, Oregon Department of Fish and Wildlife), SW= Sarah Wilson (Mitigation Site Specialist, Port of Portland), MU= Maile Uchida (Invasive Species Program Intern, City of Portland), AK=Angie Kimpo (Invasive Species Program Coordinator, City of Portland), and LKE=LKE Construction Corporation.

## 4.3 Amphibian Capture and Relocation

Twenty-two northern red-legged frogs and 13 Pacific tree frogs *(Psuedacris regilla)* were captured and relocated. Captured frogs were relocated to either the on-site relocation pond or Company Lake (see Table 2 for details of amphibian salvage). No native amphibians were captured during fish salvage efforts by ODFW or in turtle nets during turtle salvage efforts.

**Table 2. Results from Capture and Relocation of Amphibians at the Sandy River Delta, July 29 through August 21, 2013**

| Capture Date | Species | Life Stage | Capture Site | Release Site | Number Released Alive | Number of Mortalities / Transfers |
|---|---|---|---|---|---|---|
| 08-01 | *Rana aurora* | Adults (15) | Sandy River Delta | Onsite relocation pond | 15 | 0 |
| 08-01 | *Pseudacris regilla* | Adults (6), Subadults (7) | Sandy River Delta | Onsite relocation pond | 13 | 0 |
| 08-08 | *Rana aurora* | Adults (2) | Sandy River Delta | Company Lake | 2 | 0 |
| 08-13 | *Rana aurora* | Adults (1) | Sandy River Delta | Company Lake | 1 | 0 |
| 08-14 | *Rana aurora* | Adults (4) | Sandy River Delta | Company Lake | 4 | 0 |
| **Totals** | | **35** | | | **35** | |

# 5. Discussion

## 5.1 Turtle Nest Survey and Basking Survey

Although no nests were found during PWB's nest survey, western painted turtles were known to breed at the Sandy River delta site (Robin Dobson and Laura Guderyahn, personal communication). Some areas of the delta that were suitable for nesting were not surveyed because they were outside of the area impacted by dam removal and dredging activities.

## 5.2 Relocation Site Selection

The barriers of distance and vegetation between the on-site relocation pond and the historical channel did not prevent relocated turtles from rapidly returning to the channel. The upland habitat that separates them is dominated by black cottonwood trees (*Populus trichocarpa)* and densely vegetated with reed canarygrass *(Phalaris arundinacea)* as well as a diversity of other plants. The turtles were nevertheless able to navigate through the wide maze of reed canarygrass stems and other barriers and return to the channel, sometimes within one week.

## 5.3 Turtle Capture and Relocation

Turtle trapping studies in the region show that the number of turtles observed during basking surveys may represent approximately 10 percent of the total number of turtles at a given site (Laura Guderyahn, personal communication). Based on that information and the fact that three turtles were observed during the basking survey, the expected number of turtles using the historical channel was approximately 30. The range of western painted turtles captured (24 to 36) was in general agreement with the expected number present (30).

## 5.4 Amphibian Capture and Relocation

Amphibian salvage was coordinated with seine netting efforts by ODFW for the salvage of native fish. ODFW only conducted fish salvage efforts for one day because it determined (1) that the channel temperatures were too warm in July and August to support native salmonid fish, and (2) there were thousands of nonnative warm-water fish species, but no native fish. No amphibians were captured during the fish salvage effort.

The native frogs that were relocated during PWB amphibian salvage efforts at the Sandy River delta were collected at the channel access point (see Figure 1) and near the boundary of forested uplands and the historical channel. Native frogs appeared to be mostly absent from the historical channel water body. Native frogs were, however, locally common in small pools near the dam, in wetlands vegetation near the channel access point, and in upland forested habitats adjacent to water. Most of the small pools were not affected by the heavy equipment during construction activities, so frogs in those pools were not targeted for relocation.

Within the historical channel, adult and juvenile American bullfrogs *(Lithobates catesbeianus)*, a nonnative species, were abundant. The presence of these large frogs may have limited the number of native amphibian species using the channel.

# 6. Findings, Conclusions, and Recommendations

## 6.1 Relocation Site Selection

The on-site relocation pond was ultimately determined to be less than ideal for the release of turtles. Turtles quickly left the on-site relocation pond and at least half of them returned to the historical channel, which is approximately 0.1 mile away. Six of the 12 marked turtles captured in the historical channel from July 29 through August 6 were later recaptured back at the historical channel with their marks still intact. On August 14 turtles were trapped in the on-site relocation pond in order to relocate them to Company Lake. None of the six turtles captured there had been previously marked. These results suggested that most or all of the 18 turtles may have already dispersed from the on-site relocation pond prior to attempts to capture them there and relocate them to Company Lake. Trapping on August 15 and 16 at the relocation pond resulted in no captures, suggesting that few or no turtles remained in the relocation pond less than two weeks after turtles had last been released there.

It is recommended that future turtle salvage projects consider the high degree of site fidelity by turtles when choosing a relocation site. Suitable turtle habitat at a relocation site may not result in retention of relocated turtles, even in the short term. Thick vegetation may not prevent dispersal, and seemingly long distances may be quickly traveled by turtles that are determined to return to familiar areas.

## 6.2 Turtle Capture and Relocation

The hoop traps were effective for capturing and recapturing turtles. Turtles were captured on the first night of trapping and did not appear to avoid traps even after being captured (6 of the 12 turtles that were marked and released at the on-site relocation pond were later recaptured with marks still visible).

There was one exception to the effectiveness of the traps. Captured turtles, or perhaps other incidentally captured wildlife, appeared to be able to chew through the mesh netting, especially in spots where the mesh was well worn. On August 13, traps were checked at the on-site relocation pond and were found to have relatively large openings (approximately 8" x 8") in the mesh. No turtles were captured in those traps on that night. Well-maintained mesh netting appeared to be one additional key to consistent captures.

# 7. 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.

Oregon Department of Fish and Wildlife. 2008. Oregon Department of Fish and Wildlife Sensitive Species List organized by category. Oregon Department of Fish and Wildlife, Salem, Oregon.

U.S. Army Corps of Engineers. 2013. Environmental Assessment, Sandy River Delta Section 536 Ecosystem Restoration Project, Multnomah County, Oregon. A technical report by the U.S. Army Corps of Engineers, Portland District.

## Appendix H. Correspondence on Measure Adjustments

*Note: Each item includes two pieces of correspondence: a letter from the Portland Water Bureau (PWB) to the National Marine Fisheries Service (NMFS) requesting authorization and the NMFS response granting authorization. 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 Past Compliance Reports

**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

**Correspondence for the Current Compliance Year**

**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

PORTLAND WATER BUREAU
FROM FOREST TO FAUCET

**Randy Leonard, Commissioner**
David G. Shaff, Administrator

1120 SW 5th Avenue, Room 600
Portland, Oregon 97204-1926
Information: 503-823-7404
www.portlandonline.com/water

*An Equal Opportunity Employer*

April 2, 2013

Ben Meyer
National Marine Fisheries Service
1201 NE Lloyd Blvd., Ste. 1100
Portland, OR 97232

Re: Clarification of Bull Run Water Supply Habitat Conservation Plan Measure R-2—Cutthroat Trout Rescue

Dear Ben:

The City of Portland's (City) would like to discontinue the implementation of Measure R-2—Cutthroat Trout Rescue, which is one of the Bull Run Water Supply Habitat Conservation Plan (HCP) conservation measures. The City does not believe that the measure is necessary for the protection of resident cutthroat trout in Bull Run Reservoir No. 2. The City would like the National Marine Fisheries Service (NMFS) to consider the City's proposal.

Under Measure R-2, the City committed to annually removing cutthroat trout from the Bull Run Dam 2 spillway approach canal to prevent mortality due to elevated summer water temperatures. The City has been implementing the measure for three years and has used a variety of approaches to rescue the fish. For the last two years, Oregon Department of Fish and Wildlife (ODFW) has worked with the City to remove the cutthroat. ODFW provided their very skilled crew and boat to electrofish the approach canal. After electrofishing the entire canal, City staff snorkeled the relatively shallow canal to see if any fish escaped.

The cutthroat removal techniques have been quite effective but there have been very small numbers of cutthroat in the canal to rescue. For 2010, 2011, and 2012, the City and ODFW captured 11, 16, and 1 fish, respectively. The live fish were released into Bull Run Reservoir No. 2 and one fish died from handling over the 3-year period. For those same years, the City observed 0, 2, and 0 cutthroat still in the canal after the fish removal. Based on these very low numbers, the City believes that the cutthroat trout rescue is not necessary to protect the viability of the reservoir population and, in fact, may elevate the stress on the few fish that are in the approach canal. For those reasons, the City would prefer not to continue to implement that measure in the future.

In the cutthroat trout rescue measure description, it indicates that if the City does not continue implementing the measure the measure funding will be allocated to other habitat conservation measures according to the adaptive management process described in the HCP. For this measure, there have been minimal costs because ODFW volunteered their staff resources and the City used little staff time to support the effort. So, there is very little funding to apply to other habitat conservation measures. The City proposes not to pursue other actions if the trout rescue is discontinued.

Please very (via letter) that the City's approach is appropriate.

Sincerely,

Steve Kucas
Environmental Compliance Program Manager

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

**Refer to NMFS No.:**
**NWR-2008-3771**

April 26, 2013

Steve Kucas
Senior Environmental Program Manager
City of Portland Water Bureau
1120 SW 5th Avenue, Room 600
Portland, Oregon 97204-1926

Re: Clarification of Bull Run Water Supply Habitat Conservation Plan. Measure R-2 Cutthroat Trout Rescue

Dear Mr. Kucas:

On April 5, 2013, the National Marine Fisheries Service (NMFS) received a letter from you requesting concurrence on an issue relative to the Bull Run Water Supply Habitat Conservation Plan (HCP). Specifically, if NMFS agrees with discontinuing cutthroat trout rescue efforts in the Dam 2 spillway approach canal. The City has implemented the procedure for three years with very few fish being captured and no or only a couple of fish left in the canal after removal efforts ceased. NMFS has reviewed the request and believe it fits within the parameters of the HCP and agrees with your proposal due to the limited amount of fish that appear to be utilizing the approach canal.

Please direct questions regarding this letter to Ben Meyer, Chief of the Willamette Basin/Lower Columbia Branch of the Oregon State Habitat Office, at 503.230.5425.

Sincerely,

for Michael P. Tehan
Assistant Regional Administrator
Habitat Conservation Division

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

August 6, 2013

Marc Liverman
National Marine Fisheries Services
1201 NE Lloyd Blvd., Ste. 1100
Portland, OR 97232

RE: Clarification of Bull Run Water Supply Habitat Conservation Plan Measures H-25 Salmon 2 Carcass Placement and H-29 Zigzag 1A/1B/1C Carcass Placement

Dear Marc:

I would like your affirmation about the implementation of two of the Bull Run Water Supply Habitat Conservation Plan (HCP) conservation measures.

The City of Portland (Portland) currently has financial capacity to accelerate the implementation of two of its HCP commitments to place salmon carcasses to benefit fish, and it would like NMFS to consider allowing salmon carcass placement to occur in stream reaches other than those specified in the HCP. Per the HCP, Portland committed to implement Measure H-25 Salmon 2 Carcass Placement and Measure H-29 Zigzag 1A/1B/1C Carcass Placement between 2015-2019 and 2020-2024, respectively. For both of these carcass placement measures, Portland committed to provide funding for one season to place approximately 1,800 salmon carcasses. Since Portland is committed to provide funding for only one year of carcass placements in those stream reaches, it did not assume that there were any quantifiable fisheries benefits for those measures and none were indicated in the HCP. Portland committed to those measures to support other on-going carcass placement efforts in the Sandy River Basin.

Portland is planning the carcass placement measures in consultation with members of the Sandy River Basin Partners (Partners). Portland would be contributing funding to the Sandy River Basin Watershed Council, a member of the Partners that has traditionally led carcass placement efforts in the Sandy Basin. Members of the Partners have determined that Clear Fork, Clear Creek, Still Creek, Lost Creek, and Camp Creek would be more appropriate streams to benefit from the carcass placements. The City would like permission to fund carcass placements in those streams instead of stream reaches Salmon 2 and Zigzag 1A/1B/1C. If NMFS allows Portland to support fish carcass placement per the direction of the Partners, it will still meet the goal of placing a total of 3,600 salmon carcasses (at 300 carcasses per mile) in the other stream reaches, which is the commitment expressed in HCP measures H-25 and H-29.

The Sandy River Basin Watershed Council will implement the salmon carcass measures in 2013-2016, in cooperation with the Oregon Department of Fish and Wildlife and US Forest Service. Timing will be based on the availability of carcasses and other considerations.

Marc, please verify that these modifications are acceptable to NMFS.

Sincerely,

Steve Kucas
Environmental Compliance Manager

**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
Portland, OR 97232

**Refer to NMFS No.:**
**NWR-2008-3771**

December 3, 2013

Steve Kucas
Environmental Compliance Manger
City of Portland Water Bureau
1120 SW 5th Avenue, Room 600
Portland, Oregon 97204-1926

Re: Clarification of Bull Run Water Supply Habitat Conservation Plan: Measures H-25 – Salmon 2 Carcass Placement and H-29 – Zigzag 1A, 1B, and 1C Carcass Placement

Dear Mr. Kucas:

On August 8, 2013, the National Marine Fisheries Service (NMFS) received your letter requesting our confirmation that a proposal by the City of Portland (City) to substitute different stream reaches for salmon carcass placement as part of the above-named conservation measures is consistent with the Bull Run Water Supply Habitat Conservation Plan (HCP) (2008).

Based on information in your letter and the HCP including, specifically, the facts that:

- In the HCP, the City agreed to a conservation measures based on a one-time payment to place 1,800 salmon carcasses in identified reaches of the Salmon and Zigzag Rivers.
- The HCP allows the City to provide substitute measures on a case-by-case basis when, for example, other measures may be more effective.
- The Sandy River Basin Partners, including NMFS, identified 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 and Zigzag Rivers described in the HCP.
- The City will carry out all other conservation measures as described in the HCP.

Therefore I affirm that the proposed substitution is consistent with the HCP.

Please direct questions regarding this letter to Marc Liverman, Willamette Habitat Branch Chief, at 503-231-2336.

Sincerely,

Marc Liverman for

Kim W. Kratz, Ph.D.
Assistant Regional Administrator
Oregon/Washington Coastal Area Office