SYSTEM OPERATIONAL REQUEST: #2013-3

The following State, Federal, and Tribal Salmon Managers have participated in the preparation and support this SOR: Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, Idaho Department of Fish and Game, the Nez Perce Tribes, and the Columbia River Inter-Tribal Fish Commission.

TO:

Gen. Anthony Funkhouser	**COE-NWD**
Col. John Eisenhauer	**COE-NWD**
Lt. Col. Andrew Kelly	**COE-Walla Walla**
James D. Barton	**COE-Water Management**
Doug Baus	**COE-RCC**
David Poganis	**COE-PDD**
Karl Kanbergs	**COE-NWD-NP-WM-RCC**
Lorri Lee	**USBR-Boise Regional Director**
Bill Drummond	**BPA-Administrator**
Tony Norris	**BPA-PGPO-5**
Scott Bettin	**BPA- KEWR-4**
Steve Oliver	**BPA-PG-5**
Lori Bodi	**BPA-KE-4**

Thomas K. Lorz

FROM: Tom Lorz, Vice-Chair FPAC

DATE: May 28, 2013

SUBJECT: Bonneville Operations

OBJECTIVE: Due to the high rate of descaling of juvenile sockeye salmon passing through the Bonneville Dam juvenile bypass facility, implement the Fish Passage Plan Request Change Form written and recommended by the FPOM sub-group concerning Bonneville turbine operations.

SPECIFICATIONS: Immediately Implement Fish Passage Plan Change Request Form:14BON001 Table BON-16 Add Mid-Range.

JUSTIFICATION:
The Fish Passage Operations and Maintenance (FPOM) Committee directed a sub-group to investigate and recommend changes concerning turbine operations at Bonneville Dam with regard to juvenile and adult migrant passage and survival. Fish Passage Change Plan Form 14BON001 Table BON-16 Add Mid-Range is the recommendation made by the FPOM sub-group to FPOM. The

sub-group justification is in the attached memo ***Bonneville Dam Turbine Unit Operations and Fish Condition*** dated May 3, 2013. To date, this change form has been agreed upon by all fisheries agencies, but is waiting for approval from the Action Agencies. This change form and FPOM sub-group support memo are attached and can be found at the FPOM website under the May meeting minutes at: http://www.nwd-wc.usace.army.mil/tmt/documents/FPOM/2010/2013_FPOM_MEET/2013_MAY/.

The following table summarizes sockeye descaling at Bonneville Dam since May 16, 2013.

Species	**Date**	**Number Examined**	**Percent Descaled**
SO	5/16/2013	35	8.6%
	5/17/2013	70	2.9%
	5/18/2013	102	15.7%
	5/19/2013	171	15.8%
	5/20/2013	97	14.4%
	5/21/2013	106	7.5%
	5/22/2013	226	10.2%
	5/23/2013	56	3.6%
	5/24/2013	147	4.1%
	5/25/2013	104	14.4%
	5/26/2013	80	5.0%
	5/27/2013	71	8.5%
	5/28/2013	45	4.4%

With continued elevated sockeye descaling recorded at Bonneville Dam, it is the recommendation of the members signed on to this SOR that the action agencies immediately implement the change form written and recommended by an FPOM sub-group to FPOM. Attached is a memorandum written on June 7, 2012 by the Fish passage Center concerning Juvenile Fish Mortality Estimates for Bonneville Second Powerhouse Bypass.

ATTACHMENTS

FPP Change Request Form

Change Request Number: 14BON001 Table BON-16 Add Mid-Range
Date Submitted: 3/29/2013
Project: BON
Requester Name, Agency: FPOM BON Ops Task Group

Location of Change - FPP Project and Section:
BON sections 5.2 and 5.3 (Turbine Unit Operations and Maintenance), and Table BON-16 (PH2 turbine 1% range)

Proposed Changes:

5. TURBINE UNIT OPERATION AND MAINTENANCE

5.1. Powerhouse priority is detailed in **Table BON-14.** When splitting flows, as directed in section **2.1.2,** the top two available priority units for PH1 will be operated first followed by normal unit priority at PH2. If there is a need for more units, and all available units at PH2 are in operation, proceed with the normal unit priority for PH1**.**

5.2. November 1 through March 31. All turbine units will operate *as a soft constraint* within ±1% of peak efficiency (within upper and lower limits of the 1% range) as shown in **Tables BON-15** (PH1) and **BON-16** (PH2) for project heads of 35-70 feet. See **BPA Load Shaping Guidelines** (**Appendix C**) for further information on turbine operations within and outside of the 1% range.

5.3. April 1 through October 31. Except as defined below in **section 5.3.1**, all turbine units will operate *as a hard constraint* within ±1% of peak efficiency (within upper and lower limits of the 1% range) as shown in **Tables BON-15** (PH1) and **BON-16** (PH2).

5.3.1. April 10 through August 31. During the spring and summer spill seasons when the project is spilling in accordance with the Fish Operations Plan (FOP, see **Appendix E**), turbine units will operate in the following priority order to pass increasing flow:

1. Operate PH2 units within the 1% mid-range (**Table BON-16**);

2. Then, operate PH1 units up to the 1% upper limit (**Table BON-15**);

3. Then, operate PH1 units up to Best Operating Point (BOP; **Table BON-15**);

4. **From April 10 through June 20 (spring spill season)**, additional flow above what can be passed in steps 1-3 will be passed in one of the two following ways, as directed by Project Fisheries based on monitoring of juvenile and adult spring Chinook passage and collection data:

   - **a.** If the adult trigger is met (adult counts exceed juvenile collection counts for two consecutive days), then operate PH2 up to the 1% upper limit in the following unit priority order: 18, 17, 16, 15, 14, 13, 12, 11 until adult counts drop below juvenile counts for 3 consecutive days.

   - **b.** If the adult trigger is *not* met (adult counts are less than juvenile collection counts for two consecutive days), then increase spill to pass the additional flow.

5. **From June 21 through August 31 (summer spill season),** additional flow above what can be passed in steps 1-3 will be passed by operating PH2 up to the 1% upper limit.

5.4. The project turbine unit maintenance schedules will be reviewed by Project and Operations Division biologists for fish impacts. If possible, maintenance of priority units will be scheduled for winter maintenance periods, or when there are low numbers of fish passing the project.

Existing Language For Section 5:

5. TURBINE UNIT OPERATION AND MAINTENANCE

5.1. Powerhouse priority is detailed in **Table BON-14.** When splitting flows, as directed in section **2.1.2,** the top two available priority units for PH1 will be operated first followed by normal unit priority at PH2. If there is a need for more units, and all available units at PH2 are in operation, proceed with the normal unit priority for PH1**.**

5.2. Turbine units at PH1 will operate within 1% of best efficiency and within cavitation limits at various head ranges as shown in **Table BON-15**.

5.2.1. Turbine units at PH2 will operate at the mid to lower 1% range (unless total dissolved gas waivers are exceeded in the tailrace) of best efficiency and within cavitation limits at various head ranges as shown in **Table BON-16**.

5.3. Turbines will be operated within ±1% of best turbine efficiency from April 1 through October 31 (as specified in the BPA load shaping guidelines), except as outlined in **Appendix C**.

5.4. The project turbine unit maintenance schedules will be reviewed by Project and Operations Division biologists for fish impacts. If possible, maintenance of priority units will be scheduled for winter maintenance periods, or when there are low numbers of fish passing the project.

Justification for Change:
FPOM requested adding PH2 1% mid-range columns since PH2 may be limited to mid-range operation. See Memo to FPOM from Bonneville Turbine task group for justification.

Comments from others: See FPC memo

Record of Final Action:

Table BON-16. Bonneville Dam Powerhouse Two Turbine Units 11-18 (with and without STSs) Output (MW) and Discharge (cfs) at the Upper, Mid-Range and Lower Limits of the 1% of Peak Efficiency Operating Range.

Head (feet)	Powerhouse Two (units 11-18)											
	1% Limits With STS						1% Limits Without STS					
	Lower Limit		Mid-Range 13K – 15K		Upper Limit		Lower Limit		Mid-Range		Upper Limit	
	(MW)	(cfs)	(MW)	(MW)	(MW)	(cfs)	(MW)	(cfs)	(MW)	(cfs)	(MW)	(cfs)
35	27.6	11,259	**31.9**	**36.8**	44.3	18,068	28.2	11,444	36.7	14,861	45.1	18,277
36	28.5	11,27	**32.9**	**37.9**	45.8	18,09	29.2	11,45	37.9	14,88	46.6	18,30
37	29.4	11,27	**33.9**	**39.1**	47.3	18,12	30.1	11,46	39.1	14,89	48.1	18,33
38	30.3	11,28	**34.9**	**40.3**	48.8	18,13	31.0	11,47	40.4	14,91	49.7	18,35
39	31.3	11,28	**36.0**	**41.6**	50.3	18,15	32.0	11,47	41.6	14,91	51.2	18,36
40	32.2	11,28	**37.1**	**42.8**	51.8	18,16	32.9	11,47	42.8	14,92	52.7	18,37
41	33.0	11,25	**38.1**	**44.0**	53.3	18,19	33.7	11,44	44.0	14,92	54.3	18,40
42	33.8	11,23	**39.1**	**45.2**	54.9	18,22	34.6	11,41	45.2	14,92	55.8	18,44
43	34.6	11,20	**40.2**	**46.3**	56.4	18,25	35.4	11,38	46.4	14,92	57.4	18,46
44	35.4	11,17	**41.2**	**47.5**	57.9	18,27	36.2	11,35	47.6	14,92	58.9	18,49
45	36.2	11,14	**42.2**	**48.7**	59.4	18,29	37.0	11,32	48.8	14,92	60.5	18,51
46	37.0	11,13	**43.2**	**49.8**	61.0	18,36	37.9	11,32	50.0	14,95	62.1	18,58
47	37.8	11,13	**44.2**	**51.0**	61.9	18,20	38.7	11,31	50.9	14,86	63.0	18,41
48	38.7	11,12	**45.2**	**52.1**	62.7	18,04	39.6	11,31	51.7	14,78	63.8	18,25
49	39.5	11,12	**46.2**	**53.3**	63.5	17,88	40.4	11,30	52.6	14,70	64.7	18,10
50	40.3	11,11	**47.2**	**54.4**	67.5	18,59	41.3	11,30	55.0	15,06	68.7	18,81
51	41.3	11,15	**48.1**	**55.5**	69.8	18,85	42.2	11,33	56.7	15,20	71.1	19,07
52	42.3	11,18	**49.1**	**56.7**	72.1	19,09	43.2	11,37	58.3	15,34	73.4	19,31
53	43.2	11,21	**50.1**	**57.8**	74.5	19,32	44.2	11,40	60.0	15,47	75.8	19,55
54	44.2	11,24	**51.0**	**58.8**	76.5	19,53	45.2	11,43	60.9	15,43	76.5	19,43
55	45.2	11,27	**52.1**	**60.1**	76.5	19,11	46.2	11,46	61.4	15,22	76.5	18,97
56	46.4	11,34	**53.2**	**61.3**	76.5	18,71	47.4	11,53	62.0	15,05	76.5	18,58
57	47.6	11,40	**54.2**	**62.6**	76.5	18,33	48.6	11,59	62.6	14,89	76.5	18,20
58	48.8	11,46	**55.4**	**63.9**	76.5	17,96	49.9	11,65	63.2	14,74	76.5	17,83
59	50.0	11,51	**56.5**	**65.1**	76.5	17,61	51.1	11,70	63.8	14,59	76.5	17,48
60	51.2	11,56	**57.6**	**66.4**	76.5	17,26	52.3	11,76	64.4	14,45	76.5	17,14
61	51.8	11,53	**58.5**	**67.5**	76.5	16,97	53.0	11,72	64.8	14,29	76.5	16,85
62	52.5	11,49	**59.5**	**68.6**	76.5	16,69	53.7	11,69	65.1	14,13	76.5	16,58
63	53.1	11,46	**60.4**	**69.7**	76.5	16,42	54.3	11,65	65.4	13,98	76.5	16,31
64	53.7	11,43	**61.3**	**70.7**	76.5	16,16	55.0	11,62	65.8	13,84	76.5	16,05

65	54.4	11,40	**62.3**	**71.8**	76.5	15,91	55.6	11,59	66.1	13,70	76.5	15,80
66	55.4	11,44	**63.2**	**72.9**	76.5	15,67	56.7	11,63	66.6	13,60	76.5	15,57
67	56.5	11,49	**64.2**	**74.0**	76.5	15,43	57.8	11,68	67.2	13,51	76.5	15,34
68	57.5	11,53	**65.1**	**75.1**	76.5	15,21	58.9	11,72	67.7	13,42	76.5	15,11
69	58.6	11,57	**66.1**	**76.3**	76.5	14,99	59.9	11,76	68.2	13,33	76.5	14,90
70	59.6	11,610	**67.0**	**77.3**	76.5	14,775	61.0	11,803	68.8	13,248	76.5	14,693

[*] Table based on data provided by HDC, January 2001 (Table BON-16 revised 2006).

May 3, 2013

MEMORANDUM TO: The Fish Passage Operations and Maintenance Committee

FROM: Members of the FPOM Bonneville Operations Task Group

SUBJECT: Bonneville Dam Turbine Unit Operations and Fish Condition

A program designed to improve fish guidance efficiency through development of juvenile bypass systems at Columbia River hydroelectric projects has been ongoing since the 1970's. During the 1980's and 1990's new turbine bypass technologies and equipment were included at Bonneville Dam's Second Powerhouse (PH2), however fish guidance efficiency (FGE) studies continued to indicate guidance levels that fell short of expectations. In 1999, the region focused on improving guidance and survival. Prototype modifications began in 2001 and full powerhouse implementation was completed in 2008. Modifications included an increase in Vertical Barrier Screen (VBS) flow area, installation of turning vanes on the Submersible Traveling Screens (STS) to increase flow into the gatewell, addition of a gap closure device to eliminate fish loss at the VBS, and installation of interchangeable profile bar screen VBS to allow for screen removal and cleaning without turbine outages or intrusive gatewell dipping. The improvements associated with this program dramatically increased the flow into the gatewell slots which resulted in significant increases in fish guidance efficiency. Unfortunately, smolt monitoring in 2007 indicated that there may have been some unintended smolt injury consequences from the improved guidance system. Studies conducted in 2008 and 2009 confirmed that when these units were operated in the mid to upper 1% efficiency operating band, descaling and mortality was elevated in Spring Creek hatchery and run-of-river outmigrant spring and fall Chinook salmon. These results and subsequent smolt monitoring program observations of elevated smolt descaling and mortality have led to an ongoing Corps program to address the problem through design alternatives. In the meantime, operations of the units at PH2 have been modified periodically to reduce the incidence of descaling and mortality.

The following discussion examines each of the issues associated with this gatewell passage problem including an examination of some of the interim and long-term solutions. These topics include:

1. Second powerhouse gatewell fish condition test results from 2008 and 2009
2. Past (<2007) and recent (2010 – 2012) Smolt Monitoring Program data and observations
3. Second powerhouse gatewell debris/turbine loading/fish condition relationships
4. Second powerhouse turbine unit passage and survival considerations
5. NERC generation flexibility requirements and AGC programming schedule
6. First powerhouse Best Operating Point MGR unit operation
7. Adult passage concerns – spillway approach and Bradford Is. fallback
8. Total dissolved gas concerns
9. Generation limitations due to 115kv and 230kv line limitations
10. Gatewell Improvement Program alternatives and schedule

1) Gatewell Fish Condition Studies: In 2008 and 2009 the National Marine Fisheries Service, under contract to the Corps of Engineers, conducted gatewell survival, passage and injury studies at PH2 (Gilbreath et al. 2012). The work in 2008 was limited to Spring Creek hatchery fish mainly because the Submersible Traveling Screens (STS's) were pulled out in mid-May due to severe debris issues. The 2009 work included Spring Creek hatchery fish and both spring and summer run-of-river Chinook salmon.

The 2008 study used 31,988 juvenile Chinook salmon from the Spring Creek hatchery, 780 run-of-river yearling Chinook and 2,123 run-of-river subyearling Chinook salmon. The fish were fin clipped or PIT tagged and released into the gatewells at lower, middle and upper 1% peak efficiency turbine unit operating range. The test fish were subsequently captured in the smolt monitoring facility and evaluated for condition. Releases occurred from early March through early May. Tests of run-of-river yearling Chinook were not completed due to the regional decision to pull all submersible traveling screens beginning about May 21. Run-of-river subyearling Chinook tests were completed from July 1- 17.

The 2009 study used 13,497 Spring Creek subyearling Chinook, 6,771 yearling run-of-river Chinook and 10,137 subyearling run of river Chinook. The Spring Creek and yearling fish were released in the spring while the subyearlings were released in the summer. All fish were PIT tagged and recovered by the sort-by-code system in smolt monitoring facility where they were examined for condition. Tests with Spring Creek fish assessed fish condition at unit loadings of lower-middle 1% operation (13.5 kcfs) and middle 1% operation (14.7 kcfs). Tests using run-of-river fish assessed effects of running the units the middle 1% and the upper 1% (17.8 kcfs) unit operation. Spring Creek subyearling Chinook completed March 26 - May 8. Run-of-river yearling Chinook completed May 12 – June 5. Run-of-river subyearling Chinook completed June 16 – July 12.

Both study years showed that fish condition deteriorated with increasing unit flow. In 2008, high spring debris loads confounded the run-of-river spring migrant tests; however the Spring Creek Hatchery release tests were conducted in four series. From the report: "Results from Test Series 1-3 confirmed that lower-1% operation was less detrimental than upper-1% operation for Spring Creek Hatchery subyearling Chinook. After consulting with U.S. Army Corps of Engineers personnel, we changed the design for Test Series 4 to compare middle- vs. upper-1% operation: further evaluation of passage performance at lower-1% operation was not deemed necessary. Results from Test Series 4 showed that fish released to the intake had mortality rates of 2.7% for middle-1% and 18.1% for upper-1% operation. These differences were significant. The summer run-of-river subyearling Chinook tests for middle vs. upper 1% operations indicated increased descaling and mortality for the higher operation (descaling 0.4% vs. 0.7% and mortality 0.6% vs. 2.6% for mid vs. upper % operations, respectively), however the results were not significant.

In 2009, mortality of Spring Creek subyearlings was less at lower-middle than at middle 1% operation (means were 3.3% and 5.4%, respectively). Spring released run-of-river yearling Chinook showed lower descaling and mortality at middle than at the upper 1% operation (descaling means 1.0 and 11.5%, respectively and mortality means 0.5% and 4.4%, respectively). Summer tests showed similar trends for run-of-river subyearling Chinook. Descaling averaged 0.4% at the middle operating point and 2.6% at the upper 1% point; while mortality averaged 2.1% at the middle point and 4.3% at the upper 1% operating point.

2) Smolt Monitoring Observations: In 2007, observations from the Bonneville Smolt Monitoring Program indicated that mortality of Spring Creek National Fish Hatchery subyearling Chinook passing the dam in March and April were much higher than anticipated (D. Ballinger, pers. comm., 2007). Normally, mortality for these releases is in the low single digits; however in 2007 they were in the 10 to 12 percent range. The dead fish showed no evidence of physical trauma and a subsequent pathological evaluation showed no presence of disease. It was noted that mortality rates appeared to decline as the turbine unit loadings were decreased within the 1% peak efficiency operating band.

Observations in subsequent years have continued to support the turbine operations/fish condition relationship.

3) Gatewell debris/turbine loading/fish condition relationships: Higher mortality over historical levels continued which prompted questions relating fish condition relative to gatewell and VBS debris loading. Does gatewell debris result in the scattered higher injury rates noted later in the spring and early summer passage? Can increased gatewell cleaning reduce fish injury and mortality allowing operation within the normal turbine operating range? Increased cleaning may help reduce injury rates, however, the increased injury and mortality noted in the Gilbreath et. al. 2012 studies occurred with relatively clean gatewells. It is highly unlikely that increased maintenance alone would eliminate the problem.

4) Powerhouse two turbine fish passage and survival rates: Recent survival studies have provided survival and passage results for the PH2 turbines (Ploskey et al. 2011, Skalski et al. 2012 and Ploskey 2012). The 2010 study was a single release estimate that also included 81 km of river below the dam. The 2011 study was a virtual paired release study that assessed survival from the face of the dam to the first array a few kilometers below the dam. The 2010 and 2011 PH2 turbine survival point estimates for spring Chinook were 95.7% and 94.7%, respectively. The 2010 and 2011 survival point estimates for steelhead were 91.1 and 91.9%, respectively.

An important point to note is that fish guidance efficiency of the PH2 bypass system is low. In the two recent study years nearly twice as many fish passed through the turbines as through the screened bypass system. In 2010 and 2011, turbine passage (percentage of all fish passing into the intakes calculated as one minus FGE) for yearling Chinook was 71.4% and 64.6%, respectively, and for steelhead it was 74.3% and 61.7%, respectively. Another important point to consider is that the PH2 bypass system only passed a small percentage of the total project passage during these two study years. For each year, yearling Chinook bypass passage was 6.5% and 4.5% and steelhead bypass passage was 5.9% and 1.8%, respectively, of the project fish passage. The fact that the screens were pulled in May of 2011 has something to do with the low percentages for that year.

The Corps' Turbine Survival Program (TSP) has not yet conducted a bead and flow velocity/vector analysis of the second powerhouse unit model at the Engineer Research and Development Center (ERDC) in Vicksburg, Mississippi, however, this work is scheduled to occur during FY13 and 14. These data will help define fish passage conditions through the turbine and draft tubes for different operating points. An agency ERDC trip occurred during the week of December 10, 2012. The following is an excerpt from the NOAA trip report:

"Bonneville Second Powerhouse Turbine Operations: *For this work we used a 1:25 scale model of the second powerhouse turbines. Initial work on this objective was included in our trip report for the September 17- 20, 2012, trip (report dated October 29, 2012). For this investigation we observed the model at five unit flows of 11.3, 14.9, 19.1, 22.5 and 23.5 kcfs, which correspond approximately to the low and mid-levels of the 1% operating range, the generator limit (which is obtained a few hundred cfs below the upper 1% limit) and two flow levels above generator limit. The two flows above the limit were added to inform the consideration of future generator replacements, not for consideration in developing the 2013 operating limits. A head of 55' was used for all but the highest flow level which required a lower head of 47' to obtain in the model. We used the usual air, dye and bead methods (explained our previous trip reports) to investigate hydraulic conditions that would be encountered by fish passing through the turbine runner, elbow and draft tube environments.*

Results: *In general, the hydraulic conditions in this turbine are really poor overall and gave the overall impression of a turbine/powerhouse design that was not well thought out. We did note, however, that hydraulic conditions improved somewhat as flow was increased up to the generator limit flow. Beyond this, flow characteristics may have improved slightly but not significantly. We did note that beads exited the draft tube into the tailrace better than in any other powerhouse turbine design that we have examined thus far, possibly due to the draft tube design. This may help explain the seemingly inconsistent observation of really poor hydraulic conditions in the runner and elbow environment and the normally high observed turbine survival through this powerhouse. The primary take away from the turbine work was the consensus that we should not operate these units at the low end of the peak range for fish passage. The quantitative bead analysis results are still several months away (due to ERDC's workload) so a pre fish passage season operational decision will have to be made without these data."*

Battelle has conducted sensor "fish" evaluations at the second powerhouse (Carlson et al. 2008). This study evaluated sensor passage conditions at the upper and lower 1% operations with target passage routes near the blade tip and hub. The data from the sensors indicated that pressure low points (nadirs) were higher (better for fish) at the lower operating point. The rate of pressure change is also an important metric for determining risk to fish passage; however, the sensor data did not indicate a dramatic difference between the two operating levels. A quality of flow metric was also used to examine sensor acceleration and rotation (an indication of turbulence) through the runner and draft tube environment. This metric did indicate that, at least for the hub releases (likely route of higher fish passage), flow conditions were somewhat better at the upper 1% operation. The results of this study do not directly predict differences in fish survival at the different operating levels; however, they did indicate that passage conditions do change as flows were dropped from the upper to lower 1% operations. The measured pressure nadirs improved somewhat, while the hydraulic passage conditions worsened. While we do not know the rate of change in passage conditions between the upper and lower operating points, it is likely that the differences between the upper and mid-point operations currently under consideration were lower.

Overall, the results of the sensor fish work and particularly the observations of the ERDC model tend to support minimizing the operation of these units at the lower end of the 1% range. The results also indicate that the difference in passage conditions between the mid-range and upper 1% operations are probably not large enough to warrant a specific concern in the current mid-range operation discussion.

5) NERC generation flexibility requirements and AGC programming schedule: The North American Electric Reliability Corporation (NERC) develops and enforces reliability standards, monitors the bulk power system and annually assesses adequacy. As of June 18, 2007, the U.S. Federal Energy Regulatory Commission (FERC) granted NERC the legal authority to enforce reliability standards with all users, owners, and operators of the bulk power system in the United States. NERC requires automatic generation control (AGC) for the turbine units. The July 2012, FPOM meeting minutes indicate that the AGC programming necessary for this change can be completed by the end of the 2012 calendar year at little or no extra cost to the O&M budget.

6) Powerhouse One best operating point (BOP) MGR unit operation: The normal turbine operating range for FCRPS units has been restricted to +/-1% of the peak efficiency operating point since the early 1990's. The rationale for this restriction was based mostly on limited experiments and best judgment of the professionals working on turbines and fish passage survival (Oligher and Donaldson 1966, Bell 1981, etc.). Fish survival data supporting the relationship between peak efficiency operation and fish survival has been weak at best. In their retrospective analysis examining the efficacy of the 1% rule, Skalski et al (2002) concluded that survival appears not to be directly related to peak efficiency. However, they did indicate that operating within the 1% range would likely encompass the maximum turbine passage survival, mainly due to the broad zone of operation within this range. In evaluating turbine designs as a part of the McNary Powerhouse Modernization Program in the early 2000's, members of the Corps' Turbine Survival Program noted that passage conditions inside the turbine environment in the physical model looked better for fish passage at unit flows somewhat above the 1% peak efficiency operating range in the McNary units. These improvements included better stay vane/wicket gate alignment, more open blade angles, much less turbulence below the turbine runner, much improved (less turbulent and better balanced) draft tube flows and higher draft tube egress flow velocities. Subsequent quantitative bead and velocity analyses developed by the Corps' Engineer Research and Development Center supported these observations and the so called Best Operating Point or BOP operation was developed from these observations defined in a TSP white paper from May 2011 - *Bonneville Dam First Powerhouse Kaplan Operations Revised Limits*. As it turns out, the best operating point for all turbine units in the FCRPS projects in the lower Snake and Columbia Rivers lie within the upper ±1% peak efficiency range, except for the turbine units at McNary Dam and in Bonneville Dam PH1. BOP operation was not implemented at the McNary Project mainly due to concerns for reduced bypass fish condition that were observed due to increased gatewell flows and associated debris problems that resulted from the higher (~2 kcfs) unit loading.

Since the first powerhouse at Bonneville Dam does not have a screened bypass system, the TSP members considered this powerhouse as a potential candidate for BOP operation. Model investigations were conducted in 2010 by the Corps' Engineer Research and Development

Center(see Appendix A for the NOAA trip report).A physical evaluation of the minimum gap runner (MGR) turbine units in this powerhouse indicated a best operating point flow level of about 1.5 kcfs higher than the current upper 1% operating range flow limit. The model bead strike analysis indicated that this flow level had significantly lower bead strike and severe direction change scores for passage conditions within the runner environment and better draft tube egress velocities than the operating points within the peak efficiency range. While no rigorous biological evaluation of the best operating point has been done to date, there was a biological evaluation of the powerhouse one MGR units conducted in 2000 (Normandeau 2000). This study evaluated balloon-tagged fish survival at four operating points including one that was similar to the best operating point (10.5 kcfs). Of the four operating points tested in that study, the 10.5 kcfs point (what the researchers called power level three) returned the highest survival point estimate. However, it should be noted that the estimate for this point was not statistically different from those measured for the other three points.

While it appears from the data examined to date, that survival through the first powerhouse units at BOP would at least be no worse than survival within the one percent, there are other issues to consider. Higher flow passage through turbines can result in low within-runner pressure nadirs. These more extreme low pressure levels can injure or kill fish passing through the runner environment, particularly if they pass near the pressure (lower) side of the runner blades. These pressure levels are most severe in low tailwater (high head) conditions. Therefore, operating these units at flows higher than the BOP should be discouraged. Also, operation even at BOP should be limited at the higher head levels. These limitations will be incorporated in the updated Corps' Hydraulic Design Center PH1 unit operating tables for the 2013 Fish Passage Plan.

PH1 Turbine Survival: For reference, the recent project survival studies have included estimates for first powerhouse turbine passage (Ploskey et al. 2011, Skalski et al. 2012 and Ploskey 2012). The 2010 study was a single release estimate that also included 81 km of river below the dam. The 2011 study was a virtual paired release study that assessed survival from the face of the dam to the first array a few kilometers below the dam. The 2010 and 2011 PH1 turbine survival point estimates for spring Chinook were 98.7% and 96.8%, respectively. The 2010 and 2011, survival point estimates for steelhead were 90.0% and 93.6%, respectively. Turbine passage estimates (one minus powerhouse sluiceway efficiency) in 2010, for yearling Chinook and steelhead were 77.0% and 59.2%, respectively. No estimates were available for 2011.

7) Adult passage concerns – spillway approach and Bradford Is. Fallback: A simple shift of flow from the second powerhouse to the first powerhouse is not without fish issues beyond the concerns for BOP operation. The region has long known that adult salmonid fallback through the spillway of fish passing the Bradford Island exit is higher than for adults passing the Washington shore exit (Bjornn et al. 2000, Boggs et al. 2004). A shift in flow from reducing the second powerhouse unit loadings to the midpoint of the 1% operating range would shift about 30 kcfs of the river flow to the first powerhouse. Depending on river flow, this shift could affect passage distribution of adults at the project resulting in increased number of adults exposed to fallback through the spillway. Prior to the arrival of sea lions in the tailrace, the mortality consequence of fallback was considered significant (Boggs et al 2004). Since the arrival of sea lions in the project tailrace in the early 2000's, the consequence of fallback has likely increased. We do not know if fish that fall back through the spillway have a higher chance of being preyed upon but we can conclude that they at least have to face the same predation rate that they did when first approaching the dam, which has varied from 0.4% to 4.2%since consumption studies began in 2002 (Stansell et al. 2011).Bjornn et al. (2000, Figure 25) indicated that fallback increased with increasing spill levels, however it appeared that the graphs were influenced somewhat by the lower levels of fallback associated with lower (~100 kcfs) spill levels. Delay in the tailrace due to increasing spill may also be a factor leading to higher sea lion predation levels. Caudill et al. (2005draft) reported that delay didn't appear sensitive to increases in spill levels once the spill flow was in the "high" category of 85 to 160 kcfs.

To address the conflict between juvenile benefits and adult impacts, the FPOM Task Group developed a benefits analysis that compared the juvenile benefits of a mid-range PH2 operation to the adult risks. The Task Group discussed several analytical methods and settled on a comparative analysis that examined the effects of the mid-range operation on juvenile and adult spring Chinook salmon. Spring Chinook were chosen primarily because they were the species most likely to be impacted by the operation. Also, adult spring Chinook are the predominate adult passage stock present during the spring months when this operation would most likely occur. Juvenile sockeye remain a concern, and the Task Group decided that, while this species would most likely be well protected by the spring Chinook-based operation, there may be times near the end of the run when juvenile sockeye may need additional protection. During this time, mid-range PH2 operations to facilitate juvenile sockeye passage (vs. adult passage) would be addressed on a case by case basis via in-season management and observations of the Smolt Monitoring Program.

The details of adult spring Chinook passage at Bonneville Dam are presented in Appendix B and the adult vs. juvenile passage analysis is presented in Appendix C. A primary concern was the shift in adult passage from a lower fallback rate passage route (Washington shore ladder) to a higher fallback route (Bradford Island ladder). These shift would likely cause higher project adult passage fallback with associated mortality due to fallback-related injuries and sea lion predation. Data provided by the Fish Passage Center (Appendix B) indicated that this flow vs. adult shift was insignificant when spill flow levels in the range of voluntary spill levels (Appendix B, Figures 9 and 10). However, when spill levels went above the voluntary levels (Appendix B, Figures 11 and 12), adult passage began to shift towards Bradford Island indicating that fallback rates would likely began to rise. The analysis in Appendix C compared the juvenile spring Chinook survival improvement expected from the mid-range operation at PH2 (based on Gilbreath et al. 2012) with the expected increase adult loss rate (adjusted for SARs) from fallback at PH1 (Bradford Island). This analysis indicated that the benefits to juvenile spring Chinook would be eclipsed by adult spring Chinook fallback losses when adult spring Chinook passage exceeded juvenile spring Chinook Smolt Monitoring Program collection counts. Thus, this passage ratio is proposed as the new trigger for mid-range operations at Bonneville Dam and forms the basis for the proposed new operational language for the Fish Passage Plan change form presented in conclusion section below.

8) Total dissolved gas (TDG): A discussion with Oregon Department of Environmental Quality (ODEQ) staff early in 2012 indicated that any flow that results in increased TDG above the 120% tailrace waiver would be viewed as a violation of water quality standards. They also recognize that these powerhouses have hydraulic capacity limits and that involuntary spill occurs once those hydraulic capacities are reached. These hydraulic capacities are limited by many things including best operations for fish passage. The 2008 BiOp (RPA27) states that FCRPS turbine units are to be operated “to achieve best fish passage survival”. The currently accepted guideline is to operate within the 1% peak efficiency band and this limitation is not exceeded even during high river flow events that push total dissolved gas levels above the 120% waiver limit. Restricting Bonneville Dam’s second powerhouse to a mid-level operation follows the RPA27 guidance in operating these units for best fish passage survival. Exceeding the 120% TDG level for this purpose is no different than maintaining the 1% operation. Any turbine operating limits should be reconsidered as TDG levels approach 130%.

9) Bonneville Generation Limitations: The Western Electric Coordinating Council (WECC) is the largest and most diverse of the eight Regional Entities that have Delegation Agreements with the NERC. Current WECC standards are causing temporary restrictions on generation capacities of the Bonneville Dam 115kv and 230kV transmission lines. These limitations are seasonal and based on ambient temperature. For the 2013 fish passage season, the March 16 – May 31, 2013, restrictions of 160 MW and 816 MW for the 115kv and 230 kV lines, respectively, are most relevant. These limitations translate to a maximum turbine capacity (combined powerhouses) of 227.0 kcfs and a total project capacity w/o spill (but with miscellaneous flow) of 238.6 kcfs. Modeling by BPA using the high flows of the past two years has indicated that powerhouse one capacity (115kV line) could be reduced from 0 to 15 kcfs. These limitations are most restrictive in March when the tailwater is low and head is the greatest (i.e., when the generation capacity of the project is greatest). The effect of this limitation remains to be seen pending seasonal flows. While it seems unlikely, it is possible that there will be some limitation of the capacity of powerhouse one to pick up flow from powerhouse two during the limitation period. The limitation ends 2400 hours, May 31, 2013.

10) Gatewell Improvement Program alternatives and schedule: The Bonneville Second Powerhouse Fish Guidance Efficiency (FGE) Program Post Construction evaluation is an ongoing effort to understand and improve the gatewell environment and downstream passage at the Second Powerhouse.

Computational Fluid Dynamics (CFD) modeling conducted in 2010-11 indicates that gatewell hydraulic conditions may be improved by filling the Submersible Traveling Screen (STS) guide slot above the STS turning vane on both sides of the gatewell. Proof of concept testing of a Gatewell Turbulence Reduction Device (TRD) to fill this volume is underway for 2013 and will test the hypothesis that filling the guides above the STS will improve gatewell flow conditions, thereby reducing injury and mortality at the upper 1% peak efficiency turbine operation range. Results from this testing will provide hydraulic and biological information necessary during prototype design. A concurrent investigation into the gatewell environment will identify biological and hydraulic metrics necessary to evaluate flow control alternatives in numerical and physical models. A prototype design will follow results from TRD proof of concept testing and analysis of alternatives. A prototype will allow a check for errors, adjustments, and modifications to a target gatewell hydraulic and biological condition. This phase may extend one to two seasons, 2014-2015, based on performance and cost. Construction of the preferred alternative during the next phase, 2016, will follow and may extend from one to three seasons. The time duration will depend on complexity of design, costs, and operational requirements.

Conclusion: The following language was developed by the Bonneville Operations FPOM Task Group based on the preceding information and the appendices attached to this memo. The language was discussed at length during an April 11, 2013, Task Group meeting. The two day component of the adult to juvenile trigger was adopted to help prevent premature implementation of the operation. The language will be presented to the full FPOM committee as a Fish Passage Plan Change Form for consideration in operation of the Bonneville Project during 2013.

Location of Change: BON 5.2 and 5.3, Table BON-16 (re-numbering will occur as needed)

Proposed Change:
5.1. Powerhouse priority is detailed in **Table BON-14.** When splitting flows, as directed in section **2.1.2,** the top two available priority units for PH1 will be operated first followed by normal unit priority at PH2. If there is a need for more units, and all available units at PH2 are in operation, proceed with the normal unit priority for PH1**.**

5.2. November 1 through March 31. All turbine units will operate *as a soft constraint* within ±1% of peak efficiency (within upper and lower limits of the 1% range) as shown in **Tables BON-15**(PH1) and **BON-16** (PH2) for project heads of 35-70 feet. See **BPA Load Shaping Guidelines** (**Appendix C**) for further information on turbine operations within and outside of the 1% range.

5.3. April 1 through October 31. Except as defined below in **section 5.3.1**, all turbine units will operate *as a hard constraint* within ±1% of peak efficiency (within upper and lower limits of the 1% range) as shown in **Tables BON-15** (PH1) and **BON-16** (PH2).

5.3.1. April 10 through August 31. During the spring and summer spill seasons when the project is spilling in accordance with the Fish Operations Plan (FOP, see **Appendix E**), turbine units will operate in the following priority order to pass increasing flow:

6. Operate PH2 units within the 1% mid-range (**Table BON-16**);

7. Then, operate PH1 units up to the 1% upper limit (**Table BON-15**);

8. Then, operate PH1 units up to Best Operating Point (BOP; **Table BON-15**);

9. **From April 10 through June 20 (spring spill season)**, additional flow above what can be passed in steps 1-3 will be passed in one of the two following ways, as directed by Project Fisheries based on monitoring of juvenile and adult spring Chinook passage and collection data:

    a. If the adult trigger is met (adult counts exceed juvenile collection counts for two consecutive days), then operate PH2 up to the 1% upper limit in the following unit priority order: 18, 17, 16, 15, 14, 13, 12, 11 until adult counts drop below juvenile counts for 3 consecutive days.

b. If the adult trigger is *not* met (adult counts are less than juvenile collection counts for two consecutive days), then increase spill to pass the additional flow.

10. **From June 21 through August 31 (summer spill season),** additional flow above what can be passed in steps 1-3 will be passed by operating PH2 up to the 1% upper limit.

5.4. The project turbine unit maintenance schedules will be reviewed by Project and Operations Division biologists for fish impacts. If possible, maintenance of priority units will be scheduled for winter maintenance periods, or when there are low numbers of fish passing the project.

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Appendix A. NOAA December2010 ERDC Trip Report.

January 20, 2011 F/NWR-5

FILE MEMORANDUM

FROM: Gary Fredricks and Ed Meyer

SUBJECT: ERDC Trip Report – Bonneville Dam Turbine Operations

Participants: Bob Davidson – COE ERDC, Martin Ahmann – COE NWW, Dennis Schwartz and Chris Lightner – COE NWP, Rod Wittinger and Jim Kiel - COE HDC, Eric Volkman - BPA.

Purpose of the trip: The overall goal is to improve turbine survival for fish passing Bonneville Dam. The primary purpose of this trip was to investigate hydraulic conditions that exist over a specific range of operations in the First Powerhouse minimum gap runner turbine units, with an eye towards the possible revision of operating guidelines for the 2011fish passage season. A secondary purpose was to make some preliminary operating range observations of the Second Powerhouse turbine units.

Methods: We used the 1:25 scale single unit sectional models for each powerhouse to assess hydraulic passage conditions at several turbine operating points. These models are constructed primarily of Plexiglas allowing unobstructed views of the flow passage routes. The models were set at 55 feet of head for most of the observations, although a head of 60 feet was checked for some of the runs. The primary observational methods included observing dye, neutrally buoyant bead and air bubble passage through the primary turbine passage routes. The First Powerhouse model has been verified and has been used for quantitative bead analysis by the ERDC staff. Data summaries of this bead analysis were reviewed by the group between model observations. The Second Powerhouse model was recently completed and has not undergone the verification process. Observations made with this model were very general and were made with the understanding that the flow control settings (wicket gate, blade angle, etc.) might not be quite right at this time.

Results: First Powerhouse Model.

Lower 1% limit (7.3 kcfs). Model observations: We noted a significant amount of turbulence below the runner. The hydraulic “rope” (a spinning vortex extending into the draft tube elbow from the hub) is strong near the hub but there is also quite a lot of twist in the beads that pass the outer section of the blades. There was some residual turbulence from the “rope” in the draft tubes. Overall, conditions looked poor for fish passage.

Peak efficiency (7.5 kcfs). Turbulence below the runner looked substantially better. Still some direction changes in the beads and air bubbles, but no actual sustained rope. We observed nothing that would suggest a serious problem with passage below the hub. Overall, better fish passage conditions.

Upper 1% limit (9.8 kcfs). This operation was examined after the 11.5 kcfs operation (described below). We saw little difference between the two.

Best operating point (11.5 kcfs). Much more uniform flow below the runner. With air bubbles we could see a small, short-lived rope just below the hub. Beads looked good, some slight spin in those that passed near the hub. Dye moved quickly through the runner and draft tube with little apparent turbulence. Overall, conditions looked good for fish passage.

Upper operating (generator) limit (13 kcfs). Flow looked smooth through the runner and draft tubes. Dye passed through very quickly indicating high velocities through the entire turbine environment. This helped improve the immediate trailrace environment with better looking downstream egress conditions. Overall, the condition looked good for fish but we were concerned that the higher flow could lead to some pressure issues. The operation should be tested with sensor fish before considering it for use during the fish passage season.

First Powerhouse Bead Analysis Summary: The bead analysis was conducted by the ERDC staff using high speed (1,000 frames per second) cameras. The analysis used approximately 9,000 white, cylindrical, neutrally buoyant plastic beads that would approximate a smolt sized (4”) object if scaled up to model size. Bead passage was analyzed for strike and direction changes (an indication of turbulence). The cylindrical shape allows the observer to determine if the bead is tumbling which helps with determining the severity of strike or direction change. Flow velocities were measured with an laser Doppler velocimeter or LDV. This analysis was done at peak (7.5 kcfs), upper 1% (9.8 kcfs) and best operating point (11.5 kcfs) operating points with 55 and 60 feet of head. The lower end of the 1% operating range point was not included in the analysis.

In general, the bead analysis reflected what we saw in the model. In the runner region of the unit, blade contact and severe direction change decreased with increasing unit discharge. The rate of change also decreased with increasing discharge, i.e., the magnitude of change was greater between peak and upper 1% than between upper 1% and the best operating point (we can only assume that this inverse relationship would also be true between the lower 1% and peak operating points). In the distributor area (stay vane and wicket gates), the strike and severe velocity change data indicated little difference between discharge levels, although vane-gate gap passage decreased slightly with discharges above peak flow.

Unit flow was consistently split fairly evenly between the draft tube barrels with 60% passing the A (north) barrel and 40% passing the C barrel at all discharge levels. The consistency of this split was at least partly due to the unique horizontal flow splitters used in this powerhouse. Tailrace observations of beads indicated quicker egress time for higher discharges, as expected. Another tailrace observation indicated that slightly more beads (2-3% more) neared the surface after passing out of the draft tube at higher discharges.

Second Powerhouse Model. After looking at a couple of flow conditions in this model it became apparent that the model wasn’t set up correctly. Bob Davidson indicated that there was probably an issue with the cam settings since the model flow was about 9% lower than it should have been for the settings provided. The Corps will get this worked out for later model work. For this trip, we just looked at the general trends in flow conditions as flow was incrementally increased from the lower end of the 1% operating range. About all that can be said about these observation is that flow conditions in the runner and draft tube areas looked poor at the lower end of 1% and improved as more flow was added, i.e., the trend was the same as we observed for the First Powerhouse units (and for units at other dams that we have examined).

Recommendations:

First Powerhouse: Based on the model observations and the bead analysis data, we recommend that the Corps consider moving the lower operating limit of these units up from the lower end of the 1% range to the peak efficiency point, at least as a soft constraint. We also recommend that the Corps investigate adopting a new upper operating limit at the best operating point (the 11.5 kcfs point under the model head condition tested). This shift to a higher than 1% peak limit should include an investigation of the existing biological data for these units.

Second Powerhouse: Assuming that the trend we observed where hydraulic conditions improved with increasing flow is correct, we believe it would be prudent to consider minimizing the time these units operate at the low end of the 1% operating range. We have no specific operating point recommendation; however a soft constraint limit approximately midway between the low end of 1% and the peak efficiency operating points would likely avoid the most severe hydraulic conditions. In the meantime, the Corps should complete the model verification process and conduct a bead analysis.

Appendix B. Fish Passage Center adult passgae evaluation memo from March 26, 2013.

FISH PASSAGE CENTER

1827 NE 44th, Suite 240, Portland, OR97213
Phone: (503) 230-4099   Fax: (503) 230-7559
http://www.fpc.org
e-mail us atfpcstaff@fpc.org

MEMORANDUM

TO: Tom Lorz, CRITFC
Gary Fredricks, NOAA
Trevor Condor, NOAA

FROM: Fish Passage Center Staff

DATE: March 26, 2013

RE: Evaluation of Bonneville Dam project operations on the preference of adult salmonids to enter the Bradford Island fish ladder

In response to your request, the Fish Passage Center has compiled data on Bonneville Dam project operations and has evaluated the impact of these operations on the preference of adult salmonids to enter the Bradford Island fishway. Our findings indicate:

- Our findings indicate that the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) did not clearly explain variations in salmonid ladder preference over the spring periods from 2008-2012. When the dataset was partitioned into Chinook and Steelhead individually and further divided into periods of daily spill between 95-105 Kcfs and days of spill above 105 Kcfs, regressions were still not significant.
- When all five years of springtime data (April 1-June 30: 2008-2012) were combined into a single regression that explored the relationship between the proportion of salmonids passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total), the result was a weak relationship (Figure 6).
- When the data in Figure 6 were divided into Chinook and Steelhead individually, similar weak relationships resulted (Figures 7 and 8).   When these regressions were weighted by daily counts, the regression relations did not improve significantly (Tables 1 and 2).
- When the data for Chinook and Steelhead (from Figures 7 and 8) were broken into periods when daily average spill levels at Bonneville Dam were between 95-105 Kcfs

and days when spill levels were above 105 Kcfs and weighted for daily fish numbers, regressions were still not significant (Figures 9-13, Tables 3-6).

The daily average Bonneville Dam operational data were obtained from: http://www.nwd-wc.usace.army.mil/perl/dataquery.pl.
The following daily average variables were utilized from the above website: Bonneville Total Powerhouse Discharge, Bonneville Powerhouse Two Discharge, and Bonneville Spillway Discharge. Spring data between April 1 and June 30 was obtained within the years 2008-2012. For this evaluation it was necessary to obtain discharge from Bonneville Dams Powerhouse One. As this information is not available at the COE data query website (above), discharge through Powerhouse One was calculated by subtracting Powerhouse Two discharge from Total Powerhouse Discharge.

Adult and jack counts by ladder at Bonneville were obtained from the COE fish count website at: http://www.nwp.usace.army.mil/Missions/environment/fishdata.aspx.

Figures 1-5 display daily average Bonneville Dam powerhouse and spillway operations as well as the proportion of total salmonids that passed the Bradford Island fishway on a daily basis over the April through June period over the years 2008-2012.

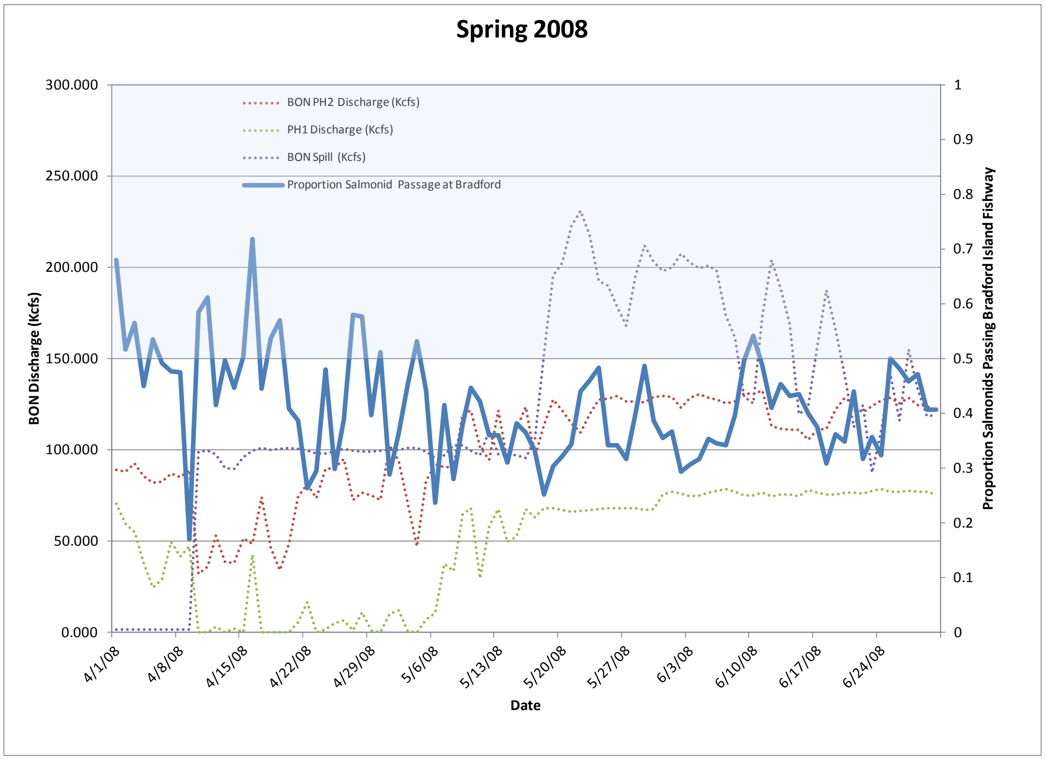

Figure 1. Bonneville Dam powerhouse and spillway operations as well as the proportion of total salmonids that passed the Bradford Island fishway on a daily basis over the April to June period of 2008.

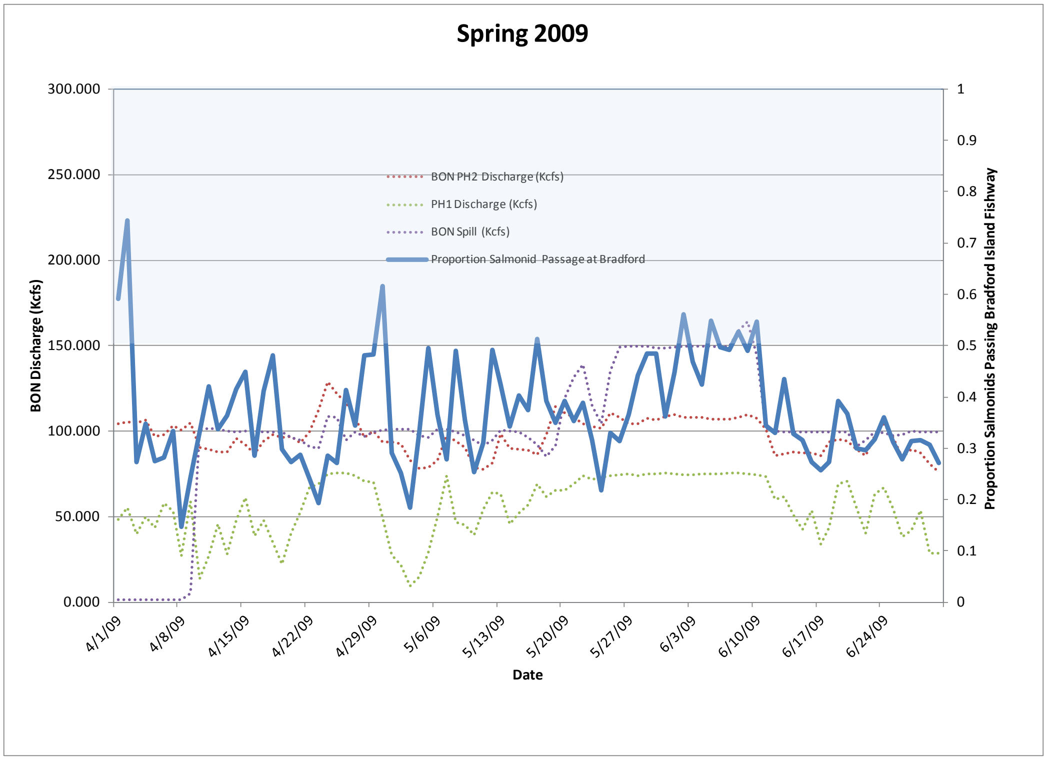

Figure 2. Bonneville Dam powerhouse and spillway operations as well as the proportion of total salmonids that passed the Bradford Island fishway on a daily basis over the April to June period of 2009.

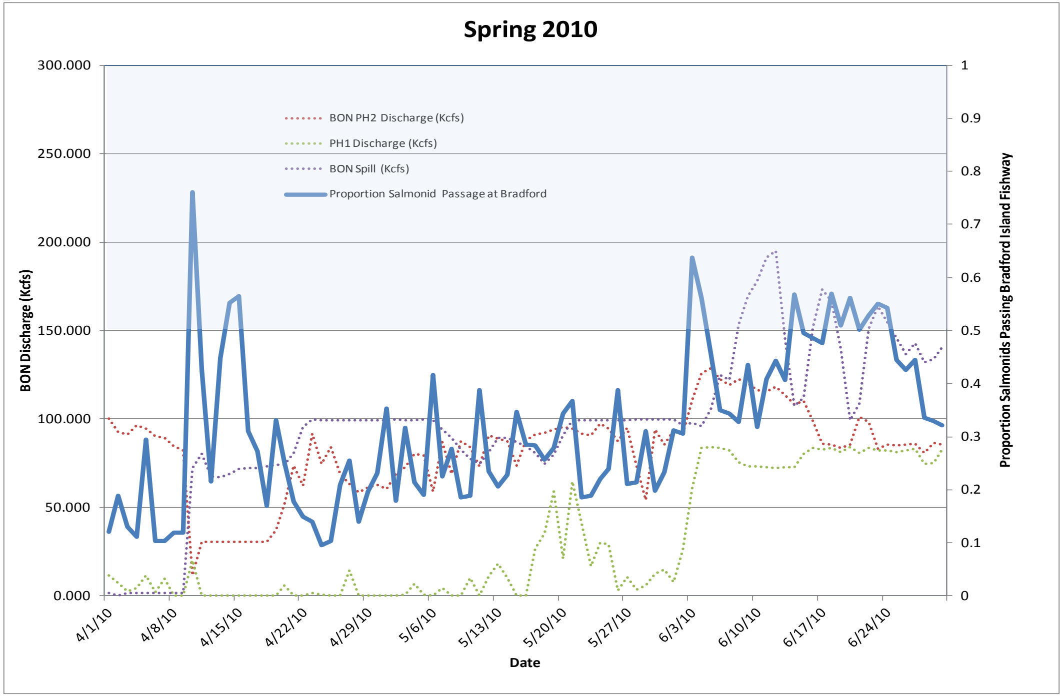

Figure 3. Bonneville Dam powerhouse and spillway operations as well as the proportion of total salmonids that passed the Bradford Island fishway on a daily basis over the April to June period of 2010.

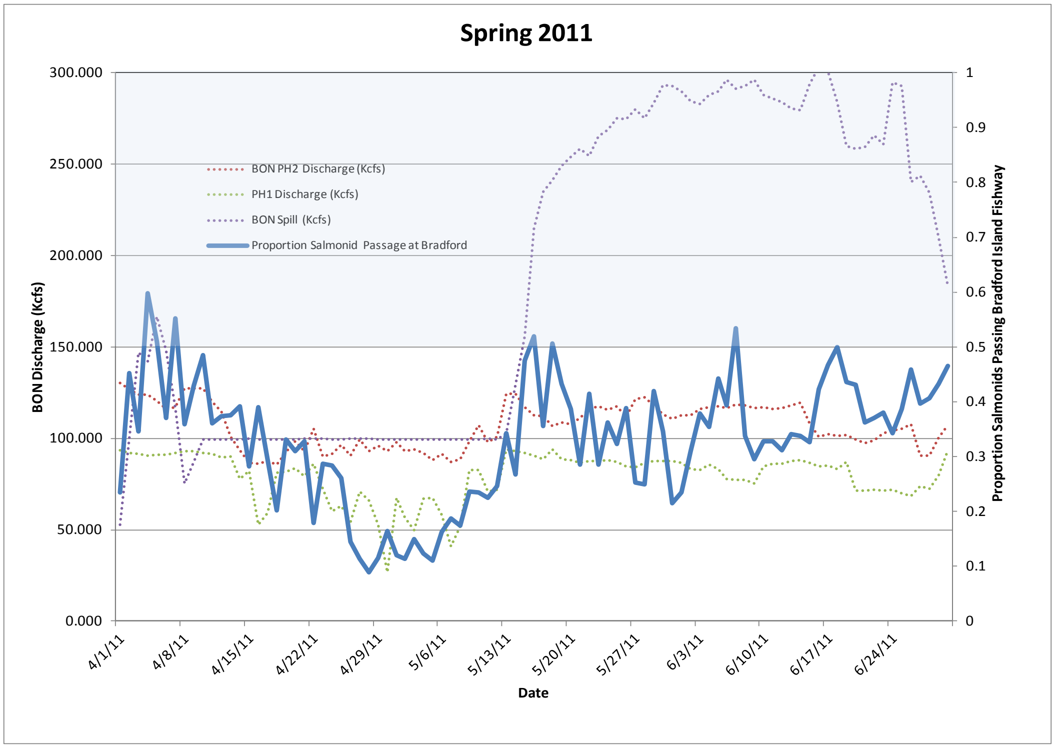

Figure 4. Bonneville Dam powerhouse and spillway operations as well as the proportion of total salmonids that passed the Bradford Island fishway on a daily basis over the April to June period of 2011.

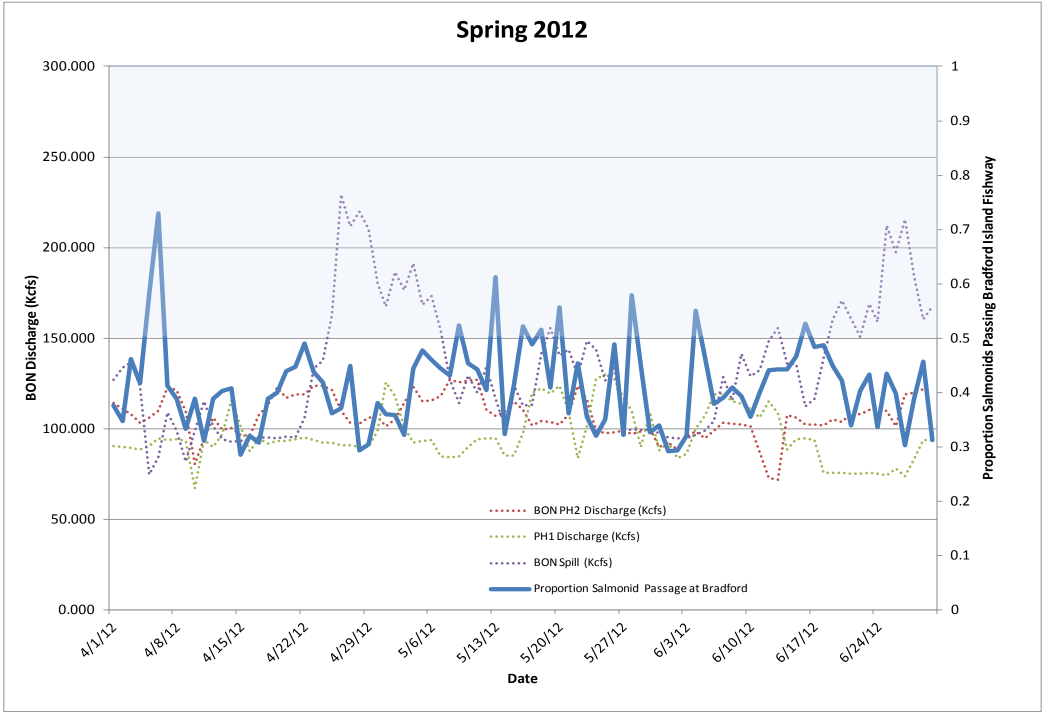

Figure 5. Bonneville Dam powerhouse and spillway operations as well as the proportion of total salmonids that passed the Bradford Island fishway on a daily basis over the April to June period of 2012.

The spring period was the primary period of interest in determining whether the proportion of flow through powerhouse one can explain the proportion of adults passing the Bradford fishway. All five years of springtime data were combined into one regression that explored the relationship between the proportion of salmonids passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total). Figure 6, displays the relationship between the proportion of salmonids passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using spring data (April through June) over the years 2008-2012 at Bonneville Dam.

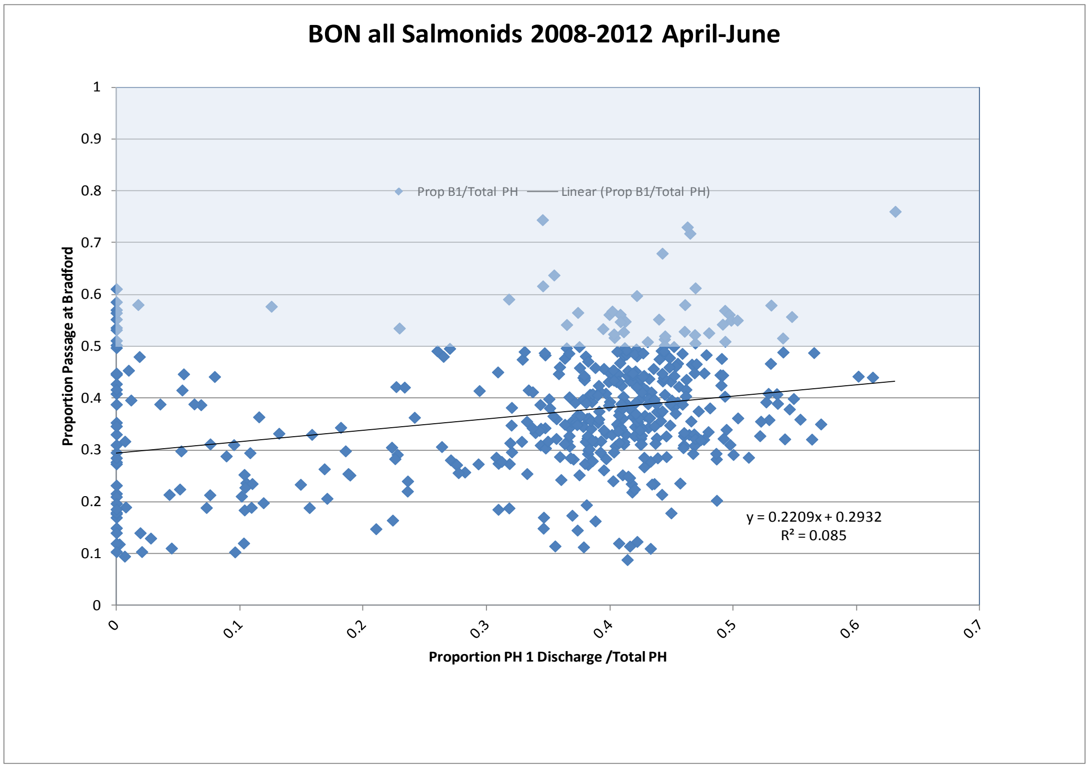

Figure 6. Relationship between the proportion of salmonids passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using spring data (April through June) over the years 2008-2012 at Bonneville Dam.

Figure 6 included all salmonids passing Bonneville Dam over the April-June period (2008-2012), for the sake of finding a better fit to the data it was of interest to create similar plots as Figure 6, however for Chinook and Steelhead, individually. Figures 7 and 8 display the relationship between the proportion of Chinook (Figure 7) and Steelhead (Figure 8) passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using spring data (April 1 through June 30) over the years 2008-2012 at Bonneville Dam.

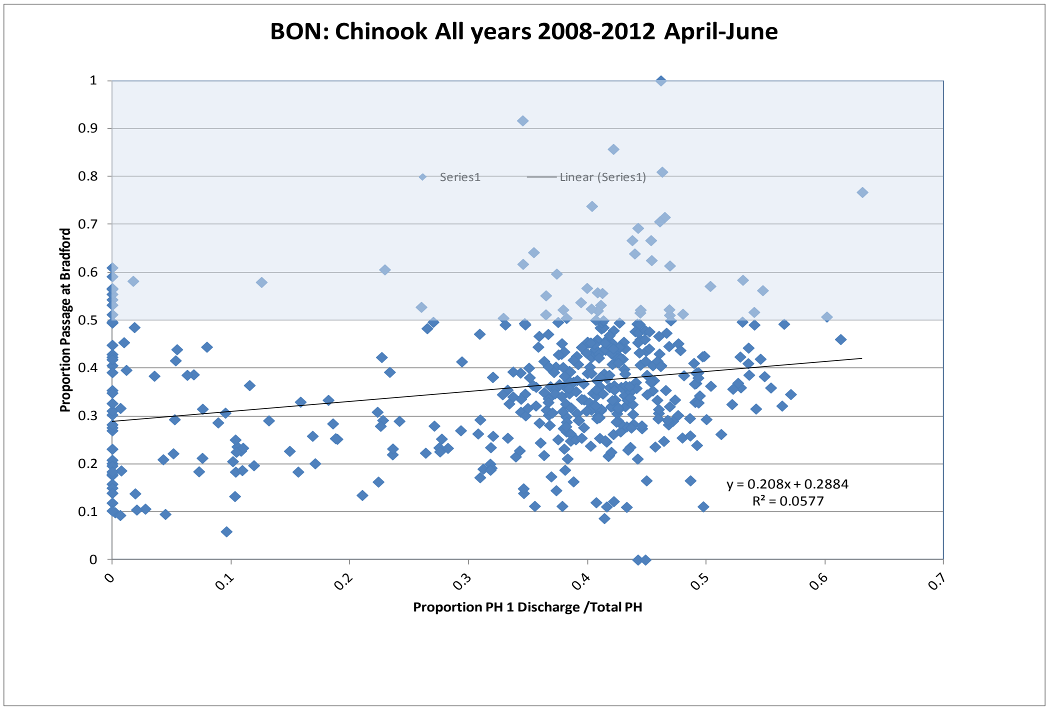

Figure 7. Relationship between the proportion of Chinook passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using spring data (April through June) over the years 2008-2012 at Bonneville Dam.

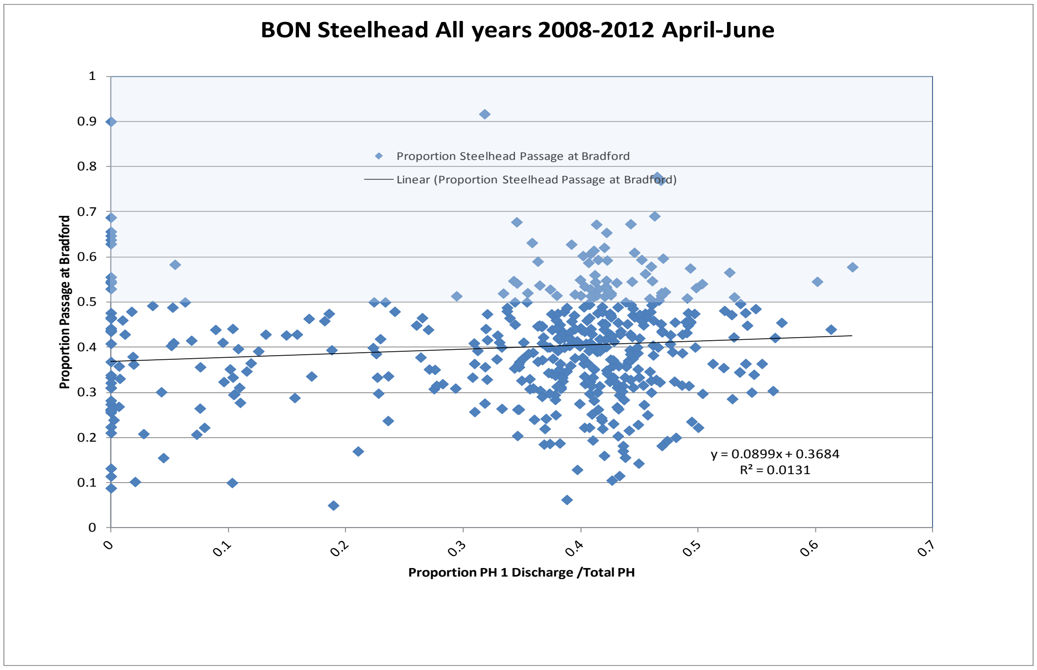

Figure 8. Relationship between the proportion of Steelhead passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using spring data (April through June) over the years 2008-2012 at Bonneville Dam.

Based on Figures 7 and 8, the regressions that utilize Chinook and Steelhead individually, did not improve the relationships between the proportion of fish passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge.

Additionally, the data from Figures 7 and 8 was imported into Systat to determine if weighting the datasets (by inverse binomial variance) led to a better fit to the regressions. Tables 1 and 2, display the output from Systat for Chinook and Steelhead, respectively. The weighting procedure in Systat also did not demonstrate a significant improvement to the regressions.

Table 1. Chinook adults 2008 to 2012 proportion Bradford vs. proportion PH1 of Total PH. Weighted regression (inverse variance using theoretical binomial variance).

Dependent Variable	PR_BRAD
N	452
Multiple R	0.30075
Squared Multiple R	0.09045
Adjusted Squared Multiple R	0.08843
Standard Error of Estimate	16.14505

Regression Coefficients $B = (X'X)^{-1}X'Y$

Effect	**Coefficient**	**Standard Error**	**Std. Coefficient**	**Tolerance**	**t**	**p-value**
CONSTANT	0.23862	0.75947	0.00000	.	0.31420	0.75352
PR_B1	0.23086	0.03451	0.30075	1.00000	6.68948	0.00000

Table 2. Steelhead adults 2008 to 2012 proportion Bradford vs. proportion PH1 of Total PH. Weighted regression (inverse variance using theoretical binomial variance).

Dependent Variable	PR_BRAD
N	455
Multiple R	0.27904
Squared Multiple R	0.07786
Adjusted Squared Multiple R	0.07583
Standard Error of Estimate	2.71064

Regression Coefficients $B = (X'X)^{-1}X'Y$

Effect	**Coefficient**	**Standard Error**	**Std. Coefficient**	**Tolerance**	**t**	**p-value**
CONSTANT	0.31409	0.12787	0.00000	.	2.45638	0.01441
PR_B1	0.22740	0.03677	0.27904	1.00000	6.18470	0.00000

The last portion of this evaluation involved utilizing the data from Figures 7 and 8 but limited the data used in plots to 1) days when spill levels were between 95-105 Kcfs, and 2) days when spill levels were above 105 Kcfs. The dataset for each species and spill level was imported into Systat and weighted by daily fish numbers.

Figures 9 and 10 and Tables 3 and 4 display the relationship between the proportion of Chinook (Figure 9, Table 3) and Steelhead (Figure 10, Table 4) passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using only the spring data (April through June) with Bonneville Spill levels between 95-105 Kcfs over the years 2008-2012 at Bonneville Dam. Tables 1 and 2, display the output from Systat for Chinook and Steelhead, respectively.

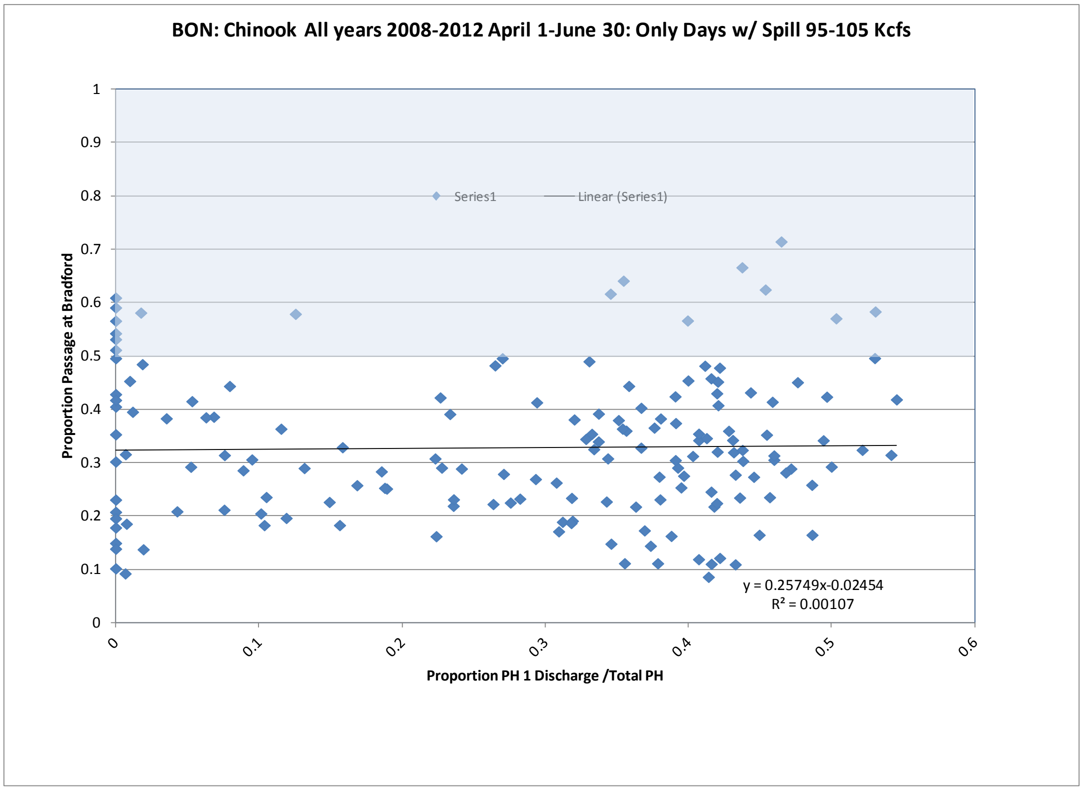

Figure 9. Relationship between the proportion of Chinook passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using only spring data (April through June) with Bonneville Spill levels between 95-105 Kcfs over the years 2008-2012 at Bonneville Dam.

Table 3. Chinook adults 2008 to 2012 proportion Bradford vs. proportion PH1 of Total PH, only days with spill levels between 95-105 Kcfs. Weighted regression (inverse variance using theoretical binomial variance).

Dependent Variable	PROP_BRAD
N	161
Multiple R	0.03278
Squared Multiple R	0.00107
Adjusted Squared Multiple R	0
Standard Error of Estimate	19.11556

Regression Coefficients B = $(X'X)^{-1}X'Y$

Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-value
CONSTANT	0.25749	1.5066	0	.	0.17091	0.86451
PROP_B1	-0.02454	0.05936	-0.03278	1	-0.4135	0.6798

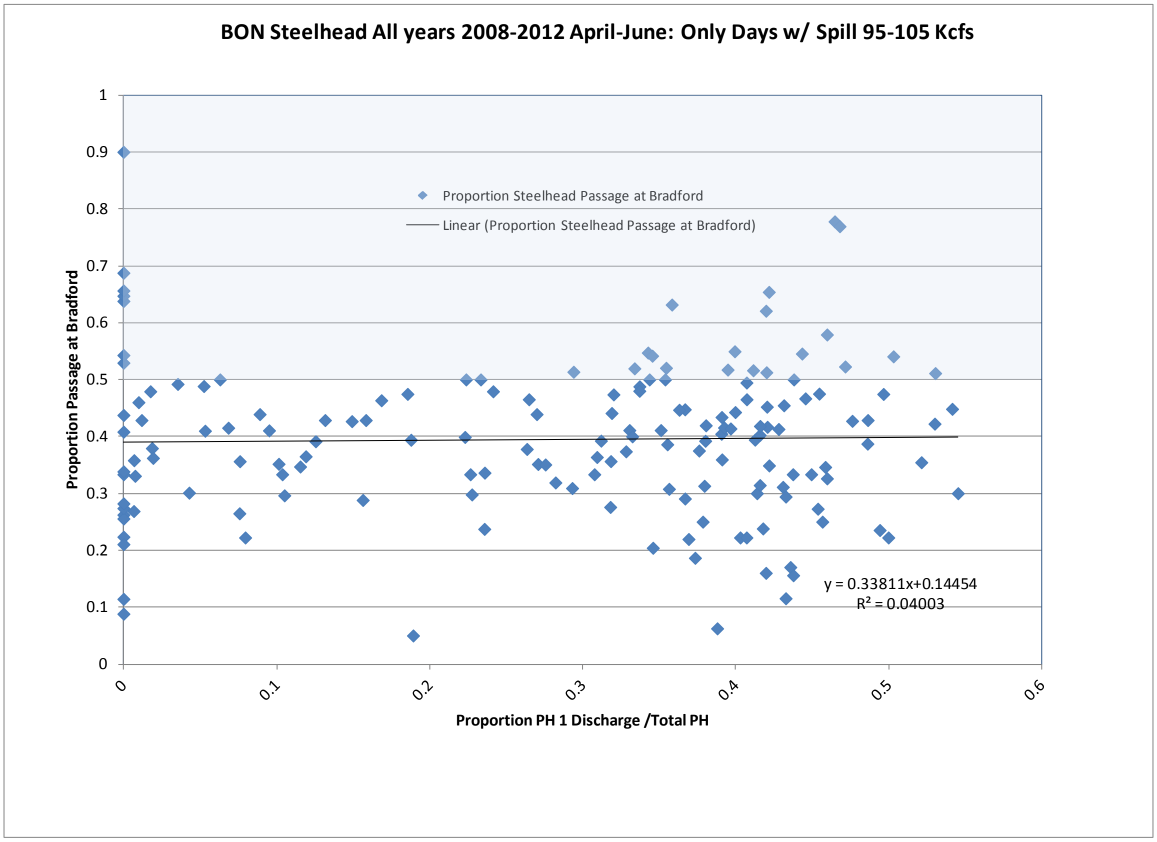

Figure 10. Relationship between the proportion of Steelhead passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using only spring data (April through June) with Bonneville Spill levels between 95-105 Kcfs over the years 2008-2012 at Bonneville Dam.

Table 4. Steelhead adults 2008 to 2012 proportion Bradford vs. proportion PH1 of Total PH, only days with spill levels between 95-105 Kcfs. Weighted regression (inverse variance using theoretical binomial variance).

Dependent Variable	PROP_BRAD
N	161
Multiple R	0.20007
Squared Multiple R	0.04003
Adjusted Squared Multiple R	0.03399
Standard Error of Estimate	2.30831

Regression Coefficients $B = (X'X)^{-1}X'Y$

Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-value
CONSTANT	0.33811	0.18272	0	.	1.8504	0.06611
PROP_B1	0.14454	0.05614	0.20007	1	2.57488	0.01094

Figures 11 and 12 and Tables 5 and 6 display the relationship between the proportion of Chinook (Figure 11, Table 5) and Steelhead (Figure 12, Table 6) passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using only the spring data (April through June) with Bonneville Spill levels above105 Kcfs over the years 2008-2012 at Bonneville Dam.

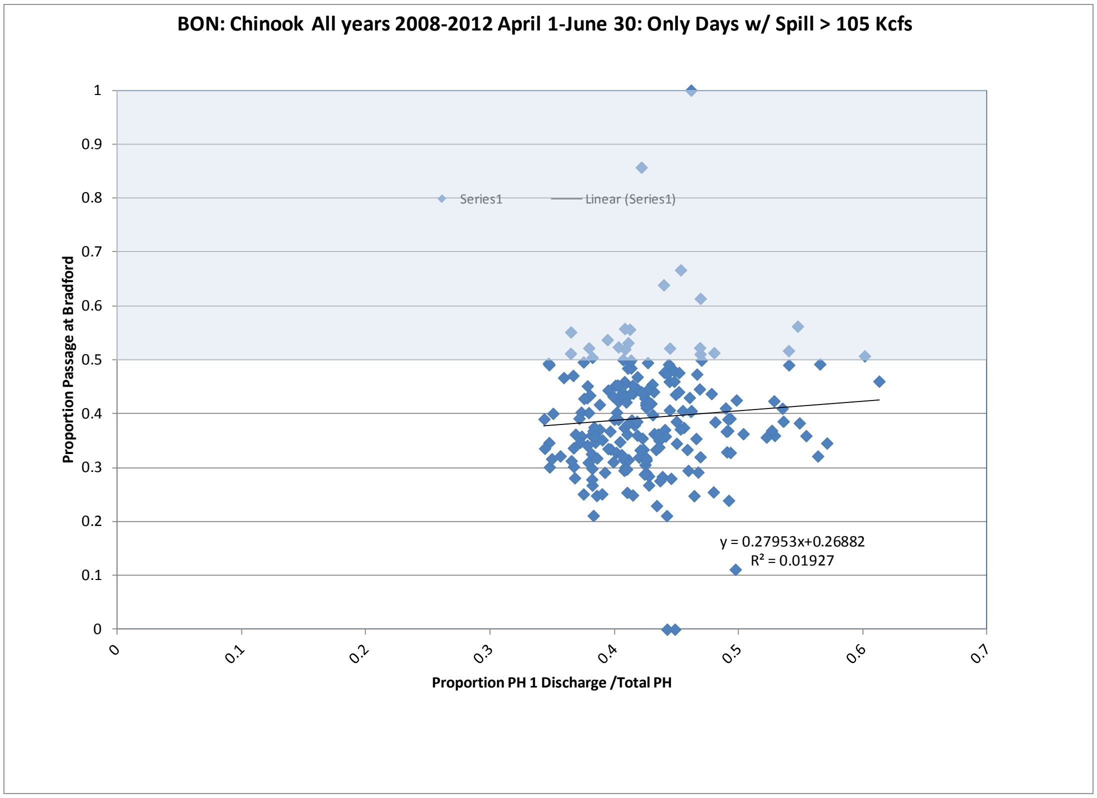

Figure 11. Relationship between the proportion of Chinook passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using only spring data (April through June) with Bonneville Spill levels above105 Kcfs over the years 2008-2012 at Bonneville Dam.

Table 5. Chinook adults 2008 to 2012 proportion Bradford vs. proportion PH1 of Total PH, only days with spill levels between greater than 105 Kcfs. Weighted regression (inverse variance using theoretical binomial variance).

Dependent Variable	PROP_BRAD
N	206
Multiple R	0.13881
Squared Multiple R	0.01927
Adjusted Squared Multiple R	0.01446
Standard Error of Estimate	9.57204

Regression Coefficients $B = (X'X)^{-1}X'Y$

Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-value
CONSTANT	0.27953	0.66939	0	.	0.41759	0.67669
PROP_B1	0.26882	0.13427	0.13881	1	2.00206	0.0466

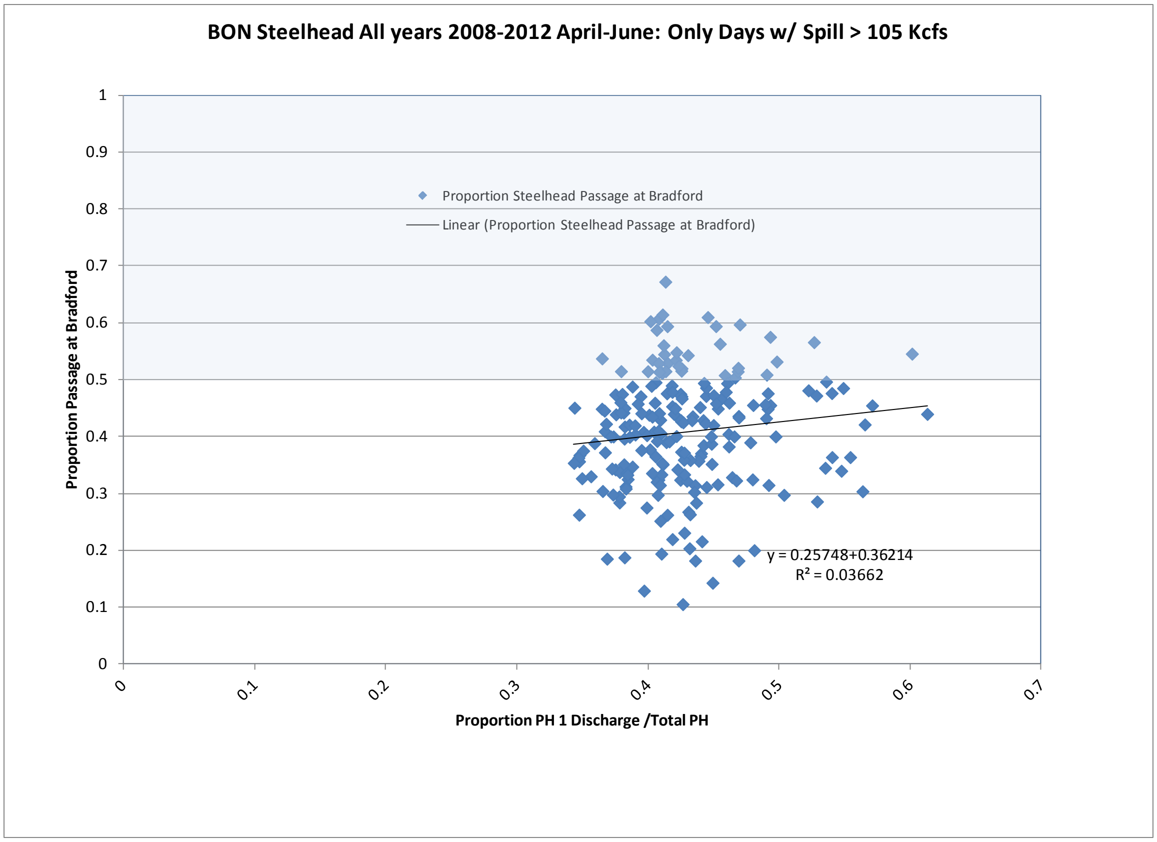

Figure 12. Relationship between the proportion of Steelhead passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) using only spring data (April through June) with Bonneville Spill levels above 105 Kcfs over the years 2008-2012 at Bonneville Dam.

Table 6. Steelhead adults 2008 to 2012 proportion Bradford vs. proportion PH1 of Total PH, only days with spill levels greater than 105 Kcfs. Weighted regression (inverse variance using theoretical binomial variance).

Dependent Variable	PROP_BRAD
N	210
Multiple R	0.19137
Squared Multiple R	0.03662
Adjusted Squared Multiple R	0.03199
Standard Error of Estimate	2.99125

Regression Coefficients B = $(X'X)^{-1}X'Y$

Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-value
CONSTANT	0.25748	0.21391	0	.	1.2037	0.23007
PROP_B1	0.36214	0.12879	0.19137	1	2.81194	0.0054

Based on Figures 9-12 and Tables 3-6, the regressions that utilize Chinook and Steelhead individually for spill ranges between 95-105 Kcfs and greater than 105 Kcfs did not produce significant relationships between the proportion of fish passing the Bradford fishway and the proportion of powerhouse one discharge to total powerhouse discharge.

In summary, the proportion of powerhouse one discharge to total powerhouse discharge (PH1/PH total) did not clearly explain variations in salmonid ladder preference over the spring periods from 2008-2012. When the dataset was partitioned into Chinook and Steelhead individually and further divided into periods of daily spill between 95-105 Kcfs and days of spill above 105 Kcfs, weighted regressions were still not significant.

Appendix C. Spring/Summer Chinook Adult to Juvenile Ratio Analysis.

Run of river spring/summer Chinook salmon juvenile bypass (JBS) mortality has been estimated to decline from 4% to .5% when Bonneville Powerhouse II (B2) turbine operations are reduced from the upper 1% to the midrange(Gilbreath 2012). Spring migrant performance test results indicated an average of 5.5% of juvenile spring Chinook migrate use the bypass system over the migration year (Ploskey et al. 2011 and Skalski et al.2012). Using this proportion and the expected survival benefit, a juvenile concrete survival increase can be expected by limiting B2 turbines to the midrange. This change in juvenile survival is expressed with the following equation:

$$\Delta\ JuvS = BPE\left({}^{Middle1\%}S_{JBS} - {}^{Upper1\%}S_{JBS}\right)$$

Where $\Delta\ JuvS$ is the expected change in juvenile survival expressed as the product of the proportion of juvenile spring/summer Chinook passing the project traveling through the Bonneville Second Powerhouse bypass$(BPE)$and the difference in expected survival between midrange and upper 1% operation$\left({}^{Middle1\%}S_{JBS} - {}^{Upper1\%}S_{JBS}\right)$. A fish to flow ration of 1:1 was assumed in this calculation. Based on these survival improvements and the proportion of juveniles using the bypass, a .2% increase in juvenile spring Chinook concrete survival is expected.

Bonneville Powerhouse 1 (B1) has been shown to have a higher fallback rate than the second powerhouse (B2). Any additional attraction to B1 can result in increased fallback and reduced survival for adults. Based on powerhouse limitations, de-rating B2 to midrange and increasing the operating range of B1 to best operating point is expected to increase the proportion of powerhouse flow going through B1. Based on empirical data, this increase in flow is not expected to increase adult attraction until uncontrolled spill (spill above the 100 kcfs Fish Operations Plan requirement) is necessary (FPC 2013, Figures 9-12). The increase in adult spring Chinook salmon migrating to B1 during uncontrolled spill as a result of increased flow at B1 is expressed with the following equation:

$$\Delta\ Adult\ B1_{passage.} = \Delta\ B1_{flow.} *\ Slope\ B1_{passage}\ vs.\ B1_{flow.}$$

Where $\Delta\ Adult\ B1_{passage}$ is the expected change in proportion of adult spring/summer Chinook passage at Bradford Island during uncontrolled spill expressed as a product of the expected change in proportion of powerhouse flow $\Delta\ B1_{flow}$ and the linear historical response of spring Chinook proportion passage $B1_{passage}$at B1 (FPC 2013, Figure 11). Based on the historical relationship of proportion powerhouse flow at B1 and adult attraction, we estimate an additional 1.5% of total adult spring Chinook will migrate to B1during uncontrolled spill.

Adult spring/summer Chinook adult fallback rates at B1 and B2 were estimated with PIT reascension data obtained from Dart (2012) and corrected for average fallback reascension rates from Keefer et al. (2005). Due to limited survival data, conversion rates to natal tributaries are used as a practical surrogate for adult survival. Conversion rates to natal tributaries for adult spring/summer Chinook fallbacks and non-fallbacks were obtained from Keefer et al. 2005. The change in adult conversion is estimated with the following equation.

$$\Delta\ Adult\ Conversion =$$

$$((B1_{prop\cdot Upper1\%}\ \ (B1_{FBprop*}FB_{conv.)+}\ (B1_{NFBprop*}NFB_{conv}))+\ (B2_{prop.Upper1\%}\ \ (B2_{FBprop*}FB_{conv.)+}\ (B2_{NFBprop*}NFB_{conv})))$$

$$-$$

$$((B1_{prop.mid1\%}(B1_{FBprop*}FB_{conv.)+}\ (B1_{NFBprop*}NFB_{conv}))+\ (B2_{prop.mid1\%}(B2_{FBprop*}FB_{conv.)+}\ (B2_{NFBprop*}NFB_{conv})))$$

Where the change in adult conversion *Δ Adult Conversion* is a function of the change in adult passage proportion *ΔBxpassge,* the fallback rate $Bx_{FBprop,}$ and conversion rates for fallback FB_{conv} and non-fallbacks NFB_{conv} at each powerhouse. Based on the change in proportion of adults migrating to B1, the increased fallback rate at B1, and the decreased survival of fallback fish, adult conversion is estimated to be reduced by .015% with B2 derated during uncontrolled spill.

To develop adult to juvenile trigger we adjust the adult survival change with the minimum spring/summer Chinook smolt to adult return rate observed in the last five years. To determine the ratio of adults to juveniles needed at the project for a relative improvement we use the following equation:

$$\Delta\ JuvS/\ (\Delta\ Adult\ Conversion/SAR) = Adult/Juv.ratio$$

Where the adult to juvenile trigger *Adult/Juvratio* needed during uncontrolled spill for a relative improvement is a function of the change in juvenile survival, the change in adult survival *Δ Adult Conversion,* and the minimum smolt to adult return rates *SAR.*

Based on this information, during uncontrolled spill, approximately 14 juveniles to every adult are needed for this operation to be a neutral impact. A conservative operation for adults would be to operate B2 to the midrange except when uncontrolled spill is occurring and juvenile spring/summer Chinook bypass collection counts are not expected to exceed total project spring/summer Chinook adult counts.

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FISH PASSAGE CENTER
1827 NE 44th Ave., Suite 240, Portland, OR 97213
Phone: (503) 230-4099 Fax: (503) 230-7559
http://www.fpc.org/
e-mail us at fpcstaff@fpc.org

MEMORANDUM

TO: Dave Statler, NPT
Dave Wills, USFWS
Charles Morrill, WDFW

Michele DeHart

FROM: Michele DeHart

DATE: June 7, 2012

RE: Juvenile Fish Mortality Estimates for Bonneville Second Powerhouse Bypass

In response to your request we have used the smolt monitoring information collected at the Bonneville PH2 bypass system to calculate the total mortality and descaling that has occurred in the juvenile salmon population passing through this bypass system thus far this year. The estimates were developed for the time period from March 2, 2012 to May 30, 2012 for the real-time project operations.

- A total of 52,496 juvenile salmonid mortalities occurred during the operation of the Bonneville PH2 juvenile bypass system through May 30, 2012. The passage through the PH2 juvenile bypass system represents a subset of the total mortality of juvenile salmonids that died as a result of passing Bonneville Dam.
- An additional total of 73,299 juvenile salmonids were descaled during the operation of the Bonneville PH2 juvenile bypass system through May 30, 2012. The expected mortality on these fish could be as high as 75%, converting to a loss of an additional 54,974 juvenile salmon.

- Based on average Bonneville to Bonneville smolt to adult returns collected since 2000, the juvenile mortalities at Bonneville PH2 convert to an expected loss of 1,106 adults and up to an additional 1,169 adults from the descaled juveniles using the 75% loss conversion estimate.
- To provide a relative perspective, this represents an equivalent percentage of the adult population passing through May 30th that was estimated to be removed by sea lions below Bonneville Dam in 2012.
- Although the action agencies routinely exceeded the FOP TDG criteria for the purpose of involuntary spill (lack of market or excess hydraulic capacity), the Action Agencies would not agree to additional voluntary spill to avoid powerhouse passage (to improve fish survival) during the Spring Creek National Fish Hatchery releases, or during passage of juvenile sockeye.
- Adopting a strategy of provision of additional spill for fish passage and decreasing the operation of the turbines at the powerhouse to the mid to low end of the 1% efficiency, could have improved juvenile survival, and adult return, by reducing the number of fish passing through the Bonneville PH2.

Background

Some level of mortality and descaling occurs at every hydro-electric project bypass system. However, over the past years the mortality and decaling rates have been elevated at Bonneville PH2. The high juvenile mortality and descaling rates were first noted in 2008 after changes were made to the juvenile bypass system at PH2 to improve the proportion of fish passing through the system. A study conducted by Hughes et al. (2011) obtained information on velocity measurements near the screens. The study revealed approach velocities exceeding recommended criteria intended to improve fish passage conditions. The authors concluded that the turbulence in the gate well region in proximity to the VBS when PH2 was operated at the upper 1% efficiency range could be expected to result in suboptimal fish passage conditions. The high velocities and turbulent conditions could cause impingement, impact, or descaling of juvenile salmonids before they exit through the orifice into the juvenile fish bypass channel. In addition, the powerhouse turbine unit discharge rate directly affected the velocity distribution as well as the turbulence conditions in the gate well. Both the velocity and the turbulence increase as the operation within the 1% efficiency range increases. Results of this COE funded study revealed that the approach velocities in the gate wells exceeded criteria intended to improve fish passage conditions recommended by National Marine Fisheries Service and the Washington State Department of Fish and Wildlife.

Based on what is known about the hydraulic turbulence in the bypass of Bonneville PH2, the best condition for fish passage survival would be to operate PH2 at the low end of the 1% operating range. In 2012, the fishery agencies and tribes recognized the high flows this year and addressed the potential for mortality at Bonneville PH2, which increases as operation includes the upper range of the 1% efficiency, by requesting that the Action Agencies cap PH2 at the mid-point of the 1% best efficiency range. The Action Agencies would not implement the request because the operation would result in additional voluntary spill in excess of the involuntary spill that was already exceeding the gas cap. The Action Agencies implemented the following flow neutral operations that at times resulted in operation near the midpoint of the 1% efficiency, but also included operating above the 50% range of the 1% and operating PH1 above the 1% efficiency range:

1. Bonneville (BON) PH2 units will be operated at the 25% of the 1% operating range;
2. To pass additional flows, operate powerhouse 1 (PH1) units up to the 100% (full capacity) of the 1% operating range;
3. To pass additional flows after PH1 is fully loaded, increase PH2 units one at a time in the order of priority within 25-50% of the 1% operating range;
4. To pass additional flow after PH1 is fully loaded and all available PH2 units are operating at 50%, increase operation of PH1 units up to best geometry;
5. To pass additional flow after all available PH1 units are operating at best geometry; increase PH2 units one at a time in the order of priority within 50-75% of the 1% operating range;
6. To pass additional flow after all available PH2 units are operating at 75%, decrease PH1 unit operation to 100% of the 1% operating range and increase PH2 units one at a time in the order of priority within 75-100% of the 1% operating range.

Juvenile Mortality and Descaling

The mortality and descaling measurements described in this memo were obtained during the implementation of the Action Agencies recommended flow neutral operation of Bonneville Dam. The daily mortality estimates have ranged from 0% to 33%, and the descaling estimates have ranged from 0% to 25%.

Condition sampling occurs daily as part of the SMP sampling. The primary role of the condition monitoring is to identify the proportion of each species of migrant juvenile salmon that are descaled or have significant injuries indicative of problems in fish passage at dams such as debris in the fish bypass apparatus or mechanical issues. In the condition monitoring, a distinction is made between fish that are descaled and fish that are descaled with concurrent injuries or predator marks. While a fish that is descaled while passing through the bypass system can also display injuries or predation marks that are independent of its descaling, the distinction is made in the SMP condition monitoring to be conservative. In addition, effort is made to assure that only recent injury and descaling data are reported to eliminate descaling or injuries that were likely not to have occurred at the dam where the fish are being examined.

In order to determine the mortality that occurred by species for fish passing through the Bonneville PH2 bypass system, the daily sample was expanded by the daily sample rate to obtain a daily collection (number of fish passing Bonneville PH2 bypass). The daily collection was then multiplied by the daily sample mortality rate and the estimates were summed over the time period. (Daily collection, mortality and descaling data are available at www.fpc.org). Table 1 displays the total mortalities in the Bonneville Powerhouse 2 bypass collection when mortality rate from the sample was expanded to the total collection on a daily basis.

Table 1. Expanded juvenile fish mortalities at Bonneville Dam PH2 bypass in 2012.

Species	Average Percent Mortality	PH 2 Bypass Mortalities
Chinook subyearling	2.4%	18,221
Chinook yearling	1.9%	14,958
Coho	0.7%	1,028
Sockeye	7.2%	17,976
Steelhead	0.4%	313

A total of 52,496 juvenile salmon mortalities occurred in the Bonneville PH2 juvenile bypass system thus far in 2012.

Table 2 displays the total number of descaled fish that were estimated passing through the PH2 bypass system after the daily estimates were summed over the time period in the same way that mortalities were estimated. It is difficult to assess the impact of descaling on the future survival of juvenile salmonids. However, there is considerable evidence stating that descaling injuries have serious implications to stress related indicators and osmoregulatory ability (Congleton et al., 1998; Zydlewski et al., 2010). Evidence suggests that impairing the osmoregulatory performance during smolting compromises the long-term survival of descaled smolts subsequently entering seawater.

Bouck and Smith (1979) concluded that the loss of scales during or immediately before a saltwater challenge is a very real threat to the life of a salmonid smolt. Removal of slime and scales from 25% of the body area of coho smolts caused no deaths in fresh water, but 75% mortality within 10 days in seawater. Since smolts at Bonneville will generally enter seawater within a few days of leaving the project, this 75% mortality estimate could be used to describe the potential mortality associated with this descaled population from Bonneville PH2 bypass system.

Table 2. Expanded juvenile fish descaled at Bonneville Dam PH2 bypass in 2012.

Species	Average Percent Descaled	PH 2 Bypass Descaled
Chinook subyearling	0.1%	686
Chinook yearling	4.3%	30,729
Coho	2.3%	2,053
Sockeye	15.2%	38,042
Steelhead	2.8%	1,789

Therefore, using the 75% mortality estimate and applying it to the total number of descaled fish yields the possibility that an estimated 54,974 additional juvenile salmonid mortalities could be attributed to the passage through the Bonneville PH2 bypass.

Conversion to Adult Equivalents

The Bonneville to Bonneville smolt to adult return estimates were calculated for PIT tagged spring Chinook and steelhead smolts arriving at Bonneville dam for seven years between 2000 and 2009; with the exception of 2001, 2004 and 2005. These years were not included because: 1) there were relatively few detections of fish at BON in those years and, 2) the smolt hydrosystem experiences (i.e., number of bypass events) was higher in those years due to the elimination of spill. In these analyses, adult returns are all adults, including jacks. The SARs for wild and hatchery combined spring Chinook ranged from 1 to 4.1%, with an average of 2.1% and, for wild and hatchery combined steelhead the SARs ranged from 1.4 to 6.0%, with an average of 3.2%. (Table 3 and 4, Steve Haeseker, USFWS, personal communication).

Table 3. Estimated smolt to adult return rates for PIT tagged juvenile wild and hatchery Chinook detected at Bonneville Dam.

Wild and hatchery Chinook			
Year	Smolts	Adults	SAR
2000	10436	382	0.037
2002	15363	231	0.015
2003	15551	123	0.008
2006	8385	113	0.013
2007	17373	222	0.013
2008	8135	336	0.041
2009	15971	274	0.017
		Average	0.021

Table 4. Estimated smolt to adult return rates for PIT tagged juvenile wild and hatchery Chinook detected at Bonneville Dam.

Wild and hatchery steelhead			
Year	Smolts	Adults	SAR
2000	2957	115	0.039
2002	3335	87	0.026
2003	3801	52	0.014
2006	1201	30	0.025
2007	2170	68	0.031
2008	11491	687	0.060
2009	16232	473	0.029
		Average	0.032

For this analysis the average Chinook SAR was applied to yearling Chinook, subyearling Chinook, coho and sockeye and the combined steelhead SAR was applied to the juvenile population of steelhead. Table 5 shows the loss of fish in terms of adult equivalents that would be expected based on the juvenile mortality estimates at Bonneville PH2.

Table 5. Expanded juvenile fish mortalities to adult equivalents at Bonneville Dam PH2 bypass in 2012.

Species	Juvenile Mortalities	Adult Equivalents
Subyearling Chinook	18,221	383
Yearling Chinook	14,958	314
Coho	1,028	22
Sockeye	17,976	377
Steelhead	313	10
Total		**1,106**

A total of 1106 adult equivalents could be lost from the returning adult population to Bonneville Dam of spring/summer and fall Chinook, coho, sockeye and steelhead combined based on the juvenile mortalities at this project through May 30, 2012. The impact of juvenile passage at Bonneville PH2 bypass system will have the greatest impact on the returning adult populations of Chinook and sockeye.

Table 6 shows the loss of fish in terms of adult equivalents that would be expected based on the juvenile descaling estimates at Bonneville PH2 bypass system, with a conversion rate of 75% mortalities based on Bouck and Smith (1979). The same average smolt to adult conversion rates were then applied to the juvenile mortalities to yields the adult equivalents.

Table 6. The number juvenile fish descaled expanded to adult equivalents at Bonneville Dam PH2 bypass in 2012, using a 75% conversion of descaling to mortality.

Species	Juvenile Mortalities	Adult Equivalents
Subyearling Chinook	686	11
Yearling Chinook	30,729	484
Coho	2,053	32
Sockeye	38,042	599
Steelhead	1,789	43
Total		**1,169**

A total of 1,169 adult equivalents could be lost from the returning adult population to Bonneville Dam of spring/summer and fall Chinook, coho, sockeye and steelhead combined based on the juvenile descaling rates and projected mortalities at this project through May 30, 2012. The impact of juvenile passage at Bonneville PH2 bypass system will have the greatest impact on the returning adult populations of spring/summer Chinook and sockeye due to the high decaling rates on these populations.

To put the number of adult equivalents that will not return to Bonneville Dam based on the juvenile mortality data in 2012 from PH2 bypass system passage, we used the percentage of adult salmonids consumed by sea lions below Bonneville Dam in 2012. Although the data are still preliminary the *Columbia Basin Bulletin (June 1, 2012)*, reports that it appears the overall predation expanded estimate will be about 1.3 percent of the January 1 through May 31 salmonid run. The expected final adjusted estimate (for unidentified prey and night time predation) will be slightly higher. While the juvenile salmon represents more species, if we were for illustrative purposes to take the total number of adult equivalents from both mortalities and descaling (2,275) at the Bonneville PH2 juvenile bypass system and divide it to the total number of salmonid adults that have passed Bonneville Dam through May 30th (169,219) it would also equal 1.3% of the 2012 adult salmon run to May 30, 2012.

Total Dissolved Gas Effects

You also requested that we attempt to quantify what the change in total dissolved gas levels would have been if the COE did not reject the recommendation based on the need to provide a flow neutral implementation of operations. You also asked if we could translate those effects into estimated juvenile mortalities that might have occurred from such an operation of increased spill levels. It is difficult to estimate the exact change in flow that would have had to be added to spill in order to operate PH2 at the middle and lower end of the 1% efficiency range, since it is dependent on the project head (the difference in elevation between the forebay and tailwater). A lower head characterizes the condition when there is high flow through the project and at a lower head; it requires that less water be spilled. We chose to do the analysis based on the information shared by the COE at the Technical Management Team call on May 30th, operating at the mid-point of the 50% range requires a reduction in flow of 25 Kcfs, while operating to the 25% of the 1% operating range reduces flow through the powerhouse by 36 Kcfs. These data are for a lower flow than occurred in late April to mid-May, but should mean that the analysis is very conservative.

The analysis used the Cascade Island tailrace gage to measure water quality compliance. We recognize that the COE uses both the Camas/Washougal and Cascade Island tailrace gage to measure compliance, however, neither the State of Oregon nor the State of Washington require the use of the Camas/Washougal gage. The use of the Camas/Washougal gage as mimicking the next downstream forebay is recognized as being problematic because other factors, such as temperature and biological processes that produce oxygen, affect the concentration of TDG at this gage. While reductions of spill upstream will decrease the TDG at this gage, the spill itself is not responsible for the excursions beyond 115%.

Using the data from 2012 through May 31st was developed an exponential regression model to predict the Cascade Island gage TDG from spill at Bonneville Dam. The Cascade gage has not been operational for most of the time period considered this year, but the COE is providing estimated modeled TDG. Using the COE data we developed the following equation (R^2= 0.65):

$$TDG = 112.71e^{(0.0005*BonSpill)},$$

The actual and predicted TDG under the various operations are shown in Table 7. As can be observed in Table 7 and in Figure 1 the majority of time spill at Bonneville was already in excess of the BIOP spill levels for most of the time period considered. The increases in spill of 25 and 36 Kcfs did cause the tailrace TDG to exceed the 120% level on more days in the 61 day period, but rarely did the TDG levels exceed the 125%. Again, these are conservative estimates and are based on the reductions stated by the COE on the May 30th TMT conference call. On average, the TDG increase was 1.4% at 25 Kcfs additional spill to 2.2% with an additional 36 Kcfs spill.

Table 7. Actual versus estimated spill and TDG for conditions that might have occurred if the Bonneville PH2 was operated at the mid or lower end of the 1% efficiency range.

Operation	**Spill**	**TDG**	**Number of Days Cascade Island Gage Exceeded out of 61 Days:**		
			120%	**125%**	**130%**
Actual	130.4 Kcfs Range: 74.6-229.1 Kcfs	122.3% Range: 117.1-131.2%	42	10	3
+ 25 Kcfs Spill	155.4 Kcfs Range: 99.6-254.1 Kcfs	123.8% Range: 119.7-131.3%	60	12	3
+36 Kcfs Spill	166.4 Kcfs Range: 110.6-265.1 Kcfs	124.6% Range: 120.4-132.1%	61	16	4

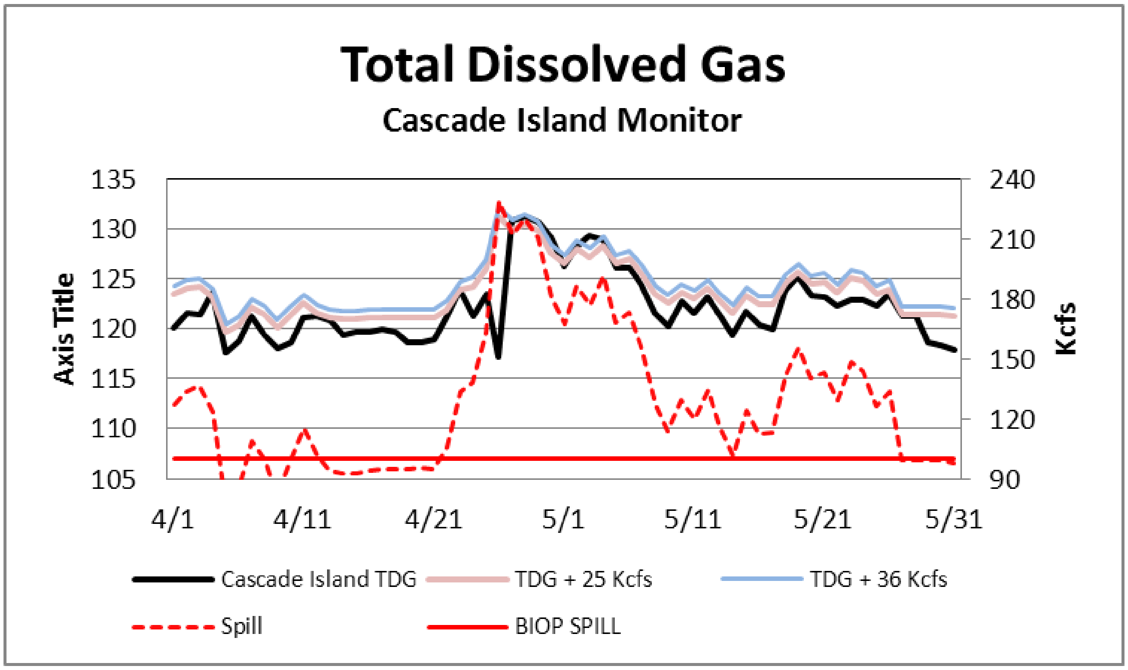

Figure 1. Actual spill compared to the Biological Opinion level of 100 Kcfs, and actual total dissolved gas concentrations compared to the modeled concentrations for two increased levels of spill.

The increased spill from the operation of Bonneville PH2 to the 25% or 50% of the 1% efficiency range would likely have caused no additional mortality to the juvenile fish population passing Bonneville Dam from gas bubble trauma. The gas bubble trauma monitoring program has demonstrated that few fish are observed with signs of GBT until TDG levels approach and are sustained for a period of time at levels above 130%. The operation as described above would only have resulted in one additional day when the TDG at Cascade Island would have been above the 130% level, and we are most likely over-estimating the change in TDG because at these already high flows the additional spill would have been considerably less than the 25 or 36 Kcfs we modeled.

In summary, the operation of Bonneville PH2 as occurred in 2012 through May 30th imposed considerable mortality on juvenile fish passing through this bypass. It is likely that fish operations requested for operating this project at the low end of the 1% operating range would have reduced both the direct mortalities that occurred and the descaling levels, while likely imposing little or no additional mortality due to the levels of total dissolved gas that were predicted to occur with increased spill levels.

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