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Bonneville Dam Powerhouse 2 Gatewell Improvement Post Construction Evaluation

Final Report

April 2025

Ryan A Harnish
Kenneth D Ham
Robert P Mueller

U.S. DEPARTMENT of ENERGY

Prepared for the U.S. Department of Energy
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Abstract

Modifications to vertical barrier screens (VBS) and the addition of concrete corbels to improve passage conditions for juvenile salmonids in the gatewells of Bonneville Dam's second powerhouse (B2) were completed before the 2024 passage season. To evaluate the effectiveness of those modifications, PNNL carried out a post-construction evaluation to contrast fish condition and mortality between the two turbine unit operational ranges within the peak efficiency range. A block-treatment study design was implemented in 2024 to contrast descaling and mortality of juvenile salmonids sampled in the juvenile monitoring facility following exposure to turbine operations (middle versus upper 1% peak efficiency range) during spring and summer passage periods. In spring, 1.96% of juvenile salmonids sampled during Mid_1% treatment operations were descaled, and 0.46% were mortalities. Due to factors unrelated to the study, most (65%) turbine unit flows during the designated Upper_1% treatment in spring were above the current upper 1% efficiency limit, so the spring Upper_1% treatment was renamed "Above_1%". Of those sampled during Above_1% treatment operations in spring, 2.90% were descaled and 0.95% were mortalities. Descaling rates were significantly higher for fish sampled in spring during the Above_1% treatment compared to the Mid_1% treatment. Differences in mortality between treatments were not statistically significant during the spring study period. During the summer study period, 0.99% of juveniles sampled during Mid_1% treatment operations were descaled, and 0.33% suffered mortality; these rates were significantly lower than the descaling (2.80%) and mortality (1.73%) rates observed during Upper_1% treatment operations. Comparing the results from the 2024 study to those from the historical (2008–2013) baseline of unmodified units revealed that the descaling and mortality rates observed during Above_1% treatment operations in spring 2024 were near the upper end of the historic range observed for mid 1% operations. Spring 2024 Above_1% descaling and mortality rates were below, or well below, the median of historical mid and upper 1% (combined) rates. This suggests that the modifications have had a positive effect, even though turbine unit flows were higher than planned during the spring study period. Summer 2024 Upper_1% descaling and mortality rates were at or above the top of the historical mid 1% range and above the median of historical mid and upper 1% (combined) rates. It is important to keep in mind that 2024 is a single year when considering these comparisons of 2024 descaling and mortality rates to those from past years.

Summary

A post-construction evaluation of structural modifications made in the gatewells of the Bonneville Dam (BON) Powerhouse 2 (B2) was implemented in 2024 to evaluate the effectiveness of the modifications at improving fish passage conditions. Objectives of the evaluation included: 1) create a timeline of gatewell modifications and operations to establish historical points of comparison for modified vs. unmodified gatewells, 2) estimate and compare descaling and mortality percentages for juvenile salmonids sampled in the BON juvenile fish monitoring facility (JMF) as part of the smolt monitoring program (SMP) during turbine unit operations in the middle and upper end of the 1% peak efficiency range in spring and summer, and 3) conduct a pilot-scale effort to evaluate run-of-river juvenile salmonid vertical barrier screen (VBS) impingement during mid and upper 1% peak efficiency range operations.

A timeline of B2 gatewell modifications and operations from 2001–2023 indicated that before the VBS porosity modifications and installation of flow control plates, which began with prototypes in 2014, most structural and operational changes affecting B2 fish guidance efficiency were completed before 2008. Therefore, the historical period of performance established for comparison of modified units (2024) to unmodified units included smolt migration years 2008–2013. Although historical operations were too variable to fit strict operational criteria, loosened approximate operational bins were created to compare descaling and mortality in SMP samples exposed to conditions that were primarily mid 1% or mid and upper 1%.

A block-treatment study was implemented at B2 during the spring and summer smolt passage periods to estimate and compare descaling and mortality of juvenile salmonids that passed through B2 gatewells during turbine unit operations in the mid and upper 1% peak efficiency range. Within each block, fish passing through B2 gatewells were exposed to each treatment (i.e., Mid_1% or Upper_1%). Treatment flow ranges (Mid_1% or Upper_1%) were imposed for all operating B2 units in the time leading up to an SMP sampling event for each designated treatment. During the Upper_1% treatment, all operating B2 units were to operate below but within 500 cfs of the 1% upper limit, which ranges from 15.4–17.9 kcfs depending on project head, as defined in Table BON-15 of the Fish Passage Plan (FPP). During the Mid_1% treatment, all operating B2 units were to operate within the mid-range as defined in the FPP (i.e., 13–15 kcfs). Fish that passed during each treatment of each block were collected over a 24-hour period in the JMF, where they were sampled for descaling and mortality as part of the standard SMP sampling.

The block-treatment study design was designed to produce ten 24-hour SMP samples during each Mid_1% and Upper_1% treatment during spring and nine 24-hour SMP samples during each Mid_1% and Upper_1% treatment during summer. The transition from the spring to summer study periods was intended to align with the transition of the SMP samples from being primarily dominated by yearling Chinook salmon to subyearling Chinook salmon. However, the transition of the SMP sample from being dominated by yearling Chinook salmon to subyearling Chinook salmon occurred earlier in 2024 compared to the historic data used to plan the study. Therefore, the transition from spring to summer study periods was shifted to reflect the species composition of the SMP samples. As such, the spring study period was reduced to eight 24-hour SMP samples during each Mid_1% and Upper_1% treatment, and the summer study period was increased to include eleven 24-hour SMP samples during each Mid_1% and Upper_1% treatment. As such, the statistical power to detect a difference in descaling and mortality rates between treatments was reduced in spring and increased in summer.

During the spring study period, unit operations during the Upper_1% treatment were above the current upper 1% limit approximately 65% of the time. This led to renaming the spring Upper_1% treatment to “Above_1%”. There were several occasions in which flows were over 500 cfs above the current upper 1% limit. It is believed that an update to the generic data acquisition and control system (GDACS) that occurred well before the spring study period caused the system to revert to the old FPP upper 1% limit table, which was in effect until spring 2022 and allowed for higher flows at the upper 1% limit. In addition, the B2 forebay elevation sensor, which is used to calculate project head and turbine unit flow, was found to be faulty in mid-May. Therefore, the BON Powerhouse 1 (B1) forebay sensor was used in its place to recalculate unit flows. This sensor change introduces relatively small inaccuracies (in most cases < 100 cfs) into the calculated turbine unit flow values and upper 1% limits for a time interval. Near the end of the spring study period, the FPP upper 1% limit table referenced by GDACS was updated to the new FPP table. As such, turbine unit operations during the summer study period more closely reflected the planned treatments.

All juvenile salmonids sampled in the JMF during each treatment and season were combined to produce spring Mid_1% descaling and mortality rates, spring Above_1% descaling and mortality rates, summer Mid_1% descaling and mortality rates, and summer Upper_1% descaling and mortality rates. Descaling and mortality rates were compared between Mid_1% and Above_1% or Upper_1% operations separately for spring and summer. Descaling and mortality rates obtained during Above_1% or Upper_1% operations in 2024 were non-statistically compared to the historic (2008–2013) distributions of descaling and mortality rates of unmodified gatewells primarily operating within the mid 1% peak efficiency range. In addition, descaling and mortality rates obtained during Mid_1%, Above_1%, and Upper_1% treatments in 2024 were non-statistically compared to the historic (2008–2013) distributions of descaling and mortality rates of unmodified gatewells primarily operating in the mid and upper 1% (combined) peak efficiency range.

During the spring study period, 1,737 and 4,421 salmonids were sampled during Mid_1% and Above_1% treatments, respectively, with similar species composition between treatments. Of those collected during the Mid_1% treatment, 1.96% were descaled and 0.46% were mortalities. Of those collected during the Above_1% treatment, 2.90% were descaled and 0.95% were mortalities. The observed difference in descaling between treatments was statistically significant ($P = 0.042$), but the difference in mortality was not significant ($P = 0.058$). The difference in mortality, which was more than twice as high during the Above_1% treatment compared to the Mid_1% treatment, was not statistically significant, even though the Above_1% treatment included conditions well outside the planned treatment range. However, as noted previously, the power to detect a significant difference was reduced for the spring study period due to a reduction in spring blocks. Because operations deviated above the upper 1% limit, additional study may be needed to evaluate descaling and mortality at upper 1% and mid 1% operations during the spring smolt outmigration.

Evaluating descaling and mortality rates over time revealed similarities between Mid_1% and Above_1% treatments through the first five spring study blocks. During blocks 6 and 7, which included SMP samples taken from 15 May through 22 May, fish collected during the Above_1% treatment experienced substantially higher rates of descaling (4.0%) and mortality (1.7%) compared to those collected during the Mid_1% treatment (descaling = 1.1%; mortality = 0.4%). The timing of the Above_1% samples collected during these blocks coincided with the dates in which the turbine unit flow levels were farthest above the upper 1% limit. Therefore, it is possible that the observed differences in descaling and mortality between treatments during these two blocks were associated with flows notably higher than the upper 1% limit.

During the collection of all summer SMP Upper_1% treatment samples, the turbine unit discharge met the operation schedule due to the correction of the GDACS table. A total of 2,415 and 3,468 salmonids were sampled during summer Mid_1% and Upper_1% treatments, respectively. Of those collected during Mid_1% operations, 0.99% were descaled and 0.33% suffered mortality. Of those collected during the Upper_1% treatment, 2.80% were descaled and 1.73% were mortalities. Both descaling and mortality were significantly higher during the Upper_1% treatment ($P < 0.001$). Because species composition was similar between treatments and operations were generally maintained within the prescribed ranges, it appears that the observed differences in descaling and mortality between treatments during the summer study period were attributed to the flow treatments.

The descaling rate observed during the Above_1% treatment in 2024 was higher than that observed in 91% of historic weeks in which B2 units primarily operated within the mid 1% range. However, the descaling rate observed during the Mid_1% treatment in 2024 was higher than 73% of the descaling rates observed during historic (2008–2013) weeks in which B2 units primarily operated in the mid 1% range. Compared to historic weeks in which B2 units operated within and above the mid 1% range, the descaling rate observed during Above_1% operations in the spring of 2024 was less than the descaling rates observed in 76% of the historic weeks, indicating a positive effect of the gatewell modifications.

The mortality rate observed during the Above_1% treatment in the spring of 2024 was higher than that observed in 100% of historic weeks in which B2 units primarily operated within the mid 1% range. Compared to historic weeks in which B2 units primarily operated within and above the mid 1% range, the mortality rate observed during Above_1% treatment operations in the spring of 2024 was less than that observed in 52% of the historic weeks.

For fish sampled during Upper_1% treatment days of the summer study period, the descaling rate was higher than that observed during 100% of the historic (2008–2013) weeks in which B2 units primarily operated within the mid 1% range. However, the descaling rate observed during the Mid_1% treatment in summer 2024 was higher than 77% of the descaling rates observed during historic weeks in which B2 units primarily operated within the mid 1% range. The summer 2024 Upper_1% descaling rate was also higher than 91% of historic weeks in which B2 units primarily operated within and above the mid 1% range.

The mortality rate observed during the Upper_1% treatment in the summer of 2024 was higher than that observed in 92% of historic weeks in which B2 units primarily operated within the mid 1% range. Compared to historic weeks in which B2 units primarily operated within and above the mid 1% range, the 2024 summer mortality rate was higher than 61% of the historic weeks.

The pilot scale evaluation of impingement using acoustic imaging sonars revealed that this methodology is ineffective for observing impingement. Due to turbulence within the gatewell and the need for imaging devices to remain steady, the imaging sonars could not be deployed at a sufficient depth to observe fish near the bottom of the VBS, where the highest velocities have been measured. Additionally, the resolution within the zone of interest was insufficient for observing impingement. Imaging sonars did reveal that fish abundance tended to be lower in C slots compared to A slots, fish were concentrated near the upper portion of the gatewells and near the upper 15 ft of the screened portion of the VBS, and fish behavior was dominated by milling behavior in C slots and more upward-directed movements in A slots.

Imaging sonar samples were supplemented by conducting spot checks of impingement using optical video cameras on three occasions during the study period. All three occasions coincided with operations generally maintained near the upper 1% limit. Only one salmonid was observed impinged during the upper 1% operations during the single spot check conducted during the spring study period, whereas nine salmonids were observed impinged during the two spot checks conducted during the summer study period. The greatest number of impinged fish was observed during late summer when subyearling Chinook salmon were smaller, indicating that fish size may be a key factor affecting impingement.

Results from the block-treatment study indicated rates of descaling and mortality were higher for fish collected during operations at or above the upper 1% limit than those collected during operations within the mid 1% range. In the spring 2024 study period, due to challenges with the software and hardware guiding operations at B2, turbine unit discharge exceeded the specified range of the upper 1% treatment 65% of the time, and the spring Upper_1% treatment was renamed "Above_1%" to reflect that. During the spring Mid_1% treatment, turbine unit operations were within the prescribed flow range 83% of the time. During the summer study period, unit operations were maintained within the prescribed treatment flow ranges for Upper_1% (83% of the time) and Mid_1% (89% of the time) treatments. Subyearling Chinook salmon, which are smaller and therefore more susceptible to impingement, dominated the SMP sample in summer when descaling and mortality rates were higher during the Upper_1% treatment than the Mid_1% treatment.

One of the goals of the most recent modifications made to the gatewells and VBS porosity was to reduce descaling and mortality rates during upper 1% operations to levels observed during mid 1% operations from 2008–2013. Although the data from this time period in which the units were operated primarily within the mid 1% range are limited, the descaling and mortality rates observed during the Above_1% treatment in spring 2024 were near the upper end of the historic range observed for mid 1% operations. Spring 2024 Above_1% descaling and mortality rates were below, or well below the median of historical mid and upper 1% (combined) rates, which suggests that the modifications have had a positive effect. Summer 2024 Upper_1% descaling and mortality rates were at or above the top of the range of historical mid 1% and historical mid and upper 1% (combined) rates for descaling. Mortality rates for 2024 Upper_1% were at the high end of the range for historical mid 1% and above the median but within the middle range of historical mid and upper 1% (combined) rates. It is important to remember that 2024 is a single year when considering these comparisons, particularly if there was a higher background level of descaling of fish before their entrance into the B2 turbine unit intakes.

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Acronyms and Abbreviations

ADV	acoustic doppler velocimetry
B1	Bonneville Dam Powerhouse 1
B2	Bonneville Dam Powerhouse 2
B2CC	Bonneville Dam Powerhouse 2 Corner Collector
BON	Bonneville Dam
cfs	cubic feet per second
DOY	day of year
El.	Elevation
FFDRWG	Fish Facility Design Review Work Group
FGE	fish guidance efficiency
FPOM	Fish Passage Operations and Maintenance
FPP	Fish Passage Plan
GDACS	generic data acquisition and control system
JBS	juvenile bypass system
JMF	juvenile monitoring facility
kcfs	kilo cubic feet per second
LOESS	locally estimated scatterplot smoothing
MW	megawatt
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NOAA	National Ocean and Atmospheric Administration
PDT	Pacific Daylight Time
PNNL	Pacific Northwest National Laboratory
PSMFC	Pacific States Marine Fisheries Commission
SCNFH	Spring Creek National Fish Hatchery
SMP	Smolt Monitoring Program
SRWG	Studies Review Working Group
STS	submersible traveling screen
TIE	turbine intake extension
TMT	Technical Management Team
TRD	turbulence reduction device
VBS	vertical barrier screen
Vs	sweeping velocity
Vx	through-screen velocity

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1.0 Introduction

Pacific Northwest National Laboratory (PNNL) conducted this 2024 study for the U.S. Army Corps of Engineers, Portland District, to evaluate the effectiveness of structural modifications to the gatewells in Bonneville Dam Powerhouse 2 in improving fish passage conditions. Section 1.1 provides background information. Section 1.2 includes the objectives of the study. Section 2.0 contains the methods used to achieve the study objectives. Section 3.0 provides the study results. Section 4.0 contains the study conclusions. Section 5.0 includes the references cited within the report. Appendix A includes a timeline of Bonneville Dam Powerhouse 2 gatewell modifications and operations changes. Appendix B presents the Memorandum of Coordination. Appendix C includes the teletype of operational instructions provided to the dam. Appendix D includes analyses of how treatments were implemented. Appendix E includes a description of how and why B2 head was calculated using the B1 forebay elevation sensor. Appendix F includes a schedule of treatment operations as implemented with associated descaling and mortality rates and the dates of impingement evaluations.

1.1 Background

The Bonneville Lock and Dam Project consists of several dam structures that together impound the Columbia River between Oregon and Washington at river mile 146.1, about 40 miles east of Portland, Oregon. From the Oregon shore north toward Washington, the Project currently is composed of a navigation lock, a 10-turbine-unit Powerhouse 1 (B1), Bradford Island, an 18-gate spillway, Cascades Island, and an 8-turbine-unit Powerhouse 2 (B2), as shown in Figure 1.1. The turbine units are numbered south to north from 1 to 10 at B1 and from 11 to 18 at B2. Each unit has three intakes A, B, and C (from south to north).

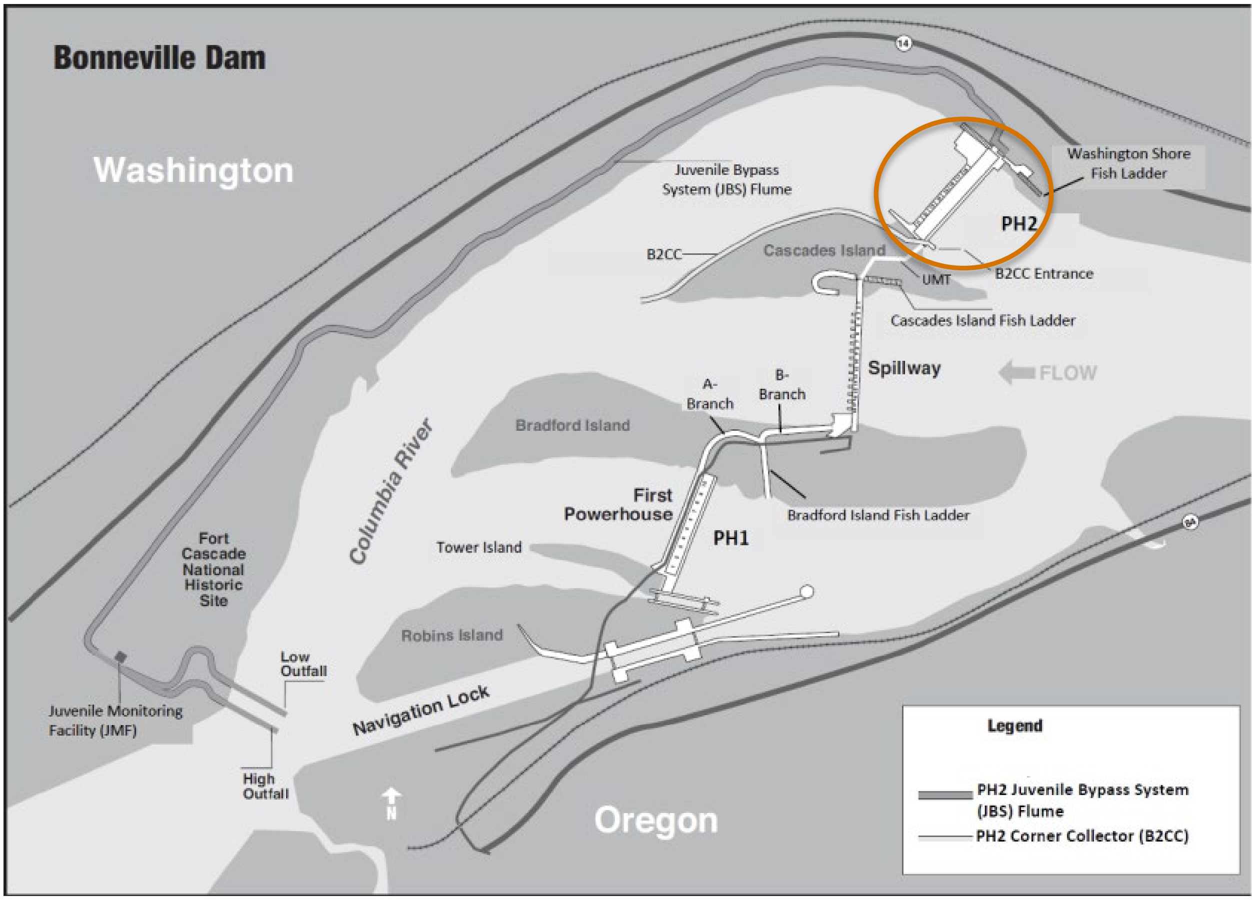

Figure 1.1. Plan view of the Bonneville Dam Project. Powerhouse 2 (B2) is circled.

Principal passage routes for juvenile salmonids include the spillway and two powerhouses, but within each powerhouse, fish can pass through a sluiceway at B1, B2 corner collector (B2CC) at B2, turbines, or the B2 juvenile bypass system (JBS)(Figure 1.1). Smolts that enter the upper portion of B2 turbine intakes are guided by submersible traveling screens (STS), which guides them upward into the gatewell (Figure 1.2 and Figure 1.3). Within the gatewell, vertical barrier screens (VBS) allow for dewatering of the gatewell. In the upper part of the gatewell, orifices pass a smaller portion of flow and fish into the downstream migrant collection channel (Figure 1.3). The collection channel exits the north side of B2 and empties into the JBS flume, which routes guided fish to the juvenile fish monitoring facility (JMF) and/or the JBS outfall pipe located about 3 km downstream of B2 (Figure 1.1).

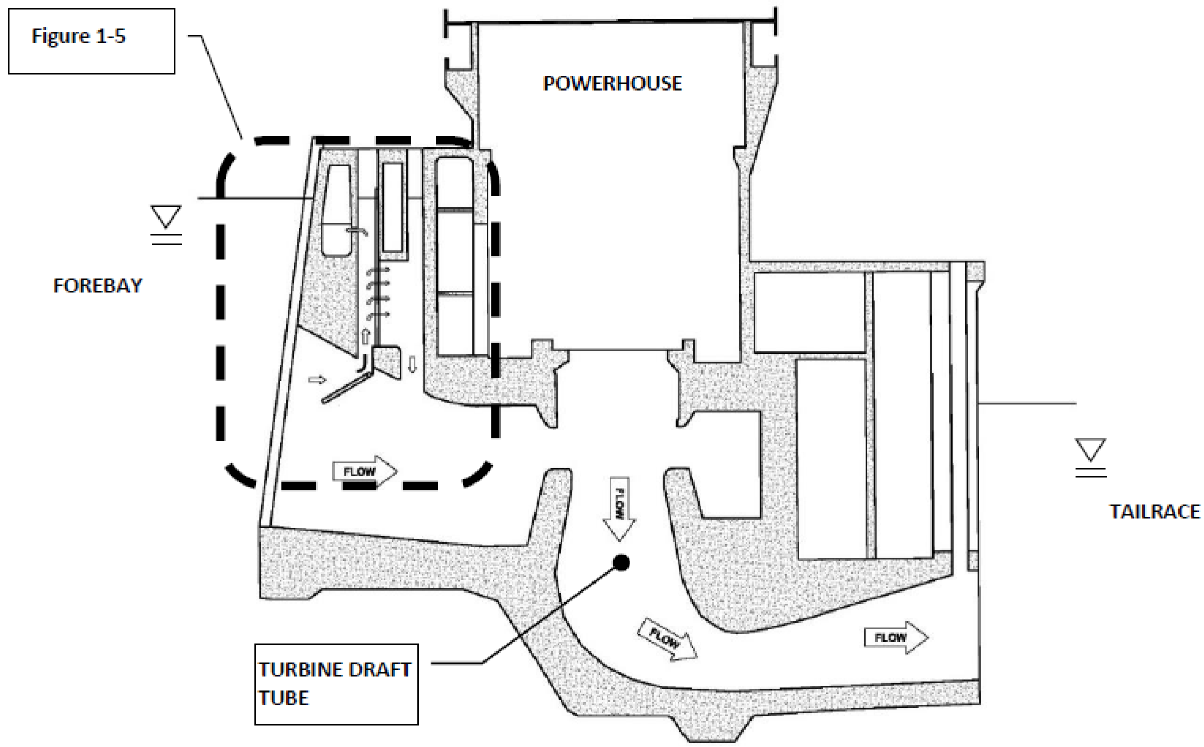

Figure 1.2. Cross section of Bonneville Dam Powerhouse 2 (B2) (from USACE).

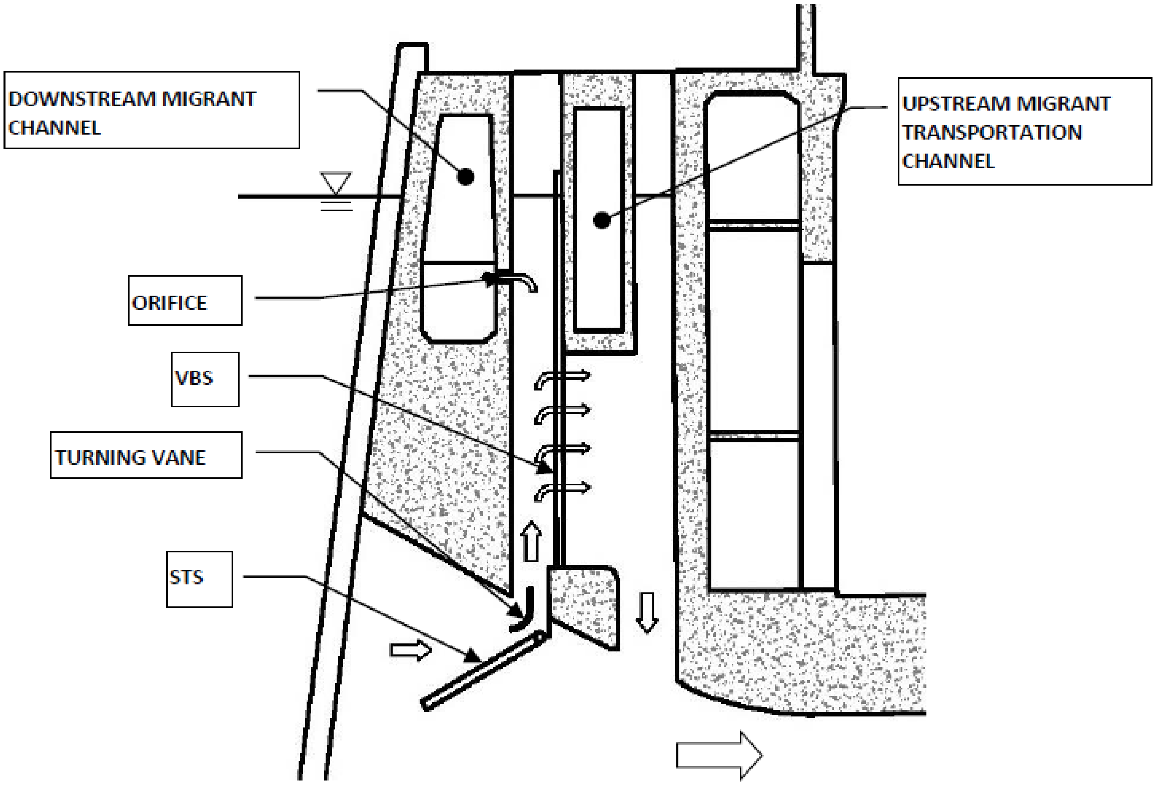

Figure 1.3. Detailed cross section of a Bonneville Dam Powerhouse 2 (B2) gatewell (from USACE).

In 2007, prior to the completion of construction to improve fish guidance efficiency (FGE) at B2, data from the Bonneville Dam Smolt Monitoring Program (SMP) indicated that substantial mortality occurred during B2 passage of Tule stock Chinook salmon *Oncorhynchus tshawytscha* released in March and April from the Spring Creek National Fish Hatchery (D. Ballinger, PSMFC, personal communication). Daily mortality rates measured at the sampling facility ranged from 1.6 to 11.7% during the passage of the early March releases (7-13 March). Fish from the April release began arriving at the monitoring facility at about 0645 PDT on 13 April, and from that time until 0900, the mortality rate was 10.1%. In contrast, SMP data from daily samples (≥100) of these same stocks showed that from 2000 to 2006, passage mortality had exceeded 1% on only one date in March (16 March 2002) and three dates in April (1 April 2002 and 17-18 April 2004).

Testing by the National Marine Fisheries Service (NMFS) in 2008 and 2009 suggested undesirable flow conditions in the gatewell. Bypass system modifications (i.e., turning vanes, larger vertical barrier screens, and gap closure devices), were the causative mechanism (Gilbreath et al., 2012). Increasing flow through B2 units during the NMFS study showed increasing rates of juvenile test fish descaling and mortality. Real-time observations by the SMP at the JMF were not as profound. NMFS test data suggest that the Spring Creek National Fish Hatchery (SCNFH) fish are more susceptible to descaling and mortality compared to tests with run-of-river fish. Many of the 2008 and 2009 comparisons of the upper 1% vs. the middle and lower 1% test conditions resulted in statistically significant ($P \leq 0.05$) differences in descaling and mortality for both SCNFH and run-of-river test fish. The smallest and earliest releases of SCNFH test fish in 2008 appeared to exhibit higher mortality at the upper end of the 1% operation compared to upper 1% releases later in the season when SCNFH and run-of-river test fish were larger. Spring Creek NFH fork length data were used in a logistic regression model, suggesting mortality at each operating level decreased as fish size increased (Gilbreath et al. 2012).

Starting in 2008, B2 units were operated at the lower end of the 1% peak efficiency range during SCNFH releases. A Fish Passage Plan (FPP) change form, 11BON014, was submitted in December 2010, modifying the B2 1% peak efficiency operation range to improve fish descaling and mortality. The change form request reduced the upper 1% operation limit to an upper limit in the mid 1% range. This was approved at the February 2011 Fish Passage Operations and Maintenance (FPOM) regional meeting, but operations did not occur as a hard constraint. In March 2011, B2 unit operation had been reduced toward the lower end of the 1% peak efficiency range (mid 1% upper limit) through operations coordination with the Technical Management Team (TMT) prompted by System Operations Requests from the Fish Passage Advisory Committee when seasonal concerns over descaling, and mortality issues were identified.

An FPOM task group was formed to address project operations during the periodic 1% operations modifications to reduce the incidence of descaling and mortality in the B2 gatewells. The Bonneville Operations FPOM task group developed language based on the examination. The language was discussed at length during an April 11, 2013, task group meeting. The language was presented to the full FPOM committee as an FPP change form for consideration in the operation of the Bonneville Dam in 2013. 14BON001 was approved on May 8, 2014. The 1% operating range guidelines were modified until structural and/or other solutions were implemented.

The Corps' B2 FGE program has been working through alternative evaluations and engineering designs with the Fish Facility Design Review Work Group (FFDRWG) and the Studies Review Work Group (SRWG) to improve juvenile passage conditions through the B2 screened bypass system while minimizing impacts to FGE. Biological and hydraulic testing of operations and structural alternatives implemented at B2 have been underway since 2008. (Biological - Gilbreath et al. 2012 and 2014, Absolon and Sandford 2016. Hydraulic – Hughes et al. 2011, Harbor and Alden 2013 and 2015, Alden 2022). Past modifications at B2 have included the installation of turning vanes and a gap-closure device, turbulence reduction devices, reduced porosity of the upper two panels of the VBS, and installation of flow control plates on the downstream edge of the gatewell beam.

The reduced porosity of the upper VBS and installation of flow control plates were intended to improve gatewell flow conditions. Testing conducted at high (18.0–18.5 kcfs) flow rates in 2015 indicated flow was restricted and more uniform at the VBS due to the reduced porosity of upper VBS panels and addition of flow control plates, which restricted flow into the VBS screened flow return slot (Harbor and Alden 2015; Absolon and Sandford 2016). However, biological testing conducted in 2013 and 2015 linked turbine unit operations in the upper 1% peak efficiency range with "missing fish" that were directly released into the turbine unit intake but never recovered at the JMF (Gilbreath et al. 2014; Absolon and Sandford 2016). One year of a two-year post-construction evaluation to estimate FGE and other passage objectives with steel plates mounted to the elevation (el.) +31 gatewell beams was conducted in 2017 (Ham et al. 2017) (Figure 1.4). This evaluation occurred with unrestricted 1% peak efficiency operations. FGE estimates were within the range of previous hydroacoustic studies and there was no indication at the JMF that injury and mortality were in the problematic ranges identified in 2007. Shortly thereafter, the steel plates were removed due to a failure of the anchoring system. A new structural solution (concrete corbel) was developed through FFDRWG and was first installed in place of the steel flow control plate on the gatewell beam in Unit 15 in 2021 (Figure 1.5).

In 2022, hydraulic testing results with corbels installed in Unit 15 A and B gatewells showed the NMFS vertical barrier screen (VBS) criteria (through-screen velocity [Vx] average < 1 ft/s) was met for all three A, B and C Unit 15 gatewells. The NMFS uniformity criteria was not met for all gatewells in 2022, and some localized areas of the screen exceeded 1 ft/s. The uniformity criteria were also not met for 2 of the 3 gatewells in 2015, which was chosen as a comparison year because it produced acceptable hydraulic and biological results and a consensus was reached that connected acceptable hydraulic results to acceptable biological results. Since then, hydraulic similitude to the 2015 results has been the goal.

The 2022 through-screen velocities at unit flows of 18 kcfs consistently trended higher than those from 2015. All gatewells met the NMFS average VBS through-screen velocity criteria. Gatewell A appeared closest to meeting the NMFS uniform flow distribution criteria, gatewell B less so, and gatewell C even less so, despite the lack of steel plates in 2015 or corbels in 2022 (i.e., no configuration change in gatewell C). The source of the perceived hydraulic disparity between years is likely a combination of the velocity probe sensitivity and the difficulty of accurately measuring Vx when a high sweeping velocity (Vs) is also present. Velocity probe misalignment and uneven hydrologic conditions may be additional possibilities contributing to the difference in hydraulic testing results between years. More information can be found in Alden 2022, *Bonneville Dam Second Powerhouse Gatewell Velocity and Pressure Measurements Data Collection Report.*

The Action Agencies, with the support of the regional fish managers, moved forward with outfitting all B2 units with a concrete corbel structural solution mounted to the el. +31 gatewell beams in gatewells A and B of each unit. Construction was finished in November 2023 in all units of B2. A post-construction evaluation was planned for 2024 to evaluate the effectiveness of these structural modifications at improving fish passage conditions. In addition, a new upper 1% limit was established in 2022, which should reduce velocities at the screens under some flows and forebay elevations. Depending on head, the new upper 1% limit and operating limit constrains units to operate between 14.8–18.1 kcfs compared to 14.8–19.5 kcfs for the old upper 1% limit.

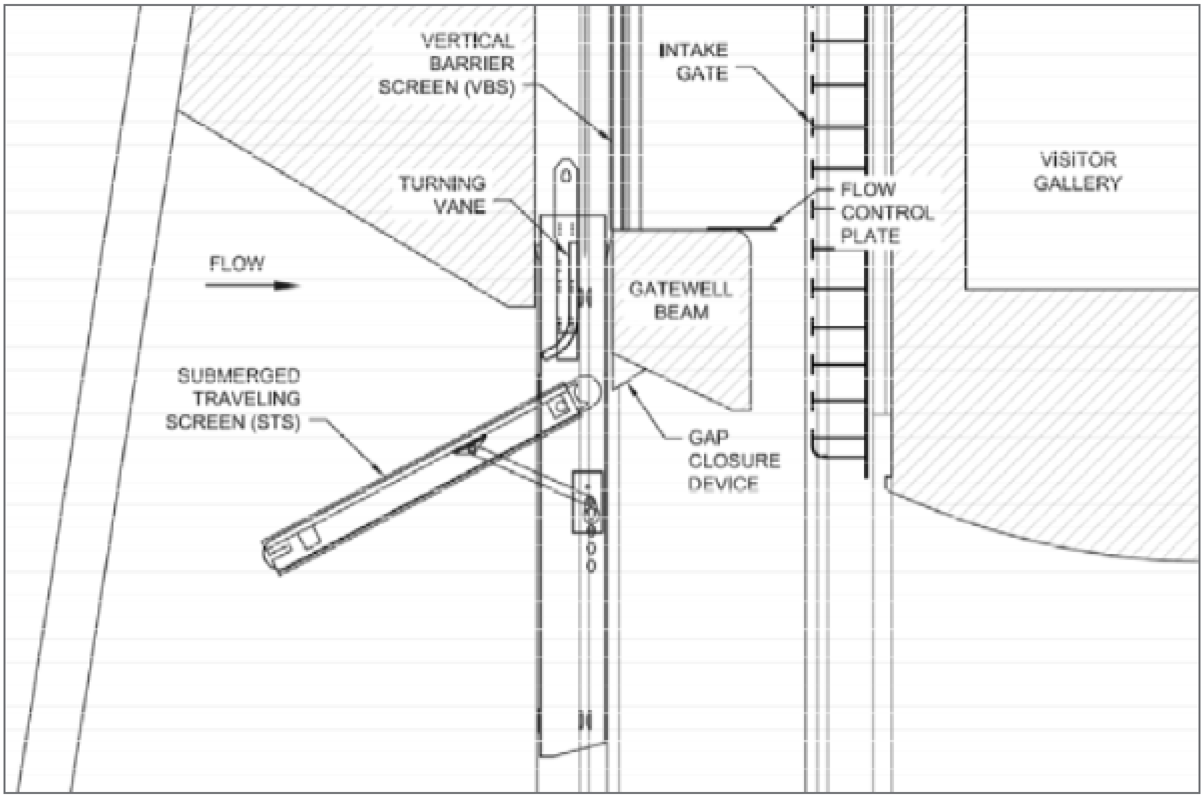

Figure 1.4. Depiction of the steel flow control plates added to the gatewell beam in gatewell slots at Bonneville Dam Powerhouse 2 (B2) (from Ham et al. 2017).

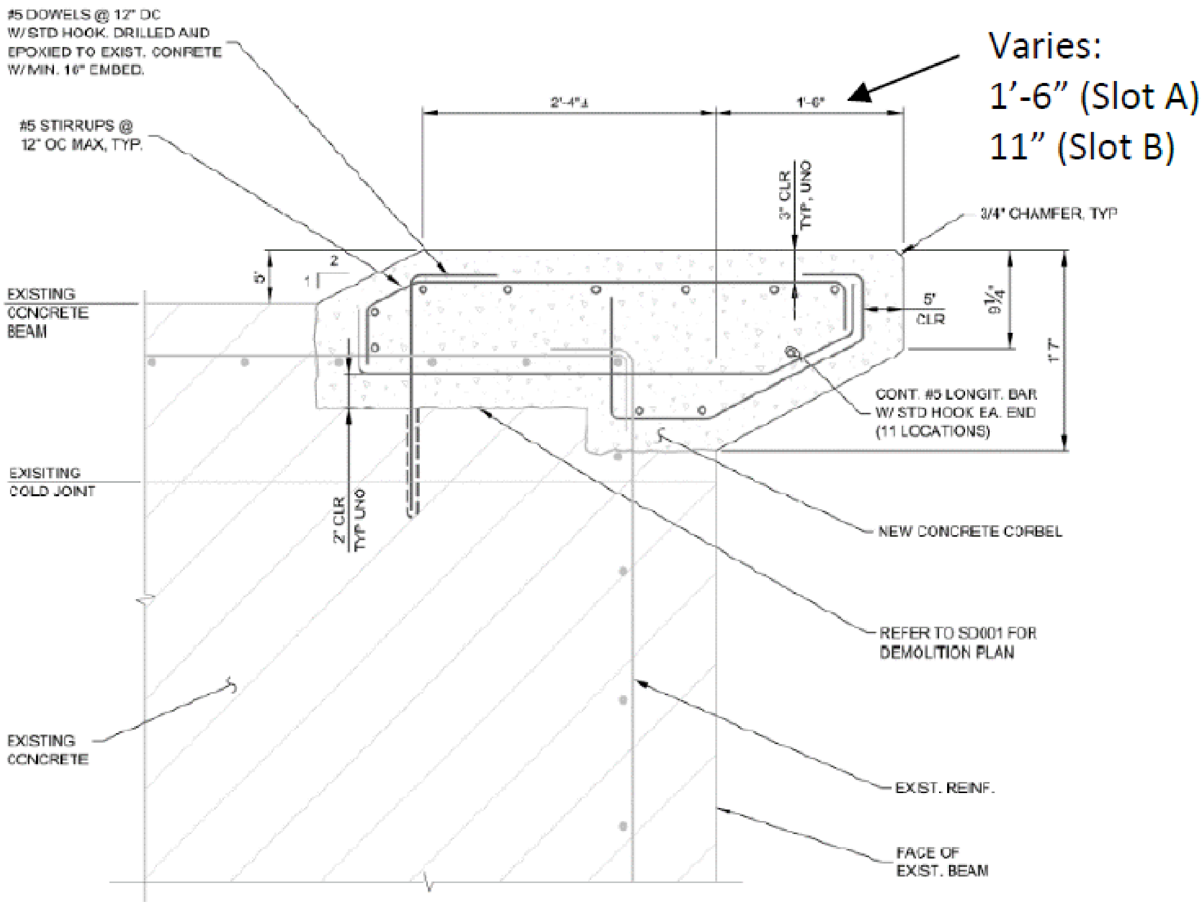

Figure 1.5. Detail of a flow control concrete corbel installed in place of the steel flow control plate on the gatewell beam in gatewell slots of Bonneville Dam Powerhouse 2 (from USACE).

1.2 Objectives

The purpose of this study was to evaluate the effectiveness of the Bonneville Dam B2 powerhouse gatewell structural modifications in improving fish passage conditions in 2024 and beyond. As stated in the SPE-P-24-1 “Evaluation of Fish Condition for Juvenile Salmonids in Modified Gatewell(s) at the Bonneville Dam’s Second Powerhouse” Research Summary, the primary purpose of the post-construction evaluation was to test the hypothesis that structural improvements made to reduce turbulence in B2 gatewell(s) and modified VBS porosity have reduced mortality, descaling, and impingement when operating in the full 1% peak efficiency turbine operation range. As such, the specific objectives of this study were to:

1. Create a timeline of gatewell modifications and operations to establish points of comparison.
2. Estimate and compare descaling and mortality percentages for juvenile salmonids (all species combined) sampled in the Bonneville Dam JMF as part of the SMP during turbine unit (modified with corbel and VBS porosity change) operations in the middle and

upper end of the 1% peak efficiency range in spring and summer. The change from spring to summer, as indicated by the date at which the SMP sample historically changes from being mostly dominated by yearling Chinook to subyearling Chinook salmon (https://www.cbr.washington.edu/dart/query/smolt_hrt), was expected to occur around 6 June.

a. Statistically compare descaling and mortality percentages between mid and upper 1% peak efficiency range operations separately for spring and summer in 2024 to test the following hypotheses:

    i. Descaling (D): H_0: $D_{upper} = D_{mid}$; H_A: $D_{upper} \neq D_{mid}$

    ii. Mortality (M): H_0: $M_{upper} = M_{mid}$; H_A: $M_{upper} \neq M_{mid}$

b. Non-statistically compare descaling and mortality percentages observed in 2024 to the range of descaling and mortality percentages observed in past years (2008–2013) separately for spring and summer:

    i. 2024 upper 1% peak efficiency range vs. 2008–2013 mid 1% peak efficiency range

    ii. 2024 mid and upper 1% peak efficiency range vs. 2008–2013 mid and upper 1% peak efficiency range

3. Conduct a pilot-scale effort to evaluate run-of-river juvenile salmonid VBS impingement during mid and upper 1% peak efficiency range operations in a corbel-modified gatewell (A slot) and an unmodified (no corbel) gatewell (C slot) of the same turbine unit.

2.0 Methods

2.1 Objective 1: Create a Timeline of Gatewell Modifications and Operations to Establish Points of Comparison

The creation of a timeline of Bonneville Dam Powerhouse 2 gatewell modifications and operations that occurred from 2001–2023 was conducted to establish historical points of comparison for modified versus unmodified gatewell comparisons. The full timeline is included in Appendix A.

2.2 Objective 2: Estimate and Compare Descaling and Mortality Percentages for Juvenile Salmonids Sampled in the Bonneville Dam JMF During Turbine Unit Operations in the Middle and Upper End of the 1% Peak Efficiency Range

2.2.1 Study Design

The most straightforward way to evaluate the biological performance of the current gatewell-VBS configuration at flows approaching the upper end of the 1% efficiency range was to compare it to the same configuration at moderate flows near the middle of the 1% efficiency range. This approach allowed for a treatment design that could be randomized within blocks to lessen the effect of seasonal changes on the comparison of treatments. There were several considerations in working at B2 that guided the development of the study design:

1) The preferred method of quantifying mortality and descaling was to follow standard SMP protocols, for which the historic record is long and consistent, and which were the basis for concerns raised about gatewell conditions prior to the current construction efforts to improve those conditions. To be consistent with SMP reporting, study dates reflect the end of the 24-hr sample collection, even though most of that period was within the previous calendar date.

2) It was not practical to determine which gatewell a fish passed through, and therefore treatment flow ranges were imposed for all operating B2 units in the time leading up to an SMP sampling event for each designated treatment. The number of operating B2 units could change within a block; however, each operating B2 unit needed to operate within the specified range required of the block-treatment design, except for brief periods as the unit started up or shut down. During blocks of the Upper_1% treatment, all operating B2 units needed to operate within 500 cfs of the 1% upper limit as defined in Table BON-15 of the FPP, with the difference in elevation between the forebay and tailrace (i.e., head) being used to compute the limit at any given time. During blocks of the Mid_1% treatment, all operating B2 units needed to operate within the mid-range as defined in the FPP (i.e., 13-15 kcfs).

3) Fish and dam operations exhibit diel cycles, and the SMP sample encompasses a 24-hr period. Therefore, the unit of study was an entire 24-hr day with any changes between treatments (Mid_1% vs. Upper_1% operations) occurring shortly after the end of the SMP sample at 0700. It was also important to consider that a few percent of fish take longer than 24 hours to travel from the turbine intakes to the JMF (Gilbreath et al. 2014), so an additional day of exposure before the sample day helped minimize the potential for

bias in the sample from fish exposed to the alternate treatment. As such, each SMP sample used to evaluate treatment differences was preceded by 48 hours at the assigned treatment operations. However, due to the randomization of treatments within each block (Table 2.1 and Table 2.2) and the impingement study schedule (Table 2.3), it was possible that a given treatment range was implemented for periods as short as 24 hours or as long as 120 hours before switching to the alternate treatment (Figure 2.1).

4) Exposing fish to the designated treatments (Mid_1% vs. Upper_1% operations) required the cooperation of operators and power managers to maintain B2 unit operations within the specified ranges. Fish operations such as VBS cleaning follow a cadence driven by the work week and remained as close to the normal schedule (Monday and Thursday) as was practical. Regular VBS cleaning between treatments was desirable to maintain similar conditions throughout the study. To the extent practical, cleaning operations occurred at times that were outside the exposure period for a given sample. Given that each exposure period extended across 48 hours, this was not entirely possible, but sampling was scheduled so that cleaning occurred at least 16 hours before the start of sample collection, which was 40 hours before the end of sampling.

5) A block design was desirable because it helped to differentiate the influence of factors not directly related to the treatment comparisons (e.g., river flow, temperature, fish size/species/numbers, etc.) that vary throughout the season from the influence of the treatments of interest.

As designed, the block-treatment study was to produce ten 24-hour SMP samples during Mid_1% treatment and ten 24-hour SMP samples during Upper_1% treatment during spring and nine 24-hour SMP samples during each Mid_1% and Upper_1% treatments during summer (Table 2.1). The spring study period was to begin with the 21 April SMP sample and extend through the 6 June SMP sample and the summer study period was to begin with the 9 June SMP sample and end with the 20 July SMP sample.

The start of the spring study period was selected to avoid the period in which the earliest releases of SCNFH subyearling Chinook salmon passed Bonneville Dam. National Marine Fisheries Service test data suggests that the smallest and earliest SCNFH fish are more susceptible to descaling and mortality compared to tests conducted later in the season when SCNFH and run-of-river test fish were larger (Gilbreath et al. 2012). Operations that coincide with the passage of early-released SCNFH Chinook salmon limit B2 turbine operations to the mid 1% peak efficiency range or below. These early-season operations were not being considered for modification based on the results of this study.

The transition from the spring to summer study periods was intended to align with the transition of the SMP samples from being primarily dominated by yearling Chinook salmon to subyearling Chinook salmon (Figure 2.2). Based on daily SMP samples collected from 2008–2015, this transition typically occurs in early June. The end of the summer study period was selected to coincide with the period at which ≥95% of subyearling Chinook salmon have passed Bonneville Dam (https://www.cbr.washington.edu/dart/query/smolt_hrt). The treatment schedule was not shared with SMP staff to reduce the potential for bias.

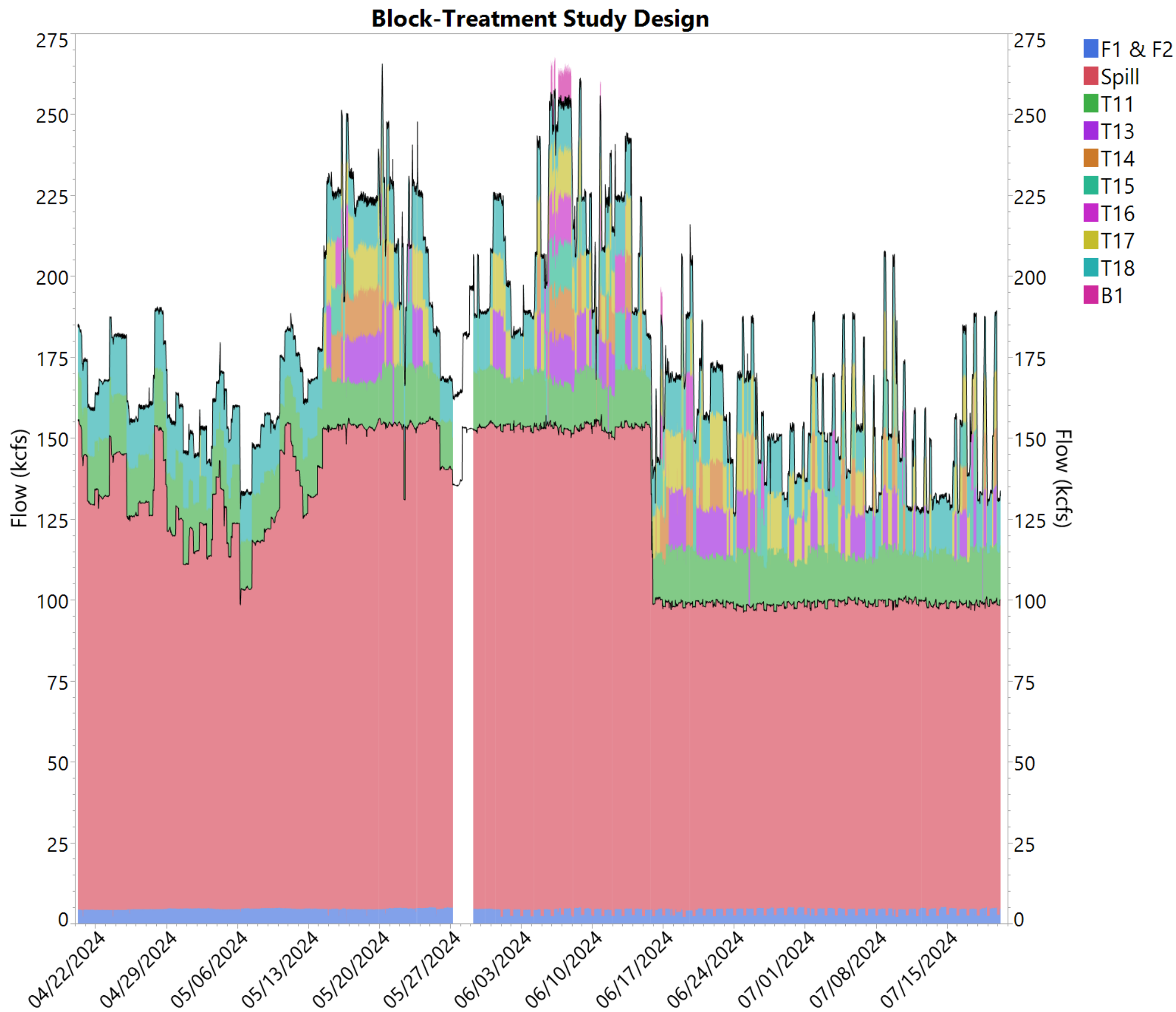

Figure 2.1. Operations required to implement the block-treatment study design at Bonneville Dam during the spring (20 April 0700 – 27 May 0700) and summer (29 May 0700 – 20 July 0700) smolt migration seasons. Powerhouse 2 operations are outlined in black. Note: Unit 12 was out of service for the duration of the study period.

Figure 2.2. Proportions of salmonid species in the B2 SMP sample by day of year, 2008–2015. Colored lines depict locally estimated scatterplot smoothing (LOESS) regression models fit to the data for each species/run. CH1 = yearling Chinook salmon, CH0 = subyearling Chinook salmon, CO = coho salmon, Uncl STH = unclipped steelhead, Cl STH = clipped steelhead, SOC = sockeye salmon.

Table 2.1. Planned spring 2024 study design for evaluating mortality and descaling at treatments representing the upper 1% and mid 1% of the efficiency range. The SMP collected daily 24-hr samples ending at 7:00 AM as usual, but only those called out in the notes column were to be included in this evaluation.

Start Date and Time (SMP Collection Start)	End Date and Time (SMP Collection End)	Study Day	Block	Treatment	Notes
20-Apr 07:01 AM	21-Apr 07:00 AM	**1**	1	Mid	
21-Apr 07:01 AM	22-Apr 07:00 AM	**2**	1	Mid	SMP Sample
22-Apr 07:01 AM	23-Apr 07:00 AM	**3**	1	Upper	VBS Cleaning
23-Apr 07:01 AM	24-Apr 07:00 AM	**4**	1	Upper	SMP Sample
24-Apr 07:01 AM	25-Apr 07:00 AM	**5**		Upper	**Impingement**
25-Apr 07:01 AM	26-Apr 07:00 AM	**6**	2	Mid	VBS Cleaning
26-Apr 07:01 AM	27-Apr 07:00 AM	**7**	2	Mid	SMP Sample
27-Apr 07:01 AM	28-Apr 07:00 AM	**8**	2	Upper	
28-Apr 07:01 AM	29-Apr 07:00 AM	**9**	2	Upper	SMP Sample
29-Apr 07:01 AM	30-Apr 07:00 AM	**10**	3	Upper	VBS Cleaning, Camera Truck
30-Apr 07:01 AM	1-May 07:00 AM	**11**	3	Upper	SMP Sample
1-May 07:01 AM	2-May 07:00 AM	**12**		Mid	**Impingement**
2-May 07:01 AM	3-May 07:00 AM	**13**	3	Mid	VBS Cleaning
3-May 07:01 AM	4-May 07:00 AM	**14**	3	Mid	SMP Sample
4-May 07:01 AM	5-May 07:00 AM	**15**	4	Upper	
5-May 07:01 AM	6-May 07:00 AM	**16**	4	Upper	SMP Sample
6-May 07:01 AM	7-May 07:00 AM	**17**	4	Mid	VBS Cleaning
7-May 07:01 AM	8-May 07:00 AM	**18**	4	Mid	SMP Sample
8-May 07:01 AM	9-May 07:00 AM	**19**		Upper	**Impingement**
9-May 07:01 AM	10-May 07:00 AM	**20**	5	Mid	VBS Cleaning
10-May 07:01 AM	11-May 07:00 AM	**21**	5	Mid	SMP Sample
11-May 07:01 AM	12-May 07:00 AM	**22**	5	Upper	
12-May 07:01 AM	13-May 07:00 AM	**23**	5	Upper	SMP Sample
13-May 07:01 AM	14-May 07:00 AM	**24**	6	Upper	VBS Cleaning
14-May 07:01 AM	15-May 07:00 AM	**25**	6	Upper	SMP Sample
15-May 07:01 AM	16-May 07:00 AM	**26**		Mid	**Impingement**
16-May 07:01 AM	17-May 07:00 AM	**27**	6	Mid	VBS Cleaning
17-May 07:01 AM	18-May 07:00 AM	**28**	6	Mid	SMP Sample
18-May 07:01 AM	19-May 07:00 AM	**29**	7	Mid	
19-May 07:01 AM	20-May 07:00 AM	**30**	7	Mid	SMP Sample
20-May 07:01 AM	21-May 07:00 AM	**31**	7	Upper	VBS Cleaning
21-May 07:01 AM	22-May 07:00 AM	**32**	7	Upper	SMP Sample
22-May 07:01 AM	23-May 07:00 AM	**33**		Upper	**Impingement**
23-May 07:01 AM	24-May 07:00 AM	**34**	8	Upper	VBS Cleaning
24-May 07:01 AM	25-May 07:00 AM	**35**	8	Upper	SMP Sample
25-May 07:01 AM	26-May 07:00 AM	**36**	8	Mid	
26-May 07:01 AM	27-May 07:00 AM	**37**	8	Mid	SMP Sample
27-May 07:01 AM	28-May 07:00 AM	**38**	9	Mid	VBS Cleaning
28-May 07:01 AM	29-May 07:00 AM	**39**	9	Mid	SMP Sample
29-May 07:01 AM	30-May 07:00 AM	**40**		Upper	**Optional Impingement**
30-May 07:01 AM	31-May 07:00 AM	**41**	9	Upper	VBS Cleaning
31-May 07:01 AM	1-Jun 07:00 AM	**42**	9	Upper	SMP Sample
1-Jun 07:01 AM	2-Jun 07:00 AM	**43**	10	Mid	
2-Jun 07:01 AM	3-Jun 07:00 AM	**44**	10	Mid	SMP Sample
3-Jun 07:01 AM	4-Jun 07:00 AM	**45**	10	Upper	VBS Cleaning, Camera Truck
4-Jun 07:01 AM	5-Jun 07:00 AM	**46**	10	Upper	SMP Sample
5-Jun 07:01 AM	6-Jun 07:00 AM	**47**		Mid	**Optional Impingement**

Table 2.2. Planned summer 2024 study design for evaluating mortality and descaling at treatments representing the upper 1% and mid 1% of the efficiency range. The SMP collected daily 24-hr samples ending at 7:00 AM as usual, but only those called out in the notes column were to be included in this evaluation.

Start Date and Time (SMP Collection Start)	End Date and Time (SMP Collection End)	Study Day	Block	Treatment	Notes
8-Jun 07:01 AM	9-Jun 07:00 AM	1	1	Upper	
9-Jun 07:01 AM	10-Jun 07:00 AM	2	1	Upper	SMP Sample
10-Jun 07:00 AM	11-Jun 07:00 AM	3	1	Mid	VBS Cleaning
11-Jun 07:01 AM	12-Jun 07:00 AM	4	1	Mid	SMP Sample
12-Jun 07:01 AM	13-Jun 07:00 AM	5		Upper	Impingement
13-Jun 07:01 AM	14-Jun 07:00 AM	6	2	Upper	VBS Cleaning
14-Jun 07:01 AM	15-Jun 07:00 AM	7	2	Upper	SMP Sample
15-Jun 07:01 AM	16-Jun 07:00 AM	8	2	Mid	
16-Jun 07:01 AM	17-Jun 07:00 AM	9	2	Mid	SMP Sample
17-Jun 07:01 AM	18-Jun 07:00 AM	10	3	Upper	VBS Cleaning
18-Jun 07:01 AM	19-Jun 07:00 AM	11	3	Upper	SMP Sample
19-Jun 07:01 AM	20-Jun 07:00 AM	12		Upper	Impingement
20-Jun 07:01 AM	21-Jun 07:00 AM	13	3	Mid	VBS Cleaning
21-Jun 07:01 AM	22-Jun 07:00 AM	14	3	Mid	SMP Sample
22-Jun 07:01 AM	23-Jun 07:00 AM	15	4	Mid	
23-Jun 07:01 AM	24-Jun 07:00 AM	16	4	Mid	SMP Sample
24-Jun 07:01 AM	25-Jun 07:00 AM	17	4	Upper	VBS Cleaning
25-Jun 07:01 AM	26-Jun 07:00 AM	18	4	Upper	SMP Sample
26-Jun 07:01 AM	27-Jun 07:00 AM	19		Mid	Impingement
27-Jun 07:01 AM	28-Jun 07:00 AM	20	5	Upper	VBS Cleaning
28-Jun 07:01 AM	29-Jun 07:00 AM	21	5	Upper	SMP Sample
29-Jun 07:01 AM	30-Jun 07:00 AM	22	5	Mid	
30-Jun 07:01 AM	1-Jul 07:00 AM	23	5	Mid	SMP Sample
1-Jul 07:01 AM	2-Jul 07:00 AM	24	6	Upper	VBS Cleaning
2-Jul 07:01 AM	3-Jul 07:00 AM	25	6	Upper	SMP Sample
3-Jul 07:01 AM	4-Jul 07:00 AM	26			VBS Cleaning
4-Jul 07:01 AM	5-Jul 07:00 AM	27	6	Mid	
5-Jul 07:01 AM	6-Jul 07:00 AM	28	6	Mid	SMP Sample
6-Jul 07:01 AM	7-Jul 07:00 AM	29	7	Mid	
7-Jul 07:01 AM	8-Jul 07:00 AM	30	7	Mid	SMP Sample
8-Jul 07:01 AM	9-Jul 07:00 AM	31	7	Upper	VBS Cleaning, Camera Truck
9-Jul 07:01 AM	10-Jul 07:00 AM	32	7	Upper	SMP Sample
10-Jul 07:01 AM	11-Jul 07:00 AM	33		Mid	Impingement
11-Jul 07:01 AM	12-Jul 07:00 AM	34	8	Mid	VBS Cleaning
12-Jul 07:01 AM	13-Jul 07:00 AM	35	8	Mid	SMP Sample
13-Jul 07:01 AM	14-Jul 07:00 AM	36	8	Upper	
14-Jul 07:01 AM	15-Jul 07:00 AM	37	8	Upper	SMP Sample
15-Jul 07:01 AM	16-Jul 07:00 AM	38	9	Mid	VBS Cleaning
16-Jul 07:01 AM	17-Jul 07:00 AM	39	9	Mid	SMP Sample
17-Jul 07:01 AM	18-Jul 07:00 AM	40		Upper	Impingement
18-Jul 07:01 AM	19-Jul 07:00 AM	41	9	Upper	VBS Cleaning
19-Jul 07:01 AM	20-Jul 07:00 AM	42	9	Upper	SMP Sample

2.2.2 Statistical Analyses

2.2.2.1 Power Analysis

Under normal SMP operations, about 400 salmonids are sampled each day of the spring treatment period (21 April – 6 June) and about 250 salmonids are sampled each day of the summer treatment period (9 June – 20 July). Therefore, we assumed ten days of sampling in spring and 9 days of sampling in summer should produce a sample size of about 4,000 fish sampled during both Mid_1% and Upper_1% treatments in spring and about 2,250 fish during both Mid_1% and Upper_1% treatments in summer.

From 2008–2013, the median weekly descaling and mortality rates of salmonids sampled during the spring treatment period were 1.2% and 0.4%, respectively, during weeks when units operated at or below the mid 1% range ≥80% of the time and >100 fish were sampled by the SMP for descaling and mortality (Figure 2.3). Assuming similar rates during Mid_1% operations in spring 2024, sampling 4,000 salmonids during each treatment (Mid_1% and Upper_1%) would provide a sufficient sample size to detect a significant difference if descaling and mortality rates were ≥1.98% and ≥0.89%, respectively, during the Upper_1% treatment (two-sample proportion test: $1–\beta = 0.80$, $\alpha = 0.05$).

From 2008–2013, the median weekly descaling and mortality rates of salmonids sampled during the summer treatment period were 0.8% and 0.9%, respectively, during weeks when units operated at or below the mid 1% range ≥80% of the time and >100 fish were sampled by the SMP (Figure 2.3). Assuming similar rates during Mid_1% operations in summer 2024, sampling 2,250 salmonids during each treatment (Mid_1% and Upper_1%) would provide a sufficient sample size to detect a significant difference if descaling and mortality rates were ≥1.71% and ≥1.86%, respectively, during Upper_1% operations (two-sample proportion test: $1–\beta = 0.80$, $\alpha = 0.05$).

2.2.2.2 2024 Mid_1% vs. Upper_1% Descaling and Mortality

All juvenile salmonids sampled in the JMF during each treatment and season were combined to produce spring Mid_1% descaling and mortality rates, spring Upper_1% descaling and mortality rates, summer Mid_1% descaling and mortality rates, and summer Upper_1% descaling and mortality rates. Descaling and mortality rates were compared between treatments separately for spring and summer using Fisher's exact tests ($\alpha = 0.05$). Due to differences among species in their susceptibility to descaling and mortality, the species composition of each treatment sample was also evaluated to ensure similarities between treatments.

2.2.2.3 2024 vs. Historic Descaling and Mortality

Descaling and mortality rates obtained during the Above_1% or Upper_1% treatment in 2024 were non-statistically compared to the historic (2008–2013) distributions of descaling and mortality rates of unmodified gatewells operated in the mid 1% peak efficiency range. In addition, descaling and mortality rates obtained during Mid_1% and Above_1% or Upper_1% treatments in 2024 were non-statistically compared to the historic (2008–2013) distributions of descaling and mortality rates of unmodified gatewells operated in the mid and upper 1% (combined) peak efficiency range.

Due to the high degree of variability in daily SMP samples, historic weekly SMP descaling and mortality rates were compared to the spring and summer season-wide descaling and mortality rates from 2024. To identify the appropriate historic SMP samples to use for comparison, weekly SMP descaling and mortality rates were associated with the B2 unit operations that occurred at the time of SMP fish collection. For example, the SMP data from the week of 19 April – 25 April 2008 was associated with the B2 unit operations that occurred between 0700 on 18 April through 0700 on 25 April 2008. Five-minute unit operations data were analyzed to determine the percent of time within each week that operating units were operating within the mid 1% range (i.e., 13–15 kcfs) and above the mid 1% (i.e., >15 kcfs). Weeks were classified as being from the spring if the first sample day of the SMP week was ≥18 April and ≤31 May and from the summer if the first day of the week was ≥6 June and ≤16 July. The transition from spring to summer corresponds to the approximate shift in the historic sample data from being primarily dominated by yearling Chinook salmon (spring) to being primarily dominated by subyearling Chinook salmon (summer).

Evaluations of SMP data and unit operations revealed the relatively small number of weeks during the historical period of performance (2008–2013) in which the units primarily operated in the mid-range (≥80% of the time) and sufficient numbers of fish (>100 fish/week) were sampled for evaluations of descaling and mortality. There were only two weeks in spring and seven weeks in summer that met these criteria. Therefore, the criteria were relaxed to define mid-range weeks as those in which operating units operated within the mid-range (i.e., 13–15 kcfs) ≥50% of the time, >18 kcfs <10% of the time, and >100 fish (all salmonid species combined) were sampled for descaling and mortality. These criteria were met by 11 weeks in spring and 13 weeks in summer.

For the historical comparison of descaling and mortality rates during combined mid and upper 1% operations, we required operating units to be operated at or above the mid-range (i.e., ≥13 kcfs) 80% of the time and >100 fish (all salmonid species combined) be sampled for descaling and mortality. Twenty-five historic spring SMP weeks and 23 historic summer SMP weeks met these criteria.

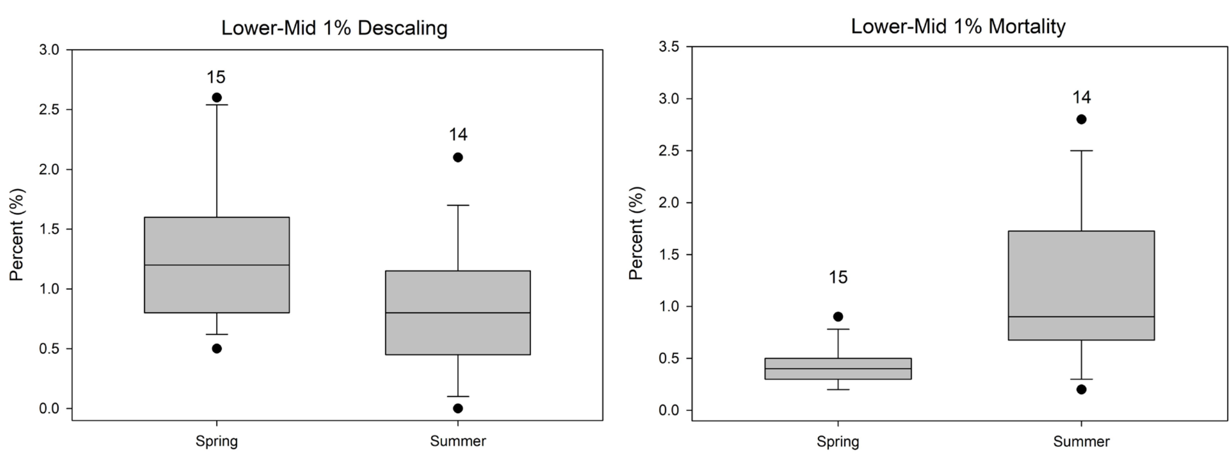

Figure 2.3. Boxplots depicting the weekly descaling (left) and mortality (right) rates for juvenile salmonids sampled in spring and summer at Bonneville Dam as part of the Smolt Monitoring Program during turbine unit operations in the lower and mid-range of the 1% peak efficiency range (i.e., ≤15 kcfs) from 2008–2013. Sample sizes (number of weeks) are shown above each box. Solid lines within the boxes are medians, the box boundary represents the 25th and 75th percentiles, whiskers indicate the 10th and 90th percentiles, and dots indicate points outside the 10th and 90th percentiles.

2.3 Objective 3: Conduct a Pilot-Scale Effort to Evaluate Run-of-River Juvenile Salmonid VBS Impingement During Mid and Upper 1% Peak Efficiency Range Operations in Modified and Unmodified Gatewells

2.3.1 Imaging Sonar

A pilot-scale effort was conducted to determine whether multibeam imaging sonars (BlueView® M900-2250-130-Mk2, Teledyne, Bothell WA), also known as underwater acoustic cameras, could be used to evaluate impingement by estimating VBS contact rates during mid and upper 1% peak efficiency range operations in a modified (A slot) and unmodified (C slot) gatewell slot. Imaging sonar sampling occurred over a 24 h period once per week from 9 May through 18 July (Table 2.3).

Unit 15 was the unit of choice for this evaluation due to the extensive research of flow conditions and fish passage conducted historically at Unit 15. However, low total B2 discharge prevented operation of Unit 15 during three impingement evaluation days. On these occasions, only the two highest priority units (11 and 18) were operated, and imaging sonars were deployed in the gatewell slots of Unit 11 for impingement evaluations (Table 2.3). Throughout each 24-hour impingement evaluation, the unit being evaluated was to remain within the flow range specified by the treatment. During the Upper_1% treatment, unit flow was to remain within 500 cfs of the upper 1% limit as defined in Table BON-15 of the FPP. During the Mid_1% treatment, unit flow was to remain between 13–15 kcfs. In addition to some smaller deviations from these operations, Unit 15 was shut down about 2 hours after imaging sonars were deployed at 0700 on 22 May due to low flows, limiting the utility of the 23 May SMP date impingement evaluation.

The imaging sonars were deployed using a portable A-frame gantry crane with an electric winch (MY-TE model AC36B) attached to a weighted aluminum frame (Figure 2.4). The frame incorporated spring loaded rollers to facilitate contact with the VBS and the concrete wall during deployment. Weights (50 lbs) and ropes from the frame to the handrails were also attached to the frames to add stability as the upper portion of the gatewells had significant upwelling flows during the upper 1% operation. The frame was lowered to an elevation of 66–69 ft msl and oriented to sample along the VBS face with an approximate screen width sample region at maximum range of ~8 ft (Figure 2.5). The sonar location within the gatewell was similar for 15A, 15C, 11A, and 11C throughout the spring and summer sampling periods and oriented to sample the bottom northern portion of the VBS, which corresponds to the regions of highest total velocity (up to 5 ft/s at 15 kcfs in Unit 15 slot C) as measured by Alden (2022). The sonars were used in the high-frequency mode to obtain higher spatial resolution (0.25 in), 23 ft optimal range, and a maximum frame rate of 25 Hz. Data were collected by computers placed in portable deck boxes located near the gatewells. Imaging sonars were programmed to collect 15-minute samples every hour for each of the 24-hour sampling periods. Four blocks were randomly selected for each day and nighttime periods and these counts were expanded to hourly counts and then the median number was used to determine daily fish counts.

BlueView files were processed using the ProViewer software. Comparisons were done to determine the relative number of fish, their depth in the gatewells and behavior in units 11 and 15, slots A and C for spring and summer sampling periods. Fish abundance was classified into three categories (low 0-50, medium 50-100, and high 100-200).

Table 2.3. Imaging sonar data collection dates and associated turbines and treatments.

Season	SMP Date	Unit 11A	Unit 11C	Unit 15A	Unit 15C	Operation
Spring	5/9	X	X			Upper 1%
	5/16	X		X		Mid 1%
	5/23[1]			X	X	Upper 1%
Summer	5/30	X	X			Upper 1%
	6/6			X	X	Mid 1%
	6/13			X	X	Upper 1%
	6/20			X	X	Upper 1%
	6/27			X	X	Mid 1%
	7/11	X	X			Mid 1%
	7/18	X	X			Upper 1%

[1]Incomplete data. Unit 15 shut down after two hours due to low flow.

Figure 2.4. Imaging sonar deployment system. Portable deployment gantry (left) and submerged sonar mounting platform (right).

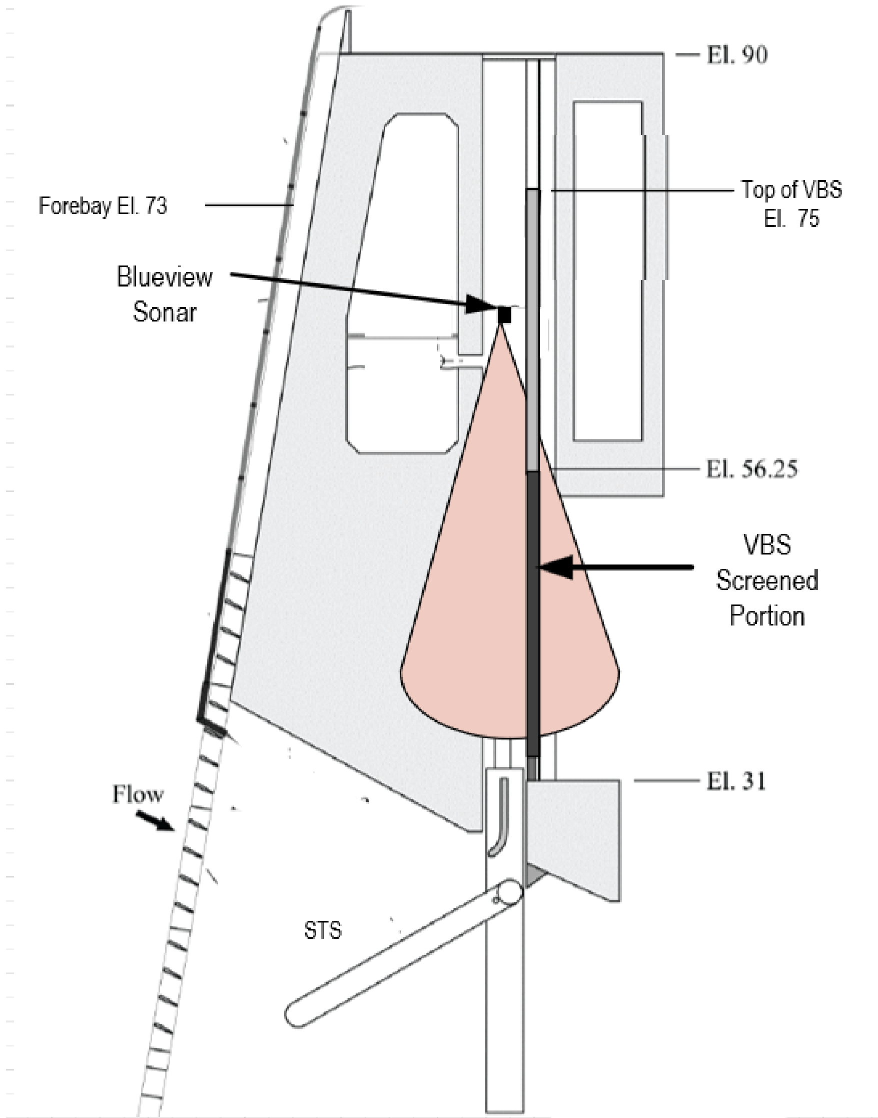

Figure 2.5. Cross-sectional view showing the deployment location and approximate sampling area of the imaging sonar deployment in B2 unit gatewell slots A and C.

2.3.2 Spot Checks with Gatewell Camera Truck

Imaging sonar samples were supplemented by conducting spot checks of impingement using optical video cameras. Bonneville Dam operates a specially designed, truck-mounted camera deployment system to monitor VBS screen condition and debris accumulation. The routine monitoring using that system occurred three times within the period of study (29 April, 3 June, and 8 July). All three occasions coincided with planned upper 1% operations. On each occasion, the camera was moved around within the gatewell to inspect each VBS panel in all three slots (A, B, and C) of each turbine unit (11-18). A digital video recorder was attached to the truck camera feed to record and document the spot check results of units 11 and 18, which were the only units operating at the time of the spot checks.

3.0 Results

3.1 Objective 1: Create a Timeline of Gatewell Modifications and Operations to Establish Points of Comparison

As outlined in Appendix A – Timeline of Bonneville Dam Powerhouse 2 Gatewell Modifications and Operations Changes, the creation of this timeline indicated that prior to the VBS porosity modifications and installation of flow control plates, which began with prototypes in 2014, most structural and operational modifications affecting B2 FGE were completed prior to 2008. Therefore, the historical period of performance established for comparison of modified units (2024) to unmodified units included smolt migration years 2008 through 2013 (Figure 3.1).

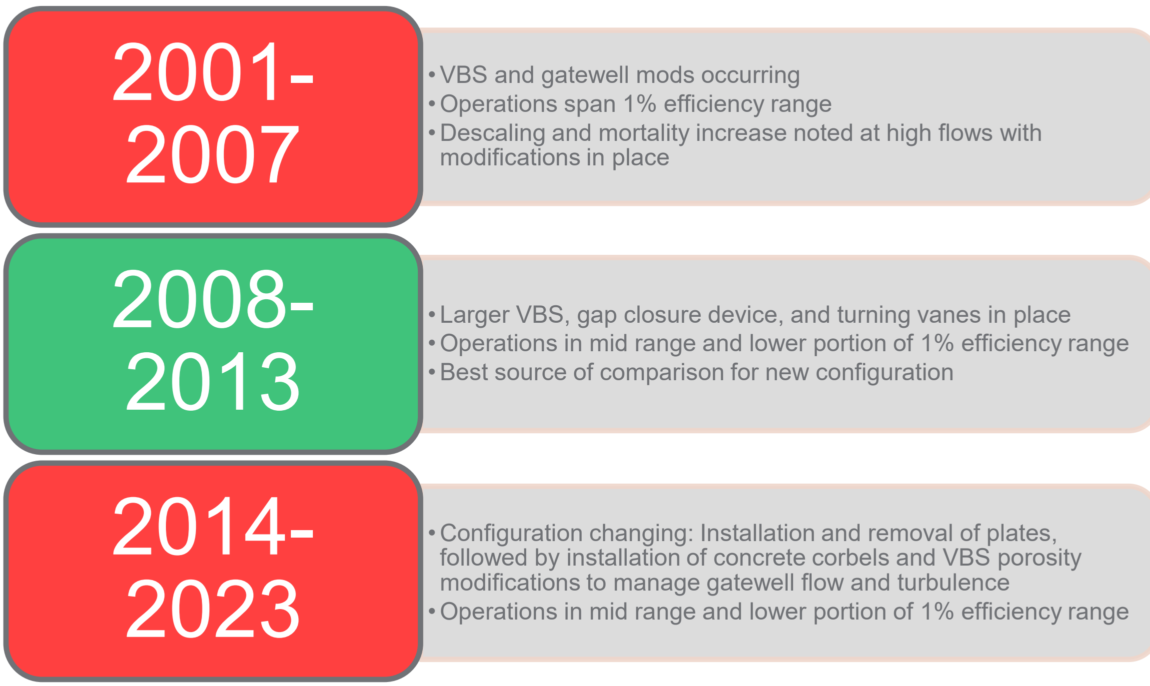

Figure 3.1. Simplified timeline of gatewell configurations and operations.

3.2 Objective 2: Estimate and Compare Descaling and Mortality Percentages for Juvenile Salmonids Sampled in the BON JMF During Turbine Unit Operations in the Middle and Upper End of the 1% Peak Efficiency Range

3.2.1 Species Composition

The transition of the SMP sample from being dominated by yearling Chinook salmon to subyearling Chinook salmon occurred earlier in 2024 compared to the historic data used to plan the study (Figure 3.2). Therefore, the transition from spring to summer study periods was shifted to reflect the species composition of the SMP samples. The spring study period extended from 20 April 0700 through 27 May 0700 and the summer period included 29 May 0700 through 20 July 0700. As such, the spring study period was reduced to eight 24-hour SMP samples during each treatment and the summer study period was increased to include eleven 24-hour SMP samples during each Mid_1% and Upper_1% treatment.

The reduction in the number of spring blocks and the lower numbers of fish sampled during Mid_1% operations reduced the sample size of spring treatments below those used for study planning. Conversely, the increase in the number of summer blocks increased the sample size of summer treatments beyond expectations. As such, the power to detect the differences described above in section 2.2.2.1 was reduced in spring and increased in summer. In spring, statistical power was reduced to about 60% and in summer power was increased to about 88%.

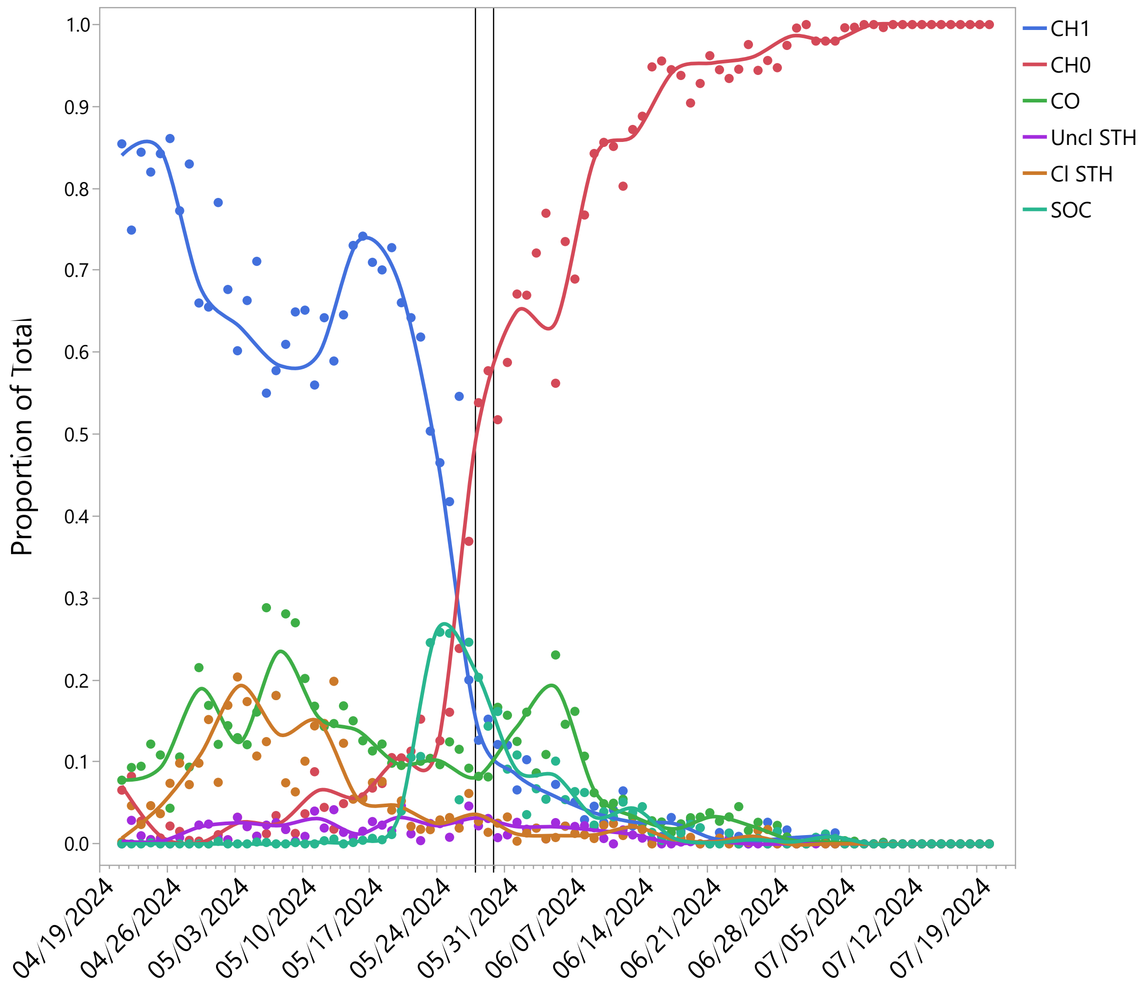

Figure 3.2. Species Composition in 2024 B2 SMP Samples. Black vertical lines indicate the transition between spring and summer species. Colored lines depict locally estimated scatterplot smoothing (LOESS) regression models fit to the data for each species/run. CH1 = yearling Chinook salmon, CH0 = subyearling Chinook salmon, CO = coho salmon, Uncl STH = unclipped steelhead, Cl STH = clipped steelhead, SOC = sockeye salmon.

3.2.2 Treatment Implementation

As described in the Implementation Plan developed for this study, the regional Memorandum of Coordination (Appendix B) and the teletype provided to Bonneville Dam and BPA (Appendix C), operations were to alternate between the mid 1% range and a range near the upper 1% limit as defined in Table BON-15 of the 2024 FPP. However, on 23 May, one of the operators identified that the units were operating above the current upper 1% limit at the beginning of their shift. The flow into the units was reduced at that time to bring the units back to the upper 1% limit. A review of the operations was conducted at that time, and it was realized that there were several occasions in which unit flows were higher than the current upper 1% limit. It is believed that an update to the generic data acquisition and control system (GDACS) that occurred well before the spring study period caused the system to revert back to the old FPP upper 1% limit table, which was in effect until spring 2022 and that older turbine efficiency curve allowed for higher flows at the upper 1% limit. Beginning with the first Upper_1% treatment on 23 April through 24 May 0200, flows were higher than the current upper 1% limit and, therefore, outside of the planned treatment range for the majority of a 24-hour sample period on 5 of the 8 Upper_1% treatment days (Figure 3.3) due to the GDACS peak efficiency table reversion. In addition, in mid-May the B2 forebay elevation sensor, which is used to calculate project head (used to calculate turbine unit flow), was found to be faulty. Therefore, the BON Powerhouse 1 (B1) forebay sensor was used in its place to recalculate unit flows and the upper 1% limit for the purposes of this study. This approach introduces relatively small inaccuracies (in most cases < 100 cfs) into the calculated turbine unit flow values and upper 1% limits for a time interval. As such, excursions from the upper 1% limit were not analyzed using the same methods or evaluated using the same criteria as those used for GDACS excursion reporting purposes. Additional detail on how flows were compared to treatment ranges can be found in Appendix D. Information on how flows were recalculated to remove the influence of the faulty elevation sensor can be found in Appendix E.

During the planned Upper_1% treatment periods in the spring, only 35% of 5-minute interval turbine unit flow rates were within the 500 cfs band below the upper 1% limit. Because of this, it was necessary to rename the spring Upper_1% treatment to reflect the actual operations. Throughout the remainder of the document and in summaries, the higher flow treatment of the spring study period is referred to as “Above_1%” to emphasize that approximately two-thirds of 5-minute interval unit flow rates were higher than the upper 1% limit. No renaming of the spring Mid_1% treatment was required because flows were typically (83% of the time) within the designated range (Figure 3.3). During the summer study period, flows were within the designated range 83% of the time for the Upper_1% treatment and 89% of the time for Mid_1% treatment (Figure 3.4), and no renaming of treatments was needed.

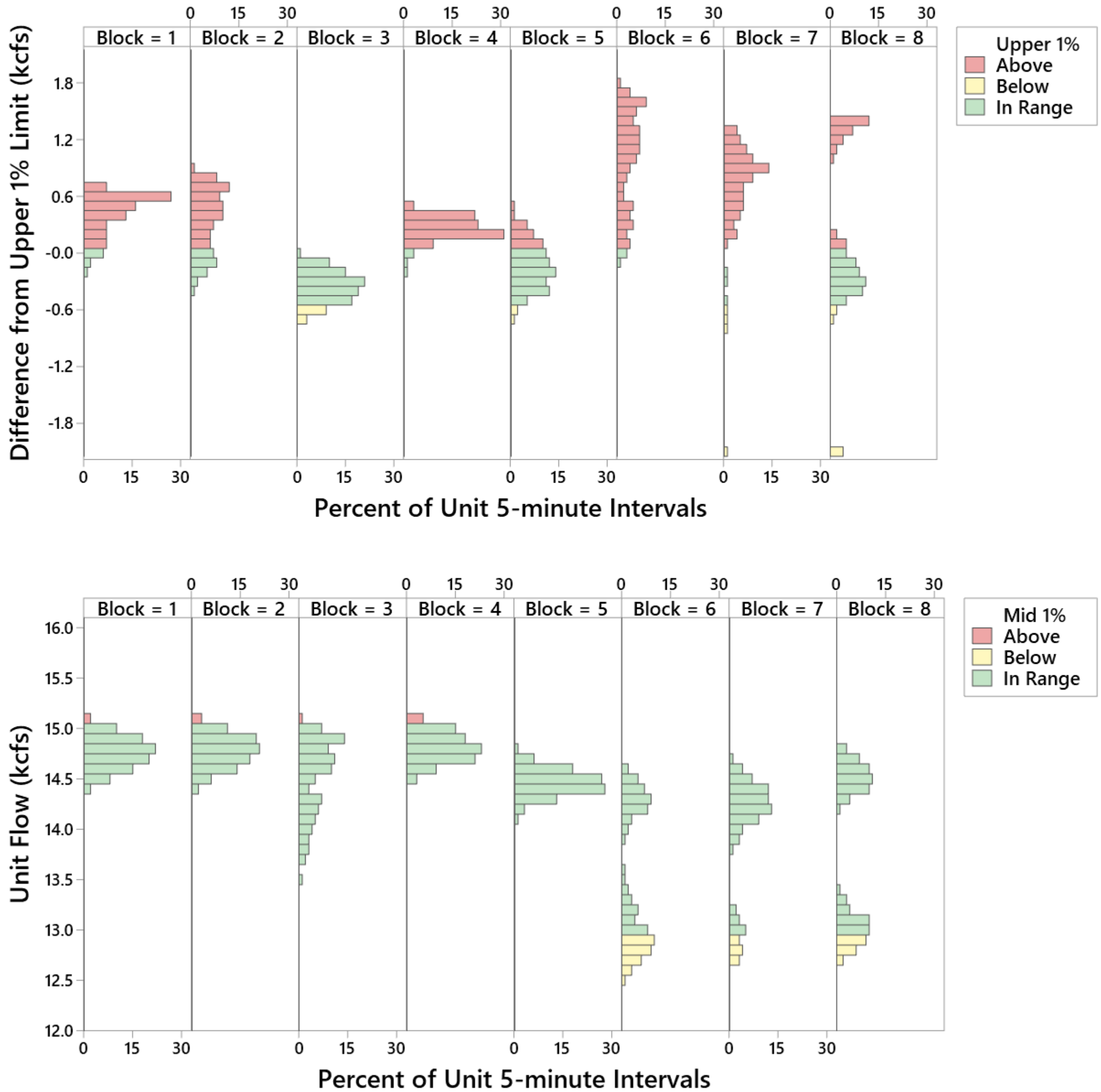

Figure 3.3. Treatment Fidelity for 5-minute Turbine Unit Flows by Block for the Upper 1% (upper panel) and Mid 1% (lower panel) Treatment Levels in Spring. The planned spring blocks 9 and 10 occurred after summer species became predominant in the species composition and were moved to the summer study. Legend colors indicate whether flows or differences fall above, below, or in the planned treatment range.

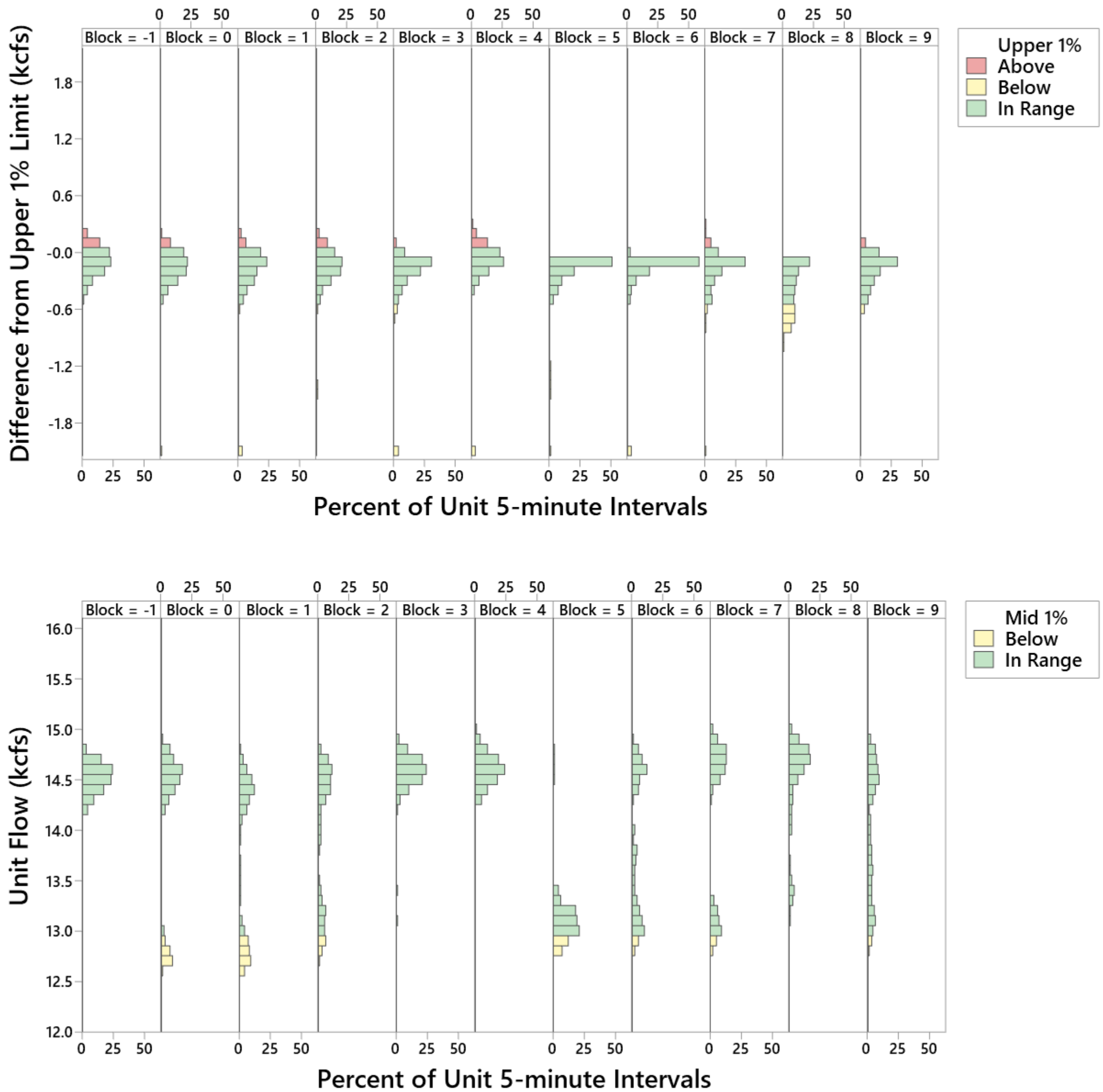

Figure 3.4. Treatment Fidelity for Turbine Unit 5-minute Flows by Block for the Upper 1% (upper panel) and Mid 1% (lower panel) Treatment Levels in Summer. The planned spring blocks 9 and 10 occurred after summer species became predominant and were reconfigured as summer blocks -1 and 0, resulting in 11 blocks numbered from -1 to 9 in the summer study. Legend colors indicate whether flows or differences fall above, below, or in the planned treatment range.

3.2.3 Treatment Test

3.2.3.1 Spring

During the spring study period, a total of 1,737 and 4,421 salmonids were sampled during Mid_1% and Above_1% treatments, respectively (Table 3.1). Of those collected during the Mid_1% treatment, 34 (1.96%) were descaled and 8 (0.46%) were mortalities. Of those collected during the Above_1% treatment, 128 (2.90%) were descaled and 42 (0.95%) were mortalities. Results from the Fisher's exact tests conducted to compare descaling and mortality between treatments indicated there was a significant difference in descaling between treatments ($P = 0.042$). The difference in mortality between treatments was not significant ($P = 0.058$). However, as noted previously, the power to detect a significant difference was reduced for the spring study period. A post-hoc power analysis indicated an Above_1% treatment mortality rate of 1.15% would have been identified as statistically significantly different ($1 - \beta = 0.80$; $\alpha = 0.05$) from the Mid_1% mortality rate given the observed spring study sample size. Although we believe the observed difference in mortality, which was more than twice as high during the Above_1% treatment compared to the Mid_1% treatment, may represent a meaningful difference, the Above_1% treatment includes conditions well outside the planned treatment range. Additional detail on descaling, mortality, and flow conditions by block is presented in Appendix F.

Table 3.1. Results of the block treatment study conducted to evaluate the effect of Mid_1% and Above_1% or Upper_1% B2 treatment operations on descaling and mortality of juvenile salmonids sampled in the B2 JBS during the spring and summer of 2024.

Treatment	Sampled n	Desc. n	Mort. n	Desc. %	Mort. %
		Spring			
Mid_1%	1737	34	8	1.96%	0.46%
Above_1%	4421	128	42	2.90%	0.95%
		Summer			
Mid_1%	2415	24	8	0.99%	0.33%
Upper_1%	3468	97	60	2.80%	1.73%

An evaluation of the species composition by treatment indicated that the proportions of each species were generally similar between treatments. For all spring study period blocks combined, the Mid_1% and Above_1% treatment samples consisted of 66 to 67% yearling Chinook salmon, 13 to 16% coho salmon, 8% clipped steelhead, 4 to 8% subyearling Chinook salmon, 2 to 3% sockeye salmon, and 1 to 3% unclipped steelhead (Table 3.2). Therefore, it is unlikely that the descaling and mortality differences observed between treatments were associated with differences in species composition between treatment samples.

Table 3.2. Species composition and species-specific descaling and mortality rates of juvenile salmonids sampled by the SMP in the B2 JBS during the spring study period.

	Mid_1%	Above_1%
Yearling Chinook		
Total Sampled	1149	2980
% of Total	66.11%	67.41%
% Descaled	2.44%	3.62%
% Mortality	0.44%	1.14%
Subyearling Chinook		
Total Sampled	131	178
% of Total	7.54%	4.03%
% Descaled	0.76%	1.69%
% Mortality	0.00%	0.56%
Coho		
Total Sampled	233	709
% of Total	13.41%	16.04%
% Descaled	0.00%	0.99%
% Mortality	0.43%	0.71%
Unclipped Steelhead		
Total Sampled	49	65
% of Total	2.82%	1.47%
% Descaled	0.00%	1.54%
% Mortality	0.00%	0.00%
Clipped Steelhead		
Total Sampled	145	363
% of Total	8.34%	8.21%
% Descaled	2.07%	1.38%
% Mortality	1.38%	0.00%
Sockeye		
Total Sampled	31	126
% of Total	1.78%	2.85%
% Descaled	6.45%	6.35%
% Mortality	0.00%	1.59%

Evaluating descaling and mortality rates over time revealed similarities between Mid_1% and Above_1% treatments through the first five spring study blocks (Figure 3.5 and Figure 3.6). Through the first five blocks, which extended from SMP dates 22 April through 13 May, the overall descaling rate was 2.4% for fish collected during the Mid_1% unit treatment and 2.3% for fish collected during the Above_1% treatment (Figure 3.5). Similarly, the mortality rate was 0.5% for the Mid_1% treatment and 0.6% for the Above_1% treatment through the first five spring study blocks (Figure 3.6).

During blocks 6 and 7, which included SMP samples taken from 15 May through 22 May, fish collected during the Above_1% treatment experienced substantially higher rates of descaling (4.0%) and mortality (1.7%) compared to those collected during the Mid_1% treatment (descaling = 1.1%; mortality = 0.4%) (Figure 3.5 and Figure 3.6). The timing of the Above_1% samples collected during these blocks coincided with the dates in which flows were well above the upper 1% limit. On average, turbine unit flow was above the 2024 FPP upper 1% limit by 915 cfs during the collection of the 15 May SMP sample and by 529 cfs during the collection of the 22 May SMP sample. Therefore, it is possible that the observed differences between treatments during these two blocks were associated with flows above the upper 1% limit.

The high rates of descaling observed during both treatments of block 8 were associated with the increased proportion of sockeye salmon in those samples. Prior to block 8, sockeye salmon accounted for <11% of the fish in the samples. In block 8, sockeye salmon accounted for 25% of the Mid_1% sample and 26% of the Above_1% sample. Sockeye salmon have been shown to experience higher rates of descaling in the B2 SMP sample, which was apparent in block 8 when sockeye descaling rates were 12.5% and 9.7% during Mid_1% and Above_1% treatments, respectively.

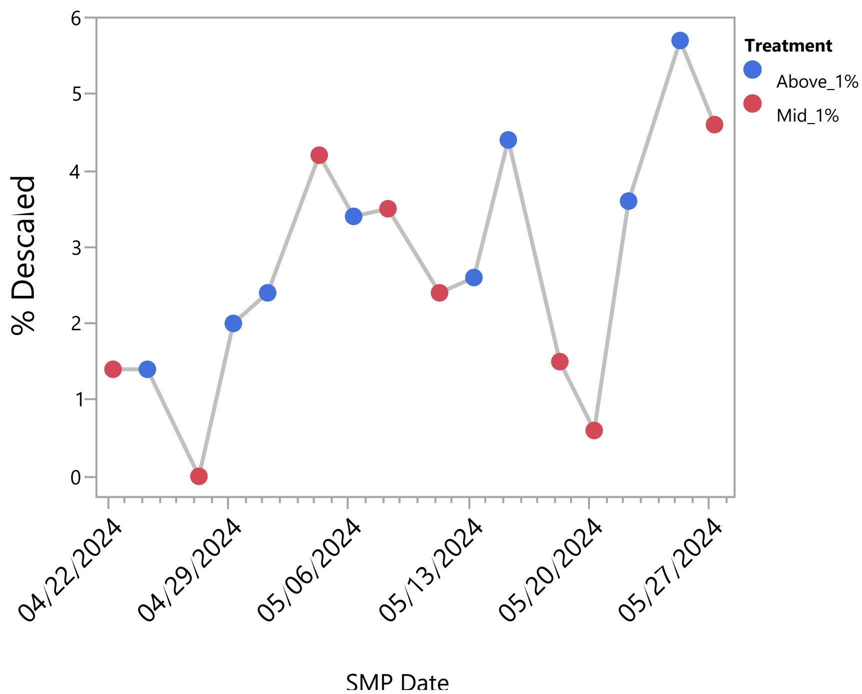

Figure 3.5. Descaling rate of juvenile salmonids sampled in the B2 JBS by the SMP during Mid_1% and Above_1% treatments of the spring study period.

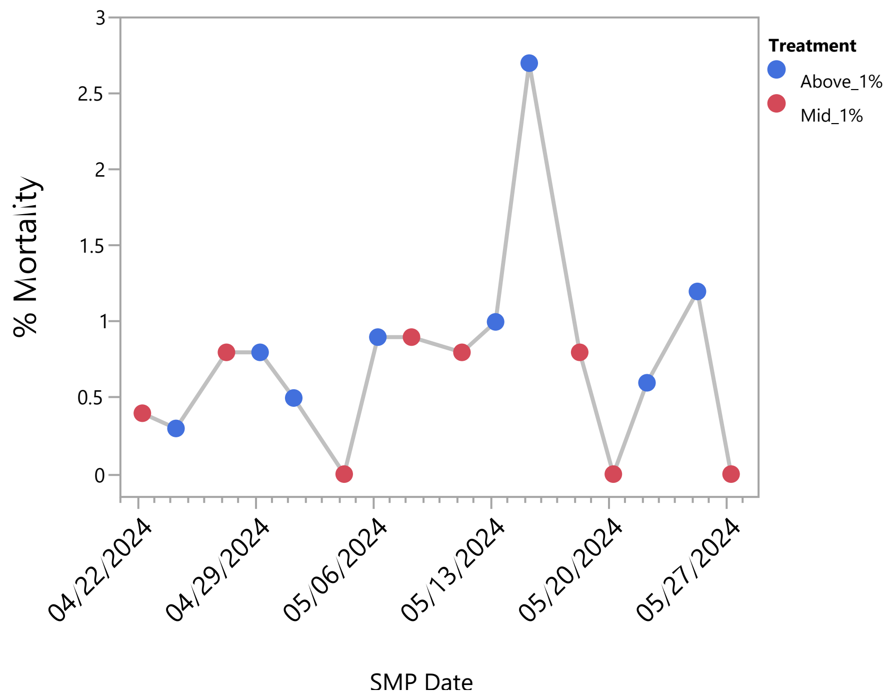

Figure 3.6. Mortality rate of juvenile salmonids sampled in the B2 JBS by the SMP during Mid_1% and Above_1% treatments of the spring study period.

3.2.3.2 Summer

During the summer study period, a total of 2,415 and 3,468 salmonids were sampled during Mid_1% and Upper_1% treatments, respectively (Table 3.1). Of those collected during Mid_1% operations, 24 (0.99%) were descaled and 8 (0.33%) suffered mortality (Table 3.1). Of those collected during Upper_1% unit operations, 97 (2.80%) were descaled and 60 (1.73%) were mortalities. Results of the Fisher's exact tests conducted to compare descaling and mortality between treatments indicated both descaling and mortality were significantly higher during the Upper_1% treatment ($P < 0.001$).

Evaluating the species composition by operational treatment indicated the proportions of each species were generally similar between treatments during the summer study period. Combining all summer study period blocks, the Mid_1% and Upper_1% treatment samples consisted of 89 to 93% subyearling Chinook salmon, 3 to 5% coho salmon, 2 to 3% sockeye salmon, 2% yearling Chinook salmon, <1% unclipped steelhead, and <1% clipped steelhead (Table 3.3). As such, it is unlikely that the observed differences in descaling and mortality between treatments were caused by a difference in species composition between treatments.

Table 3.3. Species composition and species-specific descaling and mortality rates of juvenile salmonids sampled by the SMP in the B2 JBS during the summer study period.

	Mid_1%	Upper_1%
	Yearling Chinook salmon	
Total Sampled	46	73
% of Total	1.90%	2.10%
% Descaled	0.00%	8.22%
% Mortality	0.00%	1.37%
	Subyearling Chinook salmon	
Total Sampled	2238	3083
% of Total	92.67%	88.90%
% Descaled	1.07%	2.59%
% Mortality	0.36%	1.72%
	Coho salmon	
Total Sampled	67	170
% of Total	2.77%	4.90%
% Descaled	0.00%	0.59%
% Mortality	0.00%	0.00%
	Unclipped steelhead	
Total Sampled	14	22
% of Total	0.58%	0.63%
% Descaled	0.00%	0.00%
% Mortality	0.00%	4.55%
	Clipped steelhead	
Total Sampled	10	19
% of Total	0.41%	0.55%
% Descaled	0.00%	0.00%
% Mortality	0.00%	0.00%
	Sockeye salmon	
Total Sampled	40	101
% of Total	1.66%	2.91%
% Descaled	0.00%	9.90%
% Mortality	0.00%	4.95%

An evaluation of descaling rates over time revealed consistent differences between Mid_1% and Upper_1% treatments through the first six blocks of the summer study period (Figure 3.7). During these blocks, which included SMP samples taken between 1 June and 26 June, 4.4% of the fish collected during the Upper_1% treatment were descaled compared to 1.4% for those collected during the Mid_1% treatment (Figure 3.7). During the last five blocks, which included SMP samples taken between 29 June and 20 July, descaling rates were similar between Upper_1% (0.7% descaling) and Mid_1% (0.6% descaling) treatments (Figure 3.7). In contrast, mortality rates remained consistently higher throughout the summer study period for fish sampled during Upper_1% treatment operations compared to those sampled during Mid_1% operations (Figure 3.8).

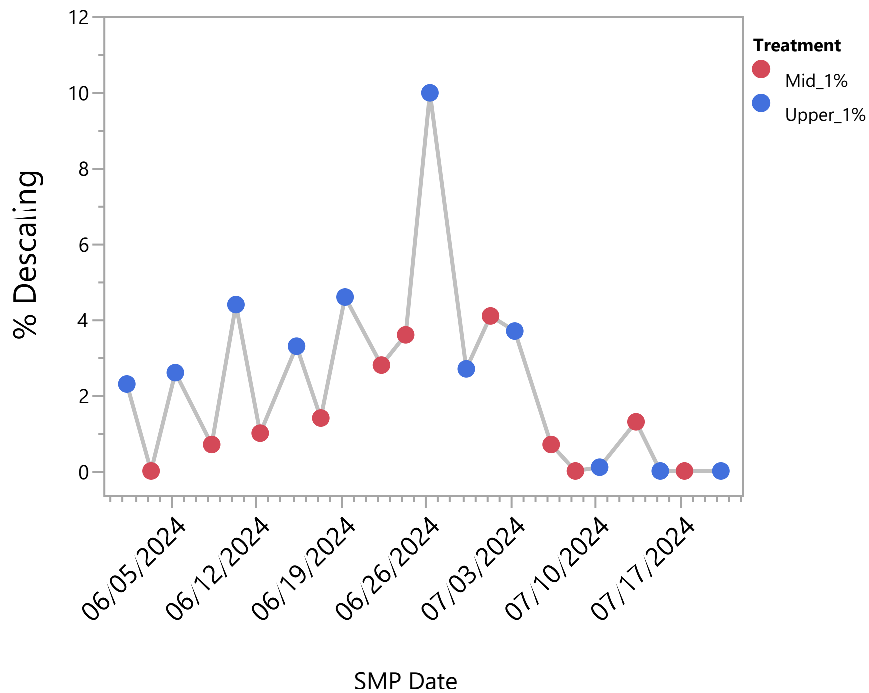

Figure 3.7. Descaling rate of juvenile salmonids sampled in the B2 JBS by the SMP during Mid_1% and Upper_1% treatments of the summer study period.

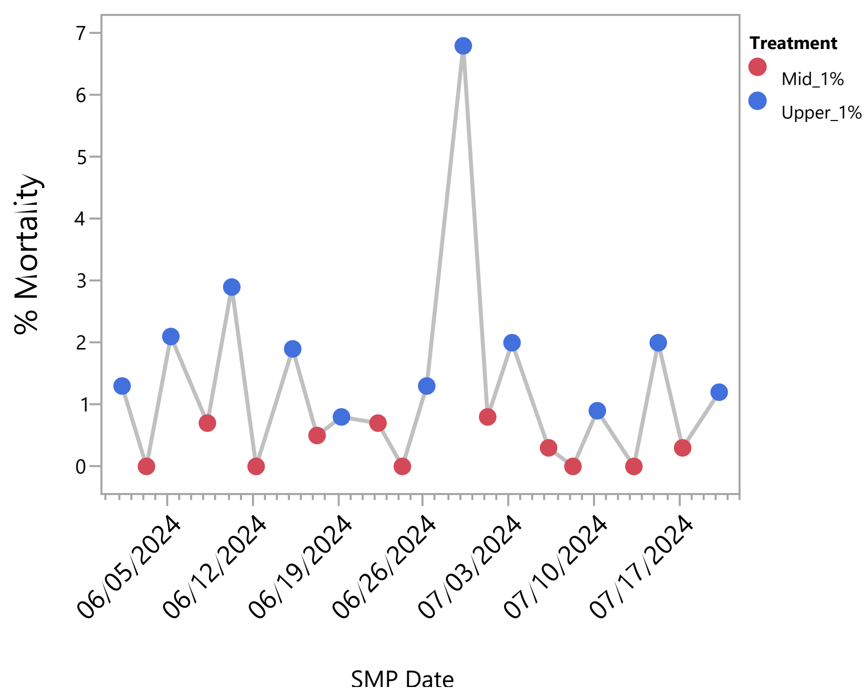

Figure 3.8. Mortality rate of juvenile salmonids sampled in the B2 JBS by the SMP during Mid_1% and Upper_1% treatments of the summer study period.

3.2.4 Comparing 2024 Results with The Historical Baseline

3.2.4.1 Spring

One of the objectives of this study was to evaluate the performance of the modified gatewells relative to past gatewell configurations and operations. The overall descaling rate was 1.96% for fish sampled during Mid_1% treatment operations of the spring 2024 study period. This rate was higher than 73% (8 of 11) of the descaling rates observed during historic (2008–2013) weeks in which B2 units operated in the mid 1% range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish (all species combined) were sampled (Figure 3.9). The 2024 spring Mid_1% descaling rate of 1.96% was lower than 84% (21 of 25) of historic (2008–2013) weeks in which B2 units operated within or above the mid 1% range (i.e., ≥13 kcfs) ≥80% of the time and >100 fish were sampled (Figure 3.9).

For fish sampled at Bonneville Dam on Above_1% treatment days, the overall descaling rate was 2.90% for the 2024 spring study period. This rate of descaling was higher than the descaling rates observed during 91% (10 of 11) of historic (2008–2013) weeks in which B2 units operated in the mid 1% range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish (all species combined) were sampled (Figure 3.9). Compared to historic weeks in which B2 units operated within and above the mid 1% range, the 2024 spring descaling rate of 2.90% was relatively low (Figure 3.9). In fact, the 2024 Above_1% descaling rate was less than the descaling rate observed in 76% (19 of 25) of the historic weeks.

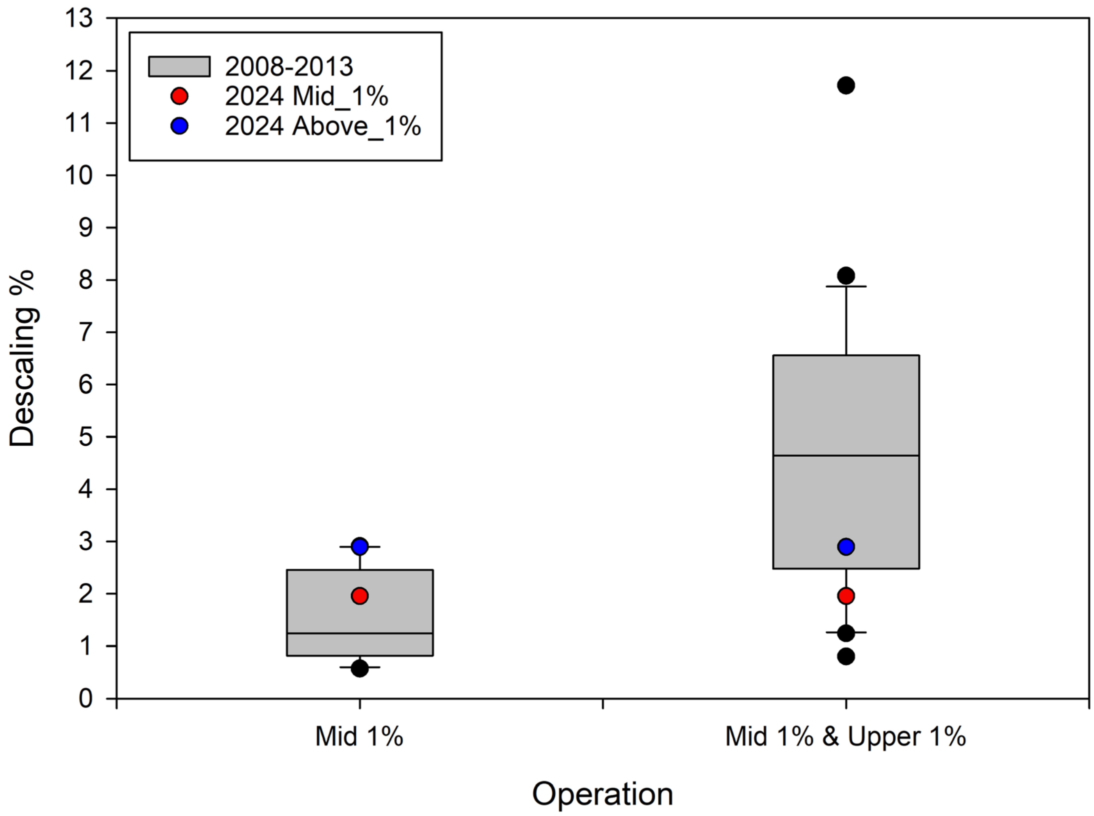

Figure 3.9. Boxplots display the distribution of descaling rates during historic (2008-2013) spring mid 1% (N = 11 SMP weeks when units operated in the mid-range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish were sampled) and historic mid & upper 1% (N=25 SMP weeks when units operated in the mid & upper ranges ≥80% of the time and >100 fish were sampled) operations. Blue dots are spring 2024 descaling rates from all Above_1% samples. Red dots are spring 2024 descaling rates from all Mid_1% samples. Black dots represent historic values outside the 10th and 90th percentiles, whiskers indicate 10th and 90th percentiles, box boundaries represent 25th and 75th percentiles, and lines within boxes indicate medians.

The overall mortality rate of fish sampled during Mid_1% operations of the spring 2024 study period was 0.46%, which was slightly higher than the median mortality rate observed during historic (2008–2013) weeks in which B2 units operated within the mid 1% range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish (all salmonid species combined) were sampled (Figure 3.10). The 2024 spring study period mortality rate of 0.46% was also lower than 80% (20 of 25) of historic weeks in which B2 units operated within or above the mid 1% range ≥80% of the time and >100 fish were sampled (Figure 3.10).

For fish sampled on all Above_1% treatment days, the overall mortality rate was 0.95% for the spring 2024 study period. This mortality rate was higher than the mortality rates observed during 100% (11 of 11) of historic (2008–2013) weeks in which B2 units operated within the mid 1% range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish (all salmonid species combined) were sampled (Figure 3.10). Compared to historic weeks in which B2 units operated within and above the mid 1% range ≥80% of the time, the 2024 spring mortality rate of 0.95% during Above_1% treatment days was near the median (Figure 3.10).

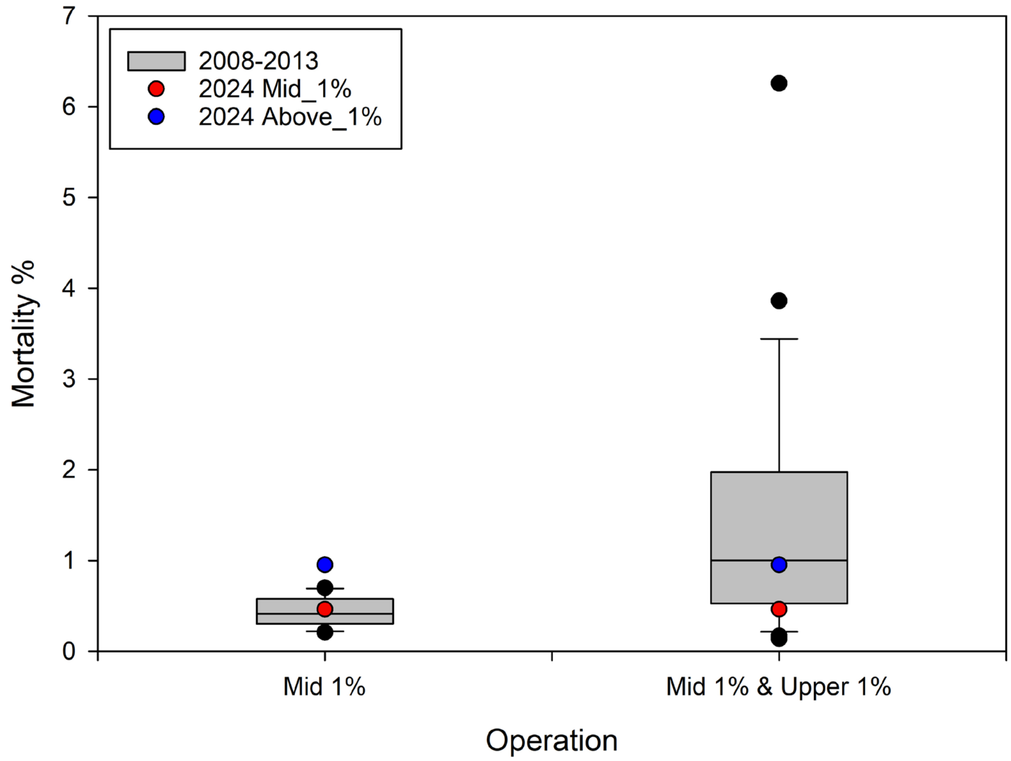

Figure 3.10. Boxplots display the distribution of mortality rates during historic (2008-2013) spring mid 1% (N = 11 SMP weeks when units operated in the mid range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish were sampled) and historic mid & upper 1% (N=25 SMP weeks when units operated in the mid & upper ranges ≥80% of the time and >100 fish were sampled) operations. Blue dots are spring 2024 mortality rates from all Above_1% samples. Red dots are spring 2024 mortality rates from all Mid_1% samples. Black dots represent historic values outside the 10th and 90th percentiles, whiskers indicate 10th and 90th percentiles, box boundaries represent 25th and 75th percentiles, and lines within boxes indicate medians.

3.2.4.2 Summer

During the summer study period, fish sampled during the Mid_1% treatment had an overall descaling rate of 0.99%, which was higher than 77% (10 of 13) of the historic (2008–2013) summer weeks in which B2 units operated within the mid 1% range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish were sampled for descaling and mortality (Figure 3.11). The 2024 summer Mid_1% descaling rate of 0.99% was lower than 57% (13 of 23) of historic weeks in which B2 units operated within or above the mid 1% range ≥80% of the time (Figure 3.11).

For fish sampled during Upper_1% treatment days of the summer study period, the overall descaling rate was 2.80%. This rate of descaling was higher than the descaling rates observed during 100% (13 of 13) of the historic (2008–2013) summer weeks in which B2 units operated within the mid 1% range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish were sampled for descaling and mortality (Figure 3.11). Compared to historic weeks in which B2 units operated within and above the mid 1% range, the 2024 summer descaling rate of 2.80% during Upper_1% treatment operations was higher than 91% (21 of 23) of the historic weeks (Figure 3.11).

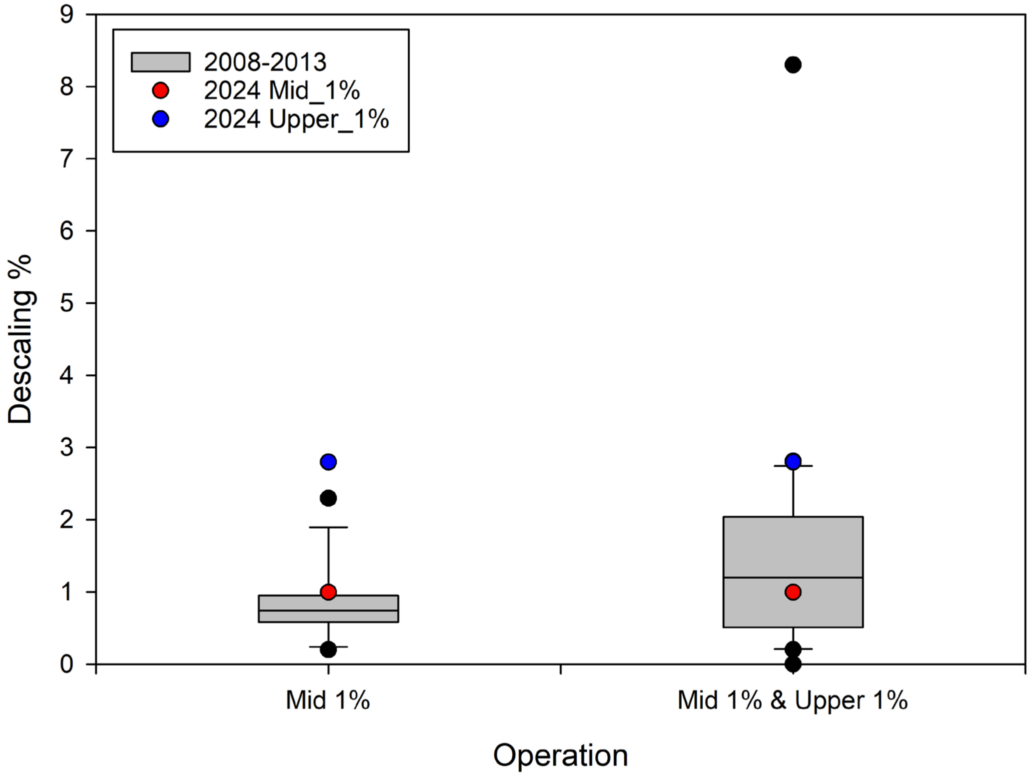

Figure 3.11. Boxplots display the distribution of descaling rates during historic (2008-2013) summer mid 1% (N = 13 SMP weeks when units operated in the mid-range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish were sampled) and historic mid & upper 1% (N=23 SMP weeks when units operated in the mid & upper ranges ≥80% of the time and >100 fish were sampled) operations. Blue dots are summer 2024 descaling rates from all Upper_1% samples. Red dots are summer 2024 descaling rates from all Mid_1% samples. Black dots represent historic values outside the 10th and 90th percentiles, whiskers indicate 10th and 90th percentiles, box boundaries represent 25th and 75th percentiles, and lines within boxes indicate medians.

The overall mortality rate of fish sampled during the Mid_1% treatment of the summer 2024 study period was 0.33%. This rate of mortality was lower than the mortality rates observed during 85% (11 of 13) of the historic (2008–2013) weeks in which B2 units operated within the mid 1% range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish were sampled (Figure 3.12). Compared to historic weeks in which B2 units operated within and above the mid 1% range ≥80% of the time, the 2024 mortality rate of 0.33% was lower than 78% (18 of 23) of the historic weeks (Figure 3.12).

Fish sampled during Upper_1% treatment days of the summer 2024 study period had an overall mortality rate of 1.73%. This rate of mortality was higher than 92% (12 of 13) of the historic (2008–2013) weeks in which B2 units operated within the mid 1% range ≥50% of the time and >18 kcfs <10% of the time (Figure 3.12). Compared to historic weeks in which B2 units operated within and above the mid 1% range, the 2024 summer mortality rate of 1.73% was higher than 61% (14 of 23) of the historic weeks (Figure 3.12).

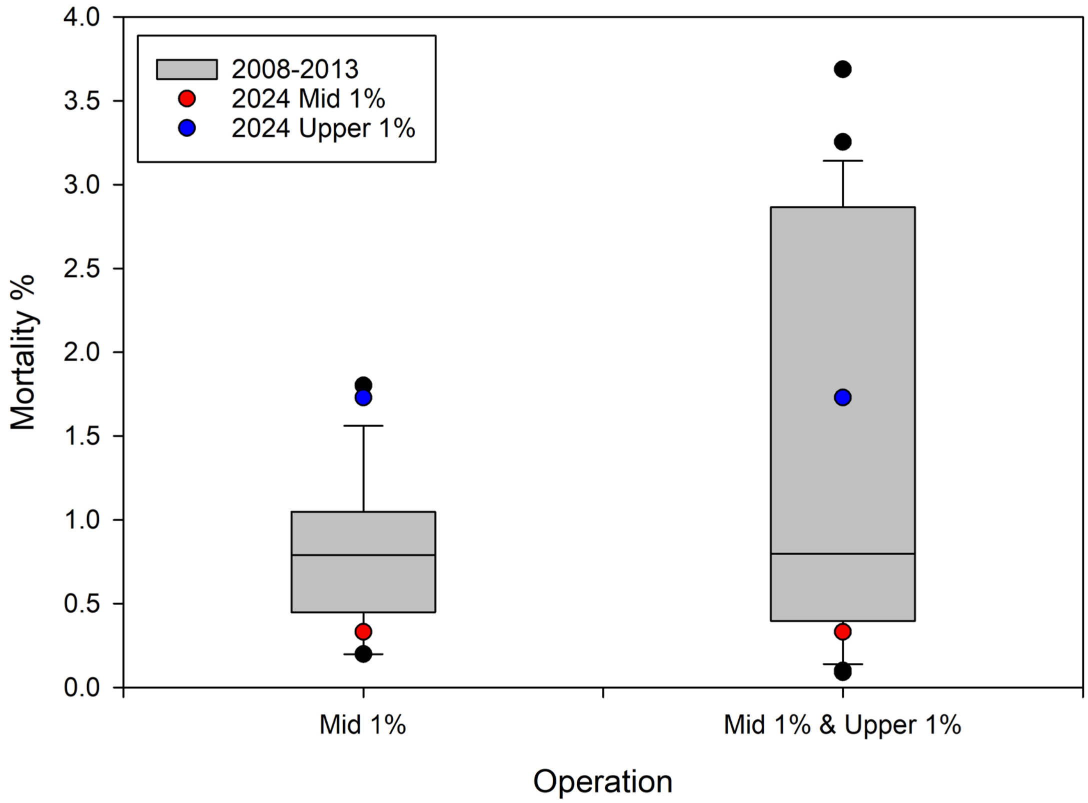

Figure 3.12. Boxplots display the distribution of mortality rates during historic (2008-2013) summer mid 1% (N = 13 SMP weeks when units operated in the mid-range ≥50% of the time, >18 kcfs <10% of the time, and >100 fish were sampled) and historic mid & upper 1% (N=23 SMP weeks when units operated in the mid & upper ranges ≥80% of the time and >100 fish were sampled) operations. Blue dots are summer 2024 mortality rates from all Upper_1% samples. Red dots are summer 2024 mortality rates from all Mid_1% samples. Black dots represent historic values outside the 10th and 90th percentiles, whiskers indicate 10th and 90th percentiles, box boundaries represent 25th and 75th percentiles, and lines within boxes indicate medians.

3.3 Objective 3: Conduct a Pilot-Scale Effort to Evaluate Run-of-River Juvenile Salmonid VBS Impingement During Mid and Upper 1% Peak Efficiency Range Operations in Modified and Unmodified Gatewells

3.3.1 Imaging Sonar

The pilot scale evaluation of impingement using acoustic imaging sonars revealed this methodology to be an ineffective means for observing impingement. Due to turbulence within the gatewell and the need for cameras to remain steady, the imaging sonars could not be deployed at a sufficient depth to observe fish near the bottom of the VBS where the highest velocities have been measured. Additionally, the resolution within the zone of interest was insufficient for observing impingement (Figure 3.13). However, some information regarding juvenile fish abundance and behavior within the upper portion of the gatewell was obtained.

Relative fish abundance observed using the imaging sonars was variable and tended to be lower in slots C for both units 11 and 15. Fish location was variable but was concentrated near the upper portion of the gatewells and near the upper 15 ft of the screened portion of the VBS. Fish behavior was also variable but more milling behavior was observed in the C slot whereas more upward-directed movements were observed in the A slot for both units 11 and 15 (Table 3.4).

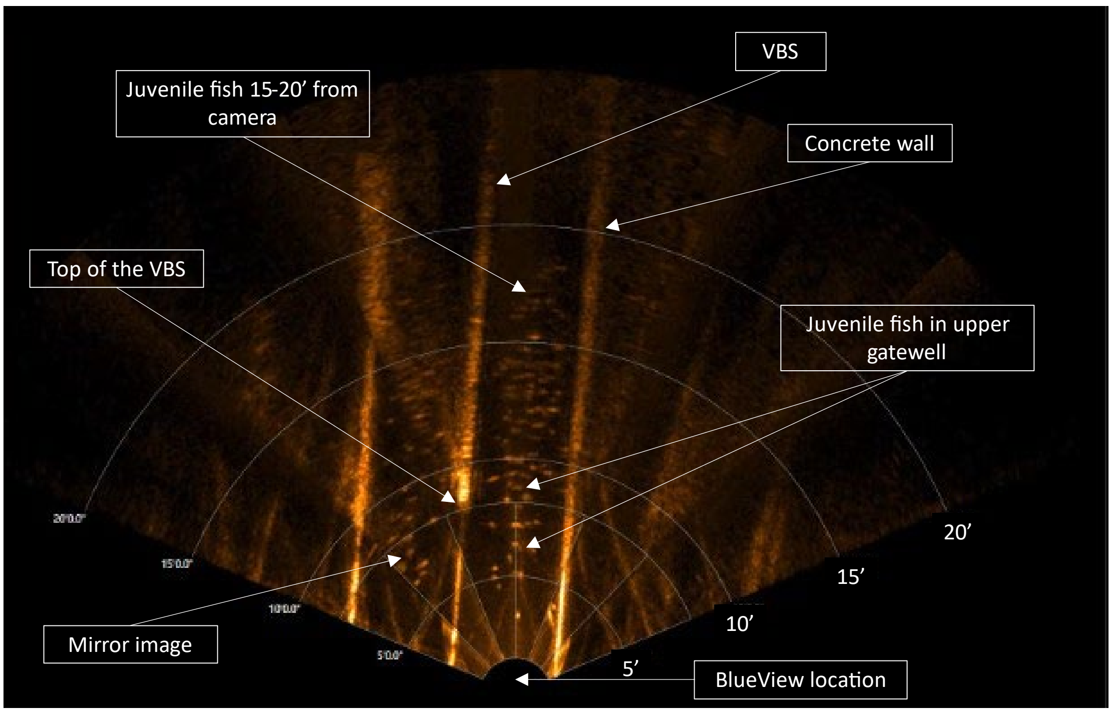

Figure 3.13. Still image from acoustic imaging sonar deployed in the gatewell of B2 Unit 15, slot A. The bottom of the image is closest to the water surface.

Table 3.4. Relative numbers of fish, their depth in the gatewells, and behavior in units 11 and 15, slots A and C during Mid 1% or Upper 1% operations in spring and summer. Fish abundance was categorized as low 0-50, med 50-100, and high 100-200.

Date	Slot	Time	Fish depth (ft) relative to sonar	Behavior	Abundance	Operation
May 8	11A	1100	0-15	Upward/milling	high	Upper 1%
May 15	11A	1300	0-15	Upward/milling	Med	Mid 1%
May 22	15A	1030	5-25	milling near VBS	High	Upper 1%
	15C	1030	5-20	milling near VBS	Med	Upper 1%
May 29	11A	1830	0-10	up and down/milling	Med	Upper 1%
	11C	1830	0-10	mostly upward	Low	Upper 1%
June 5	15A	1500	0-5	milling	Low	Mid 1%
	15C	1100	0-5	milling	Low	Mid 1%
June 12	15A	1730	0-20	upward	Med	Upper 1%
	15C	1730	0-10	milling	Low	Upper 1%
June 19	15A	1720	0-15	upwards/milling	Med/high	Upper 1%
	15C	1720	0-10	milling	Low	Upper 1%
June 26	15A	0800	0-15	milling/schooling	Low	Mid 1%
	15C	0900	0-15	milling/schooling	Low	Mid 1%
July 10	11A	1100	0-10	milling	Low	Mid 1%
	11C	1100	0-15	milling	Med	Mid 1%
July 17	11A	1730	0-15	milling/upward/near VBS	Med	Upper 1%
	11C	1730	0-15	milling	Low	Upper 1%

3.3.2 Spot Checks with Gatewell Camera Truck

Although the spot checks conducted with the gatewell camera truck were limited to three days within the study period, they proved to be an effective means for observing fish impinged on the VBS. However, it is important to acknowledge that nothing is known about the condition of fish observed on the screens prior to their impingement. It is possible that the observed impinged fish were moribund or emaciated prior to impingement. All gatewell camera truck spot checks occurred during Above_1% or Upper_1% treatment operations on 29 April, 3 June, and 8 July in the A, B, and C slots of units 11 and 18, which were the only operating units at the time of the checks. On average, it took 1 hr and 28 min (range: 40 min – 2 hr 12 min) to scan the VBSs for a single operating unit. Unit operations were generally maintained near (no more than 300 cfs greater than) the upper 1% limit immediately prior to and during the spot checks.

During the gatewell spot check conducted on 29 April, one salmonid was observed impinged on the top VBS panel in slot B of Unit 11. On 3 June, one salmonid was observed impinged on the lower portion of the top VBS panel in the A slot of Unit 11. During the spot check conducted on 8 July, eight salmonids were observed impinged on the south portion of VBS panels in the A slot of Unit 11. Of those, five appeared to be mortalities, two were still gilling, and one was unknown. No fish were observed impinged on the VBS panels of Unit 18 during any of the three gatewell spot checks.

The smaller size of subyearling Chinook salmon may have contributed to the higher numbers of impinged fish observed on 8 July. The estimated length of the eight impinged fish ranged from 71 to 97 mm on 8 July, when >99% of the salmonids sampled by the SMP were subyearling

Chinook salmon. Although the majority of salmonids passing through the gatewells during the second spot check conducted on 3 June were also likely subyearling Chinook salmon, based on 77% of the 4 June SMP sample being subyearling Chinook salmon, subyearling Chinook salmon sampled by the SMP in June were substantially larger than those sampled in July (Figure 3.14).

The lower flow in Unit 18 immediately prior to the gatewell camera truck VBS spot check may be responsible for the difference in impingement observed between units 11 and 18 during the 8 July spot check. Leading up to and throughout the spot check at Unit 11, which was conducted from 7:49 to 9:10 AM, the flow rate into Unit 11 was about 16.6 kcfs (Figure 3.15). Although the flow into Unit 18 was similar (~16.5 kcfs) during the Unit 18 spot check, which was conducted from 10:15 to 11:35 AM, Unit 18 flow was lower (~16 kcfs) during the approximately 1.5-hour period leading up to the spot check (Figure 3.15).

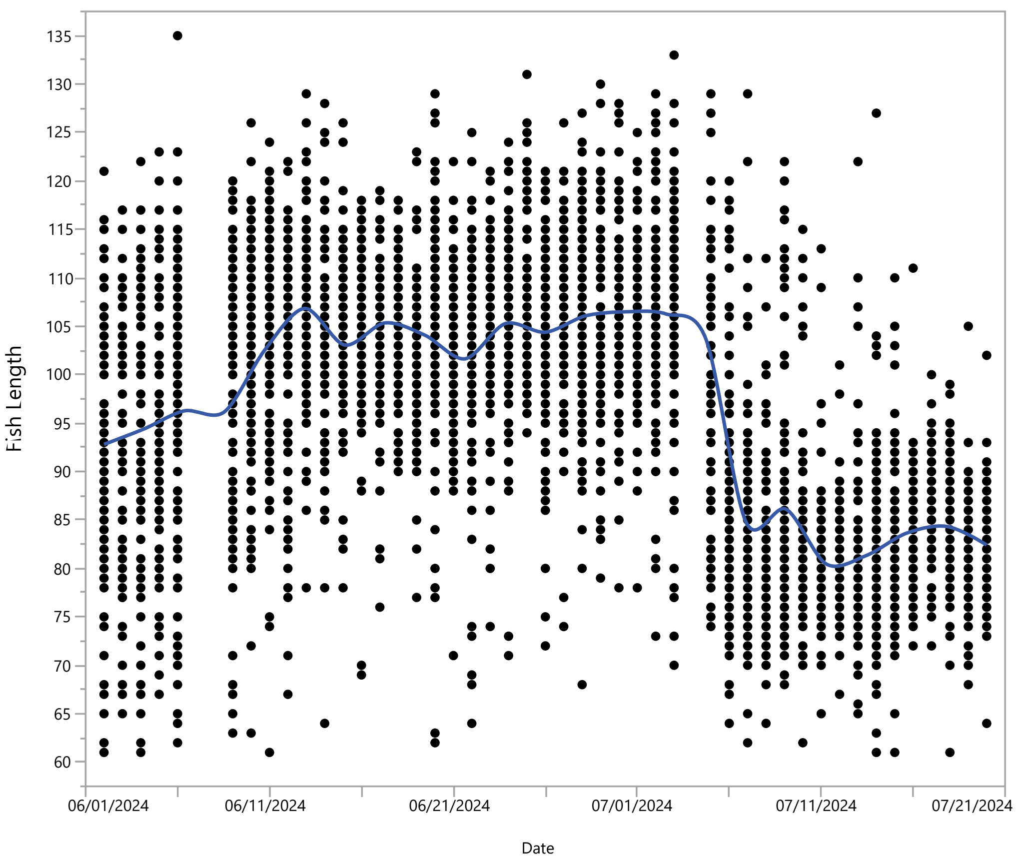

Figure 3.14. Scatterplot depicting the length of subyearling Chinook salmon sampled by the SMP at B2 during the summer study period. The blue line depicts a locally estimated scatterplot smoothing (LOESS) regression model fit to the data.

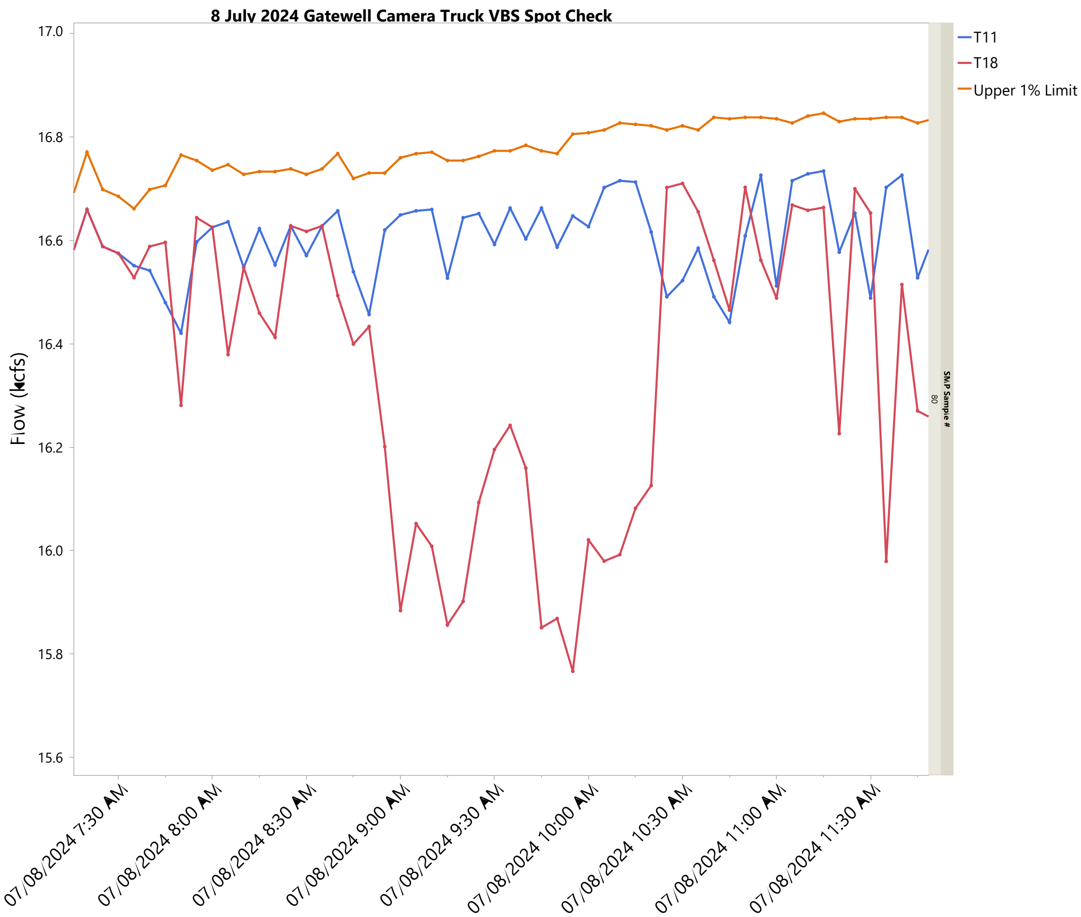

Figure 3.15. Flow rate into B2 turbine units 11 and 18 leading up to and during gatewell camera truck VBS spot checks conducted on 8 July 2024.

4.0 Conclusions

Developing a timeline of historical gatewell status and operations for Objective 1 revealed a window between 2008 and 2013 when there were few structural changes. This period was chosen as the basis for comparison with 2024 results. Operations during the chosen period were too variable to fit strict operational criteria, but loosened approximate operational bins were created for comparing descaling and mortality in SMP samples exposed to conditions that were primarily mid 1% or were primarily mid and upper 1%.

In the spring 2024 study period, due to challenges with the software and hardware guiding operations at B2, average turbine unit discharge was often above the specified range of the Upper_1% treatment (Figure 3.3). Given these issues, the reader must remain aware that spring measures of descaling and mortality do not reflect planned Upper_1% treatment conditions, leading to reduced confidence in statistical and non-statistical comparisons of 2024 spring data. To remind the reader of this difference, the spring Upper_1% treatment was renamed "Above_1%".

Results from the block-treatment study indicated rates of descaling and mortality were higher for fish collected during operations at or above the upper 1% limit (Above_1%) compared to those collected during Mid_1% treatment operations. During the summer study, unit operations were maintained within the prescribed flow ranges at least 83% of the time. Subyearling Chinook salmon, which are smaller and therefore more susceptible to impingement, dominated the SMP sample in summer when descaling and mortality rates were higher during the Upper_1% treatment compared to the Mid_1% treatment.

The pilot scale evaluation of impingement using acoustic imaging sonars revealed this methodology to be an ineffective means for observing impingement. However, the VBS spot checks conducted using the gatewell camera truck generally agreed with the results of the block-treatment study. Only one salmonid was observed impinged during upper 1% unit operations from the single spring study period spot check, whereas nine salmonids were observed impinged during two summer study period spot checks conducted while units operated at the upper 1%. The greatest number of impinged fish were observed during late summer when subyearling Chinook salmon were smaller, again indicating fish size is a key factor affecting impingement.

The recently completed modifications to the gatewells and VBS porosity were designed to reduce descaling and mortality rates during upper 1% operations. Although 2024 rates did not drop to levels observed during mid 1% operations from 2008–2013, there was evidence of improvement in the spring when fish were larger. Spring 2024 mortality and descaling rates at the upper 1% level and above, were at or below the median values for operations in the mid 1% and upper 1% range in those earlier years. There was little evidence of improvement in summer, when fish were smaller and presumably less able to resist flows. It is important to keep in mind that 2024 is a single data point for comparing the performance of the modified gatewells to the historical results particularly if there was a higher level of background descaling in 2024. Additional study could help confirm these results or seek a level of operation that achieves the desired outcomes for fish.

5.0 References

Absolon, RF, and BP Sandford. 2016. *Passage evaluation of Spring Creek Hatchery subyearling Chinook salmon at Bonneville Dam second powerhouse, 2015.* Prepared by the National Marine Fisheries Service for the U.S. Army Corps of Engineers, Portland District.

Alden. 2022. *Bonneville Dam second powerhouse gatewell velocity and pressure measurements data collection report, revision 02.* Alden document no. 7214NWP052. Prepared by Alden Research Laboratory, Inc. for the U.S. Army Corps of Engineers, Portland District.

Gilbreath, LG, BP Sandford, MH Gessel, DA Brege, and D Ballinger. 2012. *Condition and gatewell retention time of yearling and subyearling Chinook salmon guided from modified turbine intakes at Bonneville Dam second powerhouse, 2008–2009.* Prepared by the National Marine Fisheries Service for the U.S. Army Corps of Engineers, Portland District.

Gilbreath, LG, RF Absolon, BP Sandford, and D Ballinger. 2014. *Passage evaluation of Spring Creek Hatchery subyearling Chinook salmon at Bonneville Dam second powerhouse, 2013.* Prepared by the National Marine Fisheries Service for the U.S. Army Corps of Engineers, Portland District.

Harbor and Alden. 2013. *Water velocity measurements on vertical barrier screens with and without proof-of-concept turbulence reduction devices at the Bonneville Dam second powerhouse, data collection report.* Prepared by Harbor Consulting Engineers, Inc. and Alden Research Laboratory, Inc. for the U.S. Army Corps of Engineers, Portland District.

Harbor and Alden. 2014. *B2 VBS velocity profiles, Bonneville Dam, second powerhouse, data collection report.* Prepared by Harbor Consulting Engineers, Inc. and Alden Research Laboratory, Inc. for the U.S. Army Corps of Engineers, Portland District.

Harbor and Alden. 2015. *B2 VBS velocity profiles, Bonneville Dam, second powerhouse, data collection report.* Prepared by Harbor Consulting Engineers, Inc. and Alden Research Laboratory, Inc. for the U.S. Army Corps of Engineers, Portland District.

Ham, KD, RP Mueller, PS Titzler, JS Hughes, and GE Johnson. 2017. *Fish guidance efficiency of modified main unit gatewells at Bonneville Dam powerhouse 2, interim report.* PNNL-27022. Prepared by Pacific Northwest National Laboratory for the U.S. Army Corps of Engineers, Portland District.

Hughes, JS, MA Weiland, Z Deng, and JJ Martinez. 2011. *Water velocity measurements on a vertical barrier screen at the Bonneville Dam second powerhouse, final report.* PNNL-20746. Prepared by Pacific Northwest National Laboratory for the U.S. Army Corps of Engineers, Portland District.

Ploskey, GR, CR Schilt, J Kim, CW Escher, and JR Skalski. 2003. *Hydroacoustic evaluation of fish passage through Bonneville Dam in 2002.* PNNL-14356. Prepared by Pacific Northwest National Laboratory for the U.S. Army Corps of Engineers, Portland District.

Ploskey, GR, MA Weiland, and CR Schilt. 2004. *Evaluation of fish losses through screen gaps at modified and unmodified intakes of Bonneville Dam second powerhouse in 2003.* PNNL-14539. Prepared by Pacific Northwest National Laboratory for the U.S. Army Corps of Engineers, Portland District.

Appendix A – Timeline of Bonneville Dam Powerhouse 2 Gatewell Modifications and Operations Changes

2001

Unit 15 Outage: 01/29/01 - 04/19/01

Gatewells 15B & 15C

- The top 6' of intake concrete beam el. +37' to +31' was removed to accommodate larger VBS

- The existing vertical barrier screen (VBS) was extended downward to increase the screened area and facilitate upward flow.

- A curved turning vane extending across the intake width (just above top of STS) was added to turn flow upward.

- A gap closure device was attached to the intake ceiling, covering about 12 inches of the 18-inch gap that exists in an unmodified unit.

Gatewell 15A

- Partially modified by concrete beam removal on top 6', existing VBS extension, and the addition of a turning vane but did NOT receive a gap-closure device.

Unsure: Turbine intake extensions (TIEs) were installed on every other intake across B2, odd-numbered intakes have the same configurations (TIEs on A & C intakes but none on B intakes) Referenced in Monk et al. (2002) & Ploskey et al. (2004) for 2001/2002 modifications.

2002

Unit 17 Outage: 01/02/02-04/08/02

Gatewells 17A-C

- The top 6' of intake concrete beam el. +37' to +31' was removed to accommodate larger VBS.

- The vertical barrier screen (VBS) was extended downward to increase the screened area and facilitate upward flow.

- A curved turning vane (20' x 4') extending across the intake width also was added to turn flow upward.

- A gap closure device was attached to the intake ceiling, covering about 12 inches of the 18-inch gap that exists in an unmodified unit.

Structural damage to VBS in 2002 caused by debris loading initiated a redesign effort in 2003

In 2002, the B slot of Unit 17 had a higher FGE than did the C slot, and this likely was because the B slot was between two TIEs (Ploskey et al. 2003).

2003

No structural modifications and no main unit outages that were relevant to FGE modifications.

- Effort began to model and implement a VBS with better hydraulic characteristics. The Corps, in conjunction with ENSR and CH2M-Hill, completed a process of brainstorming, modeling, and designing a concept VBS for unit 17 that culminated in an interchangeable, full height VBS with profile wire screens. This appears to mean that Unit 15 and Unit 17 in 2001 and 2002, respectively, had the “existing” VBS extended downward vertically.

2004

Background:

- B2 Corner Collector operational, B1 sluiceway had 3 entrances open (2c,4c,6c), all unscreened intakes at B1.

- New VBSs delivered via barge on 04/09/04.

2005

Background:

- B2CC operational, B1 sluiceway entrances 1C, 3C, and 6C were opened and sampled in 2005. No STSs installed at B1.

- No TIEs were installed upstream of B2 turbines 11 through 14 facilitated southerly flow along the powerhouse toward the B2CC.

- Remaining TIEs potentially at: 15A, 15C, 16B, 17A, 17C, and 18B.

- Plans and specifications for the VBS modifications and bulkheads completed in fiscal year (FY) 2005. Contract award took place early in August 2005 with construction activities in the intakes being completed over three fiscal years (FY 06, 07, and 08).

- VBS lessons learned that should be incorporated into new design through P&S development: more economical wheels, improved side seals, improved lifting pins, and revisions to guide slots.

VBS Wash-down system

Turning vane design was possibly modified to provide easier access to the motors.

VBS Bar Screen Changes.

- One of the main suppliers, Hendrick Screens, made structural improvements by tightening the spacing of the U-clip spacing from 2-3/4 inch to 2 inches. It was determined that this does not adversely affect hydraulics. There have been no reported problems with the existing VBS screens with the 2-3/4 inch spacing.

- The distance of the screen to perforate plate was revised from 6-inches for the prototype to 4-3/4-inches. ENSR indicated that this should not adversely affect hydraulics.

- It was proposed to use stainless steel in lieu of carbon steel for the perforated plate. Reduction in maintenance was cited as the rationale for the change.

Sill Beam Analysis
HDC completed an analysis of the sill beams for the exterior units, Unit 11 and Unit 18. A memorandum was provided.

- There was no longer uncertainty on which units could be modified (or possible revisions to the sill beam details). **Sill beam modifications were to be typical for all units**.

Note: Structural modifications to Unit 13 began in November 2005 but are displayed under 2006 modifications since the unit went back into service in January 2006.

<u>2006</u>

Unit 13 outage: 11/01/05-01/26/06

Gatewells 13A-C

- Concrete drilling and demolition of the VBS guide slots and gatewell sill beam to lower sill 6' and modify gatewell slot to accept new larger interchangeable VBSs.

- Installation of gap closure devices.

- Installation of new turning vanes and new interchangeable VBSs.

- Installation of gatewell pressure transducers.

Unit 12 outage 01/25/06-04/18/06

Gatewells 12A-C

- Concrete drilling and demolition of the VBS guide slots and gatewell sill beam to lower the sill 6' and modify the gatewell slot to accept new larger interchangeable VBSs.

- Installation of gap closure devices.

- Installation of new turning vanes and new interchangeable VBSs.

- Installation of gatewell pressure transducers.

Unit 16 outage 10/02/06-12/04/06

Gatewells 16A-C

- Concrete drilling and demolition of the VBS guide slots and gatewell sill beam to lower the sill 6’ and modify the gatewell slot to accept new larger interchangeable VBSs.

- Installation of gap closure devices.

- Installation of new turning vanes and new interchangeable VBSs.

- Installation of gatewell pressure transducers.

2007

Unit 11 Outage 12/05/06-02/08/07

Gatewells 11A-C

- Concrete drilling and concrete demolition of the VBS guide slots and gatewell sill beam to lower the sill 6’ and modify the gatewell slot to accept new larger interchangeable VBSs.

- Installation of gap closure devices.

- Installation of new turning vanes and new interchangeable VBSs.

- Installation of gatewell pressure transducers.

Unit 15 Outage 02/08/07-05/31/07

Gatewell 15A

- Installation of gap closure device (15B-C already received GCDs in 2001).

- Drilling and demolition of VBS guide slot and modification of sill beam to accept new interchangeable VBSs.

Note: 15A already had turning vane and concrete sill beam modification from 2001 but the sill was not yet modified to accept interchangeable VBSs.

- Installation of gatewell pressure transducers.

Gatewells 15B & C

- Drilling and demolition of VBS guide slot to accept new interchangeable VBSs.

Note: 15B&C gatewells already had gap closure devices, turning vane, and concrete sill beam modification from 2001 but the sill was not yet modified to accept interchangeable VBSs.

- Installation of gatewell pressure transducers.

Unit 14 outage 08/13/07-12/22/07

Gatewells 14A-C

- Concrete drilling and concrete demolition of the VBS guide slots and gatewell sill beam to lower the sill 6’ and modify gatewell slot to accept new larger interchangeable VBSs.

- Installation of gap closure devices.

- Installation of new turning vanes and new interchangeable VBSs.

- Installation of gatewell pressure transducers.

<u>2008</u>

Unit 18 outage: 12/03/07-02/28/08

Gatewells 18A-C

- Concrete drilling and concrete demolition of the VBS guide slots and gatewell sill beam to lower the sill 6’ and modify gatewell slot to accept new larger interchangeable VBSs.

- Installation of gap closure devices.

- Installation of new turning vanes and new interchangeable VBSs.

- Installation of gatewell pressure transducers.

Unit 17 outage: 02/23/08-03/26/08

Gatewells 17A-C

- Installation of gatewell pressure transducers.

Unit 16 outage: 03/05/08-03/31/08

Gatewell 16A

- FGE Repairs. Cannot find explanation as to what type of repairs were made. Referred to in annual and weekly reports as ‘FGE repairs’ and cannot find out what happened specifically in 16A. Checked MFRs as well.

<u>Post-2008</u>

- (Gilbreath et al. 2012 and 2023 SRWG B2FGE 1-pager) - **In 2007, data from the Bonneville Dam Smolt Monitoring Program (SMP) indicated that substantial mortality occurred during second powerhouse passage of tule stock Chinook salmon *Oncorhynchus tshawytscha* released in March and April from the Spring Creek National Fish Hatchery** (D. Ballinger, PSMFC, personal communication). Daily mortality rates measured at the sampling facility ranged from 1.6 to 11.7% during passage of the early March releases (7-13 March). Fish from the April release began arriving at the monitoring facility at about 0645 PDT on 13 April, and from that time until 0900, the mortality rate was 10.1%. In contrast, SMP data from daily samples (≥100) of these same stocks showed that from 2000 to 2006, passage mortality had exceeded 1% on only one date in March (16 March 2002) and three dates in April (1 April 2002 and 17-18 April 2004).

- **Starting in 2008, B2 units were operated at the lower end of the 1% peak efficiency range during Spring Creek NFH releases**.

- Gilbreath et al. 2012 – unmodified gatewells tested in 2008 and 2009 with Spring Creek National Fish Hatchery (SCNFH) subyearling Chinook salmon and run-of-river fish.

- Operations from the lower 1%, mid 1%, and upper 1%.
- Treatment groups were released to Gatewells 12A and 14A in 2008 and to the A intake of Turbine Unit 14 in both years.

<u>2010</u>

- Hughes et al. 2011. Water Velocity Measurements on a Vertical Barrier Screen at the Bonneville Dam Second Powerhouse.

- The study was designed to sample water velocities inside the gatewell at Units 12A and 14A with two ADVs to determine whether adverse conditions for migrating juvenile salmonids were present.
- Flows were measured in Unit 12A and Unit 14A at a unit discharge of 15.8 kcfs and at Unit 14A at three unit discharge levels (12.0, 14.7, and 15.8 kcfs).
- In-river flows at the Bonneville Project in late winter–early spring 2010 were not great enough to allow for water velocities to be measured at the upper end of 1% efficiency (17.8-kcfs flow rate) as proposed.

<u>2011</u>

- A Fish Passage Plan (FPP) change form, 11BON014, was submitted in Dec. 2010 modifying the B2 1% peak efficiency operation range to improve fish descaling and mortality. The change form request reduced the upper 1% operation limit to an upper limit in the mid 1% range. This was approved at the February 2011 Fish Passage Operations and Maintenance (FPOM) regional meeting, but operations did not occur as a hard constraint. In March 2011, B2 unit operation had been reduced toward the lower end of the 1% peak efficiency range (mid 1% upper limit) through operations coordination with the Technical Management Team prompted by System Operations Requests from the Fish Passage Advisory Committee when seasonal concern, descaling, and mortality issues were identified.

<u>2013</u>

- Gilbreath et al. 2014 - **Prototype turbulence reduction devices (TRDs) were fabricated and installed in Gatewell 14A** prior to the 2013 juvenile fish-passage season. In late March and early April 2013, Harbor Consulting Engineers† and Alden Research Laboratory collected and analyzed detailed flow measurements to determine how TRDs affected gatewell flow patterns. Immediately following the collection of flow data, NOAA Fisheries conducted test releases of subyearling Chinook salmon from SCNFH to determine if the TRDs reduced passage mortality during upper 1% turbine operation.

- Operations in the low and upper 1%.
- Treatment groups released to gatewell 14A.

- Harbor and Alden 2013 – Data was collected by Harbor Consulting Engineers and Alden Research Laboratory between March 29, 2013 and April 5, 2013. Measurements were taken 0.65 feet off the upstream face of the vertical barrier screens at low (12 kcfs), medium (15 kcfs) and high (17 kcfs) flow conditions in gatewell slot 14A with TRDs installed and in slot 15A without TRDs installed. Additionally, data was collected at a high flow condition (16.5 kcfs) in gatewell slot 14C.

2014

- FPP change BON PH2 operations for mid-range 1%, Record of Final Action: First iteration approved at the 8 May 2014 FPOM meeting.

- An FPOM task group was formed to address project operations during the periodic 1% operations modifications to reduce the incidence of descaling and mortality in the B2 gatewells. The Bonneville Operations FPOM Task Group developed language based on the examination. The language was discussed at length during an April 11, 2013, Task Group meeting. The language was presented to the full FPOM committee as an FPP change form for consideration in operation of the Bonneville Dam during 2013. 14BON001 was approved on May 8, 2014. The 1% operating range guidelines are modified until structural and/or other solutions are implemented.

- The upper two panels of the spare VBS were modified with prototype solid steel plates and tested in gatewell 14A at mid[1] 1% (15 kcfs) and high 1% flows (18 kcfs) along with a test with the unmodified VBS in 14A at these same flow conditions. A prototype version of the baffle flow restriction plate (elevation +31) was tested in 15A during this testing for performance evaluation (Harbor & Alden 2014, FPOM MOC 14BON49 FGE U14 and U15 Tests, referenced again in Harbor & Alden 2015).

- Harbor and Alden 2014 – The objective of the field study was to collect water velocity data sufficient to map flow patterns within gatewell slots 13C, 14A, 14B, and 15A. Data collected in slot 14A included baseline and modified VBS configurations at mid[1] (15 kcfs) and high (18 kcfs) flows. Data collected in slot 15A included a baffle plate at mid and high flows. Velocity data was collected during two field deployments. The first deployment occurred from May 27, 2014 to June 12, 2014 and focused on high unit flow conditions. The second deployment occurred from August 19, 2014 to August 28, 2014 and targeted lower unit flow conditions.

[1]Harbor and Alden 2014 characterizes low flow (15kfcs) in this report year as what we would consider to be medium (or mid) 1%.

2015

- Full prototype testing of improvements in Unit 15 which included flow control plates installed in Gatewells 15A and 15B and modified porosity to the top two VBS screen panels in all three gatewells (Harbor & Alden, 2015).
- **Harbor and Alden 2015** - The objective of the field study was to collect water velocity data sufficient to map flow patterns within gatewell slots 15A, 15B, and 15C. Data was collected in slot 15A and 15B at high flows (18+ kcfs, upper 1%) with modified VBS baffling as well as a flow control baffle plate installed. Data was collected in slot 15C at high flows but gatewell

modifications only included modified VBS baffling. Velocity data was collected from June 2 through June 4 with a single gatewell condition measured each day.

- Absolon and Sanford 2016 - biological evaluation in 2015 to determine the efficacy of a prototype gatewell flow-control device (el. +31) and modified VBS in reducing bypass system mortality for Spring Creek subyearling Chinook salmon.

- Test series 1) Turbine intake slot 15A: both flow-control devices at upper 1% operation. Turbine intake slot 14A: no flow-control devices at middle 1% operation
- Test series 2) Turbine intake slot 15C: modified VBS only at upper 1% operation. Turbine intake slot 14A: no flow-control devices at middle 1% operation

<u>2016–2017</u>

- VBS porosity plate modifications for the upper panels of A, B, and C gatewells occurred across the powerhouse 2016 and 2017.

- 2016–2017 – Flow control plates (el. +31) installed in A and B gatewells of all remaining powerhouse units. Ready for PNNL B2FGE post construction evaluation (Ham et al. 2017)

- PNNL B2FGE post construction evaluation (Ham et al. 2017). Operations with units unrestricted in full 1%.

NOTES:

- Flow control plates (el. +31) installed in A and B gatewells of all powerhouse units. No plates in C gatewell as it met the hydraulic and biological goals.
- VBS porosity mods for all A, B, C gatewells in all units.

<u>2018</u>

- All el. +31 A and B plates removed by mid Sept. (per FPOM MOC 18BON04 and unit outage record).

<u>2022</u>

- Concrete corbel – Unit 15 – first constructed and hydraulically tested in 2022.

- Alden 2022 – The objective of this study was to collect velocity and pressure data to evaluate the hydraulic conditions with the new concrete flow control corbels at elevation +31 in Gatewells A & B of Unit 15 and compare the results with the flow control plates evaluated in Harbor and Alden 2015. The test program was conducted between May 16 – June 10, 2022. Flow velocities of the upstream VBSs were measured in all gatewells of Unit 15, at mid 1%, 15 kcfs, and upper 1%, 18 kcfs flows respectively. Pressure fluctuations were measured at the exit of Gatewell Slots 14A (no flow control corbel) and 15A (concrete corbel).

- Changes to Fish Passage Plan (FPP): In June 2022, an updated FPP Table BON-15 was provided by the Hydroelectric Design Center (HDC). The 1% peak efficiency upper flow limit with STS installed is at a different flow compared to the table used in 2021 and prior years.

- This means that in the future, operations at the upper 1% should result in less flow entering the unit intake and gatewells for some unit heads compared to prior years operations.

<u>2023</u>

- All B2 units A and B gatewells - concrete corbel mounted to the el. +31 gatewell beams. Construction finished in Nov. 2023

- Unit outages for B2FGE corbel construction -

Unit 15: 01 MAR 21 – 19 APR 21

Unit 11: 30 NOV 22 – 06 APR 23

Unit 18: 25 JAN 23 – 27 MAR 23

Unit 16: 16 MAR 23 – 27 APR 23

Unit 17: 01 MAY 23 – 15 JUN 23

Unit 14: 20 JUN 23 – 03 AUG 23

Unit 13: 07 AUG 23 – 21 SEP 23

Unit 12: 25 SEP 23 - 14 NOV 23

Appendix B – Memorandum of Coordination

Modifications to the operations of Bonneville Dam to meet the study objectives are coordinated through regional processes. The resulting Memorandum of Coordination is reproduced in the following pages.

**OFFICIAL COORDINATION REQUEST FOR
NON-ROUTINE OPERATIONS AND MAINTENANCE**

COORDINATION TITLE- 24BON010 MOC B2FGE Post Construction Evaluation 2024
COORDINATION DATE- 20April2024
PROJECT- Bonneville Lock & Dam
RESPONSE DATE- 11April2024

Description of the problem

The Corps' Bonneville Powerhouse 2 Fish Guidance Efficiency (B2FGE) Program completed structural modifications to gatewells of units 11-18, at Bonneville Lock & Dam in November 2023. See SRWG 2024 Implementation Plan (PNNL, 2024) and Research Summary SPE-P-24-1 for more background information on the B2FGE Program.

The Corps plans on implementing the B2FGE study during the spring and summer of 2024. Testing results will provide meaningful data to assist in informing the evaluation of nearly 20 years of regional forum coordination on operations and project modifications to improve conditions for juvenile salmonids at Powerhouse Two (PH2). With every year comes unique circumstances ranging from extremes in water years (e.g. low vs high water year) to unplanned events/outages/etc. Despite the unplanned outages of 9 out 10 units at Powerhouse One (PH1) as noted in recent coordination, the Corps plans on conducting the B2FGE study because hydraulic conditions at BON and operating conditions at PH2 will meet the study design objectives to evaluate modifications of PH2 units associated with this test.

The study will use biological fish condition monitoring at the Juvenile Monitoring Facility (JMF) collected for the Smolt Monitoring Program (SMP) to compare the distributions of descaling and mortality of juvenile migrants at the middle and upper 1% peak efficiency turbine operating range for spring (20 April -05 June) and summer (08 June – 20 July), 2024. These study ranges cover the approximate dates at which the SMP sample changes from being mostly dominated by yearling Chinook to subyearling Chinook salmon (https://www.cbr.washington.edu/dart/query/smolt_hrt).

A randomized block study design will be used to expose juvenile fish to the designated treatments (middle vs. upper 1% operations) to help differentiate the influence of factors not directly related to the treatment comparisons (e.g., river flow, temperature, fish size/species/number, etc.) that vary throughout the season from the influence of operational treatments of interest. The block-treatment study design will result in ten 24-hour SMP samples during mid 1% peak efficiency range operations and ten 24-hour SMP samples during upper 1% peak efficiency range operations during spring and nine 24-hour SMP samples during both mid and upper 1% range operations in summer. All fish sampled in the JMF during each treatment and season will be combined to produce spring middle 1% descaling and mortality rates, spring upper 1% descaling and mortality rates, summer middle 1% descaling and mortality rates, and summer upper 1% descaling and mortality rates. Descaling and mortality rates will be compared between middle and upper 1% operations separately for spring and summer.

In addition to the study outlined above, an impingement study to evaluate potential fish impingement on the Vertical Barrier Screens (VBSs) of a single unit will occur on selected dates through the spring and summer test periods. This study involves the use of acoustic underwater cameras (sonars) and spot checks using the STS/VBS video inspection truck. The sonars will be deployed in gatewells 15A (modified) and 15C (unmodified) during specified operations in the middle and upper 1% peak efficiency range. Acoustic camera sampling will occur over a 24hr period (≈0700 to 0700) once per week during the study periods. Unit 15 is the unit of choice for this evaluation due to the extensive research of flow conditions and fish passage that has been conducted historically at Unit 15. However, if a Unit 15 outage occurs during the impingement evaluation, Unit 16 will be the next in priority for this evaluation. In addition, to ensure Units 15 (or 16) are operating at the time of the scheduled impingement evaluations, the turbine unit priority order will need to be adjusted on impingement evaluation days.

The mobile imaging sonars will be deployed using a portable A-frame crane with electric winch attached to a weighted aluminum frame. The frame will be lowered to the desired elevation near 58 ft msl (16 ft deep) and oriented to sample along the VBS face. The sonar location within the gatewell will be similar for 15A, 15C, 16A, and 16C throughout the spring and summer sampling periods and oriented to sample the bottom northern portion of the VBS, which corresponds to the regions of highest through-screen velocity as measured by Alden (2022).

Sonar samples will be supplemented by conducting spot checks of impingement using the optical video cameras on the STS/VBS video monitoring truck during standard STS/VBS inspections performed by project staff. A digital video recorder will be attached to the truck feed to record and document the spot check results in the gatewells.

Type of outage required

No outages are required to support the study.

Impact on facility operation (FPP deviations)
See below for specified FPP deviations.

Impact on unit priority
Section 4.1 Turbine Unit Priority Order
Impingement test operations will result in PH2 units being operated out of unit priority order as defined in FPP Table BON-13.

Normal FPP PH2 Unit Priority - 11, 18, 12, 17, 13, 14, 15, 16
During specified impingement evaluations - 11, 18, 15, 16, 14, 12, 17, 13

Impact on forebay/tailwater operation
Forebay operation: To allow B2 units to operate within the upper 1% peak efficiency treatment flow range during periods when overall project head is near 57’ or greater, a lower forebay operating range (71.5’ – 73.0’) may be needed within the normal forebay operating range. This operating range is because BON PH2 units have a generator limit that restricts turbine output at higher project heads. These values are represented in FPP Table BON-15.

No impacts on tailwater operation.

Impact on spill

PH 2 units under the test schedule operation blocks of middle and upper 1% peak efficiency range may be out of criteria as defined in FPP Section 4.2.1.2.b / Table BON-14 Sequential Steps to Pass Increasing Flow per Temporary PH2 Operating Range Guidelines in section 4.2.1.2.b. Refer to **Table 1** for potential impacts on spill during B2FGE testing.

Table 1. Potential Impacts on Spill during B2FGE Test Periods

Total Q (kcfs) *	FPP PH2 Operation	FPP/FOP Spill Operation	Test Mid-Point	Test Upper 1%
Up to 293	Mid-Point	FOP (150)	No effect	Spill < 150 (-3k/unit)
293 - 317	Upper 1%	FOP (150)	Forced spill > 150 (+3k/unit)	No effect
317 - 347	Upper 1%	Forced > 150, up to 180	More forced spill (+3k/unit)	No effect
Above 347 **	Mid-Point **	Forced > 180 **	No effect	Less forced spill (-3k/unit)

* Assumes all 8 PH2 units are available + 1 PH1 unit at BOP + 12 kcfs misc flow (B2CC, ladders, etc).
** Only applies during the “juvenile trigger”. If the “adult trigger” is in effect, all flow above 317k will be additional forced spill.

Dates of impacts/repairs
Spring: 20 April – June 05, and Summer: 08 June – 20 July 2024.

Length of time for repairs
A detailed operation schedule with middle and upper 1% flow ranges defined at specific times and dates will be provided to Bonneville Dam Operations and an RCC teletype will be issued.

Analysis of potential impacts to fish

1. **10-year average passage by run during the period of impact for adults and juvenile listed species, as appropriate for the proposed action and time of year;**

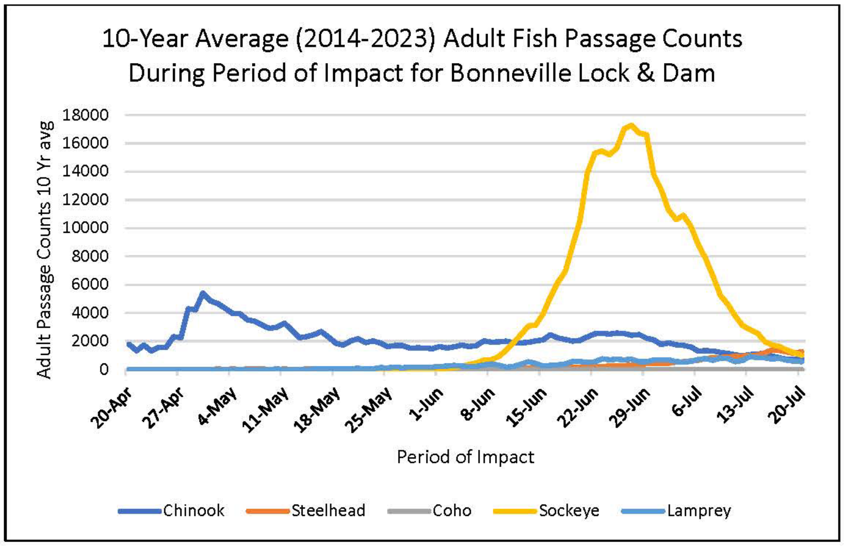

Figure 1. 10-year average (2014-2023) adult fish passage counts during the period of impact at Bonneville Lock & Dam for the B2FGE post-construction evaluation occurring between April 20 – July 20th. Data obtained from Columbia River DART.

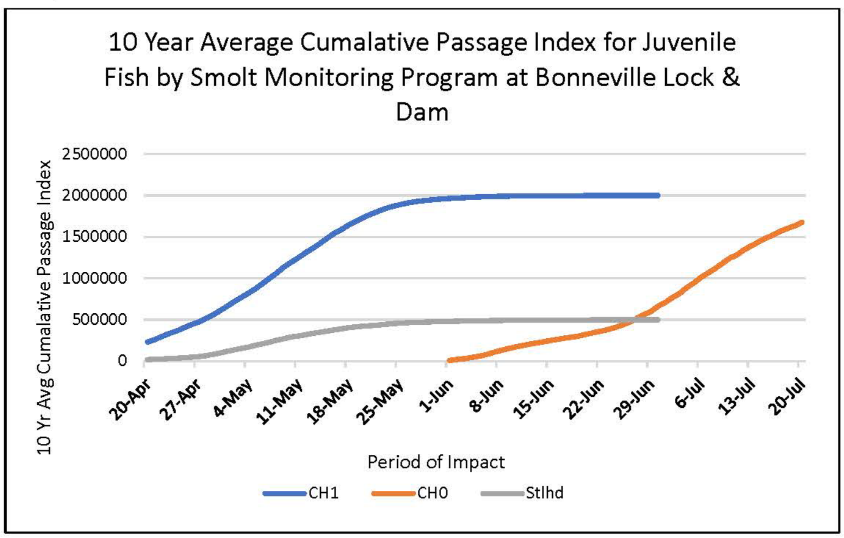

Figure 2. 10-year average (2014-2023) cumulative juvenile fish passage index for yearling Chinook (CH1), subyearling Chinook (CH0), and Steelhead at Bonneville Lock & Dam from the Smolt Monitoring Program. Data obtained from Fish Passage Center.

2. **Statement about the current year's run (e.g., higher or lower than 10-year average);**

- Based on WDFW's 2024 adult forecasts obtained from: https://wdfw.wa.gov/sites/default/files/2024-01/2024-spring-summer-forecasts.pdf
- Compared to the 10-yr avg BON passage obtained from DART at https://www.cbr.washington.edu/dart/query/adult_daily

  2024 Spring Chinook upriver total (121,000) are forecasted to be higher than the 10-yr avg of 112,443.

  2024 Summer Chinook (53,000) are forecasted to be lower than the 10-yr avg of 94,886.

  2024 Total Columbia Sockeye (401,700) are forecasted to be higher than the 10-yr avg of 315,420.

  2024 Total Upriver Steelhead (126,200) are forecasted to be lower than the 10-yr avg of 162,989.

3. **Estimated exposure to impact by species and age class (i.e., number or percentage of run exposed to an impact by the action);**
   - The study period of 20 April through 20 July covers roughly the 25-yr median of the 80% range of historic run timing for predominant juvenile outmigration at BON.
   - No adult impacts expected.
4. **Type of impact by species and age class (increased delay, exposure to predation, exposure to a route of higher injury/mortality rate, exposure to higher TDG, etc.);**

   No impacts expected.

Summary statement - expected impacts on:

Downstream migrants

The purpose of this study is to determine if the structural improvements completed in the gatewells A&B of B2 units have resulted in acceptable fish passage conditions at the middle and upper 1% peak efficiency range, therefore, at this time it is unknown if there are negative impacts to downstream migrants when implementing the test schedule.

For the impingement evaluation, sonar equipment will be deployed in a single unit's gatewells (slots A&C) for 24 hours, once per week during the study periods. The sonar platform can be seen in **Figure 3**. The sonar platform will be deployed in the middle of the gatewell slot, roughly 16 feet below the water surface near el. +58' which is near the central region of the VBS. Fish that enter the gatewells during the 24-hr impingement evaluation may encounter the sonar mounting platform. However, fish should be able to swim away from the equipment as velocities near el.+58' are relatively small in magnitude (Alden 2022) at this elevation while the unit was running at 18.2kcfs, which is greater flow condition than what this study is proposing.

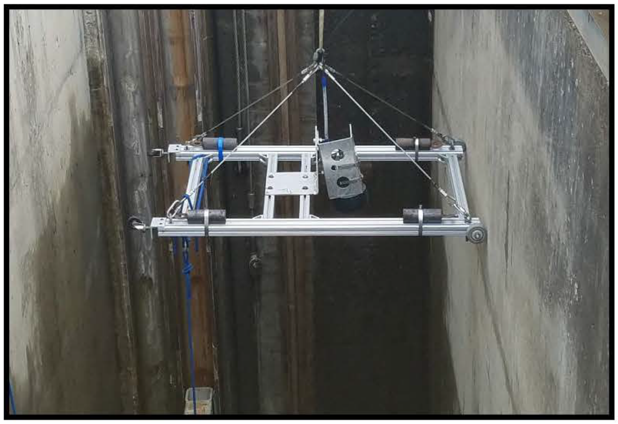

Figure 3. Photograph of sonar mounting platform. Photo from of PNNL (2024).

Upstream migrants (including Bull Trout and Lamprey)

No impacts to adult salmonids, bull trout, or lamprey ladder entry or migration since Powerhouse 2 remains the priority powerhouse and both end units (11 & 18) remain at the top of the unit priority list to aid in attraction to the adult ladder monolith entrances in the Powerhouse 2 tailrace. Lamprey nighttime operations that begin 01 June (FPP Section 2.4.2.13.vi) will not be impacted by the B2FGE test schedule.

References:

Harnish, R., Ham, K., & Mueller, R. (2024). *Study Design and Implementation Plan for Bonneville Dam Powerhouse 2 Gatewell Improvement Post Construction Evaluation Draft Report*. Pacific Northwest National Laboratory Prepared for United States Department of Energy under Contract DE-AC05-76RL01830.

Columbia River DART, Columbia Basin Research, University of Washington. (2024). Adult Passage Counts Graphics & Text. Available from https://www.cbr.washington.edu/dart/query/adult_graph_text

Fish Passage Center, FPC (2024). FPC Smolt Monitoring Program Data. Cumulative Passage Index with Average Run Timing for Past Years. Available from https://www.fpc.org/smolt/smolt_queries/Q_smolt_cumulativepassindex_dataquery.php

Washington Dept. of Fish and Wildlife (2024). WDFW. 2024 Forecast and Model Runs. Columbia River forecasts accessed at https://wdfw.wa.gov/fishing/management/north-falcon/forecasts

Comments from agencies

April 11 FPOM minutes

1.1.1.24BON010 MOC B2FGE Post Construction Evaluation 2024 – Lorz said it's fine but thinks there is still problems with this test, no Spring Creek evaluation this year since fish have already been released, and he believes the test will not answer all needed questions. Wertheimer said let's see what the results say and assess data gaps at that time. Conder is 100% supportive of the test going forward but is concerned as the study was set up to coincide with the Spring Creek releases and anticipates further discussions as testing will not be going above the upper 1%.

May 9 FPOM minutes

3.3.1.3.24BON010 MOC B2FGE Post Construction Evaluation 2024 – Evaluation is underway and going according to schedule. There is one month remaining until the switch over to summer testing. Testing is going well despite the low flows. First sonar impingement evaluation was this morning,

July 11 FPOM draft minutes – Rerecich requests to continue daily sampling over the 70ºF threshold

3.3.1.3 Update for FGE – Rerecich (USACE) said they need as much sampling as possible for FGE testing at BON PH2. Testing will continue until 0700 on 20 July. Temps are 69º currently but once we get to the 70º trigger the ask is to continue to sample as normal until test completes on 20 July. Or second best is every other day at a normal sample rate. Switch to bypass on the odd day. Van Dyke (ODFW) asked how they would account for temp impacts. Rerecich (USACE) indicated PNNL would need to look at the data and address temp increase impacts. Rerecich relayed info from SMF Bio, Ballinger, stated that at 73º there would be changes in fish behavior in the sample tanks but does not object to normal sampling if temps remain very close to 70F trigger to support the remaining days of FGE study, as long as this request does not continue indefinitely. Rerecich (USACE) said operations at the dam would remain the same. Ebel (IDFG) said the SMP has a permit, and this might be broader than asking FPOM for a change to the FPP. Ebel (IDFG) said that SMP needs to be address and asked if it was discussed with the SMP and the FPC. He also asked if there was enough fish for statistical power for their test. Rerecich said the summer period could be short on fish, due to low flows and few units operating. Conder (NOAA) said they would support continuing at 71º and if temps go over that switching to every other day sampling. Van Dyke is not sure there is enough information to support changing from the FPP criteria and recommends every other day sampling. Van Dyke said he wants to ensure this is documented in the report.
Morrill and Van Dyke also encouraged investigating the permit with SMP and PNNL to ensure they are aligned. **ACTION**: Rerecich will check with Ballinger and PNNL concerning permitting prior to proceeding with normal sampling at a 71º threshold.
Morrill (WDFW) sees no issues supporting continued sampling as needed for testing.
Lorz (CRITFC) will go with Conder's (NOAA) recommendation.
Webex CHAT from Ben Hausmann (BPA) to everyone: 10:46 AM
It sounds like we're only talking about the potential for 4 days of sampling at 70 degrees. I think the minimal risk makes sense for the integrity of the FGE study.

From: Madson, Patricia L CIV USARMY CENWP (USA)
Sent: Tuesday, July 16, 2024 6:50 AM

Subject: FPOM Official Coordination: B2 FGE sampling efforts

FPOM representatives,

Here is the update on the B2 FGE sampling efforts during elevated river temperatures.

On July 15, we met the 70F threshold per the FPP to trigger high river temperatures sampling protocols at the BON SMF.

On July 11th, we coordinated with FPOM that if we reached 70F we would continue to sample as normal until water temperatures reached 71F. This will allow the USACE and the PNNL to continue to support the B2 FGE testing. The B2 FGE sampling effort will be complete at 0700 on July 20th. The USACE POC has coordinated with SMF staff about permits and take numbers associated with the extended sampling efforts. If you have additional questions or concerns, please contact Jon Rerecich (Jonathan.g.rerecich@usace.army.mil, 503-808-4779).

2024 Fish Passage Plan — Appendix J – Smolt Facility Protocols — VERSION: 1-MAR-2024

1.4. BON JMF Sampling at Water Temperature > 70°F.

- **a)** Daily average river temperatures will be obtained from the Corps website for Lower Columbia River projects[1]. Project Fisheries will use the Project thermometer in the sample holding tank for official reporting requirements, instantaneous temperatures and when online data are unavailable.
- **b)** Daily index sampling will be reduced to every-other-day index/condition monitoring.
- **c)** The upper switchgate is used to select between sample and bypass mode.
- **d)** Sample sizes will be reduced to approximately 100 fish per day.
- **e)** Monitoring for gas bubble trauma (GBT) symptoms will continue.
- **f)** An instantaneous temperature of ≥ 70°F taken from 0630–0700 hours will trigger a change in sampling mode after Project Fisheries notify SMP Biologists.
- **g)** Normal index sampling may resume when daily average temperatures are ≤ 69.5°F.
- **h)** If there is a research need to sample at temperatures > 70°F, coordination with FPOM will be initiated by the researcher through the Corps District POC.
- **i)** If SMP and Project Fisheries biologists suspect a bypass system problem during high temperature sampling, additional sample collection may occur. FPOM will be notified ASAP and provided with updates as problem resolution attempts proceed.

1.5. BON JMF Bypass Mode Operation (or when no PDS Monitors).

- **a)** The upper switchgate will be in bypass mode.
- **b)** The Emergency fish release valve will be open.
- **c)** All rotating gates will be set to bypass.
- **d)** The bypass flume gate will be raised.
- **e)** Project Biologists will inspect the facility daily.

Patricia L. Madson
USACE Portland District
Fisheries Field Unit
o: (541) 374-3655
c: (541) 645-0619

FPOM Website:
http://pweb.crohms.org/tmt/documents/FPOM/2010/

From: VANDYKE Erick S * ODFW <erick.s.vandyke@odfw.oregon.gov>
Sent: Tuesday, July 16, 2024 11:48 AM

Subject: [Non-DoD Source] RE: FPOM Official Coordination: B2 FGE sampling efforts

Thank you for the update. ODFW did not endorse the USACE plan to forego temperature issues during B2 FGE sampling, or endorse the proposed change in sampling protocol during the FPOM discussion. I explicitly recommended to follow the rules that shift to every-other day sampling first and to check-in with 1) the permit holder (different than individual or staff at the facility), and 2) the regulators that issued the permit(s). Did USACE reach out to Fish Passage Center or Smolt Monitoring Program? Was NOAA/ODFW permitting staff consulted about the decision to sample every day without change when temperatures exceeded the permitted threshold? I would appreciate additional information be provided that inform if the other recommendations provided during the FPOM meeting were carried out and a list of actual contacts that were carried out after FPOM. Regards.

Erick Van Dyke
Oregon Department of Fish and Wildlife
Ocean Salmon and Columbia River Program
Fish Passage/Mitigation Technical Analyst
Office: 971-673-6068
Cell: 503-428-0773
erick.s.vandyke@odfw.oregon.gov

Final coordination results – Concurrence.

After Action update –

August 8 FPOM draft minutes

3.3.1.3.24BON010 MOC B2FGE Post Construction Evaluation 2024 – Completed on 20 July PNNL is working on post study data analysis report due at the end of Jan 2025.
Lorz asked if they adhered to the schedule in the implementation plan.
Cates informed FPOM that the plan was adhered to.

Impacts during high temperature sampling described in "24BON035 MFR SMF High Temperature Sampling Protocol Deviation to Support B2FGE Post-Construction Evaluation".

Please email or call with questions or concerns.
Thank you,

Rebecca Cates
Fish Passage Section
503-808-4738
Rebecca.I.Cates@usace.army.mil

Patricia Madson
NWP Columbia River Coordinator
541-374-3655
Patricia.L.Madson@usace.army.mil

Appendix C – Teletype

Regionally coordinated requirements to be implemented at Bonneville dam for the purpose of this study were sent to the dam as a teletype message. The message specifies how the dam and powerhouse 2 turbines are to be operated during the spring and summer study periods. The text of that message is presented on the following pages.

Sent to: CO

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
BON R 041624 1534 CO BON TDA JDA MCN BPA BPC NPD NPC NPP

ATTENTION: BONNEVILLE AND BPA

SUBJECT: OPERATIONS FOR POWERHOUSE TWO GATEWELL IMPROVEMENT
POST-CONSTRUCTION EVALUATION

REFERENCE CBT MSGS:

BON R 040523 1237 FOP SPRING SPILL FOR FISH PASSAGE

1\. DATES.
EFFECTIVE DURING THE DATES BELOW IMPLEMENT THE FOLLOWING OPERATIONS TO FACILITATE THE TESTING OF POWERHOUSE TWO (PH2) UNITS 11-18.

1.1 SATURDAY, APRIL 20, THROUGH THURSDAY, JUNE 6.

1.2 SATURDAY, JUNE 8, THROUGH SATURDAY, JULY 20.

OUTSIDE THE DATES SPECIFIED ABOVE OPERATE IN ACCORDANCE WITH REFERENCE CBT MSG BON R 040523 1237 FOP SPRING SPILL FOR FISH PASSAGE AND THE SUBSEQUENT FOP SUMMER SPILL OPERATION THAT WILL BE FORTHCOMING.

DO NOT OPERATE THE PH2 UNITS ABOVE THE UPPER 1% DURING THE SPRING AND SUMMER TEST PERIODS AS DESCRIBED ON PAGE 61, OF THE NOAA FISHERIES 2020 COLUMBIA RIVER SYSTEM BIOLOGICAL OPINION (2020 CRS BIOP). THE 2020 CRS BIOP MAY BE FOUND ON THE FOLLOWING WEBSITE.

https://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp.aspx

THE GOAL OF THE TESTS ARE TO EVALUATE THE EFFECTIVENESS OF RECENT STRUCTURAL MODIFICATIONS TO THE PH2 GATEWELLS FOR FISH GUIDANCE EFFICIENCY (FGE). THE TWO TEST TREATMENTS WILL EVALUATE THE BIOLOGICAL IMPACTS OF OPERATING AT THE 1% MID RANGE AND 1% UPPER LIMIT. ADDITIONALLY, THERE WILL BE A UNIT SPECIFIC TEST (UNIT 15 OR 16) TO EVALUATE FISH IMPINGEMENT IN MODIFIED (A SLOT) AND UNMIDIFIED (C SLOT) GATEWELLS AT THE 1% MID RANGE AND 1% UPPER LIMIT AND WILL REQUIRE A PH2 UNIT PRIORITY MODIFICATION DURING IMPINGEMENT TESTING SEE SECTION 3. MORE INFORMATION ASSOCIATED WITH PH2 1% OPERATING LIMITS MAY BE FOUND IN THE 2024 FISH PASSAGE PLAN (FPP), ON PAGE BON-40, IN TABLE BON-15. THE 2024 FPP IS POSTED ON THE WEBSITE.

https://pweb.crohms.org/tmt/documents/fpp/2024/

ADDITIONAL INFORMATION ON PH2 FGE TESTING IS DESCRIBED IN MEMORANDUM OF COORDINATION (MOC) 24BON010, B2FGE POST CONSTRUCTION EVALUATION 2024, DATED, APRIL 11, 2024. THE MOC MAY BE FOUND ON THE FOLLOWING WEBSITE.

https://pweb.crohms.org/tmt/documents/FPOM/2010/NWP%20Memos%20of%20Coordination%20and%20Notification/BON%20MOC%20and%20MFR/

2. FOREBAY OPERATIONS.
THE FOLLOWING ARE THE TWO DIFFERENT FORBAY OPERATIONS NEEDED TO FACILIATE HYDRAULIC CONDITIONS FOR THE TESTS.

2.1 FOREBAY OPERATION 1 (FO1) — NORMAL FOREBAY OPERATING RANGE OF 71.5 TO 76.5 FEET. THIS OPERATION IS FOR THE 1% MID-POINT TREATMENT FOR ALL PH2 UNITS.

NO RESTRICTION ON THE FOREBAY OPERATING RANGE BECAUSE THE 1% MID-POINT OPERATION ON PH2 UNITS IS ACHIEVABLE WITH THE HEAD ASSOCIATED WITH THE NORMAL FOREBAY OPERATING RANGE AND TAILWATER.

2.2 FOREBAY OPERATION 2 (FO2) — NORMAL FOREBAY OPERATING RANGE OF 71.5 TO 76.5 WHILE TARGETING 57 FEET OR LESS OF HEAD. THIS OPERATION IS FOR THE 1% UPPER LIMIT FOR ALL PH2 UNITS.

TARGETING 57 FEET OR LESS OF HEAD TO THE EXTENT PRACTICABLE WITHIN THE NORMAL FOREBAY OPERATING RANGE OF 71.5 TO 76.5 FEET IS REQUIRED BECAUSE THE OPERATING LIMIT IS LESS THAN THE TEST CONDITION OF 1% UPPER LIMIT ONCE HEAD IS GREATER THAN 57 FEET. MORE INFORMATION REGARDING THIS LIMITATION MAY BE FOUND IS DESCRIBED IN 2024 FPP, IN THE BONNEVILLE SECTION, PAGE BON-40, IN TABLE BON-15, FOOTNOTE B.

3. TURBINE UNIT 15 IMPINGEMENT TEST.
THE UNIT 15 IMPINGEMENT TEST IS BEING CONDUCTED IN ORDER TO EVALUATE FISH IMPINGEMENT IN THE MODIFIED (A SLOT) AND UNMODIFIED (C SLOT) GATEWELLS. TURBINE UNIT 15 WILL BE GOING OUT OF SERVICE DURING THE TESTING PERIODS. WHEN UNIT 15 IS OUT OF SERVICE THEN USE UNIT 16 FOR THE TEST.

3.1. THE DATES OF THE IMPINGEMENT TEST ARE IDENTIFIED IN THE TEST SCHEDULE BELOW AND MARKED AS BLOCK N/A.

3.2 AS NOTED IN THE SCHEDULE THE IMPINGEMENT TEST IS ONLY A 24 HOUR PERIOD WHILE THE MID AND UPPER 1% TESTS ARE FOR A 48 HOUR PERIOD.

3.3 FOR BPA HYDROSCEDULING PURPOSES UNIT 15 WILL NOT BE ON AGC DURING THIS TIME BUT U15 WILL BE ONLINE AND WILL BE USED FOR TESTING.

4. TURBINE UNIT PRIORITY FOR IMPINGEMENT TESTS.
4.1 DURING THE IMPINGEMENT TEST DAYS IDENTIFIED IN THE TEST SCHEDULE IMPLEMENT THE FOLLOWING TURBINE UNIT PRIORITY THAT IS A MODIFICATION FROM UNIT PRIORITY IDENTIFIED IN THE 2024 FPP (SEE PAGE BON-34, TABLE BON-13). PH2 IS THE PRIORITY POWERHOUSE DURING THE TEST OPERATIONS.

IMPINGEMENT TEST PH2 UNIT PRIORITY: 11, 18, 15, 16, 14, 12, 17, 13.
PH1 UNIT PRIORITY: 1, 10, 3, 6, 9, 4, 5, 8, 7, 2.

OUTSIDE THE DATES IDENTIFIED IN THIS TELETYPE AS BLOCK N/A IMPINGEMENT TEST DATES, CONTINUE OPERATING IN ACCORDANCE WITH UNIT PRIORITY IDENTIFIED IN THE 2024 FPP ON PAGE BON-34.

5. TEST SCHEDULE.

DATE----START TIME--BLOCK--FOREBAY OPERATING RANGE

APR 20--0700 HOURS--1------FO1. SEE SECTION 2.1 ABOVE. 71.5 TO 76.5 FEET.

APR 22--0700 HOURS--1------FO2. SEE SECTION 2.2 ABOVE. 71.5 TO 76.5 FEET. *TARGETING 57 FEET OR LESS OF HEAD.

APR 24--0700 HOURS--N/A----FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS OF HEAD. IMPINGEMENT TEST UNIT PRIORITY.

APR 25--0700 HOURS--2------FO1. 71.5 TO 76.5 FEET.

APR 27--0700 HOURS--2------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS HEAD.

APR 29--0700 HOURS--3------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS HEAD.

MAY 01--0700 HOURS--N/A----FO1. 71.5 TO 76.5 FEET. IMPINGEMENT TEST UNIT PRIORITY.

MAY 02--0700 HOURS--3------FO1. 71.5 TO 76.5 FEET.

MAY 04--0700 HOURS--4------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS OF HEAD.

MAY 06--0700 HOURS--4------FO1. 71.5 TO 76.5 FEET.

MAY 08--0700 HOURS--N/A----FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS OF HEAD. IMPINGEMENT TEST UNIT PRIORITY.

MAY 09--0700 HOURS--5------FO1. 71.5 TO 76.5 FEET.

MAY 11--0700 HOURS--5------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS OF HEAD.

MAY 13--0700 HOURS--6------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS OF HEAD.

MAY 15--0700 HOURS--N/A----FO1. 71.5 TO 76.5 FEET. IMPINGEMENT TEST UNIT PRIORITY.

MAY 16--0700 HOURS--6------FO1. 71.5 TO 76.5 FEET.

MAY 18--0700 HOURS--7------FO1. 71.5 TO 76.5 FEET.

MAY 20--0700 HOURS--7------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS OF HEAD.

MAY 22--0700 HOURS--N/A----FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS OF HEAD. IMPINGEMENT TEST UNIT PRIORITY.

MAY 23--0700 HOURS--8------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS OF HEAD.

```
MAY 25--0700 HOURS--8------FO1. 71.5 TO 76.5 FEET.

MAY 27--0700 HOURS--9------FO1. 71.5 TO 76.5 FEET.

MAY 29--0700 HOURS--N/A----FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD. IMPINGEMENT TEST UNIT PRIORITY.

MAY 30--0700 HOURS--9------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD.

JUN 01--0700 HOURS--10-----FO1. 71.5 TO 76.5 FEET.

JUN 03--0700 HOURS--10-----FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD.

JUN 05--0700 HOURS--N/A----FO1. 71.5 TO 76.5 FEET. IMPINGEMENT TEST UNIT
                           PRIORITY.

JUN 06—-0700 HOURS---------END SPRING TEST

JUN 08--0700 HOURS--1------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD.

JUN 10--0700 HOURS--1------FO1. 71.5 TO 76.5 FEET.

JUN 12--0700 HOURS--N/A----FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD. IMPINGEMENT TEST UNIT PRIORITY.

JUN 13--0700 HOURS--2------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD.

JUN 15--0700 HOURS--2------FO1. 71.5 TO 76.5 FEET.

JUN 17--0700 HOURS--3------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD.

JUN 19--0700 HOURS--N/A----FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD. IMPINGEMENT TEST UNIT PRIORITY.

JUN 20--0700 HOURS--3------FO1. 71.5 TO 76.5 FEET.

JUN 22--0700 HOURS--4------FO1. 71.5 TO 76.5 FEET.

JUN 24--0700 HOURS--4------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD.

JUN 26--0700 HOURS--N/A----FO1. 71.5 TO 76.5 FEET. IMPINGEMENT TEST UNIT
                           PRIORITY.

JUN 27--0700 HOURS--5------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD.

JUN 29--0700 HOURS--5------FO1. 71.5 TO 76.5 FEET.

JUL 01--0700 HOURS--6------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                           OF HEAD.
```

```
JUL 03--0700 HOURS--N/A----FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                          OF HEAD. IMPINGEMENT TEST UNIT PRIORITY.

JUL 04--0700 HOURS--6------FO1. 71.5 TO 76.5 FEET.

JUL 06--0700 HOURS--7------FO1. 71.5 TO 76.5 FEET.

JUL 08--0700 HOURS--7------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                          OF HEAD.

JUL 10--0700 HOURS--N/A----FO1. 71.5 TO 76.5 FEET. IMPINGEMENT TEST UNIT
                          PRIORITY.

JUL 11--0700 HOURS--8------FO1. 71.5 TO 76.5 FEET.

JUL 13--0700 HOURS--8------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                          OF HEAD.

JUL 15--0700 HOURS--9------FO1. 71.5 TO 76.5 FEET.

JUL 17--0700 HOURS--N/A----FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                          OF HEAD. IMPINGEMENT TEST UNIT PRIORITY.

JUL 18--0700 HOURS--9------FO2. 71.5 TO 76.5 FEET* TARGETING 57 FEET OR LESS
                          OF HEAD.

JUL 20--0700 HOURS---------END SUMMER TEST.
```

BEST EFFORTS WILL BE MADE TO PROVIDE 2 WEEKS ADVANCED NOTIFICATION FOR REVISIONS TO THE SCHEDULE. RCC WILL PROVIDE A REVISED CBT MSG WHEN REVISIONS TO THE SCHDULE ABOVE ARE NEEDED. ANY STUDY RELATED REVISIONS TO THE SCHEDULE ABOVE WOULD BE PROVIDED BY RYAN HARNISH (509-371-7239) FROM THE PACIFIC NORTHWEST NATIONAL LABORATORY, AND THEY WOULD BE COORDINATED WITH BECCA CATES (CORPS-NWP AT 971-322-7063) AND RCC (EG DOUG BAUS, 503-970-3413).

6. PROJECT OPERATIONAL PRIORITIES
THIS CBT MSG TAKES PRIORITY OVER BONNEVILLE DAM OPERATIONS IDENTIFIED IN THE FPP. SPECIFICALLY, THIS CBT MSG TAKES PRIORITY OVER THE FOLLOWING SECTIONS IN THE FPP: 1) 4.2 TURBINE UNIT OPERATING RANGE (SEE PAGE BON-35); 2) 4.1 TURBINE UNIT PRIORITY ORDER (SEE PAGE BON-34), AND; 3) REFERENCES TO NOT SPILLING IN EXCESS OF 150 KCFS (EG PAGES BON-35 AND 36). TEST OPERATIONS TAKE PRIORITY OVER FPP OPERATIONS.

7. THIS OPERATION WAS REQUESTED BY DOUG BAUS (CORPS-NWD), AND COORDINATED WITH PAUL KOSKI, SCOTT BETTIN, AND KRISTINE BARTLETT (BPA); JEFF FAULTH, (CORPS-BON); THE FPOM VIA EMAIL COORDINATION ON MONTH, DATE, YEAR; BECCA CATES, AND JON RERECICH (CORPS-NWP); LISA WRIGHT, AARON MARSHALL, DAN TURNER, ALEXIS MILLS, AND RICH HILT (CORPS-NWD).

8. THE FOLLOWING ARE RCC POINTS OF CONTACT.
---DOUG BAUS: 503.970.3413 (OFFICE CELL); 503.351.3692 (HOME CELL)
---LISA WRIGHT: (503) 716-6598
---RCC RESERVOIR REGULATION HOTLINE: (503) 808-4817

DOUG BAUS
CENWD-PDW-RC

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Appendix D – Treatment Implementation Detail

As described in the Implementation Plan developed for this study, and the teletype provided to Bonneville Dam and BPA (Appendix C), operations were to alternate between the mid 1% range and a range near the upper 1% limit as defined in Table BON-15 of the 2024 FPP. However, on 23 May, one of the operators identified that the units were operating above the upper 1% limit at the beginning of their shift. The flow into the units was reduced at that time to bring the units back to the upper 1% limit. A review of the operations was conducted at that time, and it was realized that there were several occasions in which unit flows were higher than the current upper 1% limit (Figure D.1). It is believed that an update to the generic data acquisition and control system (GDACS) that occurred well before the spring study period caused the system to revert back to the old FPP upper 1% limit table, which was used until spring 2022 and allowed for higher flows at the upper 1% limit. Beginning with the first Upper_1% treatment on 23 April through 24 May 0200, the upper 1% limit was exceeded for the majority of a 24-hour sample period on 5 of 8 of the Upper_1% treatment days (Figure 3.3) due to the GDACS peak efficiency table reversion.

The greatest deviations above the upper 1% limit that occurred during collection of SMP samples used for comparisons of descaling and mortality during Mid_1% and Upper_1% treatments were observed during the collection of the 15 May and 22 May SMP samples assigned to the Upper_1% treatment (Figure D.2 and Figure D.3). On average, operating units operated 915 cfs above the upper 1% limit during the collection of the 15 May SMP sample and 529 cfs above the upper 1% limit during the collection of the 22 May SMP sample (Figure D.4). Mean turbine unit discharge during collection of four other SMP samples during the Upper_1% treatment exceeded the upper 1% limit, ranging from 11 to 392 cfs above the limit (Figure D.4). For the remaining two spring Upper_1% treatment samples and all summer SMP Upper_1% treatment samples, the mean turbine unit discharge was less than the upper 1% limit due to the correction of the GDACS table.

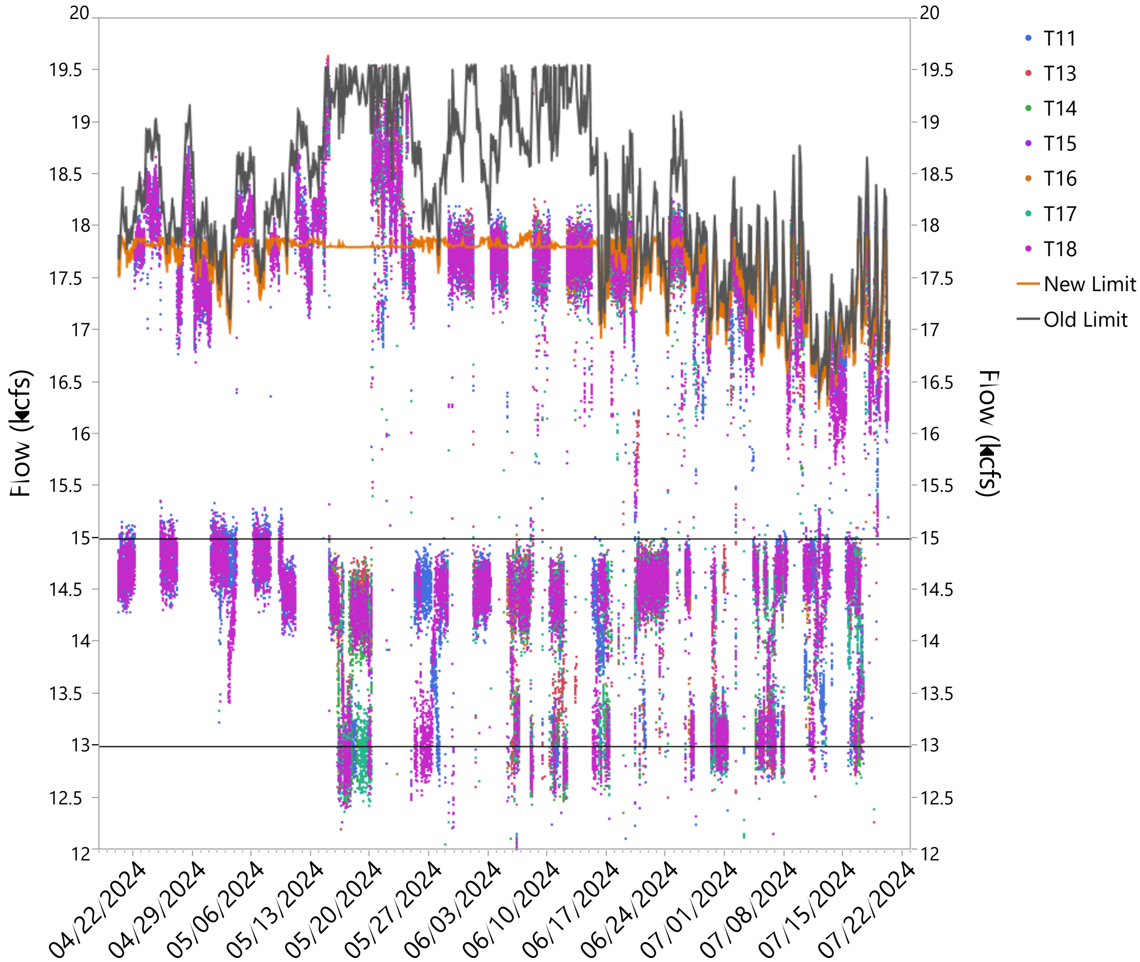

Figure D.1. B2 turbine unit discharge during 2024 Study. Each dot represents a 5-minute discharge level for a single turbine unit. Horizontal lines indicate upper and lower bounds of the mid 1% range. Series lines indicate old and new upper 1% limits.

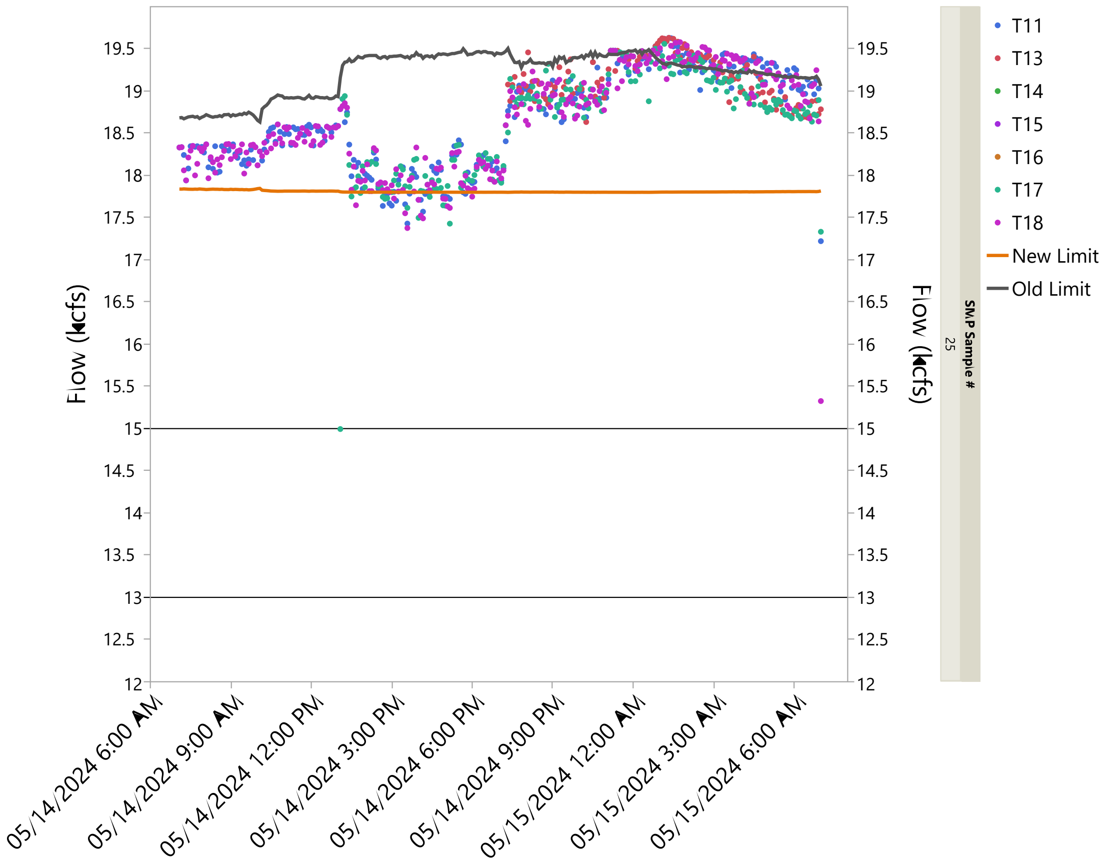

Figure D.2. Five-minute turbine unit operations during the collection of the 15 May Upper_1% treatment SMP sample compared to the new and old FPP upper 1% limits. Each dot represents a 5-minute discharge level for a single turbine unit. Horizontal lines indicate upper and lower bounds of the mid 1% range. Series lines indicate old and new FPP upper 1% limits.

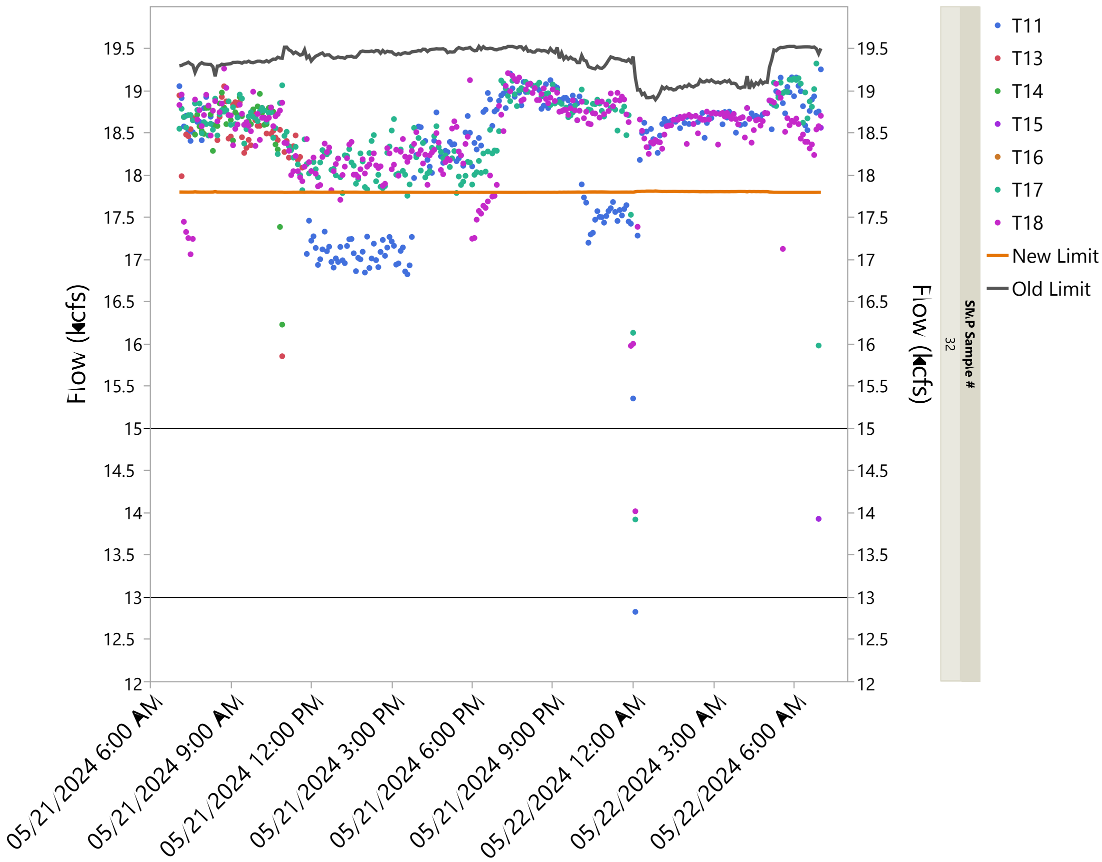

Figure D.3. Five-minute turbine unit operations during the collection of the 22 May Upper_1% treatment SMP sample compared to the new and old FPP upper 1% limits. Each dot represents a 5-minute discharge level for a single turbine unit. Horizontal lines indicate upper and lower bounds of the mid 1% range. Series lines indicate old and new FPP upper 1% limits.

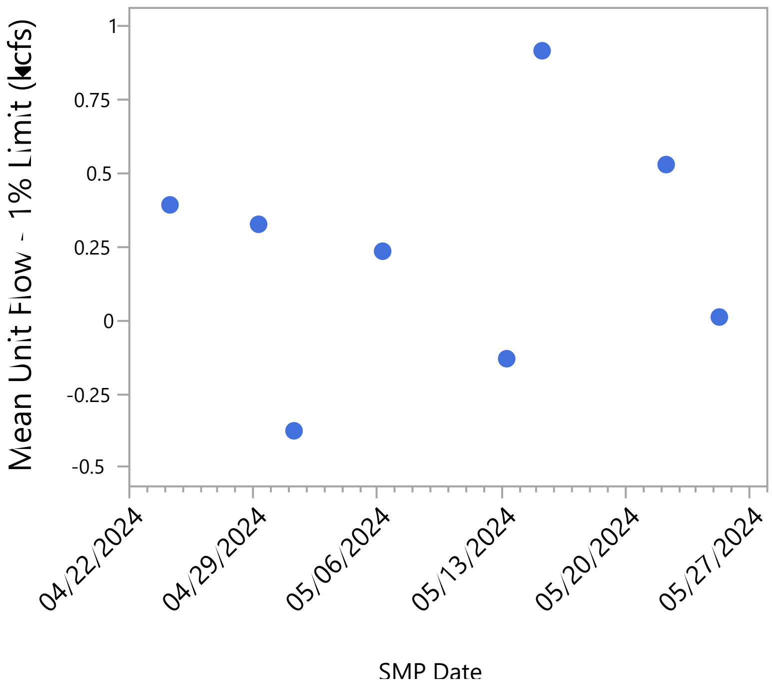

Figure D.4. Difference of mean unit discharge from the upper 1% limit during collection of SMP fish for spring period Upper_1% treatment days.

Appendix E – Forebay Elevation Sensor

In mid-May, it was discovered that the B2 forebay elevation sensor, which is used to calculate B2 head, turbine unit flow, and the 1% upper turbine unit flow limit was found to be faulty. From the beginning of the study through 15 May, forebay elevation readings from the B2 sensor were substantially higher than those from the forebay elevation sensors installed at B1 and the spillway (Figure E.1). The B2 forebay sensor reported no elevation readings between 9 May and 11 May and again from 15 May to 23 May. Following replacement on 23 May, the B2 forebay sensor provided readings that were more similar to the B1 and spillway forebay sensors (Figure E.2).

Because data from the B2 forebay sensor could not be used to accurately calculate B2 turbine unit flow throughout the entire study period, an alternative method was used. Because the B1 forebay elevation sensor produced forebay elevations that were more similar to those from the new B2 sensor from 23 May through 20 July (Figure E.2), B2 head was calculated as the difference between B1 forebay elevation and B2 tailwater elevation. The B2 tailwater elevation sensor was used because it consistently produced tailwater elevations that were different (i.e., higher) than those from the B1 and spillway tailwater elevation sensors (Figure E.3).

A sensitivity analysis was conducted to determine the effect of using the B1 forebay elevation sensor on calculations of B2 head, B2 unit flow, and the 1% upper flow limit. For the period when the B2 forebay sensor was working properly (23 May through 20 July), head was calculated using two methods: 1) as the difference between B2 forebay elevation and B2 tailwater elevation, and 2) as the difference between B1 forebay elevation and B2 tailwater elevation. The calculated head values from the two methods were regressed against one another and a 1:1 line was fit to the data (Figure E.4). The distribution of residuals from the 1:1 model fit revealed that 97.5% of the head values calculated using the B1 forebay sensor were within 0.46 feet of the head values calculated using the B2 forebay sensor (Figure E.5). A difference in head of 0.46 feet results in little change (≤ 79 cfs) to the 1% upper turbine unit discharge limit for head values between 50–58 feet (Figure E.6), which was the range of head values typically encountered during the spring study period (Figure E.7). Therefore, using the B1 forebay elevation sensor to calculate head should have produced reasonably accurate estimates of the 1% upper limit. For head values > 58 feet, which were frequently encountered during the summer study, a change in head of 0.46 feet could change the 1% upper limit by ≤ 162 cfs. Therefore, it is unlikely that using the B1 forebay elevation sensor to calculate head resulted in substantial (> 500 cfs) deviations above the 1% upper limit.

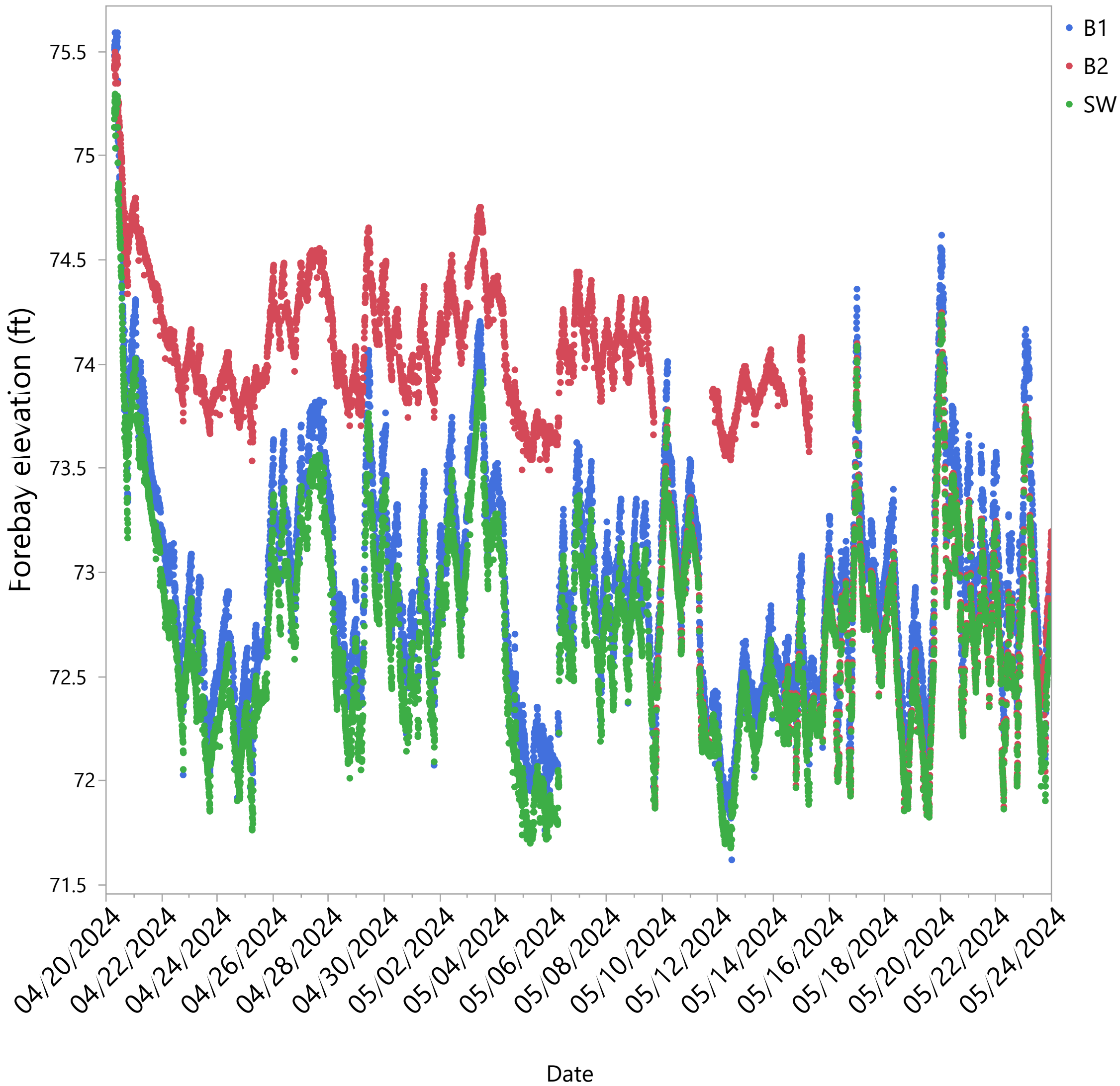

Figure E.1. Five-minute forebay elevation readings from sensors deployed at Bonneville Dam powerhouse 1 (B1), powerhouse 2 (B2), and spillway (SW) from late-April through late-May 2024.

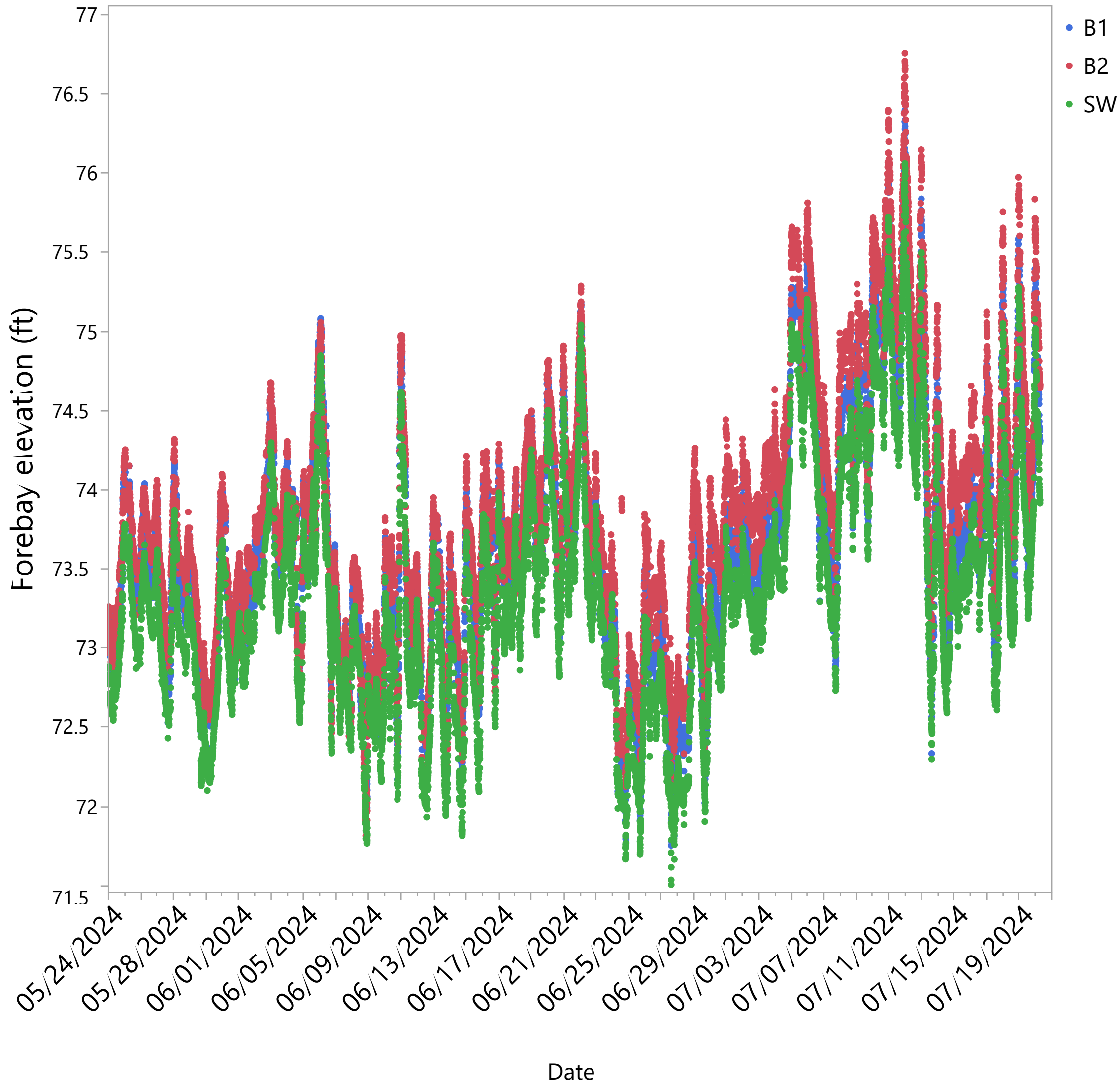

Figure E.2. Five-minute forebay elevation readings from sensors deployed at Bonneville Dam powerhouse 1 (B1), powerhouse 2 (B2), and spillway (SW) from late-May through late-July 2024.

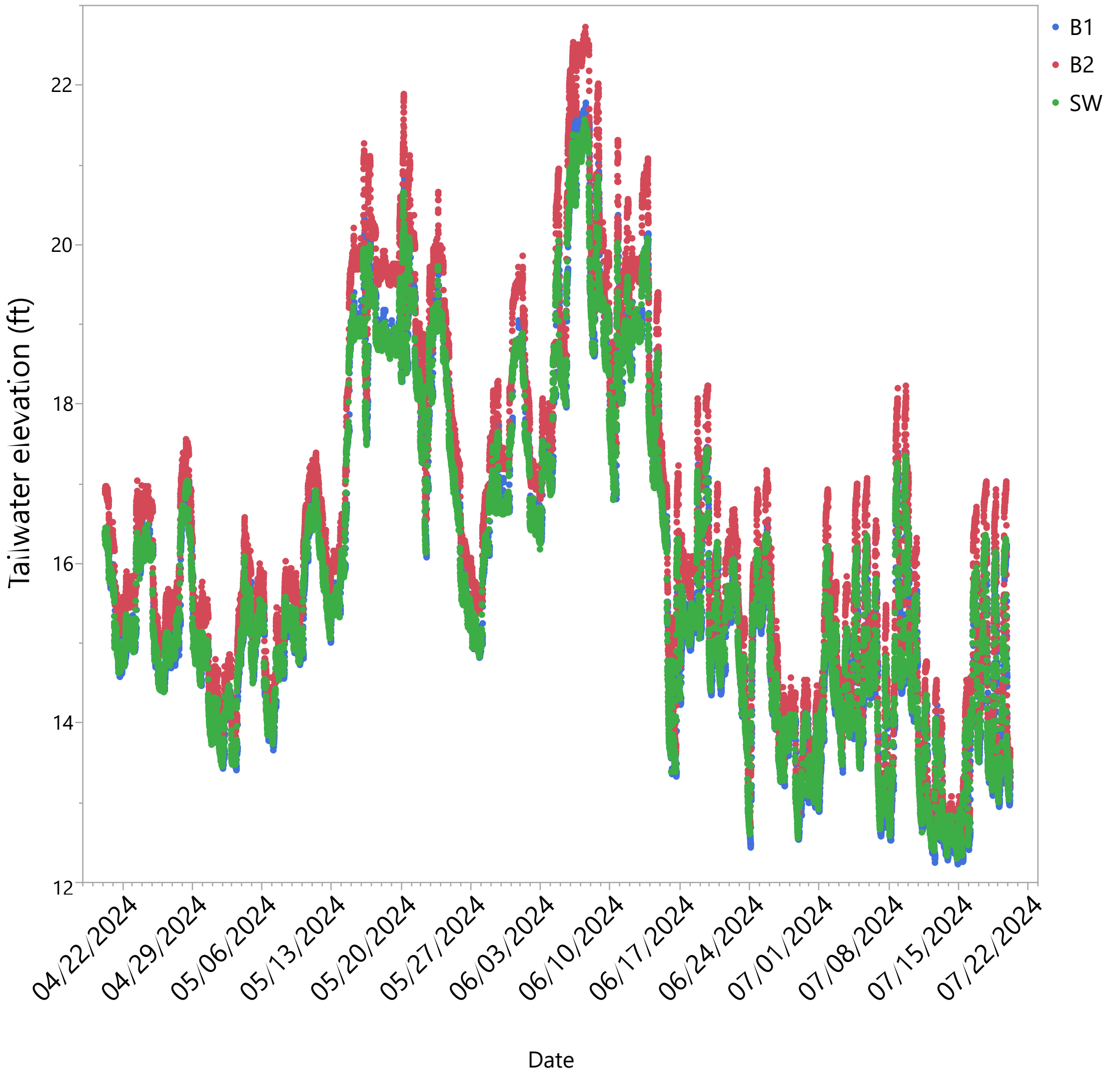

Figure E.3. Five-minute tailwater elevation readings from sensors deployed at Bonneville Dam powerhouse 1 (B1), powerhouse 2 (B2), and spillway (SW) from late-April through late-July 2024.

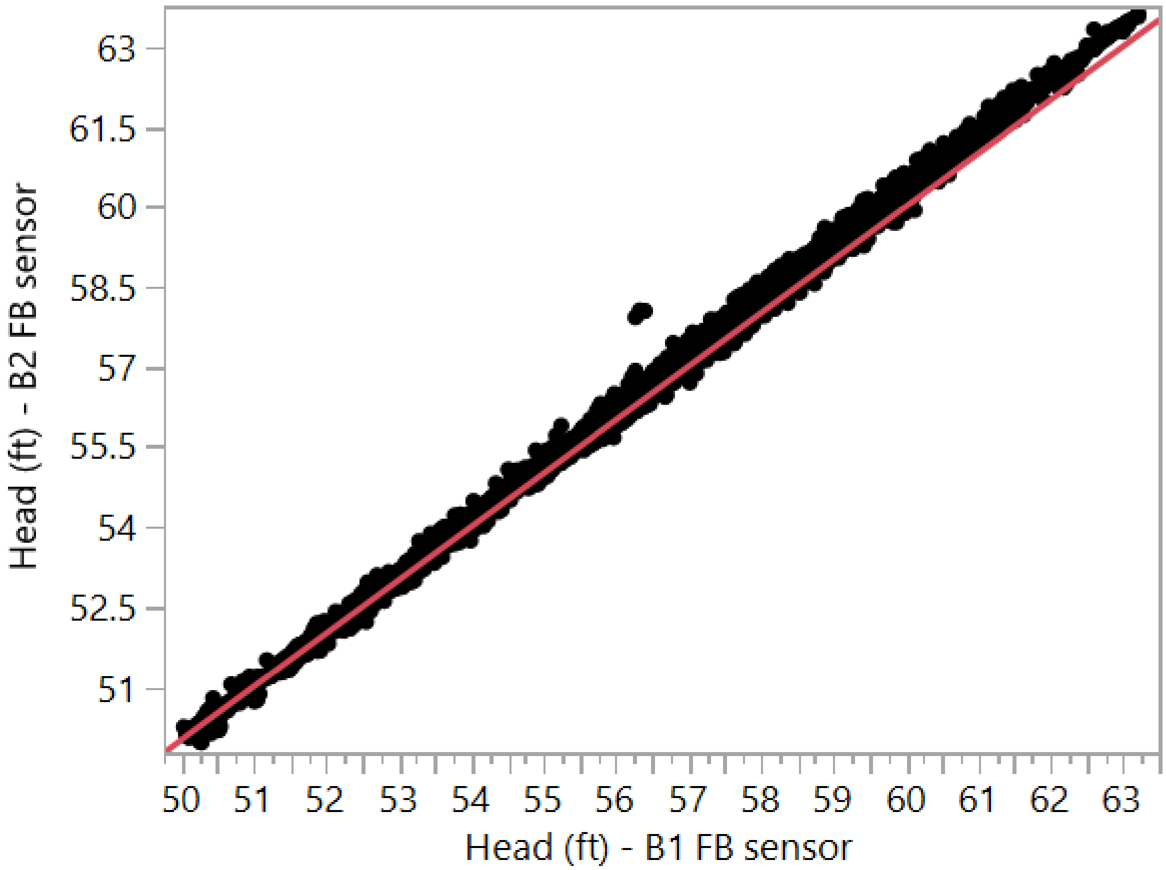

Figure E.4. Relationship between B2 head calculated using the B2 forebay (FB) elevation sensor versus B2 head calculated using the B1 FB elevation sensor for the period 23 May – 20 July 2024. Both methods used the B2 tailwater elevation sensor. The red line represents a 1:1 relationship.

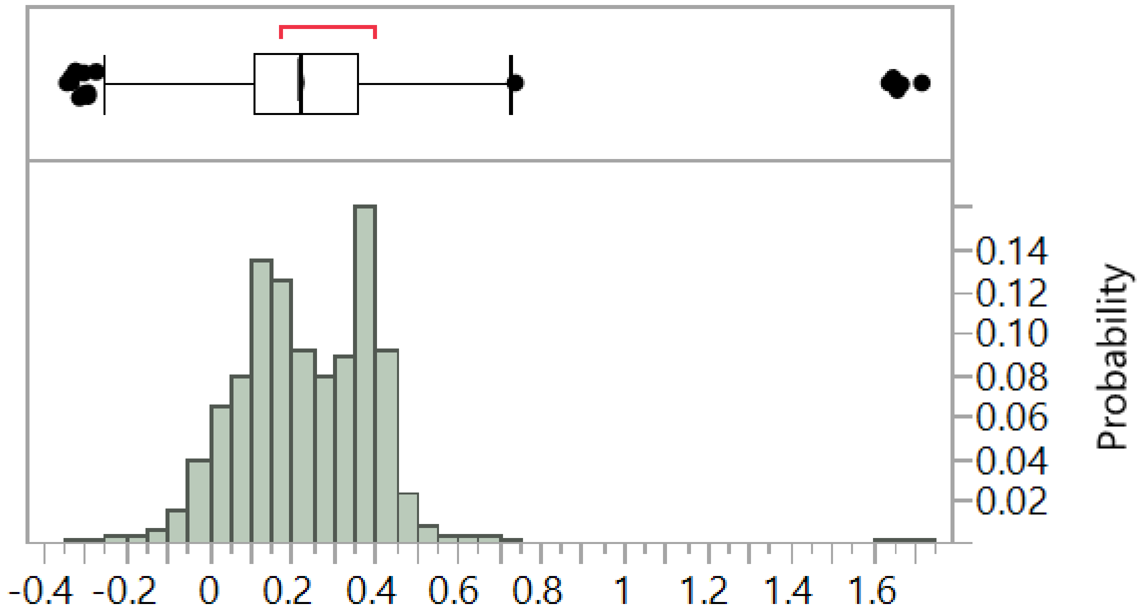

Figure E.5. Distribution of residuals from the 1:1 relationship of B2 head calculated using the B2 forebay elevation sensor versus B2 head calculated using the B1 forebay elevation sensor for the period 23 May – 20 July 2024.

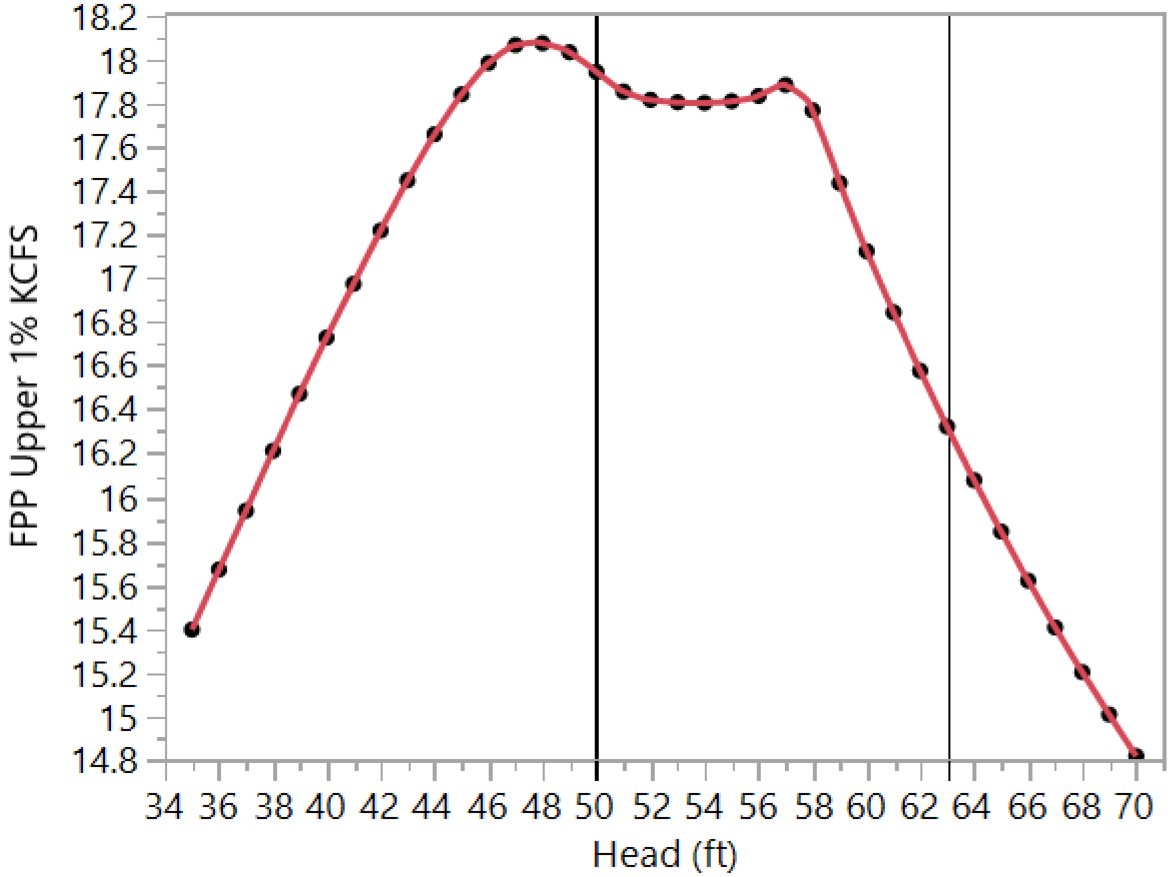

Figure E.6. Relationship between the 1% upper B2 turbine unit flow limit versus head from the 2024 Fish Passage Plan. The red line represents a smoothing spline fit to the data. Black vertical lines indicate the range of head values (50–63 ft) during the 2024 study.

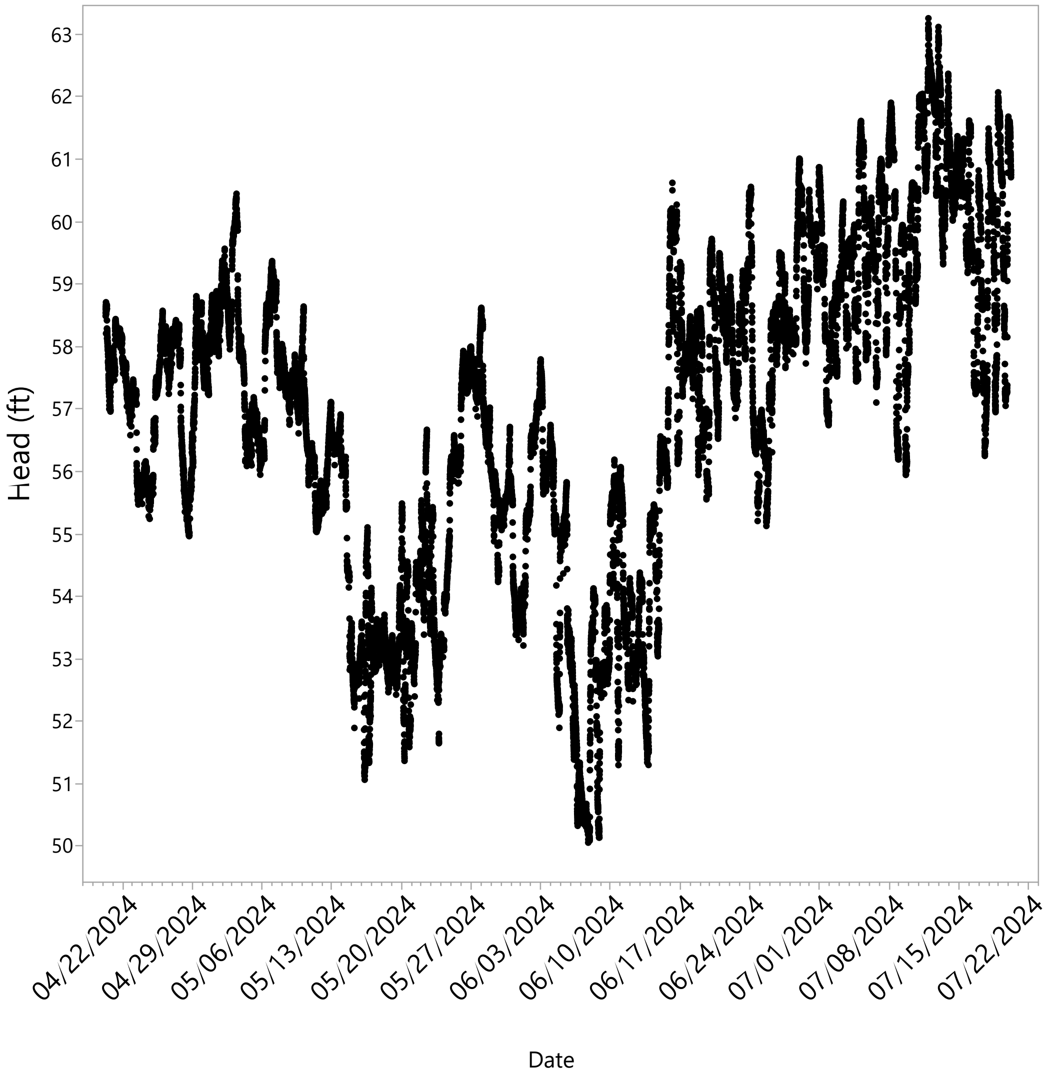

Figure E.7. Five-minute B2 head calculated using the B1 forebay elevation sensor and B2 tailwater elevation sensor from late April through late July 2024.

Appendix F – Treatment Study Schedule with Descaling and Mortality Rates

The treatment schedule calls for at least 48-hours of Bonneville Dam Powerhouse 2 turbine unit operation at the specified treatment level (Mid or Upper 1%) prior to the end of daily sample collection at the Juvenile Monitoring Facility.

Table F.1. Spring Treatment Schedule Blocks and Impingement Study Periods and Operations Exceeding Treatment Range Limits

						Mean CFS above Treatment Limit	
Sample Ending	Season	Block	Treatment	% Desc	% Mort	Day 1	Day 2
4/22/2024 7:00	**Spring**	1	Mid	1.4	0.4		
4/24/2024 7:00	**Spring**	1	Upper	1.4	0.3		392
4/27/2024 7:00	**Spring**	2	Mid	0	0.8		
4/29/2024 7:00	**Spring**	2	Upper	2	0.8		326
5/1/2024 7:00	**Spring**	3	Upper	2.4	0.5		
5/4/2024 7:00	**Spring**	3	Mid	4.2	0		
5/6/2024 7:00	**Spring**	4	Upper	3.4	0.9	189	234
5/8/2024 7:00	**Spring**	4	Mid	3.5	0.9		
5/9/2024 7:00	**Spring**	IMP	Upper				
5/11/2024 7:00	**Spring**	5	Mid	2.4	0.8		
5/13/2024 7:00	**Spring**	5	Upper	2.6	1	304	
5/15/2024 7:00	**Spring**	6	Upper	4.4	2.7	321	915
5/16/2024 7:00	**Spring**	IMP	Mid				
5/18/2024 7:00	**Spring**	6	Mid	1.5	0.8		
5/20/2024 7:00	**Spring**	7	Mid	0.6	0		
5/22/2024 7:00	**Spring**	7	Upper	3.6	0.6	752	529
5/23/2024 7:00	**Spring**	IMP	Upper			599	
5/25/2024 7:00	**Spring**	8	Upper	5.7	1.2	381	11
5/27/2024 7:00	**Spring**	8	Mid	4.6	0		

Table F.2. Summer Treatment Schedule Blocks and Impingement Study Periods

Sample Ending	Season	Block	Treatment	% Desc	% Mort
5/30/2024 7:00	**Summer**	IMP	Upper		
6/1/2024 7:00	**Summer**	-1	Upper	2.3	1.3
6/3/2024 7:00	**Summer**	-1	Mid	0	0
6/5/2024 7:00	**Summer**	0	Upper	2.6	2.1
6/6/2024 7:00	**Summer**	IMP	Mid		
6/8/2024 7:00	**Summer**	0	Mid	0.7	0.7
6/10/2024 7:00	**Summer**	1	Upper	4.4	2.9
6/12/2024 7:00	**Summer**	1	Mid	1	0
6/13/2024 7:00	**Summer**	IMP	Upper		
6/15/2024 7:00	**Summer**	2	Upper	3.3	1.9
6/17/2024 7:00	**Summer**	2	Mid	1.4	0.5
6/19/2024 7:00	**Summer**	3	Upper	4.6	0.8
6/20/2024 7:00	**Summer**	IMP	Upper		
6/22/2024 7:00	**Summer**	3	Mid	2.8	0.7
6/24/2024 7:00	**Summer**	4	Mid	3.6	0
6/26/2024 7:00	**Summer**	4	Upper	10	1.3
6/27/2024 7:00	**Summer**	IMP	Mid		
6/29/2024 7:00	**Summer**	5	Upper	2.7	6.8
7/1/2024 7:00	**Summer**	5	Mid	4.1	0.8
7/3/2024 7:00	**Summer**	6	Upper	3.7	2
7/6/2024 7:00	**Summer**	6	Mid	0.7	0.3
7/8/2024 7:00	**Summer**	7	Mid	0	0
7/10/2024 7:00	**Summer**	7	Upper	0.1	0.9
7/11/2024 7:00	**Summer**	IMP	Mid		
7/13/2024 7:00	**Summer**	8	Mid	1.3	0
7/15/2024 7:00	**Summer**	8	Upper	0	2
7/17/2024 7:00	**Summer**	9	Mid	0	0.3
7/18/2024 7:00	**Summer**	IMP	Upper		
7/20/2024 7:00	**Summer**	9	Upper	0	1.2

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