US Army Corps of Engineers®
Portland District

Engineering Documentation Report

Bonneville Second Powerhouse Orifice Improvements Study

Columbia River, Oregon-Washington

Oct 2017

100%EDR

EXECUTIVE SUMMARY

This report documents engineering investigations and provides recommended designs to improve Bonneville second powerhouse juvenile fish passage for the downstream migrant (DSM) system from the downstream bulkhead slot to the dewatering system. Study goals were focused on improvements to reduce injury and delay to migrating fish species that include:

- Improving the ability for the project operators to detect debris plugs at the orifice;
- Reducing the likelihood of fish impingement due to alignment of orifice flow; and
- Improving gatewell egress times with improved lighting.

Modifications to DSM system features, such as the bulkhead slot orifice plates, horizontal pipe through the bulkhead slot wall, light tubes, and downstream gate system, may be needed to provide biologically acceptable fish passage to the DSM channel. Additional biological improvements are concurrently being studied for the fish guidance efficiency features, located upstream of this effort.

Four main categories of alternatives were developed by the Product Delivery Team (PDT): (1) aerate jet to improve means of discerning upstream debris blockage through observation of orifice exit; (2) provide means of discerning upstream debris blockage through observation of orifice entrance; (3) reduce or prevent jet trajectory impingement for lesser flows; and (4) decrease fish passage retention time through attraction lighting. Twelve alternatives were developed as potential solutions.

An alternative matrix was used to evaluate and rank the 12 alternatives. The alternatives were grouped together by concept and rated for the following attributes: observable passage route, fish condition with modification, alignment with DSM criteria, technical viability, O&M cost, ease of testing proof of concept, construction timing, and construction cost. The ranking resulted in the following top three alternatives:

- Alternative 3: Re-core orifice tube to larger size (18-inch I.D.) and return to 1997 13-inch orifice ring.
- Alternative 4: Reduce orifice ring size (≤ 12 inches) and open additional orifices, as needed, to maintain channel design flow.
- Alternative 5: Seasonally increase capacity of DSM, reduce orifice ring size (≤ 12 inches) and open additional orifices, as needed, to maintain channel design flow.

Alternative 4 was initially selected as the recommended alternative due to its ability to meet all study goals at approximately 50% and 70% the estimated cost of Alternatives 5 and 3 respectively. Alternative 4 would reduce the orifice ring size to 12 inches and open additional orifices, as needed to maintain channel design flow and velocities which may increase the potential for orifice discovery. Both Alternative 11 (minimize overall tube length) and Alternative 12 (use lighted orifice ring) were assumed to be included with the chosen Alternative.

Regional collaboration through FFDRWG has been influential in the development of alternatives and defining incremental benefits. Appendix C includes regional coordination at the 60% and 90% EDR reviews as well as the regional FFDRWG notes. In this process, the FFDRWG has expressed their strong concerns that a reduction in orifice size (such as Alternative 4 and 5) would be detrimental to adult fallback salmon and steelhead and that a reduction of orifice ring size would not be acceptable. This would leave Alternative 3 as the remaining alternative (Re-core orifice tube to larger size (18-inch I.D.) and return to 1997 13-inch orifice ring) with a substantial cost increase.

Throughout the B2 Orifice Study process, the B2 FGE program has been moving forward on a parallel path with the B2 Orifice study. Knowledge gained through the B2 FGE program has further emphasized the interrelationship between the two projects.

The recommendations below provide a phased approach to the study and testing of orifice improvement alternatives. The information gained during prototype testing and results of B2 FGE program alternatives have provided value in the understanding of juvenile salmonid condition and survival through the B2 screened bypass system. The recommendations of this report are influenced by the results of the B2 FGE program as well orifice lighting technology and its potential for fish passage benefits.

Further investigation of these alternatives from both programs contribute to overall improved jet quality (reduces likelihood of fish impingement), inspection efficiency (detects debris plugs harmful for fish), and orifice lighting (improves gatewell egress) at the Second Powerhouse.

Chapter 7 provides a summary of the progression of the B2 Orifice Study and a recommendation for the implementation of alternatives that acknowledges and incorporates the B2FGE program’s direction.

PERTINENT PROJECT DATA

PROJECT DESCRIPTION

Stream	Columbia River (river mile 146.1)
Location	Bonneville, Oregon
Owner	U.S. Army Corps of Engineers
Project Authorization	Rivers and Harbors Act of 1935
Authorized Purposes	Power, Navigation
Other Uses	Fisheries, Recreation

LAKE/RIVER ELEVATIONS (elevation above sea level in feet)

Maximum Controlled Flood Pool	90.0
Maximum Spillway Design Operating Pool	82.5
Maximum Regulated Pool	77.0
Minimum Pool	69.5
Normal Operating Range	71.5 - 76.5
Maximum 24-Hour Fluctuation at Stevenson Gage	4.0
Maximum Flood Tailwater (spillway design flood)	51.5
Maximum Operating Tailwater	33.1
Standard Project Flood Tailwater	48.9
Minimum Tailwater	7.0
Base (100-year) Flood El. (at project site tailwater)	39.8

POWERHOUSES

First Powerhouse (Oregon)	
Length	1,027 feet
Number of Main Units	10
Nameplate Capacity [2 @ 43 megawatts (MW), 8 @ 54 MW]	518 MW
Overload Capacity (2 @ 47 MW, 8 @ 60 MW)	574 MW
Station Service Units (1 @ 4 MW)	4 MW
Hydraulic Capacity	136,000 cfs

Second Powerhouse (Washington)	
Length (including service bay & erection bay)	985.5 feet
Number of Main Units	8
Nameplate Capacity (8 @ 66.5 MW)	532 MW
Overload Capacity (8 @ 76.5 MW)	612 MW
Fish Water Units (2 @ 13.1 MW)	26.2 MW
Hydraulic Capacity	152,000 cfs

SPILLWAY

Capacity at Pool Elevation (El. 87.5)	1,600,000 cfs

FISH PASSAGE FACILITIES

Fish Ladders
Washington Shore
Cascades Island
Bradford Island
Juvenile Bypass System – First Powerhouse
Downstream Migrant System – Second Powerhouse
Upstream Migrant System

ACRONYMS AND ABBREVIATIONS

ACFM	actual cubic feet per minute
cfm	cubic feet (foot) per minute
cfs	cubic feet (foot) per second
DSM	downstream migrant
EDR	Engineering Documentation Report
El.	elevation
EM	Engineer Manual
ERC	emergency relief conduit
FFDRWG	Fish Facilities Design and Review Work Group
FGE	fish guidance efficiency
fps	feet (foot) per second
ft.	feet (foot)
ft-c	foot-candle(s)
HMI	human-machine interface
I.D.	inside diameter
LED	light-emitting diode
NMFS	National Marine Fisheries Service
O.D.	outside diameter
O&M	operation and maintenance
PDT	Product Development Team
PIT	passive integrated transponder
PLC	programmable logic controller
PNNL	Pacific Northwest National Laboratory
psi	pounds per square inch
RM	river mile(s)
SCFM	standard cubic feet per minute
STS	submersible traveling screen
USACE	U.S. Army Corps of Engineers
VBS	vertical barrier screen

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1. INTRODUCTION

1.1. Purpose and Scope

The purpose of this Engineering Documentation Report (EDR) is to document engineering investigations and provide a recommended design to improve Bonneville second powerhouse juvenile fish passage from the powerhouse bulkhead slot orifice entrance to the downstream channel entering the dewatering system. Goals are focused on improvements to the collection system that will reduce injury and delay to migrating fish species to include:

- Improve the ability for the project operators to detect debris plugs at the orifice;
- Reduce fish injury during orifice passage; and
- Improve gatewell egress times with improved lighting.

The scope of this EDR is to identify and recommend modifications to pertinent downstream migrant (DSM) system features, such as the bulkhead slot orifice plates, horizontal pipe through the bulkhead slot wall, light tubes, and downstream gate system, to provide biologically acceptable fish passage to the DSM channel as part of the overall DSM system. Additional biological improvements are concurrently being studied for the fish guidance efficiency (FGE) features, located upstream of this effort.

1.2. Project Authorization

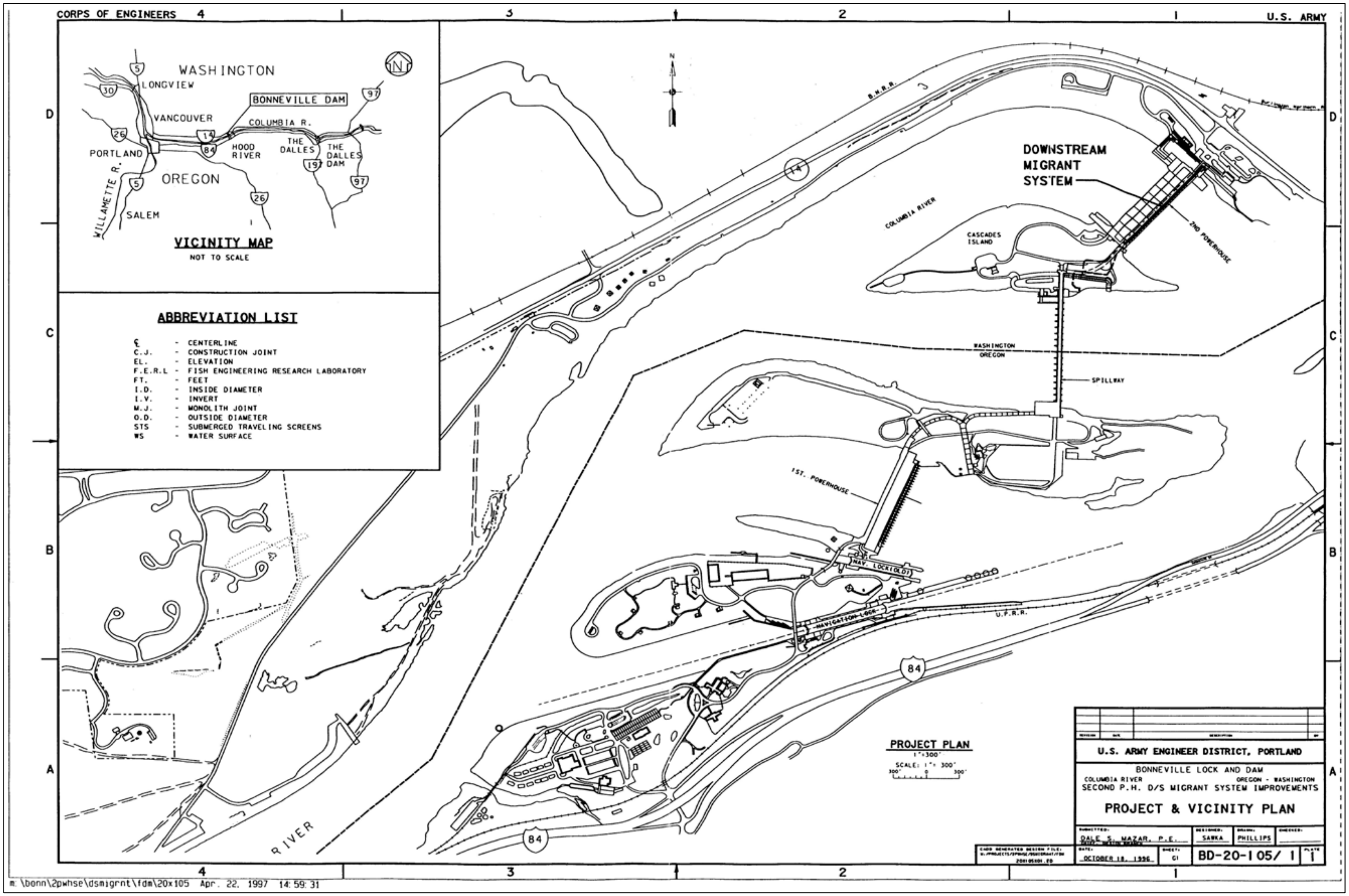
The Bonneville Project began with the National Recovery Act, 30 September 1933, and was formally authorized by Congress in the Rivers and Harbors Act of 30 August 1935. Authority for the completion, maintenance, and operations of Bonneville Dam was provided in Public Law 329, 75th Congress, 20 August 1937. This act provided the authority for the construction of additional hydroelectric generation facilities (Bonneville second powerhouse) when requested by the Administrator of Bonneville Power Administration. Letters dated 21 January 1965 and 2 February 1965 from the Administrator identified the need for the construction of Bonneville second powerhouse. Construction started on the second powerhouse in 1974 with units 11 through 18 and two fishway units, and was completed in 1982.

This project is funded through the Columbia River Fish Mitigation (CRFM) Program and is executed under the following authorizations; 1937 Bonneville Project Act; 1995 Energy and Water Development Appropriation Bill; WRDA 1999, Section 582; Federal Columbia River Power System (FCRPS) 2008 Biological Opinion (BiOp) and 2010 Supplemental BiOp. The authorizations and the CRFM program directed the Corps of Engineers to use appropriations to aggressively improve effectiveness and efficiency of the fish bypass systems, reduce mortality by predation and enhance passage conditions.

1.3. Project Location

The Bonneville Project is located on the Columbia River approximately 42 miles east of Portland, Oregon at river mile (RM) 146. The Bonneville second powerhouse is located between Cascades Island and the river’s north shore in the State of Washington (Figure 1-1).

Figure 1-1. Bonneville Project and Vicinity



2. DESCRIPTION OF PROJECT FEATURES

The components being studied are contained within the existing DSM system. The main features of the DSM system are the bulkhead slot orifices, the DSM collection channel, the dewatering facility, the discharge well and conduit, the emergency relief conduit, and the DSM sampler and sorter. Provided below is a discussion of pertinent project features as designed in 1982 (Figure 2-1), as well as pertinent modifications to date.

2.1. ORIGINAL PROJECT FEATURES

2.1.1. Bulkhead Slot Orifices

The original B2 facility (1983) had 28 operating and 28 blind-flanged (sealed) orifices at centerline elevation (El.) 65.5 feet. There are eight turbine units, each with three bulkhead slots. In addition, there are two fish units, each with two bulkhead slots. There are two orifices in each bulkhead slot, originally with one operating on the north side and one blind-flanged orifice on the south side. Light wells are present at each orifice (Figures 2-2 and 2-3). Each orifice originally had a 12-inch diameter replaceable orifice plate bolted into a 16-inch outside diameter (O.D.) and 15 inch inside diameter (I.D.) steel pipe extending through the bulkhead slot wall. The orifices provide a free discharging jet into the downstream collection channel. The observed quality of the jet from the downstream end was used to determine potentially harmful obstructions at the orifice entrance. The head and therefore, flow from the orifice is dependent upon the elevation of the forebay, head across the trashracks, debris accumulation, and orifice blockages. The originally designed 12-inch orifice plate velocity ranged from 11.3 feet per second (fps) to 16 fps (forebay El. 71.5 and 76.5 feet, respectively). The orifice flow rate was 8.9 cubic feet per second (cfs) to 12.6 cfs (forebay El. 71.5 and 76.5 feet, respectively). The orifices are illuminated for fish attraction purposes. Each operating orifice has a pneumatically operated gate and pneumatically operated back-flush system that cycles automatically and can be manually operated to remove debris (Figure 2-4).

The DSM collection channel extends from the service bay (downstream end), through generator bays 11 to 18, and into the erection bay and evaluator monoliths (upstream end). The original channel was a 9-foot-wide rectangular channel that was sized to accommodate inflows from fifty-six 12-inch orifices, totaling 500 cfs to 700 cfs (forebay El. 71.5 and 76.5 feet, respectively). The flow in the channel increases in the downstream direction, as each orifice discharges into the channel. Originally, operation was limited to 28 orifices, providing 250 cfs to 350 cfs (forebay El. 71.5 and 76.5 feet, respectively). The operation was limited to comply with the revised allowable velocity of 0.4 fps through the dewatering screens. The channel velocity increased from 0.1 fps in unit 11 to 2.1 fps in the erection bay at forebay El. 71.5 feet. The channel velocity increased from 0.2 fps in unit 11 to 3.0 fps in the erection bay at forebay El. 76.5 feet. The channel invert sloped at a steady grade from El. 51.0 feet at the downstream end of the fishway units to El. 57.0 feet in unit 12 (station 11+99.81). The channel was flat in the remainder of units 12 and 11. The water depth at the downstream end was 13.2 feet. A steel grated walkway running the full length and width of the collection channel allows for orifice inspection and maintenance.

Figure 2-1. Original DSM System Design Sectional Plan

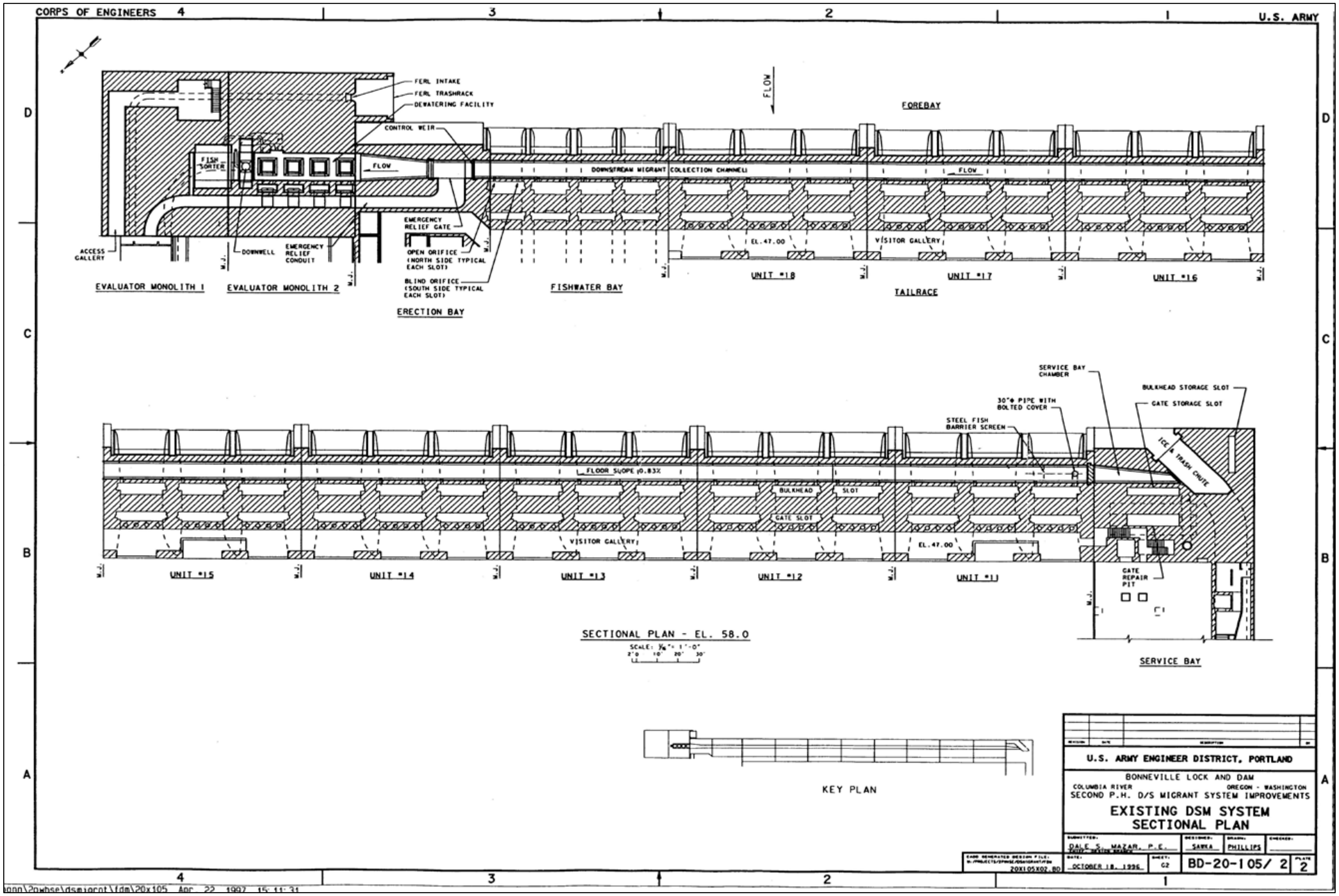


Figure 2-2. Light Well Section View

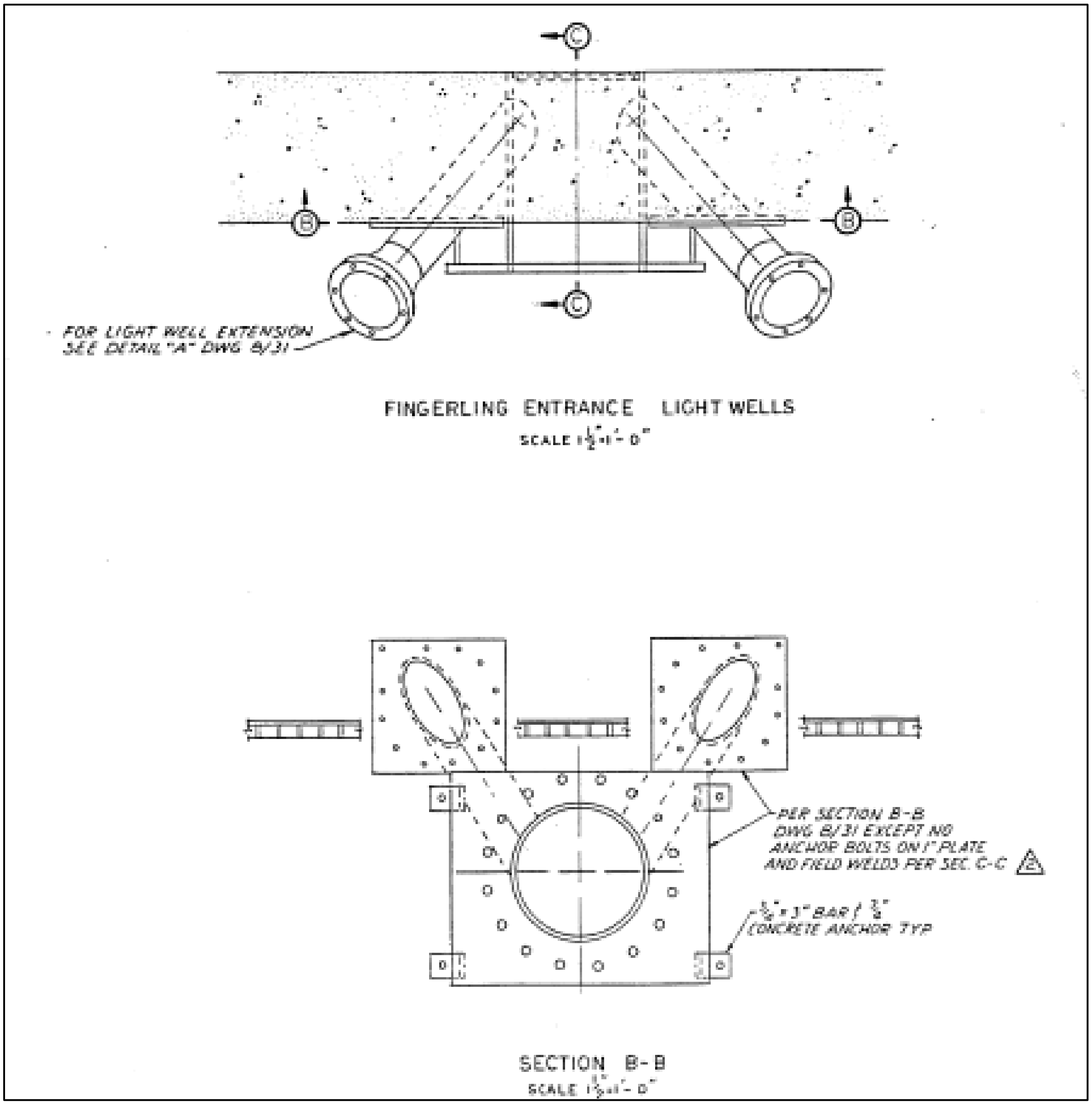


Figure 2-3. Light Well Section View

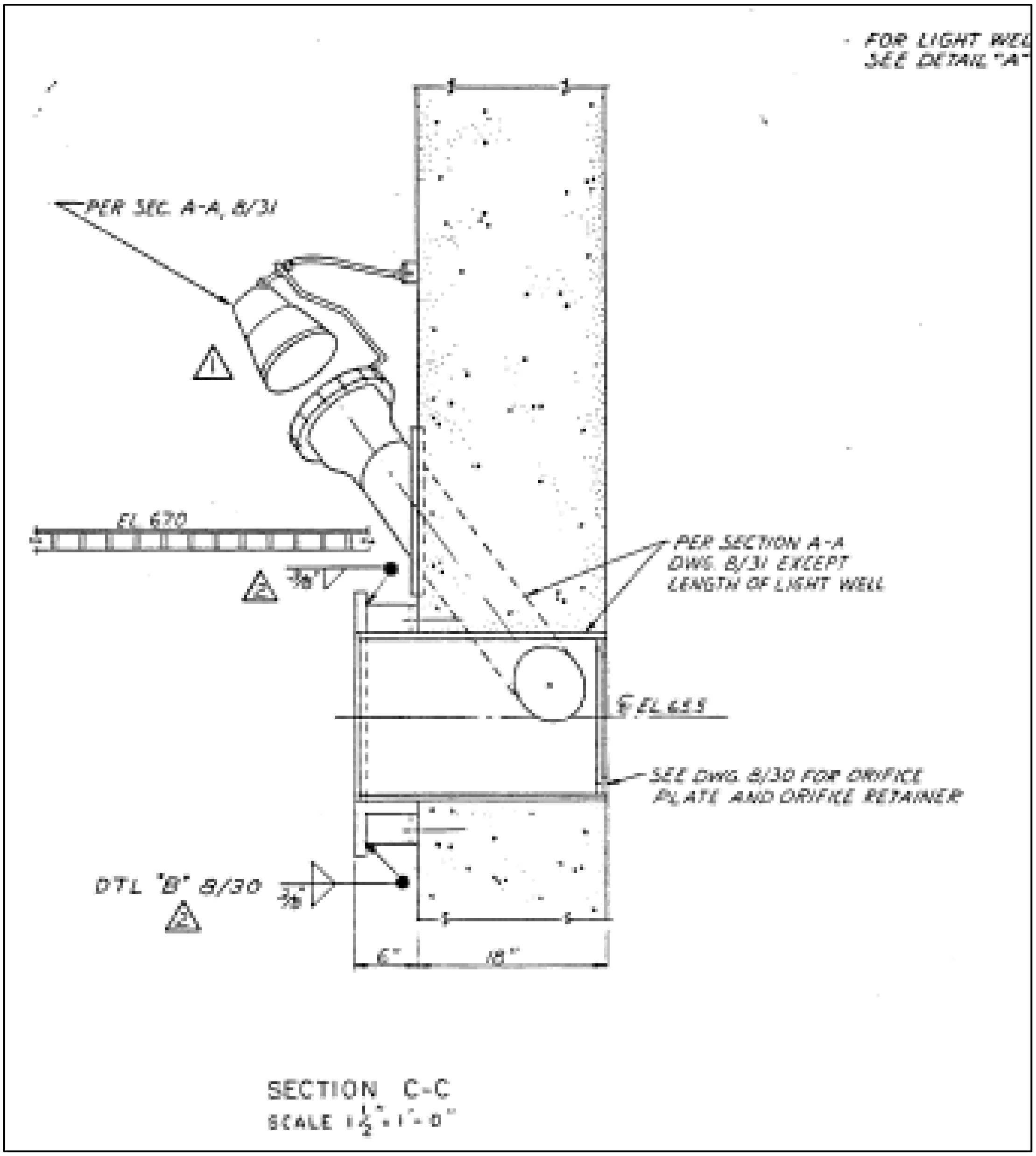
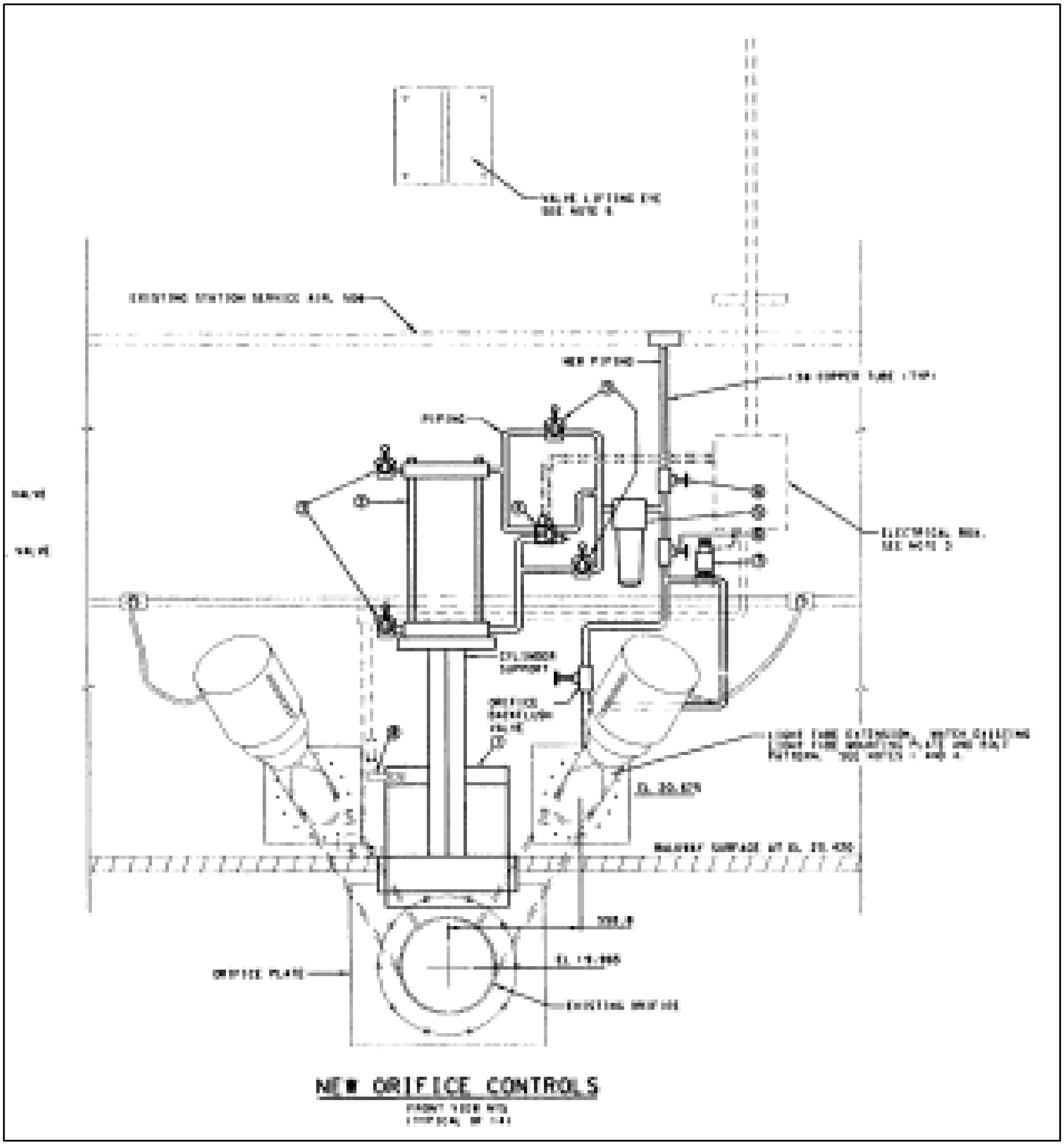


Figure 2-4. Existing Orifice Controls



2.1.2. Control Weir

The control weir was located at station 19+21 in the erection bay. The control weir regulated the water surface elevation in the collection channel.

2.1.3. Dewatering Facility

The dewatering facility consisted of an inclined screen that was 14-feet-wide by 50-feet-long and is inclined by 6.84 degrees from horizontal. The area of the screen was 700 square feet, representing a maximum use of floor screen area within the operating confines. The original design allowed for a velocity of 1.0 fps through the screen. This has been revised to 0.4 fps. Below the screen were four discharge outlets and gates that released water into the emergency relief conduit (ERC). Only the two downstream discharge gates were in operation. The water passing through the dewatering screens flowed through the ERC and ultimately to the tailrace. The remaining water flowed over the 14-foot-wide control weir into the discharge well. The dewatering screen is cleaned with a brush system.

2.1.4. Operation

The design of the Bonneville second powerhouse included provisions for a DSM system. The purpose of the DSM system is to provide passage for juvenile fish from the forebay to the tailwater without having them pass through the turbines. The juveniles bypass the turbines by being directed into the bulkhead slots by submersible traveling screens (STS). The juveniles pass through the lighted orifices into the DSM collection channel, past the originally inclined dewatering floor screen (Figures 2-5 and 2-6).

Figure 2-5. Transverse View Gate Well and Slots

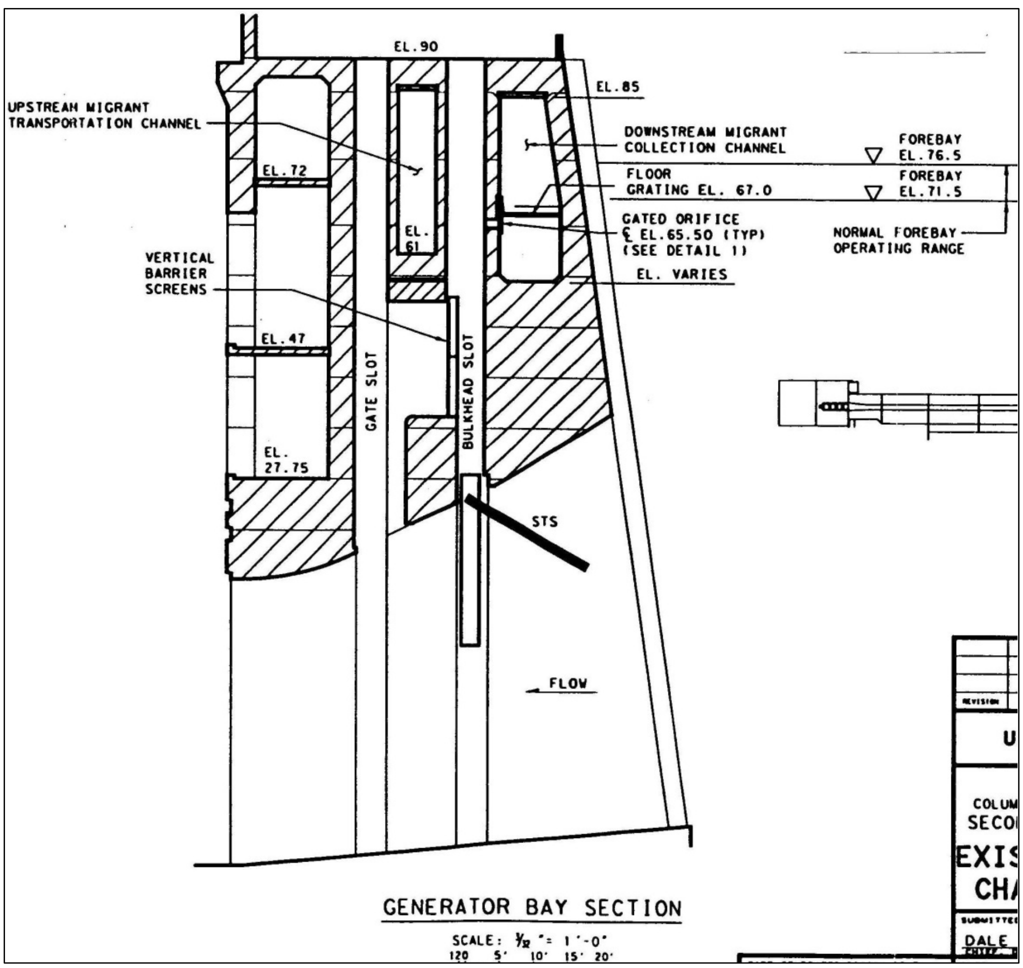
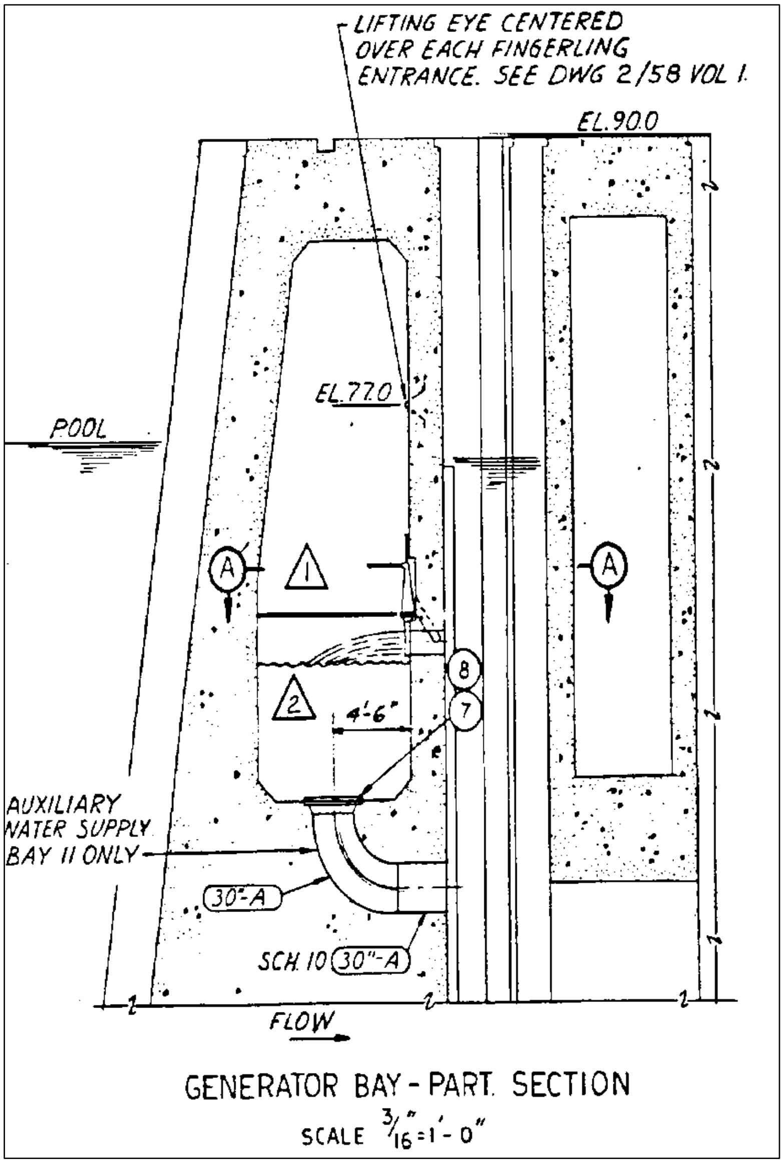


Figure 2-6. Erection Bay Section View – Original Design



2.2. DSM IMPROVEMENTS IN 1999

2.2.1. Bulkhead Slot Orifices

The 1999 DSM system improvements included unsealing and gating 12 of 28 previously sealed orifices (units 11-14) to provide constant flow in the channel for a full range of forebay elevation operations (El. 71.5 to 76.5 feet). The orifice ring diameter was also increased from 12 to 13 inches increasing flow and allowing higher velocities in the collection channel. It should be noted that these new gates have larger actuators resulting in gates and seals extending further downstream from the orifice entrance than the 28 originally gated orifices. This effectively increases the distance that the arc of the jet must travel to clear the gate housing as it exits into the collection channel.

2.2.2. DSM Collection Channel

Add-in water was included in the collection channel entrance and the channel geometry was modified to improve channel velocities that encourage fish passage and reduced stall and delay of juvenile fish.

2.2.3. Control Weir

The control weir was removed to eliminate an observed fish holding area and improve flow conditions.

2.2.4. Dewatering Facility

The dewatering facility was replaced with wall screens to provide more uniform velocities and to maintain criteria for velocity normal to screens.

2.2.5. Operation

Operation was modified to provide constant flow for all design forebay elevations and operating conditions without the need for weir adjustments within the dewatering facility. A constant water surface elevation is maintained over the range of forebays by adding or subtracting the number of orifices in use. In 1999 a programmable logic controller (PLC) system was installed. In auto mode, the regulating orifices at units 11-14 are operated based on water elevation at the north end of the DSM channel. The entire system of orifice slide gates for units 11-18 are normally in auto and are operated to flush out potential debris buildup in the system. The B2 DSM PLC program operation orifice flush cycle takes approximately 5.7 minutes per orifice to complete. The sequence includes orifice close, 1 second air flush, 4 second wait for flush recovery, orifice open, and delay before starting the flush cycle on the next orifice. If an orifice is not in automatic, or jammed (meaning it takes more than the 30 second maximum orifice movement time limit to fully open or fully close), it is skipped in the cycle. Assuming no skips or jams, with 40 orifices to flush, the entire flush cycle takes approximately 3.8 hours to complete. This cycle then repeats until it is stopped.

The other mode of operation is manual, allowing individual control of the slide gate and can be done so from a touchscreen human-machine interface (HMI) in the control room or at the PLC cabinet in the electrical building on elevation 90 of the intake deck. The PLC is a Square-D SyMax. Another location for manual operation is at the orifice in the DSM channel. There has been interest expressed to investigate the inspection benefit with installation of a local manual control switch to eliminate manually overriding the solenoid valves at the orifice during the inspection.

Current biological practice has been to inspect the condition of the jets at least daily to determine whether debris buildup at the orifice entrance is indicated. If the jet is not clear, it is assumed that debris is likely at the entrance, which is known to harm fish. The gate is immediately closed and flushed with compressed air, thereby clearing debris and reducing the probability of fish injury.

2.3. Additional Modifications

2.3.1. Bulkhead Slot Orifice Rings

Bulkhead slot orifice rings are bolted to the entrance of the opening in the bulkhead slot (see Figures 2-2, 2-3, 2-4. In 2002, the size of orifice rings was reduced from 13 inches to 12 5/8 inches in order to provide the intended 1999 design flow (see Section 3.3.1).

Table 2-1 lists the individual orifices and their operational configurations from the original project in 1983 to the current operation.

Table 2-1. Orifice Arrangement and Operation from 1983 to Current

Orifice	Current Actuator Type	Original 1983 Design	1983 Operation After Allowable Velocity Through Dewatering Screens was Revised to V=0.4 fps	1999 Added 14 Operable Orifices to 28 Orifices That Remain Open
		56 (12 inch) Orifices Built for ~ 500-700 cfs	Only 28 (12 inch) Orifices in use ~250-350 cfs	28 (13 inch) Orifices Open + 14 (13 inch) Orifices Operable to Maintain Q
			A = Always Open	O/C = Open/Close with Forebay
11 A (S)	Blue	X	(Blind-Flanged)	O/C
11 A (N)	Silver	X	A	A
11 B (S)	Blue	X	(Blind-Flanged)	O/C
11 B (N)	Silver	X	A	A
11 C (S)	Blue	X	(Blind-Flanged)	O/C
11 C (N)	Silver	X	A	A
12 A (S)	Blue	X	(Blind-Flanged)	O/C
12 A (N)	Silver-Recessed	X	A	A
12 B (S)	Blue	X	(Blind-Flanged)	O/C
12 B (N)	Silver-Recessed	X	A	A
12 C (S)	Blue	X	(Blind-Flanged)	O/C
12 C (N)	Silver-Recessed	X	A	A
13 A (S)	Blue	X	(Blind-Flanged)	O/C
13 A (N)	Silver-Recessed	X	A	A
13 B (S)	Blue	X	(Blind-Flanged)	O/C
13 B (N)	Silver-Recessed	X	A	A
13 C (S)	Blue	X	(Blind-Flanged)	O/C
13 C (N)	Silver-Recessed	X	A	A
14 A (S)	Blue	X	(Blind-Flanged)	O/C
14 A (N)	Silver	X	A	A
14 B (S)	Blue	X	(Blind-Flanged)	O/C
14 B (N)	Silver	X	A	A
14 C (S)	Blue	X	(Blind-Flanged)	O/C
14 C (N)	Silver	X	A	A
15 A (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
15 A (N)	Silver-Recessed	X	A	A
15 B (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
15 B (N)	Silver-Recessed	X	A	A
15 C (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
15 C (N)	Silver-Recessed	X	A	A
16 A (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
16 A (N)	Silver	X	A	A
16 B (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
16 B (N)	Silver	X	A	A
16 C (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
16 C (N)	Silver	X	A	A
17 A (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
17 A (N)	Silver	X	A	A
17 B (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
17 B (N)	Silver	X	A	A
17 C (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
17 C (N)	Silver	X	A	A
18 A (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
18 A (N)	Silver	X	A	A
18 B (S)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
18 B (N)	Silver	X	A	A
18 BC(N)	Blind-Flanged	X	(Blind-Flanged)	(Blind-Flanged)
18 C (N)	Silver	X	A	A
F1 A (N)	Silver	X	A	A
F1 B (N)	Silver	X	A	A
F2 A (S)	Blue	X	(Blind-Flanged)	O/C
F2 A (N)	Black/Silver	X	A	A
F2 B (S)	Blue	X	(Blind-Flanged)	O/C
F2 B (N)	Black	X	A	A
Total No. Orifices		**56**	**28**	**42**

3. PROBLEM STATEMENT

The current operation of the DSM system does not provide adequate monitoring of debris blockage at the orifice entrance in the bulkhead slot for the full range of design forebay elevations (El. 71.5 to 76.5 feet). As originally designed, the observance of a clear consolidated jet exiting the downstream pipe indicated unobstructed safe fish passage. In contrast, a spreading jet filling the pipe indicated an obstructed entrance that would be harmful to juvenile salmonids. This monitoring allowed personnel to correct the situation, as needed.

Currently, the character of the DSM system orifice jets are inconsistent and predominately spreading throughout the range of forebay operations due to a combination of jet impingement (at lower forebay elevations) and lack of adequate air supply to support the jet (at higher forebay elevations).

Lightwell studies at the Bonneville Second Powerhouse indicated that existing light sources are inadequate for attraction of juvenile salmonids (Mueller and Simmons, 2008). Based on a review of lighting studies, Mueller and Simmons (2008) recommended a minimum luminance value of 200-300 lux at the orifice entrance. Juvenile salmonid egress testing in a gatewell at McNary Dam with an orifice light ring in 2010 indicated benefits to gatewell passage times under most conditions (Axel et al., 2011). The light treatment levels evaluated included: reference light with light off (<1 lux), 50 lux, and 300 lux.

The goals of this study focused on improvements to the collection system that will reduce injury and delay to migrating fish species:

- Improve the ability for the project operators to detect debris plugs at the orifice;
- Reduce the likelihood of fish impingement due to alignment of orifice flow; and
- Improve gatewell egress times with improved lighting.

The sections below outline the history of studies and modifications to the DSM system at the Bonneville second powerhouse leading to the conclusions expressed in the problem statement above.

3.1. History of DSM System Studies and Subsequent Modifications

The DSM system at the Bonneville second powerhouse has undergone several modifications over the last 29 years in an effort to provide a safe, efficient passage route for juvenile salmonids. The information below describes the chronology of pertinent issues with the DSM system and improvements for the system since its construction in 1982.

Since construction in 1982, there have been a number of modifications made to improve the operation of the DSM system, with extensive changes being completed in 1999. These modifications were recommended after studies in 1987 to 1991 showed that fish using the bypass system were stressed and fatigued, particularly at low tailwater elevations, which likely contributed to the apparent high rate of tailrace predation. Poor survival appeared to be related to low water velocities in the collection channel, high turbulence in the channel from orifice jets, high turbulence over the dewatering screen due to energy dissipation over the channel control weir, air entrainment in the downwell, and negative pressures in the first elbow of the closed pipe (Design Memorandum Supplement #6).

According to Bonneville Project personnel, one of the aspects of the design that worked well was the hydraulic characteristics of the free-discharging jets. They were described as consistent and clean and functioned well as indicators of potentially harmful upstream debris blockage at the orifice entrance.

Typically during this time, debris blockage checks occurred multiple times a day to detect and eliminate any blockage, as these conditions are known to be harmful for fish.

3.2. MODIFICATIONS IN 1999

The DSM improvements described in Section 2.2 were completed in 1999. Studies done after the 1999 improvements indicated that the once clean jets (1982 design) were now disturbed and spreading jets. It was observed that the jet spreading was even worse for those orifices that had previously been sealed and been made operational in 1999 (south blind flanged orifices – see Table 2-1). Most of the jets often hit the downstream gate housing (potentially harming fish) especially at lower forebays. Collectively, there was more flow in the system than predicted, causing the dewatering system to be out of criteria. It was suggested that the lack of a fully contracting jet was causing the discharge coefficient to be higher and more variable than designed, which resulted in flow in excess of design.

3.3. FURTHER MODIFICATIONS AND STUDIES

3.3.1. Hydraulic Field Testing in 2002

Field observation/testing in 2002 at a turbine unit not in service recommended decreasing the orifice plate diameter to 12 5/8 inches to effectively decrease the individual orifice flows, thereby bringing the dewatering system back into criteria. It was suspected that the difference between the 1999 orifice diameter (13 inches versus 12 inches for orifices in 1983) and inner pipe diameter (15 inches) was insufficient to maintain the continual airflow needed to produce a cohesive jet. Project operators noted that immediate and temporary improvement of the jets could be produced by releasing bursts of compressed air into the pipes. It was also noted that the orifice rings and support rings (with same diameter I.D.) were not aligned when installed, causing a discontinuity that disturbed the outside of the jet and further exacerbating jet instability and reduced air flow back into the pipe.

When disturbed, jets spread to fill the pipe and air is prevented from entering the pipe to vent the base of the orifice. This causes the orifice jet to be subjected to vacuum within the transport pipe, and consequently, the head differential (the gatewell head minus the pressure head in the orifice pipe) tends to be higher. The result is a higher discharge through the orifice and pipe than when properly vented. Basically, the orifice flow becomes full pipe flow with a minor constriction caused by the orifice. On the other hand, venting would deliver air to the base of the orifice at the upstream end of the pipe so that the orifice jet would contract downstream of the orifice and stay separated from the inner pipe walls.

The reduction in orifice size to 12 5/8 inches was a relatively easy way to improve air movement somewhat and ultimately solve the excess flow problems; however, this did not fix the disturbed jets. Field biologists and regional fishery agencies were still concerned that the continuously disturbed jets made it impossible to monitor potential upstream orifice obstructions, thereby endangering the fish utilizing the DSM system.

3.3.2. Hydraulic Field Testing 2006

Further field testing in 2006 (see Appendix A, *Hydraulic Design*) using a working turbine unit indicated that using smaller diameter orifice rings (in relation to the existing I.D. of the steel pipe) consistently produced cleaner jets. However, the additional 12 previously sealed orifices located on the south side of each bulkhead (made functional in 1999) were consistently more disturbed and more likely to impact the downstream end (pipe end and gate housing) than the original orifices located on the north side of each bulkhead. This was assumed to be related to the larger actuators and gate housing installed during the 1999 modifications that essentially elongated the jet path. It was also surmised that testing with the turbine units off (2002 testing) versus units on (2006) does affect jet quality.

The 2006 field testing utilized several orifice ring sizes and the smallest (11 inches) appeared to have the most consistent and clean jet. It was deduced that the 11 inch orifice ring was superior due to increased space between the outer circumference of the jet and the inside of the pipe (15 inches I.D.) allowing for adequate air supply to feed the jet. As the jet moves through the bulkhead wall, it entrains air into the jet. If that air is not sufficiently replaced, a low-pressure zone develops in the vent tube area from the orifice ring to the downstream side of the gate. A properly vented orifice jet would continue to contract downstream of the orifice, but due to the low pressure in the vent tube, the orifice jet is “pulled” apart as it passes through the bulkhead wall and may even impact the gate structure. The low pressure could also change the orifice efficiency, allowing more flow into the DSM collection channel than expected.

The field study concluded that a properly sized orifice in relation to pipe diameter would alleviate jet spread and hydraulic capacity issues. It was recommended that for a 13-inch diameter orifice ring (as originally designed for 1997 DSM improvements), the appropriate I.D. of the steel pipe should be about 17.75 inches to allow the adequate air supply needed for a clean jet. The field study occurred during an average forebay operation at El. 73.6 feet (mean = El. 74 feet); it should be noted that less air would likely be needed at lower forebays because the flow and velocity would be reduced. Based on preliminary air demand calculations (see Appendix A), the 11-inch orifice ring with a 15-inch (I.D.) pipe would result in an air demand of 1.8 cfs, or 108 ACFM, versus the existing orifice ring (12 5/8 inches) with 2.2 cfs, or 132 ACFM, air demand.

It should be noted that when tests are done either on an operating or a non-operating unit, one would expect that the orifice jet performance would be different between them. The approach flows to the orifices (gate well flow and turbulence) would be significantly different with the turbine unit operating than without. It would also most likely effect the discharge coefficient of the orifice as well as the uniformity of flow entering the orifice. For any given forebay elevation the water surface elevation in the gatewell of a non-operating turbine unit would also be higher than the water surface elevation of an operating unit as there would be virtually no head loss from the forebay to the gatewell of a non-operating turbine unit.

Consequently, the data from the 2002 Hydraulic Field Testing may have shown better hydraulics and more flow than if the turbine unit was on. In regular operation, the turbine units would be on and the flows would likely be less than the predicted flows from the 2002 data. The 2006 testing (3.3.2) had a working turbine unit thereby providing a more realistic flow scenario.

3.3.3. Light Study at Bonneville

In 2011, research was conducted by the Pacific Northwest National Laboratory (PNNL) to provide USACE biologists and engineers with general design guidelines for using artificial lighting to enhance the passage of juvenile salmonids into the collection channel at the Bonneville second powerhouse. There were three primary objectives of the research: (1) review and synthesize all relevant studies where artificial light was evaluated in a field or laboratory setting for the potential to guide fish at passage barriers within juvenile salmonid outmigration corridors; (2) conduct a field study at the Bonneville second powerhouse to evaluate the output levels of two artificial light sources at one orifice entrance within gatewell 12; and (3) compare, in a laboratory setting, the performance of three light sources in terms of light intensity values.

The PNNL reviewed 36 sources in the published gray and peer-reviewed literature and prepared a synopsis that included study objectives, species and life stage, experimental conditions, type of lighting used, and a summary of results. It was found that artificial lighting has been used in two general applications: (1) as a means to induce avoidance behavior by altering the fishes' swimming pathway, and (2) as a guidance or attraction avenue to assist fish in locating safe passage routes. The literature review indicated that several factors play a combined role in the fishes' ability to safely navigate passage barriers. These factors included genetic makeup (species and subspecies), life stage, season, time of day, light levels, presence of predators, distance to cover, water temperature, group size, noise regime, and water current.

The review by PNNL determined that juvenile salmonids can be attracted to illuminated regions during nocturnal periods and can perceive light levels down to approximately 0.25 lux or 0.023 foot-candles (fc), equivalent to the light produced by moonlight. At the other end of the spectrum, it was found that juvenile salmonids generally avoid or are startled when exposed to more intense light levels that correspond to daylight conditions or near 400 lux (37.16 fc). To guide fish through manufactured structures using artificial lights requires an understanding of the types of illumination and the nature of salmonid light perception. To respond to a light source, the fish visual system must be able to respond to the appropriate wavelengths that correspond to peaks in the spectral response of the photoreceptors in the eye. Studies that have examined the use of artificial light to guide salmonids safely through migration barriers such as hydroelectric dams show measurable differences in juvenile responses to both the quantity and quality of the light stimulus. The literature review concluded that any fish passage guidance structure must be based on an understanding of fish behavior and environmental and hydraulic conditions at the specific location.

The field study at the Bonneville second powerhouse found the existing lighting conditions at the orifice tubes in the downstream migration channel to be less than ideal to illuminate the entrance of the orifice. Based on review of the lighting studies, a minimum luminance value of approximately 200-300 lux is needed at the orifice entrance. While some studies, in controlled laboratory experiments, have shown that this light intensity could possibly startle test fish (if exposure is sudden), light intensity values are expected to decrease rapidly within a short distance from the orifice. The high water turbidity present for much of the spring outmigration period in the Columbia River also would play a role in decreasing light intensity at the orifice.

Field measurements of light intensity from light-emitting diode (LED) light bulbs at a single orifice in gatewell 12 were low, at approximately 0.1 lux with a water-scaled lens. Light output for a 90-watt halogen light with a water-scaled lens was 0.25 lux at the opening. When the water-scaled lens was exchanged for a new lens, the readings increased to 0.6 lux for the LEDs and 3.25 lux for the halogen light. For comparison, 1 lux is the amount of light produced by moonlight at high altitude and 10 lux is the intensity of a candle at a distance of 1 foot. The halogen lights were far more effective at producing illumination near the orifice regions and outward to approximately 16 inches on axis with the opening, where the values were similar to the ambient light background measurements. The LEDs were less effective at illuminating the region; this was especially evident when the water-scaled lens was used. Both light sources produced light levels below effective minimum luminance values noted in the literature.

Laboratory tests were conducted at PNNL's Aquatic Research Laboratory in Richland, Washington. Researchers measured the light output from halogen spotlights and mercury vapor lamps, as well as the LED lamps currently in use at the Bonneville second powerhouse. The results using a water-scaled glass lens showed that the light loss for the halogen and the aqua green LED lamp was 5-6 times higher than the loss with a clean lens. Output from a mercury vapor lamp, when the water-scaled lens cap was placed at the light face, was reduced by only a factor of two. The drawback to using mercury vapor and halogen lamps is the amount of heat produced by the lens (250°F for mercury vapor and 143°F for halogen) and the reduced bulb life as compared to the LEDs.

Based on the study, some options for improving the lighting at the orifice entrances at the Bonneville second powerhouse include the following:

- Incorporate a ring of LEDs that would be recessed into the orifice opening, thus eliminating the need for the light tubes. An automated cleaning system also would be required.
- Incorporate the light source into the lens cap so that the cap and light housing is one waterproof unit. This would allow for all of the light to be directed into the light tube and eliminate the water scaling and debris-buildup issue, although water buildup still could pose a problem due to the splashing of water upward into the light tubes. Cleaning of the light and cap assembly also would be simplified.
- Use a white-emitted light source that has a minimum luminance value of approximately 200-300 lux near the immediate orifice entrance.
- Incorporate higher-intensity LED lamps. Several manufacturers have developed high-output LEDs that have been used in a variety of applications, including automobiles, flashlights, and residential/industrial interior and exterior lighting. These relatively new LEDs provide almost 50% more light (some up to 250 lux) than a standard 5-watt LED bulb. Models of the cool white version have an expected 50,000-hour lifespan and peak wavelengths of 440 and 550 nanometers.

To evaluate the effectiveness of any modification to the existing system, tests could be conducted in which tagged fish are released in the gatewell with a light-on/light-off scenario and the orifice passage efficiency evaluated. Different lighting sources could be tested to determine if white light or light emitted within the peak action spectra of juvenile salmonids (blue-green region) is best for attracting fish near the orifice where the flow component is sufficient for entrainment into the collection channel.

3.3.4. Light Attraction Studies at McNary Dam in 2010

Artificial lighting is currently being used in varying applications and intensities for illumination of gatewell exits at USACE hydroelectric projects to decrease delays for bypassed fish on the Snake and Columbia Rivers. While previous studies have shown a variable response to light across salmonid species, the literature suggests that improvements can often be made in fish passage if light intensity, wavelength, and/or directionality are optimized.

In 2010, PNNL designed a light ring system for illuminating the orifice entrance in a gatewell. Staff from the Pasco Research Station of the National Marine Fisheries Service (NMFS) collaborated with PNNL on the design, fabrication, and installation of a track system for the light. The track system was used to lower, retrieve, and positions the light ring over the orifice entrance. The light ring was deployed and tested during 2010 on an existing 30.5-centimeter orifice in gatewell 6B (south orifice) at McNary Dam.

Three levels of light intensity were evaluated, 50 lux, 300 lux, and reference (light off with <1 lux), to determine whether there was a difference in gatewell egress associated with each treatment. The light ring directed most of the light inward and produced a glow that projected outward into the gatewell. Intensity could be adjusted by an external control module. Prior to each test, a light meter was used to measure luminance and adjust output to meet the designated treatment schedule. Changing turbidity levels required adjustment of light output to meet the required treatment conditions.

Using a hose, groups of PIT (passive integrated transponder)-tagged fish were released behind the trash rack for entrainment into the gatewell of turbine unit 6B. During each light treatment, tagged fish moved volitionally out of the gatewell, passing through the orifice and into a flume, where two in-line PIT-tag detectors recorded their passage. Researchers released fish for one light treatment per day, during both day and night diel periods, and monitored detections for each group over a 12-hour period.

For each release group, mean passage time (gatewell egress) was estimated from release until first detection at the PIT-tag monitors on the downstream side of the test orifice. Passage distribution was modeled using time-to-event methods. The models included three factors: *week* (1-6), *diel period* (day/night), and *light treatment* (300 lux, 50 lux, and reference or light off); and three covariates (*fork length*, *turbidity*, and turbine unit *flow*). Akaike's information criterion was used to determine which set of factors and covariates were best supported by the data. Prediction of 50% passage was estimated for each cohort from the model-averaged individual estimates.

Both orifice light treatments decreased delay in the gatewell and improved egress for yearling and subyearling Chinook salmon, sockeye salmon, and juvenile steelhead under most conditions. Sample sizes for coho salmon were insufficient for analysis. Differences in passage-time distribution between the two light treatments (50 lux and 300 lux) were minimal. The magnitude of delay between the 50-lux and 300-lux treatments and the reference (light off) treatment was greater for fish released in the evening than for those released in the morning, indicating that the orifice light was less effective during daytime due to ambient light. By covering the gatewells, egress for illuminated orifices during the daytime could be improved. The 50-lux and 300-lux treatments also provided a significant reduction in passage delay during periods of high turbidity, which occurred during the end of May and early June.

3.3.5. Site Visits and Further Observations (2011)

Several observations have been made during this study to augment the conclusions made in previous field observations. A definite correlation can be seen between the particular gate assembly and its placement versus jet quality. There are two different sizes of actuators used on the orifice gate valves. The smaller of the two is used on orifices such as 12A-N. On orifices like 12A-N, the concrete has been chipped away allowing room for the actuator to be recessed into the concrete. This also allows the gate valve to be mounted flush with the mounting plate giving an overall distance of 0.6 inches from DSM wall to upstream face of the gate (Photo 3-1).

Although the smaller actuators were used on many orifices, orifices such as 14A-N did not have the concrete removed so the gate valve had to be mounted offset from the wall using spacer rings to allow clearance for the actuator. This results in an overall distance of 4.2 inches from DSM wall to upstream face of the gate (Photo 3-2).

The larger actuators are used on orifices such as 14A-S. The concrete was not removed at any of these orifices and to provide clearance for the larger actuators the gate valves were offset further resulting in an overall distance of 7.2 inches from DSM wall to upstream face of the gate (Photo 3-3).

Table 3-1 demonstrates the correlation between jet quality and gate type/placement. The gates with the largest offset (7.2 inches) tend to consistently present a poor quality jet. The gates with the medium offset

(4.2 inches) were observed to have somewhat better performance related to a cohesive free jet. The Grey actuators that have the gates flush with the wall (0.6 inch offset) routinely present a better jet. This is likely caused by the jet trajectory especially for the lower forebays where jets will have less discharge and lower velocities. If jet impingement occurs, there is deterioration around the exit of the jet which also reduces the air available to sustain the continuity of the jet. The combination of the impact itself and reduced air access to the jet causes poor jet quality. Observations at a higher forebay indicate a reduction in jet quality as discharge and velocities increase requiring more air to support the jet. This reduction in jet quality is most likely caused by lack of sufficient air supply to the jet. For both conditions, the Grey actuators with the least offset from the wall fair better with regards to jet quality.

Other situations that may cause variation in jet quality during observations include turbine unit operation (on/off) and fish screens (in/out). The concurrent study for Bonneville second powerhouse fish guidance efficiency is looking at various alternatives to increase efficiency and decrease gatewell mortality. Alternatives that are being considered include modifications to reduce turbulence and streamline flow up the gatewell. Biological testing will further our understanding of mortality in the juvenile bypass system. These two programs are proceeding concurrently with frequent coordination and with the expectation that any recommendations will be further explored jointly.

Photo 3-1. Grey Actuators with Concrete Chipped Away (Offset = 0.6 inches)

Photo 3-2. Grey Actuators with No Concrete Chipped Away (Offset = 4.2 inches)

Photo 3-3. Blue Actuators with No Concrete Chipped Away (Offset = 7.2 inches)

Table 3-1. Field Observations Citing Relative Jet Quality

Orifice	Current Actuator Type	Field Observations for 12 5/8 inch Orifice Rings		Existing Gap Between Gatewell Wall (Orifice Entrance) and Gate (inches)
			7-Jul-11	
		Forebay = El. 72.7 ft.	Forebay = El. 74.4 ft.	
		Jet Condition	Jet Condition	
11 A (S)	Blue	poor	poor	7.2
11 A (N)	Silver	poor	poor	4.2
11 B (S)	Blue	closed	closed	7.2
11 B (N)	Silver	closed	closed	4.2
11 C (S)	Blue	poor	poor	7.2
11 C (N)	Silver	good	poor	4.2
12 A (S)	Blue	poor	poor	7.2
12 A (N)	Silver-Recessed	good	poor	0.6
12 B (S)	Blue	poor	closed	7.2
12 B (N)	Silver-Recessed	good	good	0.6
12 C (S)	Blue	poor	closed	7.2
12 C (N)	Silver-Recessed	good	good	0.6
13 A (S)	Blue	poor	closed	7.2
13 A (N)	Silver-Recessed	good	poor	0.6
13 B (S)	Blue	poor	closed	7.2
13 B (N)	Silver-Recessed	good	good	0.6
13 C (S)	Blue	closed	closed	7.2
13 C (N)	Silver-Recessed	good	good	0.6
14 A (S)	Blue	closed	closed	7.2
14 A (N)	Silver	good	poor	4.2
14 B (S)	Blue	closed	closed	7.2
14 B (N)	Silver	poor	poor	4.2
14 C (S)	Blue	closed	closed	7.2
14 C (N)	Silver	poor	poor	4.2
15 A (S)	Blind-Flanged			
15 A (N)	Silver-Recessed	good	good	0.6
15 B (S)	Blind-Flanged			
15 B (N)	Silver-Recessed	good	good	0.6
15 C (S)	Blind-Flanged			
15 C (N)	Silver-Recessed	good	good	0.6
16 A (S)	Blind-Flanged			
16 A (N)	Silver	poor	poor	4.2
16 B (S)	Blind-Flanged			
16 B (N)	Silver	poor	poor	4.2
16 C (S)	Blind-Flanged			
16 C (N)	Silver	poor	poor	4.2
17 A (S)	Blind-Flanged			
17 A (N)	Silver	poor	poor	4.2
17 B (S)	Blind-Flanged			
17 B (N)	Silver	poor	poor	4.2
17 C (S)	Blind-Flanged			
17 C (N)	Silver	poor	good	4.2
18 A (S)	Blind-Flanged			
18 A (N)	Silver	poor	poor	4.2
18 B (S)	Blind-Flanged			
18 B (N)	Silver	good	poor	4.2
18 BC(N)	Blind-Flanged			
18 C (N)	Silver	good	poor	4.2
F1 A (N)	Silver	poor	poor	4.2
F1 B (N)	Silver	good	good	4.2
F2 A (S)	Blue	poor	poor	7.2
F2 A (N)	Black/Silver	closed	closed	4.2
F2 B (S)	Blue	poor	poor	7.2
F2 B (N)	Black	closed	closed	4.2
Total No. Orifices				**42**

4. ALTERNATIVES DEVELOPMENT

4.1. BIOLOGICAL CONSIDERATIONS

4.1.1. Biological Criteria

Biological criteria for current and existing systems will adhere to the most current NMFS design criteria for passage systems. The most pertinent criteria driving the design are as follows:

- Through dewatering screen criteria of ≤ 0.4 fps at the screen face.
- DSM channel velocities of 3-5 fps over the entire length of channel.
- Depths with the main channel will be greater than 2 feet at all times.

4.1.2. Biological Considerations

Since modifications in 1999, regional fish representatives and USACE fish biologists have been critical of the second powerhouse orifice system. This is because of the inability to ascertain whether or not the orifice is being affected by debris due to the physical and hydraulic conditions that resulted from the new orifice ring size (changed from 12 inch to 13 inch diameter). In years prior to modifications, inspectors could view the condition of the jet exiting the wall and determine if the orifice had a blockage because of a change in the jet's characteristics. Under the new operation, the disturbed jet and water scaled light tube lenses do not allow the inspector to determine with certainty whether or not there is debris. One of the goals of this program is to return the orifices to their clean jet status with minimal modifications, and also to incorporate a new orifice lighting system to increase fish attraction and avoid fish passage delay under the same modification contract.

4.2. HYDRAULIC CONSIDERATIONS

4.2.1. Hydraulic Design Criteria

4.2.1.1. General

Hydraulic design of the DSM system is driven by hydraulic criteria for safe passage of downstream migrating juvenile salmonids. The primary objective of the criteria is to minimize injury or delay to fish. Criteria for forebay range, orifices, collection channel, dewatering structure and exit section were provided by NMFS during design of the 1999 improvements (see Sections 4.2.1.2 to 4.2.1.5). Additional standards desired for juvenile fish safety and hydraulic integrity of the system operation pertain to the orifice jet characteristics (see Section 4.2.1.6) and dewatering system operation (see Section 4.2.1.7).

4.2.1.2. Design Forebay Operating Ranges

Design forebay elevation range for DSM system constant flow operation is El. 71.5 to 76.5 feet.

4.2.1.3. Orifices (1999 Improvements)

- Plate velocity ≥ 10 fps.
- Orifice discharge ≥ 11 cfs.

- Centerline trajectory of the orifice jets should enter the collection channel water surface at least 4 feet from the opposite wall.

4.2.1.4. Collection Channel

- Channel velocity minimum ≥ 2 fps (acceptable for unit 11 per NMFS discussion).
- Channel velocity 3-5 fps.
- Channel water depth ≥ 4 feet.

4.2.1.5. Dewatering Facility

- Channel velocity between 3-5 fps.
- Average gross velocity entering dewatering screens ≤ 0.4 fps.
- Bypass outflow rate = 30 fps.
- Channel water depth ≥ 2 feet.

4.2.1.6. Orifice Jet Characteristics

- Provide clean free jet suitable for monitoring debris and obstructions at orifice entrance.
- Adequately aerate jet to reduce fluctuations in discharge due to air deprivation and vacuum conditions (especially for higher forebay elevations).
- Reduce current jet impingement at downstream exit of orifice pipe and gate housing for lower forebay elevations in order to reduce risk of fish impingement and avoid compounding air deprivation of the jet.

4.2.1.7. Dewatering System Operations

Water surface elevation downstream of the collection channel must remain at a constant elevation for dewatering system to remain in criteria for 0.4 fps screen velocity (fry criteria). Orifices must be opened or closed to maintain the correct total flow (~465-477 cfs) for full range of forebays to maintain a depth of 13.2 feet at the downstream end of the collection channel.

4.2.2. Alternative Hydraulic Concepts

There are four main categories of alternatives that were developed by the Product Delivery Team (PDT) during a brainstorming session: (1) aerate jet to provide means of discerning upstream debris blockage through observation of orifice exit; (2) provide means of discerning upstream debris blockage through observation of orifice entrance; (3) reduce or prevent jet trajectory impingement for lesser flows; and (4) decrease fish passage retention time through attraction lighting.

4.2.2.1. Aerate Jet to Provide Means of Discerning Upstream Debris Blockage through Observation of Orifice Exit (Alternatives 1-5)

This concept is based on field assessments made from 2000 to present. Often, adding a short influx of compressed air clears up the jet temporarily, but not in all cases. The inconsistency is likely due to the forebay elevation and the associated controlling mechanism affecting the jet characteristics. For higher forebay elevations, the controlling factor appears to be the higher flow, higher velocities and more air demand. The delivery of compressed air tends to clear up the jet but is unlikely to be uniform and consistent around the orifice causing differential pressures around the downstream face of the orifice plate. This coincides with the transitory benefit that has been observed. For lower forebay elevations (and a working turbine unit), the controlling factor appears to be related more to jet trajectory impingement. The 2006 testing (forebay El. 73.6 feet) compared various size orifice rings and clearly, the "best" jet hydraulics occurred when the ratio of pipe I.D. to orifice ring I.D. was greatest.

Alternatives to introduce air to the jet include both adding air externally, and increasing the ratio between the pipe I.D. and the orifice ring I.D. With a fully aerated jet, obstructions at the orifice entrance could be seen by inspection of the jet and actions could be taken to remove the debris. In addition, a more consistent discharge would likely result with this concept along with a more confined jet less likely to impact the downstream pipe and gate housing. See Appendix A for table showing air demand calculations for previous field testing and alternative comparisons.

4.2.2.2. Provide Means of Discerning Upstream Debris Blockage through Observation of Orifice Entrance (Alternatives 6-8 and 9-10)

This concept focuses on alternative means of monitoring debris buildup than inspecting the jet characteristics. These alternatives include the use of cameras in the bulkhead for visual observation, as well as pressure transducers or sonic/acoustic sensors placed across the orifice plate. In conjunction with the upstream modifications, inserts to partially support the jet, rounded entrances for full flow and realignment of the orifice ring and gates housing could be used to enhance safe fish passage.

4.2.2.3. Reduce or Prevent Jet Trajectory Impingement for Lower Forebays and Reduced Flow

Field testing and observations indicate that for lower forebay elevations within the operating range, jet disturbances are more likely caused by jet trajectory impact than air demand. Lower forebays result in less discharge per orifice with commensurate reduction in velocities. This results in less air demand and issues with vacuum conditions but decreases the trajectory distance to impact. Field observations indicate three different gate valve offset distances from the DSM system wall:

- Grey actuators with concrete chipped away have an offset of 0.05 feet (0.6 inches; Photo 3-1).
- Grey actuators with no concrete chipped away have an offset of 0.35 feet (4.2 inches; Photo 3-2).
- Blue actuators with no concrete chipped away have an offset of 0.6 feet (7.2 inches; Photo 3-3).

The larger the offset, the more likely it is that the orifice jet will impact the downstream gate housing before it reaches the collection channel. This effect is amplified by lower forebays and resulting lower orifice discharge velocities. Jet trajectory calculations are included in Appendix A. Estimates indicate the bottom of the jet for the lowest forebay elevation (71.5 ft.) appears to contact the pipe approximately 9 inches upstream of the pipe end and the highest forebay elevation (76.5) contacts the pipe at approximately 2 inches from the pipe end.

4.2.2.4. Decrease Fish Passage Retention Time through Attraction Lighting

Field testing at McNary Dam in 2010 showed that a light ring system for illuminating the orifice entrance in the bulkhead provided a reduction in fish passage retention time for the 50 lux and 300 lux light levels, as compared to lights turned off for the spring and summer migrants tested (see Section 3.3.4). Mueller and Simmons (2008) recommended a minimum luminance value of 200-300 lux at the orifice entrance. They also reported a startle and avoidance response in juvenile salmonids with more intense light levels near 400 lux. A white emitted light source of 200-300 lux measured near the orifice with methods employed by Axel et al. (2011) will serve as the light intensity design criteria to maximize light around the orifice during the varying water clarity conditions through the seasons.

5. ALTERNATIVES

Twelve alternatives were identified as potential solutions for the current DSM system from the downstream bulkhead slot to the dewatering system. These alternatives are described below.

5.1. Alternative 1 – Add Compressed Air to Orifice Pipe (13-inch Orifice Ring)

5.1.1. General Description

Introducing compressed air to the area surrounding the jet should supply some relief for the required air demand of the jet. Preliminary air demand calculations were based on USACE hydraulic design criteria charts 050-1 and 050-2 for the design of air vents in regulated outlet works. The air demand is caused by the drag force between the water surface and the air above. This results in an air demand for a 13-inch orifice ring with existing pipe I.D. of 15 inches of approximately 2.3 cfs (see Appendix A) or 139 ACFM. Compressed air would be injected through air supply lines periodically during regularly scheduled inspection to meet the air demand. This should allow for a more cohesive jet character that can be used as an indicator for orifice blockage. This alternative would apply to the 42 existing gated orifice systems and assumes that providing sufficient air supply to feed the jet will return flows to the 1997 designed 13-inch orifice ring flows.

5.1.2. Mechanical Design Components

The calculated air demand for each orifice is 141 standard cubic feet per minute (SCFM). The current copper air supply lines have a 0.5-inch I.D.. At 100 pounds per square inch (psi) nominal station service air they do not have adequate airflow capacity. The air supply lines would need to be at least 1-inch I.D. (Figure5-1). The most economical use of the compressed air would be manually injecting the air individually at the time of inspection to support the jet and allow for inspection personnel to observe a clean jet if no blockage is present. The existing 2-inch I.D. air supply header would have adequate airflow capacity for this use. This use is recommended over continuous injection of air, which for 42 orifices would require almost 6,000 SCFM of air supply. This would require the air supply header from the air receiver to be increased to 8-inch I.D. and a 1,000 hp centrifugal style air compressor and receiver system just for the DSM. Operating a 1,000 hp air compressor just to provide continuous jet support is highly impractical from a sustainability standpoint and should only be considered as a last resort.

Assuming that the air-on-demand method is used for inspection, the existing 2-inch I.D. air supply header would remain in service and the individual orifice supply lines and valves would be increased to 1-inch pipe. It is apparent that a considerable increase in O&M costs would result with this alternative due to increased usage of the powerhouse station service air compressors. Even with using the air system during inspection only, a dedicated air compressor system is recommended to provide the 141 SCFM of air. If a rotary compressor was used then it would require a 40 hp motor which is a significant power requirement.

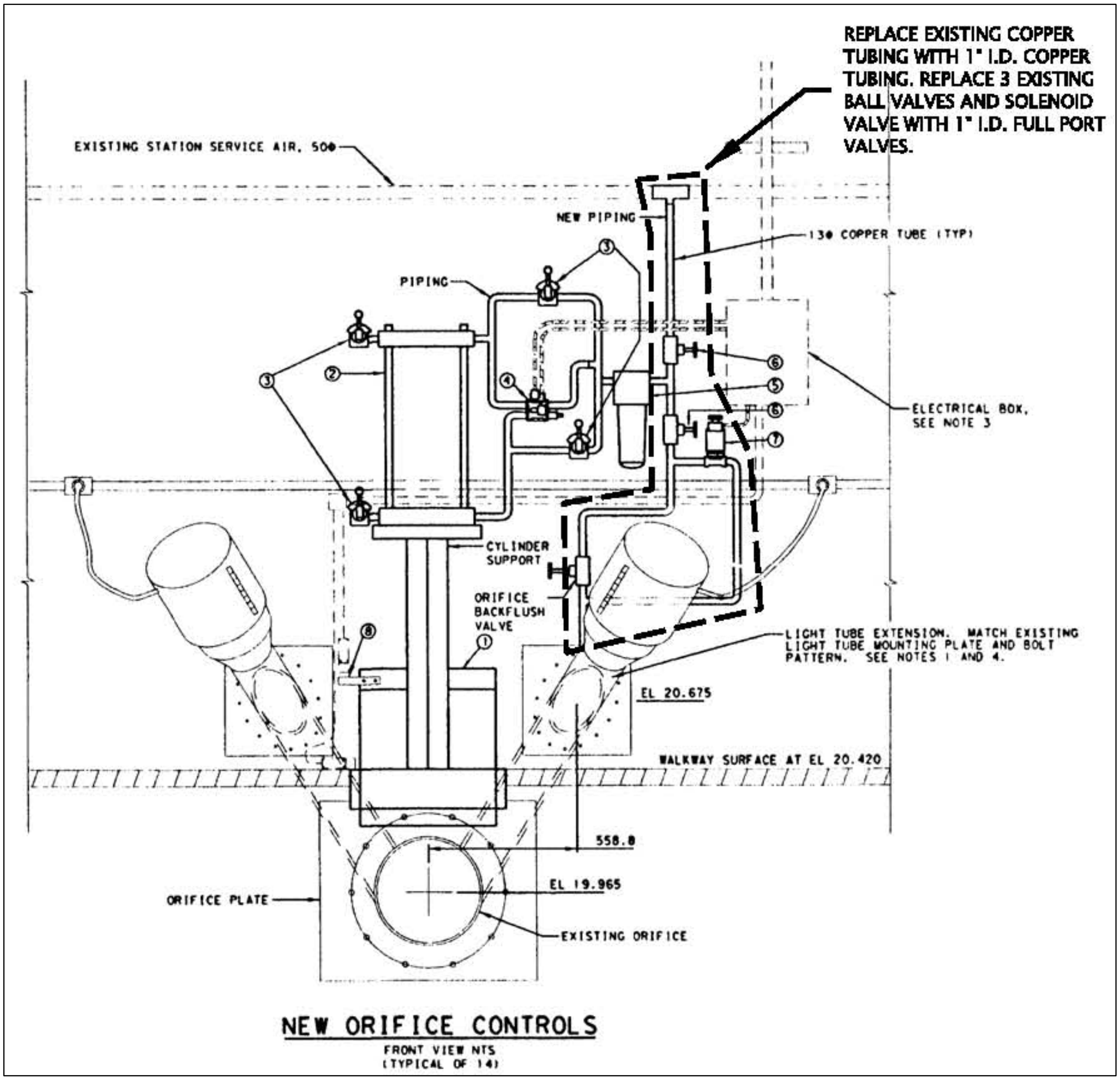
5.1.3. Electrical Design Components

Significant electrical power upgrades would have to be made in order to provide power to the 40 hp air compressor.

5.1.4. Structural Design Components

The pneumatic piping from the compressor will need new brackets and anchorage. The new piping off the main line will need new anchorage.

Figure 5-1. Alternative 1 – Add Compressed Air to Orifice Tube



5.2. ALTERNATIVE 2 – VENT ORIFICE PIPE WITH EXISTING LIGHT TUBE (13-INCH ORIFICE RING)

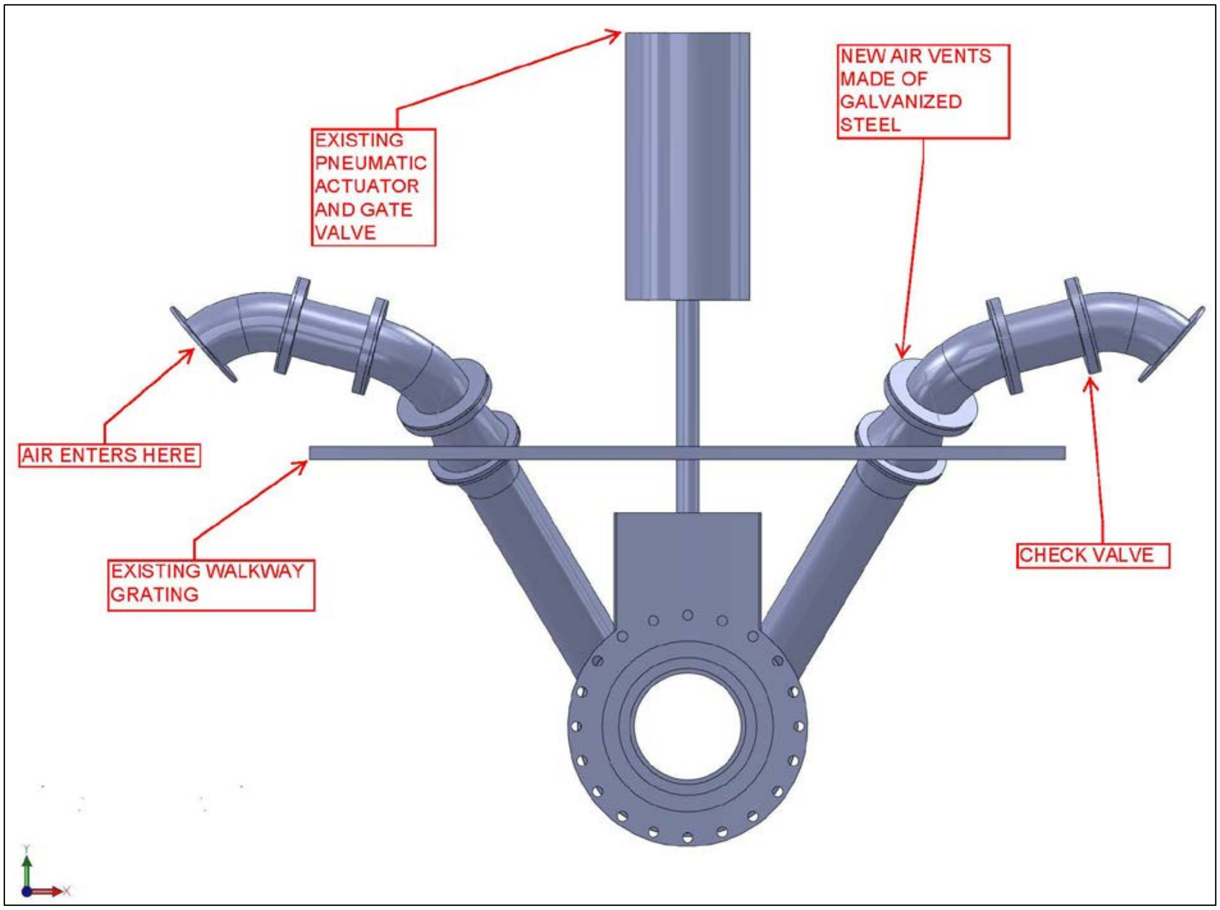
5.2.1. General Description

Similar to Alternative 1, introducing air to the area surrounding the jet through the existing light tubes should supply some relief for the required air demand of the jet (likely occurring when forebay is high). This should allow for a more cohesive jet character that can be used as an indicator for orifice blockage. Similar to Alternative 1, air demand for a 13-inch orifice ring with existing pipe I.D. of 15 inches would be approximately 2.3 cfs (see Appendix A) or 139 ACFM. The existing light tube covers would be removed to allow air to flow unobstructed into the pipe just downstream of the orifice opening. However, based on preliminary field observations, it does not appear likely that there will be enough air to satisfy the deficit. The jet may also be impacted by the inability of the air in the light tubes to provide uniform pressure around the jet further deteriorating the cohesiveness of the jet. Opening the light tubes in the field during lower forebays did not show a marked difference in jet characteristics and any improvement was transitory. It could potentially help the jet cohesion for higher forebays somewhat. This alternative would apply to the 42 existing gated orifice systems and assumes that providing sufficient air supply to feed the jet will return flows to the 1997 designed 13-inch orifice ring flows.

5.2.2. Mechanical Design Components

Since this design is supplying air through passive vents working off of the vacuum created by the jet, no supplemental compressed air is required. This design would include a combination of 6-inch galvanized pipe fittings to convert the light tubes into one way air vents and redirect any leakage back down into the DSM. A check valve would be added so that water cannot exit the air vents when the gate valve is closed. A swing check valve modified to minimal cracking pressure would maximize the naturally entrained airflow. The existing light tube lens covers would be removed and new custom match-drilled flanges would be used to make the connection (Figure 5-2). Fasteners would be 300 series stainless steel. Flange gaskets would be buna-N or EPDM.

Figure 5-2. Alternative 2 – Vent Orifice Tube with Existing Light Tube



5.2.3. Electrical Design Components

No electrical design specifically for this alternative. Reference section 5.12.3 for lighted orifice ring requirements.

5.2.4. Structural Design Components

To vent orifice pipe through existing light tubes that will no longer be used will require a check valve and will be directed into DSM channel in the event of check valve failure and backflow. Flow should be comparable to existing due to the elimination of vacuum conditions which will offset the increase due to a larger orifice ring. The check valve will need anchorage. It could be possible to anchor to the existing bolts used for the lens. It is possible that some of the grating for the walkway will need to be modified.

5.3. ALTERNATIVE 3 – ENLARGE OUTER CORE AND INCREASE INTERIOR PIPE DIAMETER (13-INCH ORIFICE RING)

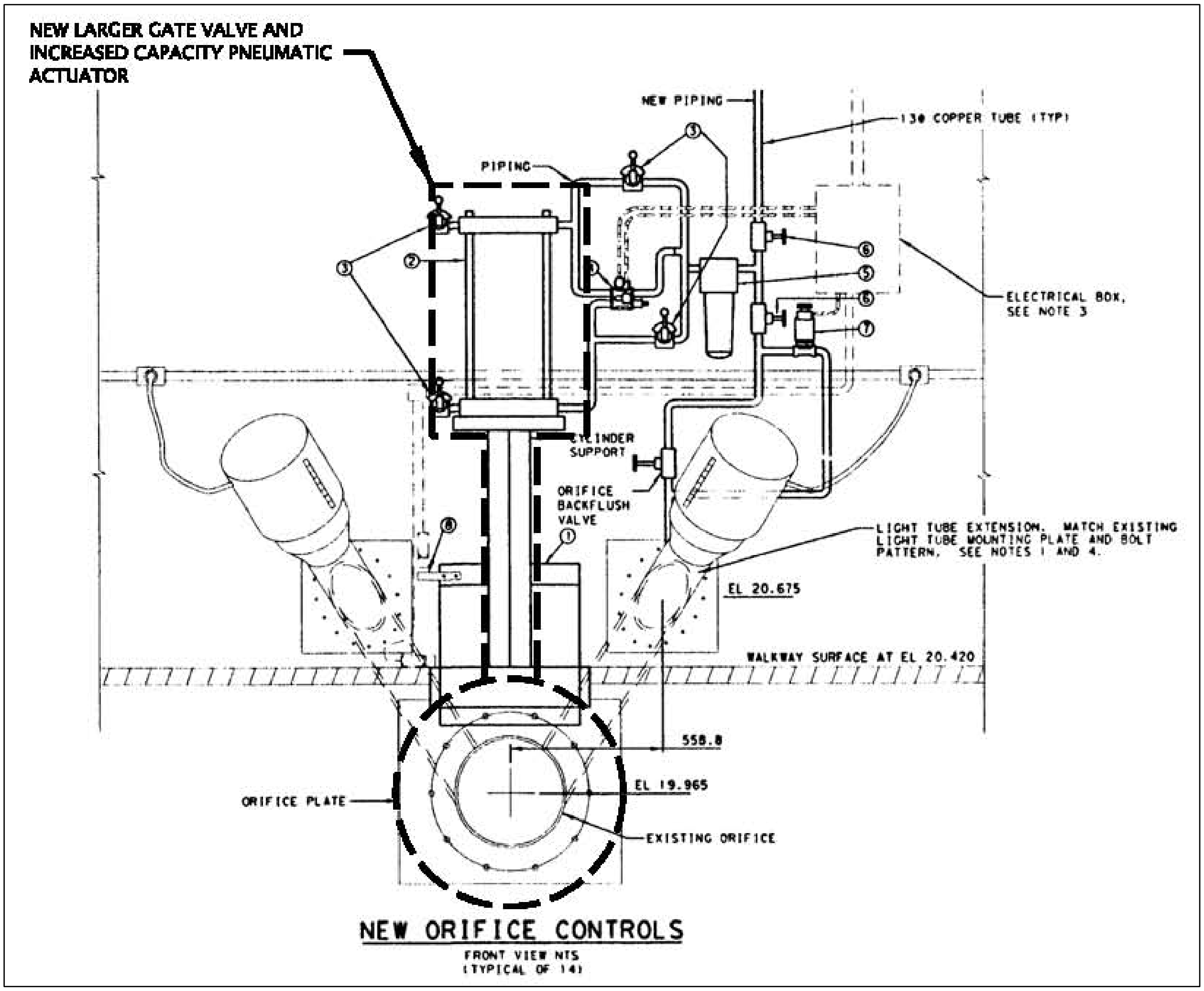
5.3.1. General Description

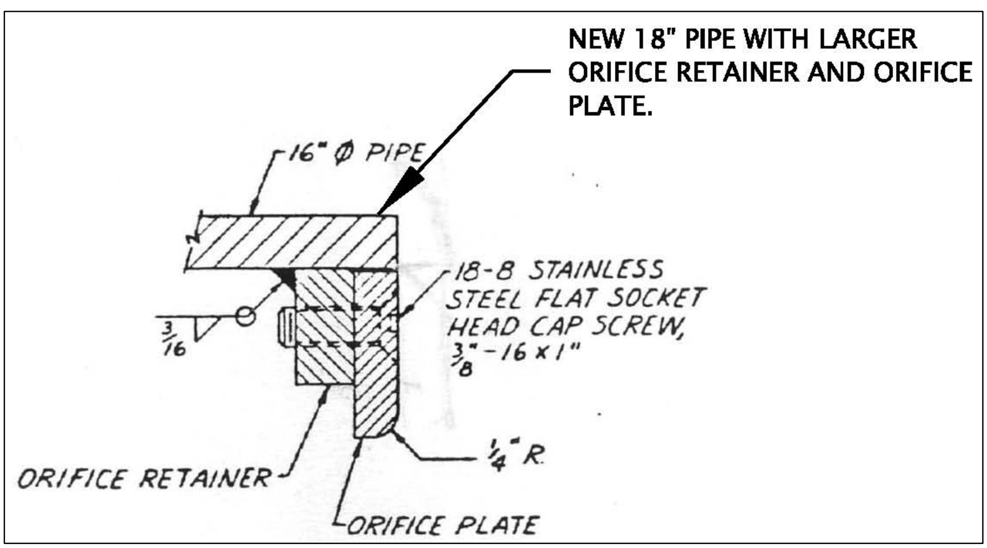
Enlarging the diameter of the concrete core and replacing the existing pipe with a larger diameter one should improve the air circulation and supply to the jet providing a jet character suitable for debris blockage observation. Increasing the available air space surrounding the jet by increasing the ratio of pipe diameter to orifice ring diameter, will allow more air entrainment to feed the jet and reduce the tendency for jet expansion and fragmentation. Preliminary air demand calculations for a 13-inch orifice ring with a larger steel pipe I.D. of 17.75 inches would be approximately 2.3 cfs (see Appendix A) or 139 ACFM. This alternative would apply to the 42 existing gated orifice systems and assumes that providing sufficient air supply to feed the jet will return flows to the 1997 designed 13-inch orifice ring flows.

5.3.2. Mechanical Design Components

If the jet pipe diameters are increased, then the gate valve size will need to be increased as well to allow more room for the jet to clear them before entering the DSM, in addition to allowing more air to enter the pipe. If the gate valves do get larger, then the pneumatic actuators will need to be replaced with actuators that have a higher force output. This is due to the increased weight of the larger valve and the increased friction force developed by having a larger surface area subject to upstream pressure. Additionally, the larger valves will require a longer stroke to open and close completely. The recommended valve size for a 17.75-inch I.D. pipe is 18-inches I.D. (Figure 5-3). Additionally, the new 17.75-inch I.D. pipe sleeve will need to be added. New 13-inch diameter orifice rings would need to be manufactured. In order to reattach the orifice ring and gate valve, a new orifice retainer and gate valve mounting plate will need to be added to the new pipe assembly (see Figure 5-3). The pneumatic piping will need to be reconfigured slightly to attach to the new actuators.

Figure 5-3. Alternative 3 – Re-core Orifice Tube to Larger Size





5.3.3. Electrical Design Components

No electrical design specifically for this alternative. Reference section 5.12.3 for lighted orifice ring requirements.

5.3.4. Structural Design Components

The current out-to-out diameter of the bore holes is 15.75 inches. The structural focus will be on coring, anchoring, and reinforcement. Re-core the orifice to larger diameter ≥ 19 inches (existing about 16 inches) to allow for ≥ 17.75-inch I.D. inner sleeve (pipe) while increasing the upstream orifice ring size from about 12 5/8 to 13 inches. This should provide enough area surrounding the jet to allow sufficient air to maintain a clean jet for higher forebay elevations. Flow should be comparable to existing due to the elimination of vacuum conditions which will offset the increase due to a larger orifice ring. Actual size of inner sleeve will depend somewhat on the anticipated jet trajectory and the balance between increased length due to gate housing and the added clearance provided by the increase in pipe diameter.

Concrete coring will require over excavation and grouting back concrete cover in order to provide adequate protection of the reinforcement in accordance with EM-1110-2-2104. The over excavation will require 3-inch grout. This requires the first cut to be at least 20 inches and the second cut line is located 22 inches from the centerline of the core. Coring will be limited to a maximum 36-inch core with a 30-inch conduit. Anchorage to the concrete wall of any new fixtures will require post installed bolts. Given the location, age, and quality of concrete, undercut anchors will be used at a minimum for anchorage.

5.4. Alternative 4 – Reduce the Orifice Ring Size (≤ 12 inches) and Open Additional Orifices

5.4.1. General Description

Reducing the orifice ring size, while maintaining the existing inner diameter of the pipe, will increase the volume of air space surrounding the jet. This should alleviate some of the air demand and produce a cohesive jet. Field testing in 2006 indicated that the 11-inch diameter jet appeared better than the 12-inch diameter jet; however, both were considered better than the existing 12 5/8-inch diameter jet. Air demand calculations indicate approximately 2.1 cfs, or 126 ACFM, for a 12-inch diameter orifice and a 15-inch steel pipe I.D. Reducing the current orifice ring size from 12 5/8 inches will reduce the total flow. This can be compensated for by opening seven additional orifices (were originally cored but not gated) to maintain the design flow, as needed (49 orifices total). This will also impact the existing collection channel velocities (see Appendix A for comparison of channel velocities for 13-inch versus 12-inch orifice rings).

5.4.2. Mechanical Design Components

New 12-inch diameter orifice rings would need to be manufactured. The new rings could easily be installed using the existing orifice retainer. New 300 series stainless steel fasteners would be installed. Additional gate systems would need to be added to seven of the existing cored but blanked-off south orifices that were included in the original design. This includes 15A, 15B, 15C, 16A, 16B, 16C, and 17A. These locations will require new gate valves, pneumatic actuators and air supply lines tapped into the air supply header. Because the demand per actuator does not change and the duration is only increased by several seconds per actuator, the existing air system has adequate capacity to operate these additional actuators. The controller will be updated to include the additional gates into the control system.

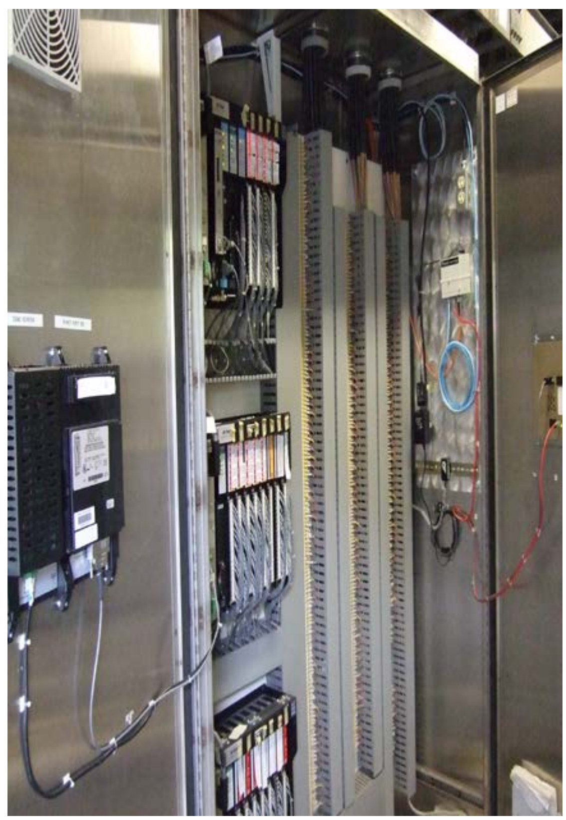
5.4.3. Electrical Design Components

New orifice control cabinets similar to what's shown in Figure 5-4 will need to be installed for each of the seven new gate systems. Each control cabinet will be equipped with terminal strips, control switches, conduit and control wiring to the new solenoid valves and back to the existing PLC located in the electrical room on the elevation 90 intake deck (Figure 5-5) on the Washington side of the second powerhouse. Although there are 18 spare inputs and 14 spare outputs on the existing PLC system, the processor and I/O modules are antiquated and availability of spare parts is dwindling. Consequently, there may be a need to use newer PLC technology from such manufacturers as Opto 22 or an Opto 22/Allen-Bradley combination which is used in other systems at Bonneville. The DSM air burst system and vertical barrier screen (VBS) both use Opto 22 hardware and then newer domestic water system uses Opto 22/Allen Bradley technology. Using the existing SyMax PLC would be less expensive than using all new hardware, but life expectancy and technical support from the manufacturer has been limited as reported from maintenance personnel at Bonneville. For either option, the PLC and HMI would need to be programmed.

Reference section 5.12.3 for lighted orifice ring requirements.

Figure 5-4. Actuator Local Control Panel

Figure 5-5. PLC Cabinet, Elect. Rm +90 Deck



5.4.4. Structural Design Components

Assume using new inner diameter and keeping the old outside diameter and existing bolts.

5.5. ALTERNATIVE 5 – REDUCE THE ORIFICE RING SIZE TO 12 INCHES AND SEASONALLY MODIFY OPERATION OF DSM SYSTEM

5.5.1. General Description

The maximum allowable velocity through the dewatering screens for the existing system is 0.4 fps (fry criteria). This limits the amount of flow that the dewatering system can handle. Currently, orifices are opened/closed to maintain a downstream collection channel depth of 13.2 feet for the full range of forebays. This alternative proposes a modification to the maximum screen velocity to 0.6 fps (fingerling criteria) for a portion of the fish passage season for which fry have already passed downstream. This criteria change would allow approximately 100 cfs of additional flow into the system. Approximately 14 new orifices (56 total) could be operated by modifying the all of the south orifices that have been cored and blind flanged. Four additional orifices (60 total) in units 11 and 12 could be cored and gated and still remain within the 100 cfs additional flow gained by the change in criteria. However, there is not a significant biological gain for the extra cost of coring four new orifices so the maximum of 56 orifices would be made operative for this alternative. Hydraulic challenges for this alternative include re-setting the dewatering gates mid-season for fry criteria. This will likely be a difficult task and success of this alternative is contingent on adequate drainage downstream of the weirs.

Similar to Alternative 4, preliminary air demand calculations indicate approximately 2.1 cfs, or 121 ACFM, for a 12-inch diameter orifice and a 15-inch steel pipe I.D. This will also impact the existing collection channel velocities (see Appendix A for comparison of channel velocities for 13-inch versus 12-inch orifice rings).

5.5.2. Mechanical Design Components

In addition to the work covered under Section 5.4.2, five additional gate valve systems would be added to existing south orifice cores 17B, 17C, 18A, 18B, and 18C. These locations will require new gate valves, pneumatic actuators and air supply lines tapped into the air supply header. Because the demand per actuator does not change and the duration is only increased by several seconds per actuator, the existing air system has adequate capacity to operate these additional actuators. The controller will be updated to include the additional gates into the control system.

5.5.3. Electrical Design Components

Similar electrical equipment and wiring as discussed in Section 5.4.3 will need to be installed to support the additional 14 gate valve systems. Reference section 5.12.3 for lighted orifice ring requirements.

5.5.4. Structural Design Components

See Section 5.4.4.

5.6. Alternative 6 – Camera in Bulkhead for Visual Inspection

5.6.1. General Description

This alternative provides a different means of monitoring the orifice entrance for potential debris blockage using submersible cameras in the bulkhead slot for viewing. This would allow other downstream options to include bottom supported jet flow (Alternative 9) alleviating potential jet impingement at lower forebays. This alternative would apply to the 42 existing gated orifice systems and can be combined with Alternative 9.

5.6.2. Mechanical Design Components

Due to space limitations in the bulkhead slot, a submersible camera would require a steel frame for deployment, similar to the frame used to inspect the VBS and STS (Figure 5-6). The frame would be left in place until that slot needed to be accessed. This alternative assumes that the water is clear enough for adequate visibility. It is assumed that the lights from the new light rings would provide adequate light to provide a silhouette of the debris blocking the orifice. This visual indication of debris would be used to determine if an orifice should be manually cleaned or not. If the amount of light is not adequate, then it may not be possible to add additional lights to the frame since it could possibly distract the fish in the gatewell from noticing the orifice light rings. The frame would allow for easy extraction of the cameras for maintenance and could simplify the install. The camera frame would need to be extracted by the second powerhouse gantry crane or a mobile crane.

Didson cameras were considered for this application. Although the cameras would be able to provide an adequate image of the orifices for debris detection there would need to be one camera per orifice due to viewing angles. Each camera is approximately $80k so the cost would be $2 to $3 million dollars. Additionally the mounting areas are not ideal and the cameras, signal wire, and power wire would be prone to damage by gates and debris. The team has ruled this out as a viable option.

Mounting any style of camera over the orifice is also not feasible due to fish strike risk and potential for damage to the equipment.

5.6.3. Electrical Design Components

The cameras would require submersible fiber optic data cable, power cable, fiber optic/coax receivers for each camera feed, a central processor/matrix switcher receiver, and at least one monitor for control room viewing. Moreover, each camera would require power from a nearby panel board in the gallery.

Reference section 5.12.3 for lighted orifice ring requirements.

5.6.4. Structural Design Components

This assumes the camera is deployed using a steel frame similar to the current camera frame used to inspect the VBS and STS. This additional camera will utilize the VBS slot (see frame in Figure 5-6).

Figure 5-6. Alternative 6 – Camera in Bulkhead for Visual Inspection

5.7. ALTERNATIVE 7 – PRESSURE TRANSDUCER ACROSS ORIFICE OPENING

5.7.1. General Description

This alternative provides a different means of monitoring orifice entrance for potential debris blockage using pressure transducers across the orifice opening in the bulkhead slot to sense blockage. This would allow an alternative downstream option to the free jet such as a bottom-supported jet (Alternative 9), alleviating potential for jet impingement at lower forebays. This alternative would apply to the 42 existing gated orifice systems.

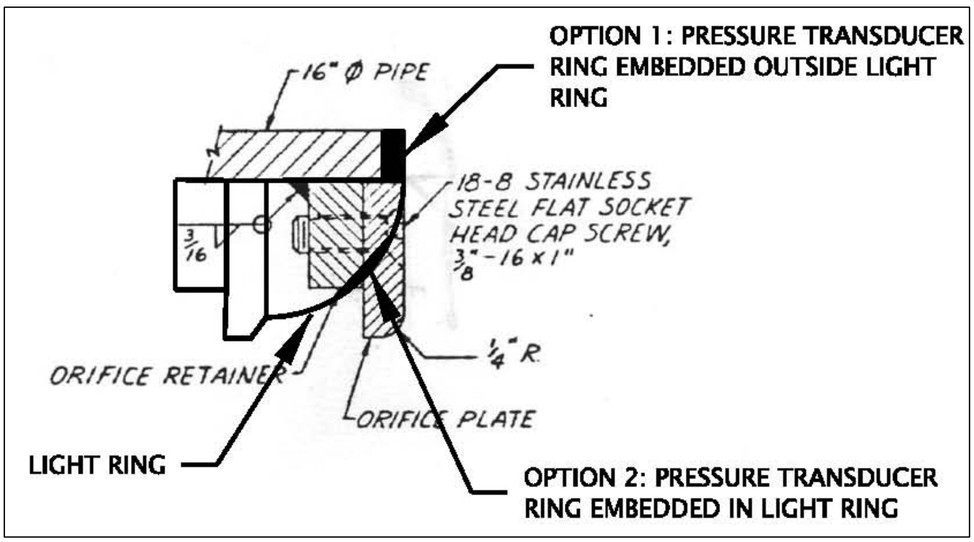
5.7.2. Mechanical Design Components

There are two options for this alternative.

- Option 1: The pressure transducer ring could be incorporated into the light ring. When debris is present, it would get lodged across the light ring and create a rise in pressure on the pressure ring. This increase in pressure would be signaled to the operators and the orifice could then be manually cleaned. To accomplish this, signal cable could be run to the PLC analog input module for monitoring.
- Option 2: The transducer could be mounted just outside the light ring embedded in the wall. The ring's function would be the same as Option 1 but would be used in case the pressure transducer ring was too large to fit inside the light ring (Figure 5-7).

In either configuration the pressure transducers would be very difficult to access for maintenance or replacement. An outage would be required for personnel to enter the gate well. A redundant pressure transducer ring could be built in to provide robustness but failures due to damage from debris would likely affect both sensors. The O&M challenges associated with this alternative are significant.

Figure 5-7. Alternative 7 – Pressure Transducer Across Orifice Opening



5.7.3. Electrical Design Components

Materials would include a local pressure-monitoring device for each orifice, submersible signal cable, conduit, and wiring between the output contact and a digital input on the existing SyMax PLC and submersible signal cable. The SyMax PLC has 18 spare inputs which would not be enough for 42 orifice transmitters thus two additional 16-point digital input modules are required. Furthermore, the transmitters would require one or multiple 24VDC power supplies for loop power. However, as discussed in Alternative 4 (Section 5.4.3), if the Bonneville project personnel expressed a desire to move away from using the existing PLC system then this alternative would also include new PLC hardware. A time delay would be utilized to prevent nuisance indication from debris striking the sensor as it passed by the orifice.

Reference section 5.12.3 for lighted orifice ring requirements.

5.7.4. Structural Design Components

Assume using existing light tube for electrical cable and conduit routing with the pressure transducer power and signal cable being rated for submersible use.

5.8. Alternative 8 – Sonic/Acoustic Sensor Across Orifice

5.8.1. General Description

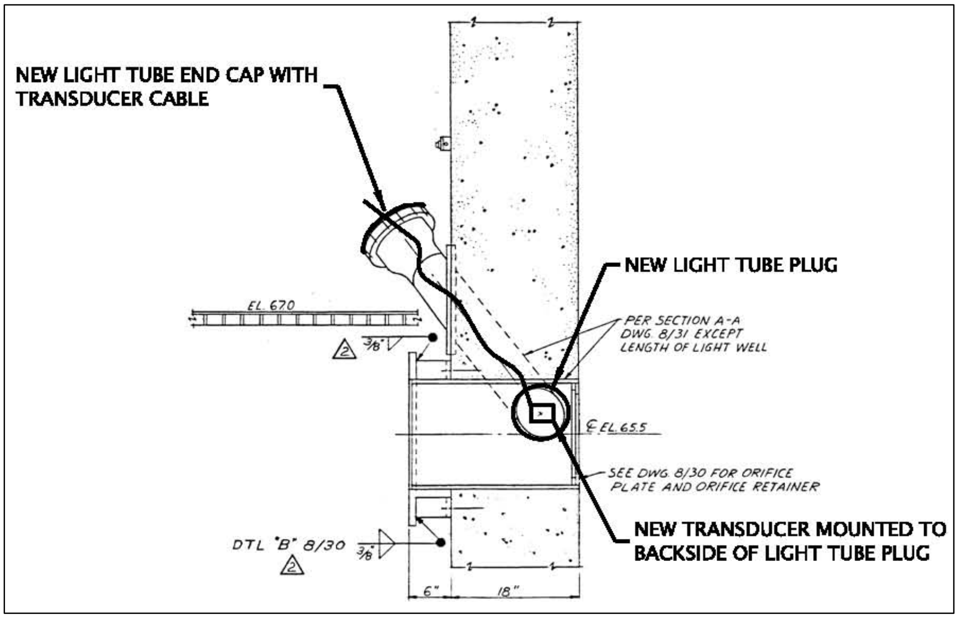
This alternative provides a different means of monitoring orifice entrance for potential debris blockage using sonic/acoustic sensors across orifice openings. This would also allow the pipe to flow full (Alternative 10) eliminating potential jet impingement at lower forebays. This alternative would apply to the 42 existing gated orifice systems.

5.8.2. Mechanical Design Components

This alternative uses a sonic sensor to measure turbulence in the pipe and compare it to turbulence observed with a clean orifice. When the orifice is blocked the jet would become more turbulent and the operators would know that the orifice was blocked based on the output of the sonic sensor. The operators could initiate a cleaning cycle from the control room specifically for that blocked orifice instead of cleaning all of them. A sensor would need to be installed in each orifice pipe sleeve and connected to a PLC analog input for reporting. The existing light tubes and pipe sleeve would need to be modified to accommodate the transducer. A steel plate plug would be installed in the existing light tube opening and the transducer would be mounted to the backside of the plate inside the light tube space. The signal cable from the transducer would run up through a new cap that would seal the light tube in place of the lens (Figure 5-8).

Preliminary research indicates that the sonic sensors available on the market would not be able to differentiate between the acoustic signals of a clean jet and a disturbed jet. They could be used to detect debris directly from the gatewell side of the orifice but the current market offering does not include water proof sonic sensors rated for full submersion. Photoelectric sensors were recommended by the manufacturer in lieu of sonic sensors but the range is only up to several inches in clear water. In seasonally variable turbid water the sensors would be so close to the orifice that they would interfere with fish egress from the gatewell and increase the likelihood of fish strike.

Figure 5-8. Alternative 8 – Sonic/Acoustic Sensor Across Orifice



5.8.3. Electrical Design Components

Electrical requirements would be similar to that described in Section 5.7.3.

Reference section 5.12.3 for lighted orifice ring requirements.

5.8.4. Structural Design Components

No structural effort noted.

5.9. Alternative 9 – Pipe Insert to Act as Trough

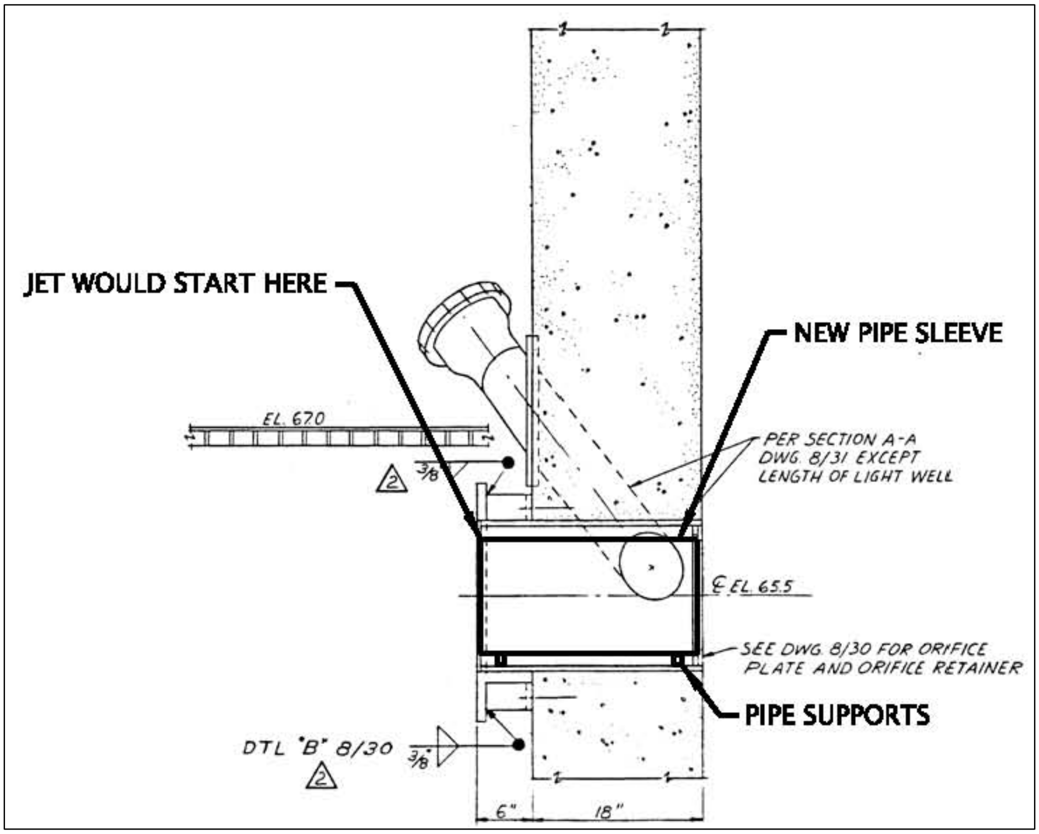
5.9.1. General Description

This alternative could be combined with Alternatives 6 and 7. The insert would support the underside of the jet, eliminating opportunity for impingement at the orifice exit. This alternative would apply to the 42 existing gated orifice systems.

5.9.2. Mechanical Design Components

A painted or stainless steel pipe with the same I.D. as the orifice would be installed in the existing pipe sleeve and be sealed against the backside of the orifice ring (Figure 5-9).

Figure 5-9. Alternative 9 – Tube Insert to Act as Trough



5.9.3. Electrical Design Components

No electrical design specifically for this alternative. Reference section 5.12.3 for lighted orifice ring requirements.

5.9.4. Structural Design Components

No structural effort noted.

5.10. Alternative 10 – Round Entrance Pipe Insert

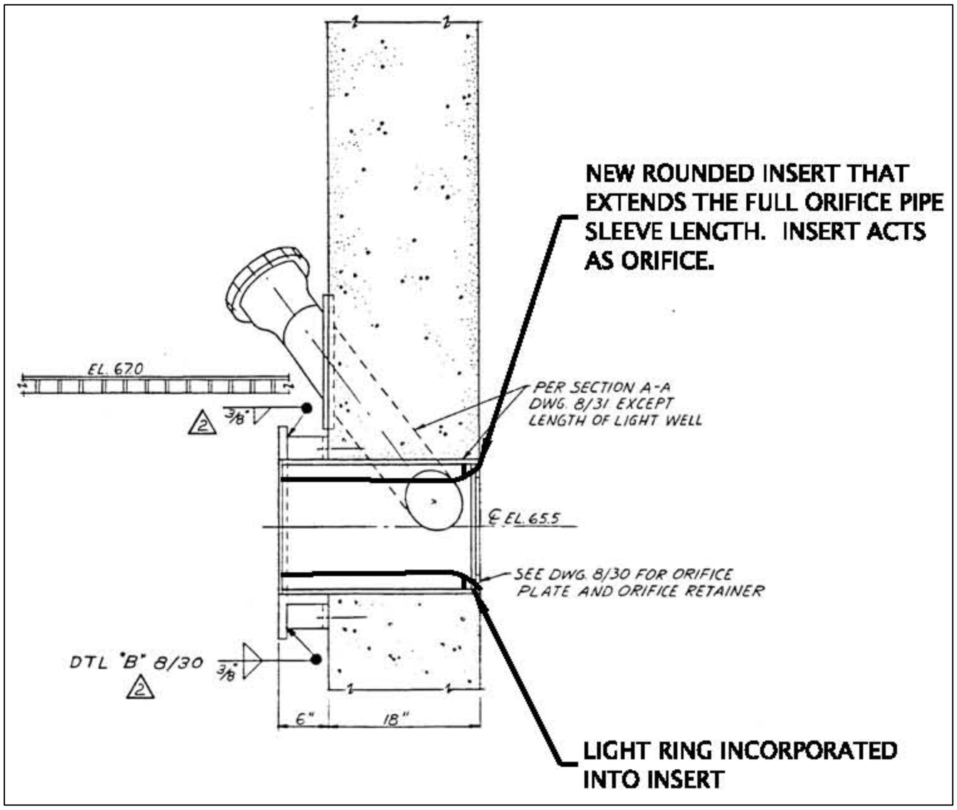
5.10.1. General Description

This alternative could be combined with Alternative 8. The rounded entrance tube insert would support the full flow jet, eliminating opportunity for impingement at the orifice exit. This alternative would apply to the 42 existing gated orifice systems.

5.10.2. Mechanical Design Components

The insert would be cast or machined on a CNC milling machine to make sure that the correct profile is achieved. The insert would be anchored to the existing pipe sleeve and/or orifice retainer (Figure 5-10). The slight expansion in the insert toward the downstream end will prevent debris from collecting and wedging further into the insert beyond the smallest diameter portion.

Figure 5-10. Alternative 10 – Round Entrance Tube Insert



5.10.3. Electrical Design Components

No electrical design specifically for this alternative. Reference section 5.12.3 for lighted orifice ring requirements.

5.10.4. Structural Design Components

Provide a full-flow jet supported all of the way to the gate housing by adding an insert likely with rounded entrance and potentially expanding diameter downstream. The insert would be sized to provide comparable flow to existing flow.

5.11. Alternative 11 – Minimize Length of Pipe and Mounting Flange

5.11.1. General Description

Several field observations have indicated that the quality of the jet tends to be better for those orifices where the concrete was chipped away at the exit to allow the gate to align as closely as possible with the downstream wall (Table 3-1). This occurs on nine of the working orifices. Alternative 11 will be combined with Alternatives 1 to 5 to reduce opportunity for jet trajectory impingement and further reduce the air deficit. This alternative would apply to approximately 33 of the 42 existing gated orifice systems and all newly opened orifices, depending on the alternative selected.

5.11.2. Mechanical Design Components

There are two different sizes of actuators used on the orifice gate valves. The smaller of the two is used on orifices such as 12A-N. On orifices like 12A-N the concrete has been chipped away allowing room for the actuator to be recessed into the concrete. This also allows the gate valve to be mounted flush with the mounting plate giving an overall distance of 0.6 inches from DSM wall to upstream face of the gate.

Although the smaller actuators were used on many of the orifices, orifices such as 14A-N did not have the concrete removed so the gate valve had to be mounted offset from the wall using spacer rings to allow clearance for the actuator. This results in an overall distance of 4.2 inches from DSM wall to upstream face of the gate.

The larger actuators are used on orifices such as 14A-S. The concrete was not removed at any these orifices and to provide clearance for the larger actuators the gate valves were offset further resulting in an overall distance of 7.2 inches from DSM wall to upstream face of the gate.

This alternative would remove the concrete as needed to allow all of the gate valves to be mounted flush on the mounting plate resulting in a uniform 0.6 inch offset between valve gate and DSM wall. This reduces the distance required for the jet to clear the gate valve housing and also reduces the distance required for the air to reach and support the jet.

The majority of the existing mechanical components would be reused for this option. The pneumatic piping would need to be modified at the end connections to match the slightly relocated pneumatic actuators (Figure 5-11). Each valve would be recessed according to the size of the pneumatic actuator.

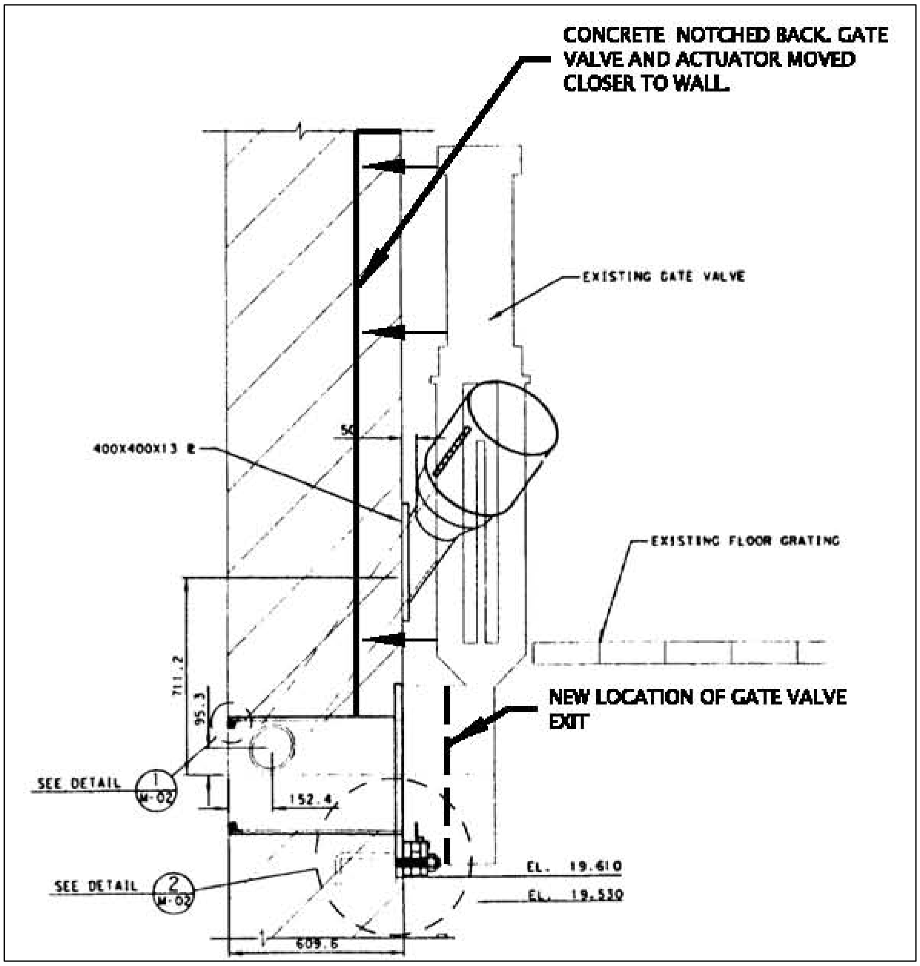
5.11.3. Electrical Design Components

No electrical design specifically for this alternative. Reference section 5.12.3 for lighted orifice ring requirements.

5.11.4. Structural Design Components

This will require mining out the concrete surrounding the actuator and installing a galvanized steel frame around the excavation. The affected area of concrete would be about 3 cubic feet of mining. The frame would be roughly 8 feet of 8 x 2 x ¼-inch pipe that is steel grouted and anchored into the concrete.

Figure 5-11. Alternative 11 – Minimize Length of Pipe and Mounting Flange



5.12. ALTERNATIVE 12 – REPLACE ORIFICE RING WITH LIGHTED ORIFICE RING

5.12.1. General Description

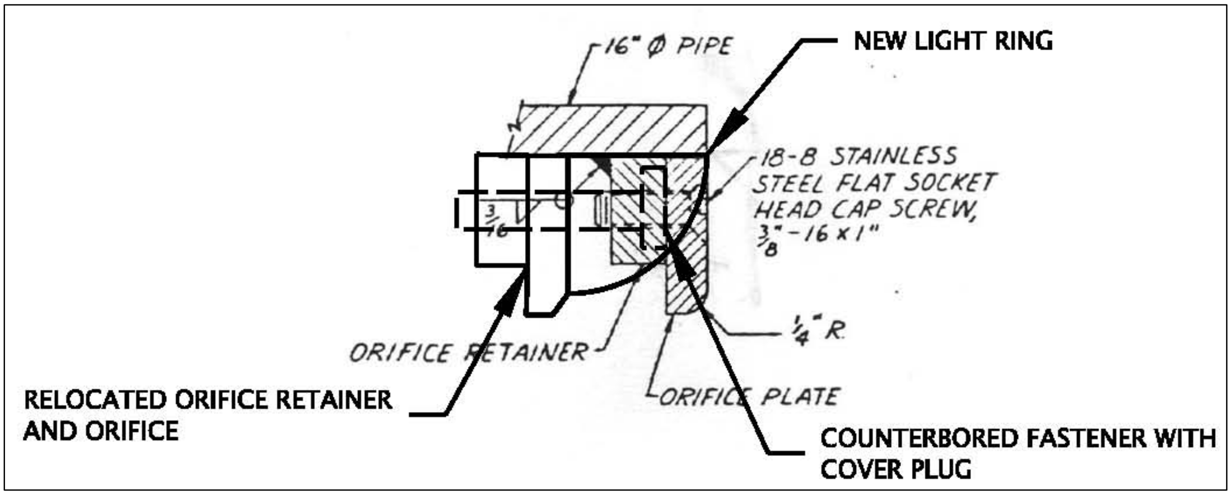
This alternative will be undertaken in conjunction with any selected alternative. Number of lighted orifice rings will be determined by the alternative selected.

5.12.2. Mechanical Design Components

The new light ring containing LED's can be mounted inside the existing orifice pipe sleeve. The outside of the light ring would be flush with the wall inside the gatewell. In order to accommodate the light ring, the orifice retainer would need to be relocated further back inside the pipe sleeve. The light ring would be mounted using the same fasteners as the orifice ring. A new retainer ring and fasteners would be required since the existing components will most likely be destroyed during removal (Figure 5-12). This alternative should have a very smooth transition from the radius light ring to the orifice plate contrary to the abrupt transition in the figure.

Similarly, lighting could be provided via fiber optic cables routed through the existing light tubes to the back of the light ring. This would potentially provide significant improvements in both lighting and O&M costs for light replacement. The lighting would be improved over the existing lighting because the light could be emitted right at the orifice ring. The O&M costs are anticipated to be less because the fiber optics would stay embedded while the lights themselves could be replaced from the DSM channel walkway. Conversely, the lighted orifice ring using LED's would require entry to into the gatewell for replacement.

Figure 5-42. Alternative 12 – Replace Orifice with Lighted Orifice Ring



5.12.3. Electrical Design Components

The lighted orifice ring would be comprised of LED lights encased in clear epoxy, similar to acrylic. The light ring would emit 27.9 fc, equivalent to 300 lux. A series of emitters would be oriented toward the center of the pipe to give the illusion the fish are entering a lighted space or pool. The ring will output 200-300 lux in the gate well measured near the orifice with methods employed by Axel et al. (2011).

Each ring would include a power supply transformer that converts 120VAC to 24VAC. The existing incandescent lights will be removed and an abandoned light tube can be used to route the power cable from the new LED light to the power source. The leads from the LED light power supply cable can be wired to 120VAC power from the circuit that feeds the receptacles.

Six light emitting diodes are wired in series in a chain with several chains in the overall LED ring. The possibility exists that one LED could stop emitting but it is uncommon for more than one LED in that chain to burn out. The LEDs are designed for an ambient temperature of 25°C (78°F), however the actual ambient temperatures of the LEDs will depend on the thermodynamics of the epoxy used. The water temperature in which it will be submersed has a temperature range from 1°Celsius (34°F) to 22 °C (72° F). It is likely that the light will be operating in lower ambient temperatures than what it is designed for which is conducive to its longevity and is inversely proportional to temperature; the lower the temperature the longer the life so it is quite likely the LED ring could last beyond five years. Consideration of the appropriate type of encasing materials to benefit longevity will be explored in the DDR.

Another feature that could be added to the LED ring is redundant lighting within the same encapsulated ring that could be switched on separately should the primary LEDs burn out after several years and are no longer producing the desired luminance. This could prolong the useful light of the ring itself without going to the trouble of removing it and replacing it with an entirely new light ring. Moreover, the light ring could also be equipped to a dimmer giving even more control of light output.

While fiber optic lighting holds some promise, this type of lighting system was never tested by PNNL like the LED light ring solution. The light ring was placed outside the orifice so we have some idea what its efficacy is for fish attraction at a known illumination level.

Installing the fibers into the light tubes just inside the orifice would be easy but the light source has been essentially relocated and this may or may not have an impact on fish attraction. Moreover, it is unknown, without doing further research, what the illumination level should be and how many end-emitting fibers would be required to produce the required illumination level factoring in fiber attenuation which is proportional to the length of fiber.

The concept has merit but would require further development and testing.

5.12.4. Structural Design Components

Possibly mining out the existing concrete where the light tube and ring anchor. Grout back the new orifice ring and install new anchors.

6. ALTERNATIVES EVALUATION

6.1. Evaluation of Alternatives

The initial rating for the Alternatives described in the EDR was undertaken by the Product Delivery Team (PDT). The PDT developed an alternative matrix (Table 6-1) designed to evaluate and compare the 8 alternatives developed in this study. Although the matrix was designed and weighted by the PDT, Agency thoughts and concerns were relayed through responses to the 60% and 90% reports and special FFDRWG meetings and are included in Appendix C-Regional Coordination. (Note that in Table 6-1: Alternative Evaluation Matrix, Agency comments are shown in red).

The alternatives were divided into three main categories of means to improve downstream fish passage: Alternatives that allow observable passage route; Alternatives that reduce jet impingement in conjunction with alternatives #6-#8; and Alternatives that can be included with other alternatives. Within each Alternative category there are individual concepts to consider, each with several options (see below).

ALTERNATIVES THAT ALLOW OBSERVABLE PASSAGE ROUTE

- Aerate Free Jet to Provide Observable Passage Route Downstream of Orifice
  1. Add Compressed Air to Orifice Tube
  2. Vent Orifice Tube Using Existing Light Tube Ports
  3. Re-Core Orifice Tube to Larger Size

- Aerate Free Jet to Provide Observable Passage Route Downstream of Orifice + Add More Opportunity for Exposure With Additional Orifices
  4. Reduce Orifice Ring Size <= 12” & Open Additional Orifices as Needed
  5. Increase Capacity of DSM, Reduce Orifice Ring Size <= 12” & Open Additional Orifices as Needed and/or Add Gates/Rings to Additional S. Entrances

- Provide Observable Passage Route Upstream of Orifice
  6. Cameras in Gatewell for Visual Inspection Upstream in Conjunction With Alt. #9
  7. Pressure Transducers Across Orifice Openings in Conjunction With Alt. #9
  8. Sonic/Acoustic Sensors Across Orifice Openings in Conjunction With Alt. #10

ALTERNATIVES THAT REDUCE JET IMPINGEMENT IN CONJUNCTION WITH ALTERNATIVES #6-8

- Reduce Jet Impingement in Conjunction With Alts. #6-7

9. Tube Insert in Bottom to Support Bottom of Jet to the full length of Tube

- Reduce Jet Impingement in Conjunction With Alt. #8

10. Rounded Entrance Tube Insert Flowing Full in Conjunction With Alt. #8 Only

ALTERNATIVES THAT WILL BE INCLUDED WITH ANY CHOSEN ALTERNATIVE

- Reduce Potential for Jet Impingement in Conjunction With Chosen Alternative

11. Reduce Effective Orifice Tube Length by Removing Wall Concrete at Exit For 17 N. Orifices in Units 12-15 as well as all working S. Orifices.

- Increase Fish Attraction in Conjunction With Chosen Alternative
  12. Replace Orifice Rings with Light Emitting Orifice Rings

The first round of scoring was undertaken by the PDT for the 8 alternatives grouped together by concept and separated by color in the table. The alternatives were rated relative to each other based on the following seven attributes below where higher numbers represent positive impacts. Note that the Technical viability score is a combination of the following feasibility, practicality, capability, sustainability.

- Observable passage route.
- Fish condition with modification.
- Alignment with DSM criteria.
- Technical viability.
- O&M cost.
- Ease of testing proof of concept.
- Construction timing.

This first-round scoring ranged from 1 to 4 (poor to excellent) for all but the O&M cost category, which ranged from 0 (high cost) to 4 (low cost). Comments from the PDT related to the alternatives during the matrix evaluation are in black type under the "Comments" column in Table 6-1. Additional comments from Fish Facilities Design and Review Work Group (FFDRWG) members at the 17 August 2011 special FFDRWG meeting are included in the "Comments" column in red. The scoring utilized a relative comparison between the options within the designations of:

Poor	= 1
Fair	= 2
Good	= 3
Excellent	= 4

This method allowed a comparative assessment between ideas and groupings to allow clusters of potential options.

First-round scoring did not include construction cost considerations, nor weighting factors. Based on the seven attributes shown above, the remaining top six alternatives are shown below:

Alternative 1: Add compressed air to orifice tube (13-inch orifice rings). = 17
Alternative 2: Vent orifice tube using existing light tube ports (13-inch orifice rings). = 18
Alternative 3: Re-core orifice tube to larger size (13-inch orifice rings). = 20
Alternative 4: Reduce orifice ring size (≤ 12 inches) and open additional orifices, as needed, to maintain channel design flow. = 20
Alternative 5: Seasonally increase capacity of DSM, reduce orifice ring size <= 12" & open additional orifices as needed and/or add gates/rings to additional S. Entrances. = 19
Alternative 6: Install cameras in gatewell for visual inspection upstream in conjunction with Alternative 9 (tube insert). = 17
Note: Subsequently Alternative 6 was deleted due to excessive O&M cost and interference with existing fish operations, thereby leaving only 5 remaining top Alternatives.

Second-round scoring included Weighting Factors and Construction Costs for further comparison of the 5 remaining alternatives. Weighting factors (see below) range from 1 to 4 for the previously chosen 5 top Alternatives. Similar to the initial scoring process the weighting factors are based on comparison between the alternatives rather than a specific value.

Observable passage route	= 3
Fish condition with modification	= 2.5
Alignment with DSM criteria	= 2
Technical viability	= 1
O&M cost	= 1
Ease of testing proof of concept	= 1
Construction timing	= 1

Construction cost scoring was based on the following conditions:

High	= 0
Medium-High	= 1
Medium	= 2
Low-Medium	= 3
Low	= 4

Combining the weighting factors (multiplying initial 7 categories by weighting factors) and adding 0-4 construction cost numbers resulted in the following values:

Alternative 1	30.5 + 1 = 31.5
Alternative 2	28 + 3 = 31
Alternative 3	35 + 0 = 35
Alternative 4	32.5 + 2 = 34.5
Alternative 5	31.5 + 2 = 33.5

This results in Alternatives 3, 4 and 5 (noted in green in the table below) as the higher ranking alternatives.

Table 6-1. Alternatives Evaluation Matrix

		Weighting Factors - Used on Top 5 of Initial Scores =		3	2.5	2	1	1	1	1		Top 6 Alternatives	Add'l Rated Item- Weight = 1	Top 3 Alternatives
Alternatives				Rated Item	Rated Item	Rated Item	Rated Item	Rated Item	Rated Item	Rated Item			Rated Item	
Concept	No.	Description	Orifice Ring Size	Observable Passage Route	Fish Condition With Modification	Alignment With DSM Criteria	Technical Viability	O & M Cost	Ease of Testing Proof of Concept	Construction Timing	Comments	Total Score for all Alternatives - No Weighting	Construction Cost -- (Added to top 5 scored alternatives only)	Top 5 Total Scores With Construction Cost Added and Weighting Factors Applied

Concept	No.	Description	Orifice Ring Size	Observable Passage Route	Fish Condition With Modification	Alignment With DSM Criteria	Technical Viability	O & M Cost	Ease of Testing Proof of Concept	Construction Timing	Comments	Total Score for all Alternatives - No Weighting	Construction Cost	Top 5 Total Scores
Alternatives that Allow Observable Passage Route														
Aerate Free Jet to Provide Observable Passage Route Downstream of Orifice	1	Add Compressed Air to Orifice Tube	13"	3	3	3	2	0	3	3	Ability to provide and maintain necessary air would be impractical due to space requirements, O&M costs & risk of compressor outage.	17	1	
	2	Vent Orifice Tube Using Existing Light Tube Ports	13"	2	2	3	2	3	3	3	Not likely enough air could be pulled in through light tubes based on field tests.	18	3	31
	3	Re-Core Orifice Tube to Larger Size	13"	3	4	3	3	3	3	1	Larger orifice ring size with larger diameter tube preferred by several members of FFDRWG - more similar to original design ring to tube diameter ratio and less potential for debris blockage.	20	0	35
Aerate Free Jet to Provide Observable Passage Route Downstream of Orifice + Add More Opportunity for Exposure With Additional Orifices	4	Reduce Orifice Ring Size <= 12" & Open Additional Orifices as Needed	<= 12"	3	3	2	4	2	3	3	Possibly more debris blockage; concern with increased adult fallback injury w/ smaller orifice rings.	20	2	34.5
	5	Increase Capacity of DSM, Reduce Orifice Ring Size <= 12" & Open Additional Orifices as Needed and/or Add Gates/Rings to Additional S. Entrances	<= 12"	3	3	2	3	2	3	3	Possibly more debris blockage; concern with increased adult fallback injury w/ smaller orifice rings.	19	2	33.5
Provide Observable Passage Route Upstream of Orifice	6	Cameras in Gatewell for Visual Inspection Upstream In Conjunction With Alt. # 9	13"	4	3	3	1	1	3	2	Large O&M cost and interference with existing fish operations; therefore, not included in top 5.	17	x	x
	7	Pressure Transducers Across Orifice Openings In Conjunction With Alt. #9	13"	3	3	3	1	1	2	2	Interest in full flow option, but concern with debris jamming inside and whether debris blockage at entrance could be "seen."	15	x	x
	8	Sonic/Acoustic Sensors Across Orifice Openings in Conjunction With Alt. # 10	13"	3	2	3	1	1	2	2	Would require full pipe/tube flow in conjunction with Alternative #10.	14	x	x
Alternatives that Reduce Jet Impingement in Conjunction with Alternatives 6-8														
Reduce Jet Impingement in Conjunction With Alts #6-7	9	Tube Insert in Bottom to Support Bottom of Jet to the full length of Tube	-	x	x	x	x	x	x	x	As Alts 6-8 have lowest ratings, these add-on alternatives are not ranked.	x	x	x
Reduce Jet Impingement in Conjunction With Alt. # 8	10	Rounded Entrance Tube Insert Flowing Full in conjunction w/ Alt. # 8 only	-	x	x	x	x	x	x	x	As Alt #8 has lowest rating, this add-on alternative is not ranked. Interest in full flow option, but concern with debris jamming inside and whether a debris blockage at entrance could be "seen."	x	x	x
Alternatives that will be Included with any Chosen Alternative														
Reduce Potential for Jet Impingement in Conjunction With Chosen Alternative	11	Reduce Effective Orifice Tube Length by Removing Wall Concrete at Exit For ~17 N. Orifices in Units 12-15 as well as all working S. Orifices.	-	No Ranking - Assumed to be Ancillary to any Alternative.							Field assessments indicate existing orifice exits with this installation provide better jet hydraulics in S. Orifices especially for low TW. Assumed repositioning existing gates would be extension of current as built design and ancillary to chosen alt.	x	x	x
Increase Fish Attraction in Conjunction With Chosen Alternative	12	Replace Orifice Rings with Light Emitting Orifice Rings	-								Testing at McNary in 2010 showed high potential for attraction and deemed ancillary to chosen alternative.	x	x	x

NOTES:

Key	Meaning	Criteria for Ranking: General Scoring:	Cost Scoring:
22	Alternatives 9-10 not considered viable as would only be used in conjunction with alternatives 6-8 that had lowest ratings.		
X	No ratings for these alternatives as they are paired with alternatives 6 - 8 which were ranked low.		high = 0
	Top 6 Scores for 7 rating categories (no weighting or construction cost)	Poor = 1	Medium-High = 1
	Of the Top 6 Scores: Top 3 Scores for 8 rating categories and weighting (added construction cost)	Fair = 2	Medium = 2
	Ancillary features to be included in chosen alternative	Good = 3	Low-Medium = 3
Concern with injury	Comments from FFDRWG, 17 August 2011	Excellent = 4	Low = 4

Below are alternatives that were dropped after the second round along with the primary reason they didn't score as high:

- Alternative 1: Add compressed air to orifice tube.
  Ability to provide and maintain necessary air would be impractical due to space constraints, O&M costs and risk of compressor outage.
- Alternative 2: Vent orifice tube using existing light tube ports.
  Based on field observations, it is not likely that enough air could be supplied through the existing light tubes to allow this to function as a standalone alternative with a 13 inch orifice.
- Alternative 6: Cameras in gatewell for visual inspection
  Large O&M costs and interference with existing fish operations such as VBS cleaning etc.

The top scoring alternatives remaining after the second-round scoring resulted in the following:

✓ Alternative 3: Re-core orifice tube to larger size (18 inches with 13-inch orifice rings).

✓ Alternative 4: Reduce orifice ring size (≤ 12 inches) and open additional orifices, as needed, to maintain channel design flow.

✓ Alternative 5: Seasonally increase capacity of DSM, reduce orifice ring size (≤ 12 inches) and open additional orifices, as needed, to maintain channel design flow.

Table 6-2 provides the number of orifices that will need to be modified for Alternatives 3, 4 and 5.

Table 6-2. Orifice Modifications by Powerhouse Unit Groupings and the Top Three Alternatives

Orifice Groupings	Number Operating Orifices/Bay	Number of Bays per Unit	Number of Units	Available Pre-Drilled Holes Without Gates	Alt 3	Alt 4	Alt 5
					Replace Existing Working Orifices with 18" Pipe & 13" Orifice Ring	Additional Orifices with 12" Ring that would be Added to Maintain Current Channel Flow	Additional Orifices with 12" Ring that can be Added by Increasing Flow by ~100 cfs Using Existing Pre-Cored Holes
Units 11-14	2	3	4	0	24	0	0
Units 15-18	1	3	4	12	12	7	5
Fish Unit #1	1	2	1	2	2	0	2
Fish Unit #2	2	2	1	0	4	0	0
Subtotal of Orifices			10	14	42	7	7
Total Number of Orifices by Alternative					42	49	56

6.2. PRELIMINARY COST ESTIMATES

Table 6-3 summarizes the preliminary cost estimates for the top three alternatives, as well as Alternatives 11 and 12. Alternative 11 (reduces opportunity for jet trajectory impingement and air deficit) and Alternative 12 (uses lighted orifice ring) will be included with any alternative selected. A breakdown of the costs is located in Appendix B, *Cost Estimate*.

Table 6-3. Preliminary Cost Estimate

B2 Orifice Improvements 2012					
Preliminary Cost Estimate (Rounded to 100,000$)					
Prepared by: RLR					
10/25/2011					
Modified by: KAK 11/23/11					
Physical Description	**Re-core opening for 18" ID pipe; Minimize overall pipe length; Replace 12 5/8" orifice rings With 13" LED orifice rings.**	**Minimize overall pipe length; Replace 12 5/8" orifice rings with 12" LED orifice rings; Add gates to currently blind flanged orifices; Operate with additional orifices to maintain current channel operation/flow.**	**Minimize overall pipe length; Replace 12 5/8" orifice rings with 12" LED orifice rings; Add gates to currently blind flanged orifices; Modify screen velocity criteria for part of fish passage season to operate with additional flow allowing additional orifices to open.**	**Minimize overall pipe length.**	**Replace 12 5/8" orifice ring with LED orifice ring.**
(costs rounded to $100k)	**Alt 3 (42 Orifices Modified)**	**Alt 4 (49 Orifices Modified)**	**Alt 5 (56 Orifices Modified)**	**Alt 11 only (42 Orifices Modified)**	**Alt 12 only (42 Orifices Modified)**
Direct Costs	$4,000,000	$2,100,000	$3,000,000	$900,000	$1,500,000
Markups (Overhead, Profits, Bond, tax, OT)	$2,200,000	$1,100,000	$1,600,000	$500,000	$800,000
SUBTOTAL COSTS	$6,200,000	$3,200,000	$4,600,000	$1,400,000	$2,300,000
CONTINGENCY (35%)	$2,200,000	$1,100,000	$1,600,000	$500,000	$800,000
TOTAL ESTIMATE CONSTRUCTION COST	**$8,400,000**	**$4,300,000**	**$6,200,000**	**$1,900,000**	**$3,100,000**
<u>NOTES</u>					
Escalation & inflation NOT included.					
Engineering, supervision, admin, etc costs NOT included.					
Alternative 3: Utilizes 42 existing gated orifices; provides aerated jets, maintains similar jet flows, reduces opportunity for impingement, increases attraction through light ring					
Alternative 4: Utilizes 42 existing gated orifices; requires 7 additional gate systems for currently blind flanged orifices; provides aerated jet maintaining current total channel flow, uses additional orifices increasing opportunity for attraction, reduces probability for jet impingement at lower flows, increases attraction through light ring.					
Alternative 5: Utilizes 42 existing gated orifices; requires 14 additional gate systems for currently blind flanged orifices; increases DSM system flow with seasonally modified criteria at dewatering screens; provides aerated jet increasing current total channel flow, uses additional orifices increasing opportunity for attraction, reduces probability for jet impingement at lower forebays, increases attraction through light ring.					
Alternative 11: Utilizes 42 existing gated orifices; reduces probability for jet impingement at lower forebays.					
Alternative 12: Utilizes 42 existing gated orifices; increases attraction through light ring.					
Cost of Alt 11 & Alt 12 cannot be subtracted from the other alternatives due to work not being mutually exclusive.					
Cost of "Alt 11" only cannot be added to "Alt 12 only" due to overlapping costs/tasks.					
Nine Orifice lengths have already have been shortened by concrete mining. Costs in this spreadsheet do not reflect the reduction in cost for these orifices.					

6.3. ALTERNATIVE SELECTION

Alternative 3 would re-core the orifice tube to a larger size, install a larger 18-inch I.D. transport pipe, and replace the 12 5/8-inch orifice ring with a 13-inch orifice ring. Based on a higher cost of approximately $8.4 million, as compared to $4.3 million for Alternative 4, Alternative 3 was dropped from further consideration.

Alternative 5 would seasonally increase capacity of the DSM, reduce orifice ring size to 12 inches, and open additional orifices, as needed, to maintain channel design flow and velocities. Based on strong environmental agency concerns for relaxing the dewatering screen velocity criteria for part of the fish passage season, Alternative 5 was dropped from further consideration.

Alternative 4 was initially selected as the recommended alternative because of the improved ability for the project to detect debris plugs at the orifice and reduce the likelihood of fish impingement due to alignment of orifice flow. This considered system operations and its inclusion with Alternative 11 (reduces opportunity for jet trajectory impingement and air deficit) and Alternative 12 (uses lighted orifice ring). Alternative 4 would reduce the orifice ring size to 12 inches (with a smooth lip similar to existing orifice rings) and open additional orifices, as needed, to maintain channel design flow and velocities. Table 7-1 shows some of the major components by orifice. Table 7-2 compares the expected channel velocities between the 1997 design and Alternative 4. These preliminary estimates show that Alternative 4 channel hydraulics mimic the 1997 design velocities fairly well.

Table 6-4. Major Components of Alternative 4 by Orifice

Orifice	Current Actuator Type	Recommended Alternative (Alt 4)		
		Mine Concrete to Reduce Gap Btn Wall & Gate	Flanged Cores/Tubes to be Gated	12" Lighted Orifice Rings
11 A (S)	Blue	X		X
11 A (N)	Silver	X		X
11 B (S)	Blue	X		X
11 B (N)	Silver	X		X
11 C (S)	Blue	X		X
11 C (N)	Silver	X		X
12 A (S)	Blue	X		X
12 A (N)	Silver-Recessed	NA		X
12 B (S)	Blue	X		X
12 B (N)	Silver-Recessed	NA		X
12 C (S)	Blue	X		X
12 C (N)	Silver-Recessed	NA		X
13 A (S)	Blue	X		X
13 A (N)	Silver-Recessed	NA		X
13 B (S)	Blue	X		X
13 B (N)	Silver-Recessed	NA		X
13 C (S)	Blue	X		X
13 C (N)	Silver-Recessed	NA		X
14 A (S)	Blue	X		X
14 A (N)	Silver	X		X
14 B (S)	Blue	X		X
14 B (N)	Silver	X		X
14 C (S)	Blue	X		X
14 C (N)	Silver	X		X
15 A (S)	Blind-Flanged	X	X	X
15 A (N)	Silver-Recessed	NA		X
15 B (S)	Blind-Flanged	X	X	X
15 B (N)	Silver-Recessed	NA		X
15 C (S)	Blind-Flanged	X	X	X
15 C (N)	Silver-Recessed	NA		X
				X
16 A (S)	Blind-Flanged	X	X	X
16 A (N)	Silver	X		X
16 B (S)	Blind-Flanged	X	X	X
16 B (N)	Silver	X		X
16 C (S)	Blind-Flanged	X	X	X
16 C (N)	Silver	X		X
17 A (S)	Blind-Flanged	X	X	X
17 A (N)	Silver	X		X
17 B (S)	Blind-Flanged			
17 B (N)	Silver	X		X
17 C (S)	Blind-Flanged			
17 C (N)	Silver	X		X
18 A (S)	Blind-Flanged			
18 A (N)	Silver	X		X
18 B (S)	Blind-Flanged			
18 B (N)	Silver	X		X
18 BC(N)	Blind-Flanged			
18 C (N)	Silver	X		X
F1 A (N)	Silver	X		X
F1 B (N)	Silver	X		X
F2 A (S)	Blue	X		X
F2 A (N)	Black/Silver	X		X
F2 B (S)	Blue	X		X
F2 B (N)	Black	X		X
Total No. Orifices		**40**	**7**	**49**

Table 6-5. Preliminary Comparison of Channel Velocities between 1997 Design Flows/Velocities and Alternative 4 Flows/Velocities

Estimated Change in Collection Channel Hydraulics Between 1997 Design and Alternative A4

Channel Discharge Increases Down Page S to N	Forebay El. 71.5 ft.				Forebay El. 74.5 ft.				Forebay El. 76.5 ft.			
	Orifice Discharge (cfs)		Channel Velocity (fps)		Orifice Discharge (cfs)		Channel Velocity (fps)		Orifice Discharge (cfs)		Channel Velocity (fps)	
	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice	1997 - 13" Orifice	Alt 4 - 12" Orifice
↓												
11 A	10.4	8.9	2.0	2.0	13.2	11.2	2.1	2.0		12.6	2.1	2.1
	10.4	8.9			13.2	11.2			14.7	12.6		
11 B	10.4	8.9	3.0	2.8	13.2	11.2	3.4	3.1		12.6	2.7	3.3
	10.4	8.9			13.2	11.2			14.7	12.6		
11 C	10.4	8.9	3.3	3.0	13.2	11.2	3.9	3.5		12.6	2.9	3.7
	10.4	8.9			13.2	11.2			14.7	12.6		
12 A	10.4	8.9	3.4	3.1		11.2	3.8	3.7		12.6	2.9	3.9
	10.4	8.9			13.2	11.2			14.7	12.6		
12B	10.4	8.9	3.6	3.3		11.2	3.8	3.9		12.6	3.0	4.2
	10.4	8.9			13.2	11.2			14.7	12.6		
12 C	10.4	8.9	3.8	3.4		11.2	3.7	4.1			3.1	4.1
	10.4	8.9			13.2	11.2			14.7	12.6		
13 A	10.4	8.9	3.9	3.5		11.2	3.6	4.1			3.1	4.0
	10.4	8.9			13.2	11.2			14.7	12.6		
13 B	10.4	8.9	4.0	3.5		11.2	3.6	4.2			3.1	3.9
	10.4	8.9			13.2	11.2			14.7	12.6		
13 C	10.4	8.9	4.0	3.6			3.6	4.1			3.1	3.8
	10.4	8.9			13.2	11.2			14.7	12.6		
14 A	10.4	8.9	4.0	3.6			3.5	3.9			3.1	3.7
	10.4	8.9			13.2	11.2			14.7	12.6		
14 B	10.4	8.9	4.1	3.6			3.4	3.8			3.1	3.6
	10.4	8.9			13.2	11.2			14.7	12.6		
14 C	10.4	8.9	4.1	3.6			3.4	3.7			3.1	3.6
	10.4	8.9			13.2	11.2			14.7	12.6		
15 A		8.9										
	10.4	8.9	3.9	3.5	13.2	11.2	3.3	3.6	14.7	12.6	3.0	3.4
15 B		8.9										
	10.4	8.9	3.8	3.5	13.2	11.2	3.2	3.5	14.7	12.6	3.0	3.4
15 C		8.9										
	10.4	8.9	3.7	3.5	13.2	11.2	3.2	3.4	14.7	12.6	3.0	3.3
16 A		8.9										
	10.4	8.9	3.7	3.6	13.2	11.2	3.2	3.4	14.7	12.6	3.1	3.4
16 B		8.9										
	10.4	8.9	3.7	3.7	13.2	11.2	3.3	3.5	14.7	12.6	3.2	3.4
16 C		8.9										
	10.4	8.9	3.7	3.8	13.2	11.2	3.4	3.5	14.7	12.6	3.2	3.5
17 A		8.9										
	10.4	8.9	3.7	3.9	13.2	11.2	3.4	3.5	14.7	12.6	3.3	3.5
17 B	10.4	8.9	3.8	3.9	13.2	11.2	3.5	3.6	14.7	12.6	3.4	3.6
17 C	10.4	8.9	3.8	3.9	13.2	11.2	3.5	3.6	14.7	12.6	3.5	3.6
18 A	10.4	8.9	3.8	3.9	13.2	11.2	3.6	3.6	14.7	12.6	3.5	3.7
18 B	10.4	8.9	3.8	3.9	13.2	11.2	3.6	3.7	14.7	12.6	3.6	3.7
18 C	10.4	8.9	3.9	3.9	13.2	11.2	3.7	3.7	14.7	12.6	3.7	3.8
F1 A	10.4	8.9	3.9	3.9	13.2	11.2	3.7	3.8	14.7	12.6	3.7	3.8
F1 B	10.4	8.9	3.9	4.0	13.2	11.2	3.8	3.8	14.7	12.6	3.8	3.9
F2 A												
	10.4	8.9	4.0	4.0	13.2	11.2	3.9	3.9	14.7	12.6	3.9	3.9
F2 B												
	10.4	8.9	4.0	4.0	13.2	11.2	3.9	3.9	14.7	12.6	4.0	4.0
(cfs)	**476.7**	**477.6**			**468.5**	**464.5**			**472.7**	**474.7**		

Dashed Lines Indicate Bays With 2 Orifices

6.4. REGIONAL COORDINATION

Regional review of this EDR has been conducted through the FFDRWG. This body made up of federal, state and tribal partners who work closely with the USACE to provide input and comment on major improvements at Columbia River Fish Mitigation projects. The FFDRWG has been briefed of progress throughout the study. Comments received from the 60% and 90% EDR as well as responses are included in Appendix C.

7. SUMMARY

Because of its ability to meet all study goals at a reasonable estimated cost, Alternative 4 was originally selected as the recommended alternative. Alternative 4 would reduce the orifice ring size to 12 inches and open additional orifices, as needed, to maintain channel design flow and velocities. In addition, both Alternative 11 (minimizes overall tube length) and Alternative 12 (uses lighted orifice ring) would be included.

Regional collaboration through FFDRWG has been influential in the development of a phased approach to implementing alternatives and achieving incremental benefits. Please see Appendix C for the regional coordination at the 60% and 90% EDR reviews as well as the FFDRWG notes.

The B2 FGE program has been moving forward on a parallel path to the B2 Orifice study. Knowledge gained through the B2 FGE program has further emphasized the interrelationship between the two projects. The information gained during prototype testing and results of B2 FGE program alternatives have provided value in the understanding of juvenile salmonid condition and survival through the B2 screened bypass system.

Hydraulic and biological testing through the B2FGE program in 2008, 2009, 2013, 2014, and 2015 has provided a better understanding of the mechanisms of mortality in the JBS. The primary sources have been identified and include undesirable gatewell hydraulic conditions and excessive through-screen velocities on the two uppermost panels of the VBS during turbine operations in the upper 1% range. An alternative has been tested and full powerhouse implementation occurred during fall and winter of 2016/2017. A B2 FGE two-year post construction evaluation is underway in 2017 and 2018.

Based on FGE test data and fish condition data collected through the Smolt Monitoring Program, there appears to be little biological benefit for making adjustments to minimize overall orifice pipe length (Alt. 11) and installation of orifice light rings to improve gatewell egress times (Alt. 12). Given the high cost, substantial O&M and low biological benefit the light ring alternative is not being pursued. However, improving the ability for the project personnel to detect debris plugs at the orifice continues to be a FFDRWG concern. Providing a cohesive jet through re-coring the tube to a larger 18" diameter and minimizing overall pipe length by moving the actuators that have a longer distance to the orifice ring are the highest ranked EDR based alternatives to achieve this objective.

1. Design Goals at the initiation of the study:
    - Improve the ability for the project operators to detect debris plugs at the orifice;
    - Reduce the likelihood of fish impingement due to alignment of orifice flow, and
    - Improve gatewell egress times with improved lighting.
2. Initial Assumptions
    - Field observations of orifice jet characteristics and testing different ring sizes in previous years was indicative of the primary factors that influence the jet performance.
    - Past and current FGE improvement modifications would have minimal impact to orifice jet performance.
3. 90% Recommendations

- For all major alternatives considered, Alternatives A11 and A12 were assumed to be included:
  - A11 – Minimize Overall Length of Pipe and Mounting Flange
  - A12 – Replace Existing Orifice Ring with Lighted Orifice Ring

- Alternative A5 – Seasonally increase capacity of DSM, reduce orifice ring size to 12” and open additional orifices as needed to maintain channel design flow and velocities
  - Based on strong environmental Agency concerns for relaxing the dewatering screen velocity criteria for part of the fish passage season, Alternative A5 is no longer being considered.

- Alternative A3 – Re-core orifice tube to larger size, install larger I.D. orifice tube of 18”, replace 12 5/8” orifice ring with 13”orifice ring
  - Based on large cost of $8.4M (compared to $4.3M for A4), Alternative A3 is no longer being considered.

- Alternative A4 – Reduce Orifice Ring Size to 12” and open additional orifices as needed to maintain channel design flow and velocities. In conjunction with Alternatives A11 and A12, components for this alternative include the following:

  - Replace 12 5/8 inch orifice rings with 12 inch lighted orifice rings to:
    - Bring hydraulics back to a cohesive jet that can be used to detect debris plugs at the orifice entrance;

    - Reduce residence time in gatewell by increasing probability of fish locating and entering orifice opening through light attraction and increased number of entrances.

  - Mine out concrete on collection channel side of gatewell wall to inset the larger actuators allowing slide gates to be closer to the entrance of the orifice pipe. This will effectively decrease the distance the jet will need to travel to clear the gate housing preventing impingement. Table 7-1 shows the locations of the major components of A4.

  - Add gates and actuators to additional orifices to match the current hydraulic conditions in the DSM collection channel as closely as possible.

4. Additional Information influencing recommended plan for B2 Orifice Improvements Study

- Hydraulic modeling undertaken by the B2 FGE gatewell improvements study suggests excessive turbulence in the gatewell may contribute to elevated fish mortality. This has prompted prototype testing of a turbulence reduction device to decrease risk of injury and delay. The severity of the turbulence in the model brought into question the impact that it may have on the quality and consistency of the orifice jet.

- Biological concerns have been raised regarding the benefits of reducing orifice size from 12 5/8 inch to 12 inch to improve jet cohesiveness and reduce gatewell residence time vs. the risk of increased impacts to adult fish that may fallback through the DSM system.

- Throughout the study, additional field observations are showing more inconsistency in the quality of jet for a range of conditions that may run counter to the initial design assumptions. This has prompted the need for additional observations and testing under various flow conditions as the system is operated.

- Bonneville project biologists informed the team that the existing compressed air system used to dislodge debris from the orifice, both in an automatic timed cycle and in manual local operation, does not work consistently amongst all orifices. This is being addressed in the operations and maintenance forum.

- It has been determined that in the best interest of the overall function of the B2 DSM, that further studies, designs, and recommendations should incorporate features of both the FGE and Orifice elements.

RECOMMENDATIONS

5. The engineering recommendation for B2 Orifice Improvements to improve the ability for the project personnel to detect debris plugs at the orifice and reduce the likelihood of fish impingement due to alignment of orifice flow:

A. Modified alternative 3: Re-core orifice tube to a larger size (18 inch inside diameter) and maintain existing 12 5/8 inch orifice ring size.

B. Alternative 11: Minimize overall pipe length.

Prototype test new configuration on poorest performing orifice(s) if determined necessary following the B2FGE program gatewell modifications post construction evaluation as well as the evaluation of O&M program improvements.

APPENDIX A – HYDRAULIC DESIGN

Memorandum for Record for Orifice Plate Site Visit and Testing

CENWP-EC-HD 31 May 2006

MEMORANDUM FOR RECORD

SUBJECT: B2 DSM Orifice Plates – Site Visit

1. On 15 May 2006 subject trip was made to view the hydraulics of 6 new juvenile fish passage orifice rings with variable diameters installed at Unit 12 and to select the orifice that provides a consistently clean jet. Using the selected orifice we will determine the corresponding core to use. Attending from NWP where Rick Mettler EC-DM, Steve Schlenker and Randy Lee EC-HD.

A contractor removed the 6 existing fish passage orifice rings from Unit 12's intake gate slots. There are two orifice rings per gate slot and there are three slots per unit. The new orifice rings vary in opening dimensions from 12 ¼" to 11" in ¼" increments and installed in the locations shown below.

Intake Gate Slot	Orifice Ring ID
12 A-South	12 ¼"
12 A-North	12"
12 B-South	11 ¾"
12 B-North	11 ½"
12 C-South	11 ¼"
12 C-North	11"

2. Background. In 1997, Design Memorandum 9, supplement 6 for DSM improvements called for 13-inch orifices in order to increase the flow rates and channel velocities in the DSM collection channel. The same discharge coefficient was assumed for the new 13-inch orifice that had been measured in the DSM channel in 1996 with the original 12-inch orifices. Unfortunately, the cores and the steel pipe liner were left the same. After construction in 1999, HD realized that two things were apparent during testing for the initial water-up:

- Many of the jets were no longer clean jets--where there is clear separation between the jet and tube walls--but instead were disturbed with spreading, splattering flow filling the entire tube opening.
- The discharge coefficients were higher and more variable because the jets were not fully contracted passing from the orifices as intended, used the entire tube flow area, and operated under an increased vacuum on the downstream end that effectively raised the overall the head differential across the orifice.

The reason all this occurred was that difference between diameters of the orifice (13-inches) and the inside diameter of the tube (about 15.25") was insufficient to properly vent the orifice. Specifically, the conveyance area that allows air flow to move from the downstream opening of the tube to the location immediately downstream of the orifice lip at the upstream end of the tube is too restricted. Factor in the fact that there must be a layer of air at the jet perimeter that is pulled outwardly with the jet and the air inflow must work against the friction that this layer causes. The lesser the opening dimension, the greater the amount friction between air moving upstream (inflow) and downstream (along periphery of jet). So the thinner the gap between jet and tube, the more constriction occurs to air inflow. This is further aggravated by the fact that the orifice jets are often partly submerged at the upstream end of the collection channel--which further restricts air flow capacity.

In 2001, HD tested smaller orifices and settled on 12 5/8 inch to fix the excessive flow problem and hopefully reduce the disturbed jet problem. Unfortunately, the evaluation for jet condition for different sized orifice was incomplete since the unit with the test orifices was never operated during the evaluation. The high flow problem was fixed but only marginal improvements were found with the disturbed jet problem.

3. Observations. Project Conditions: Unit 12 operating at 18.5 kcfs, forebay elevation 73.6 ft and tailwater elevation 23 ft.

Unit 12 A – South

General observation: This orifice did not show separation between the jet and tube. This is considered no good. See following photos.

Unit 12 A – North

General observation(s): Marginal jet separation from top and sides. There is some splatter of the jet. This is considered okay. See following photos.



Unit 12 B – South

General observation(s): No separation of the jet. Water was splashing through the walkway grating. This orifice is considered no good. See following photos.

Unit 12 B – North

General observation(s): This jet at time looked good, but, did not always have separation. This orifice is considered no good. See following photos.

Unit 12 C – South

General observation(s): This orifice did have separation at times. This orifice was considered no good. See following photos.

Unit 12 C – North

General observation(s): This orifice had complete separation and considered good. See following photos.




Conclusions:

5. Upon visual observations by the attendees and the primary criteria of complete separation of the orifice jet, we ranked the orifices from 1 to 6 (1 being best, 6 being worst).

Ranking	Orifice Location
1	12C-North
2	12A-North
3	12B-North
4	12C-South
5	12A-South
6	12B-South

Another observation was that orifices on the north side of the bays produced consistently higher quality jets than those on the south side. In fact, none of the south bay jets were acceptable even when the orifices were smaller than an adjacent north side orifice that was acceptable. Rick Mettler, EC-DM, noted that the valves on the south side were the new gates installed with the DSM improvements in 1999. The new (south) gates have cylinders that are about 4 inches wider than the old gate cylinders on the north side. This places the opening of the new valves comparatively 4 inches downstream of the old valves and causes the tube length to be 4 inches longer. The extended tube length or distance of gate from orifice apparently reduces the conveyance of air into tube. More importantly, the extra distances causes the jet to flare to the point that it impacts the gate housing (either at the bottom of on the sides) and thus disrupts or effectively blocks the intake opening for air into the tube.

Thus, the recommended orifice size only applies to either a gate with an equal or smaller cylinder than the old gate, or with tube lengths that are equal or smaller than the old tube lengths. There may be some room for refinement given that the orifice size is proportioned upwards; however, it also important to remember that the centerline arc of the jet trajectory will not change with orifice enlargement.

<u>Recommendations:</u>

6. Based on the above conclusions it is recommended a minimum inside core diameter of 17.75 inches (I.D.) be used. (The inside core diameter is the inside diameter of the pipe tube inserted and grouted into core for orifice and valve connection.) The recommended inside core diameter is based on the following relationship:

$$C_n = (O_n/O_e) \text{ x } Ce$$

where

C_n = New Core Diameter (I.D.)
O_e = Existing Orifice Diameter = 11”
O_n = New Orifice Diameter = 13”
C_e = Existing Core Diameter (I.D.) = 15”[1]

Randy Lee, Steve Schlenker
EC-HD

CF:
EC-DM (Mettler)
PM-E (Schwartz)

[1] Existing inside core was provided by Ron Wridge, EC-DM, as required to piping for the valve. Existing outside diameter of core, or drill hole diameter, is 16 inches.

Estimate of Air Demand for Field Test Conditions

DRAFT Calculations for air demand (Q and V) for Field test conditions and proposed design geometry to improve jet performance

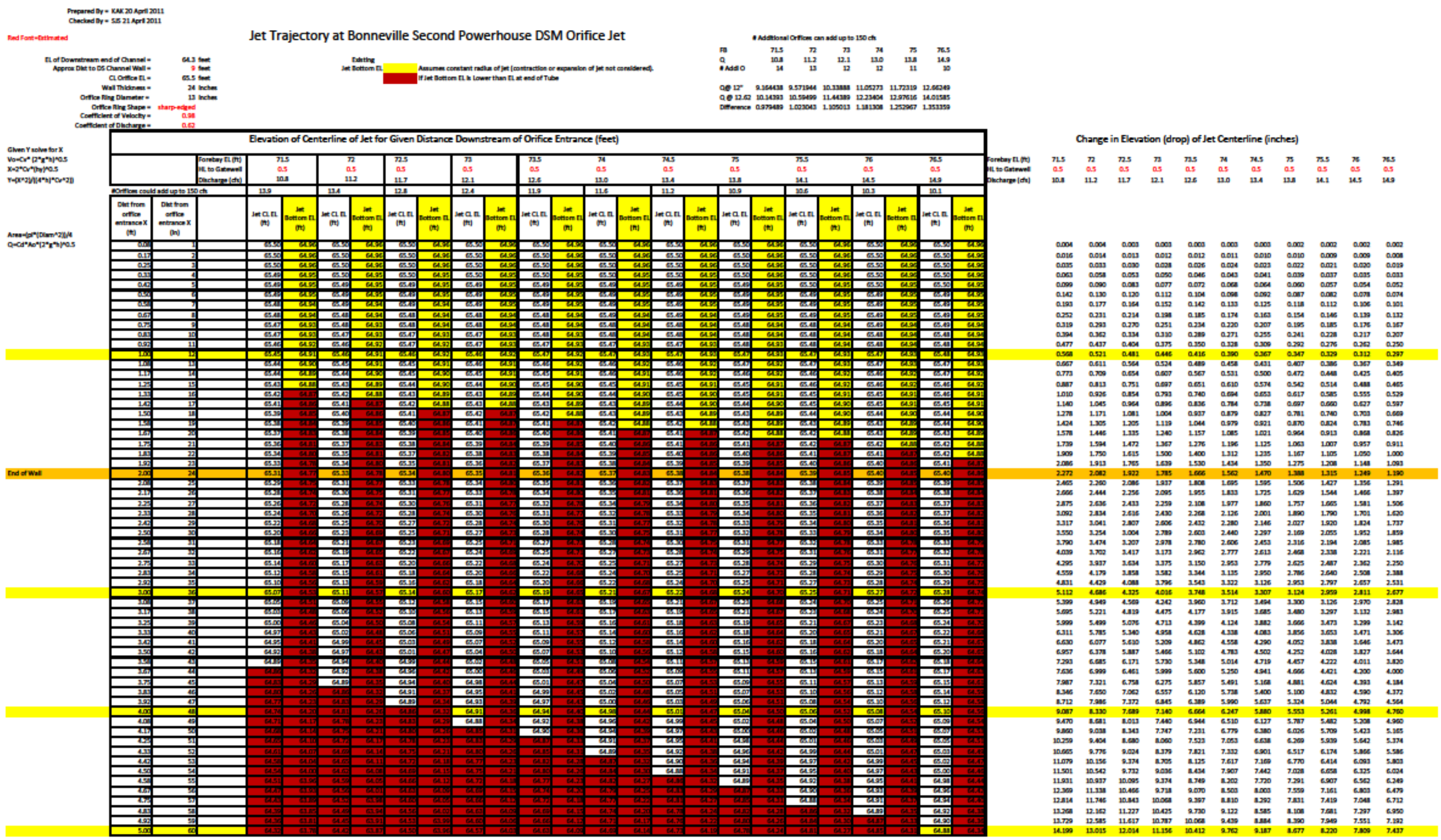
Coefficient of Discharge CD	0.65				
Orifice Centerline EL	65.5		gatewell drawdown:	0.33	0.9
			forebay elevation:	71.5	76.5

	Orifice Diam in	Tube Diam in	Orifice Area (ft²)	Tube Area (ft²)	Open Area (ft²)	Flow (min) cfs	Flow (max) cfs	Velocity min ft/sec	Velocity max ft/sec	Froude Number	Beta Qa/Qw	Qa =B*Qw	Va
5/31/2006	12.25	15.00	0.818	1.227	0.409	10.2	13.6	12.4	16.6	5.78	0.158	2.138	5.23
5/31/2006	12.00	15.00	0.785	1.227	0.442	9.8	13.0	12.4	16.6	5.84	0.160	2.079	4.71
5/31/2006	11.75	15.00	0.753	1.227	0.474	9.4	12.5	12.4	16.6	5.90	0.162	2.021	4.26
5/31/2006	11.50	15.00	0.721	1.227	0.506	9.0	12.0	12.4	16.6	5.97	0.164	1.962	3.88
5/31/2006	11.25	15.00	0.690	1.227	0.537	8.6	11.4	12.4	16.6	6.03	0.166	1.904	3.55
5/31/2006	11.00	15.00	0.660	1.227	0.567	8.2	10.9	12.4	16.6	6.10	0.169	1.847	3.26
Existing	12.63	15.00	0.869	1.227	0.358	10.8	14.4	12.4	16.6	5.70	0.155	2.228	6.23
Alternative 4	12.00	15.00	0.785	1.227	0.442	9.8	13.0	12.4	16.6	5.84	0.160	2.079	4.71
Alternative 3	13.00	17.75	0.922	1.718	0.797	11.4	15.3	12.4	16.6	5.61	0.152	2.318	2.910

Assumptions: 0.33 ft. drawdown at low forebay= 71.5 ft; 0.9 ft drawdown at high forebay=76.5 ft

References: HDC chart 050-1/1 Show two maxima for air demand, roughly at 5% and 80% gate opening
HDC chart 050-2 'Air demand - regulated outlet works

JET TRAJECTORY AT BONNEVILLE SECOND POWERHOUSE DSM ORIFICE JET



Prepared By = KAK 20 April 2011
Checked By = SJS 21 April 2011

Red Font=Estimated

Jet Trajectory at Bonneville Second Powerhouse DSM Orifice Jet

EL of Downstream end of Channel =	64.3	feet
Approx Dist to DS Channel Wall =	9	feet
CL Orifice EL =	65.5	feet
Wall Thickness =	24	inches
Orifice Ring Diameter =	13	inches
Orifice Ring Shape =	sharp-edged	
Coefficient of Velocity =	0.98	
Coefficient of Discharge =	0.62	

Existing Jet Bottom EL (yellow): Assumes constant radius of jet (contraction or expansion of jet not considered).
(red): If Jet Bottom EL is Lower than EL at end of Tube

Additional Orifices can add up to 150 cfs

FB	71.5	72	73	74	75	76.5
Q	10.8	11.2	12.1	13.0	13.8	14.9
# Add'l O	14	13	12	12	11	10
Q@ 12"	9.164438	9.571944	10.33888	11.05273	11.72319	12.66249
Q @ 12.62	10.14393	10.59499	11.44389	12.23404	12.97616	14.01585
Difference	0.979489	1.023043	1.105013	1.181308	1.252967	1.353359

Given Y solve for X
Vo=Cv* (2*g*h)^0.5
X=2*Cv*(hy)^0.5
Y=(X^2)/((4*h)*Cv^2))
Area=(pi*(Diam^2))/4
Q=Cd*Ao*(2*g*h)^0.5

Elevation of Centerline of Jet for Given Distance Downstream of Orifice Entrance (feet)

Forebay EL (ft)	71.5	72	72.5	73	73.5	74	74.5	75	75.5	76	76.5
HL to Gatewell	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Discharge (cfs)	10.8	11.2	11.7	12.1	12.6	13.0	13.4	13.8	14.1	14.5	14.9
#Orifices could add up to 150 cfs	13.9	13.4	12.8	12.4	11.9	11.6	11.2	10.9	10.6	10.3	10.1

Columns for each forebay EL: Jet CL EL (ft); Jet Bottom EL (ft)

Change in Elevation (drop) of Jet Centerline (inches)

Dist from orifice entrance X (ft)	Dist from orifice entrance X (in)	71.5	72	72.5	73	73.5	74	74.5	75	75.5	76	76.5
	HL to Gatewell	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Discharge (cfs)	10.8	11.2	11.7	12.1	12.6	13.0	13.4	13.8	14.1	14.5	14.9
0.08	1	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002
0.17	2	0.016	0.014	0.013	0.012	0.012	0.011	0.010	0.010	0.009	0.009	0.008
0.25	3	0.035	0.033	0.030	0.028	0.026	0.024	0.023	0.022	0.021	0.020	0.019
0.33	4	0.063	0.058	0.053	0.050	0.046	0.043	0.041	0.039	0.037	0.035	0.033
0.42	5	0.099	0.090	0.083	0.077	0.072	0.068	0.064	0.060	0.057	0.054	0.052
0.50	6	0.142	0.130	0.120	0.112	0.104	0.098	0.092	0.087	0.082	0.078	0.074
0.58	7	0.193	0.177	0.164	0.152	0.142	0.133	0.125	0.118	0.112	0.106	0.101
0.67	8	0.252	0.231	0.214	0.198	0.185	0.174	0.163	0.154	0.146	0.139	0.132
0.75	9	0.319	0.293	0.270	0.251	0.234	0.220	0.207	0.195	0.185	0.176	0.167
0.83	10	0.394	0.362	0.334	0.310	0.289	0.271	0.255	0.241	0.228	0.217	0.207
0.92	11	0.477	0.437	0.404	0.375	0.350	0.328	0.309	0.292	0.276	0.262	0.250
1.00	12	0.568	0.521	0.481	0.446	0.416	0.390	0.367	0.347	0.329	0.312	0.297
1.08	13	0.667	0.611	0.564	0.524	0.489	0.458	0.431	0.407	0.386	0.367	0.349
1.17	14	0.773	0.709	0.654	0.607	0.567	0.531	0.500	0.472	0.448	0.425	0.405
1.25	15	0.887	0.813	0.751	0.697	0.651	0.610	0.574	0.542	0.514	0.488	0.465
1.33	16	1.010	0.926	0.854	0.793	0.740	0.694	0.653	0.617	0.585	0.555	0.529
1.42	17	1.140	1.045	0.964	0.896	0.836	0.784	0.738	0.697	0.660	0.627	0.597
1.50	18	1.278	1.171	1.081	1.004	0.937	0.879	0.827	0.781	0.740	0.703	0.669
1.58	19	1.424	1.305	1.205	1.119	1.044	0.979	0.921	0.870	0.824	0.783	0.746
1.67	20	1.578	1.446	1.335	1.240	1.157	1.085	1.021	0.964	0.913	0.868	0.826
1.75	21	1.739	1.594	1.472	1.367	1.276	1.196	1.125	1.063	1.007	0.957	0.911
1.83	22	1.909	1.750	1.615	1.500	1.400	1.312	1.235	1.167	1.105	1.050	1.000
1.92	23	2.086	1.913	1.765	1.639	1.530	1.434	1.350	1.275	1.208	1.148	1.093
2.00 (End of Wall)	24	2.272	2.082	1.922	1.785	1.666	1.562	1.470	1.388	1.315	1.249	1.190
2.08	25	2.465	2.260	2.086	1.937	1.808	1.695	1.595	1.506	1.427	1.356	1.291
2.17	26	2.666	2.444	2.256	2.095	1.955	1.833	1.725	1.629	1.544	1.466	1.397
2.25	27	2.875	2.636	2.433	2.259	2.108	1.977	1.860	1.757	1.665	1.581	1.506
2.33	28	3.092	2.834	2.616	2.430	2.268	2.126	2.001	1.890	1.790	1.701	1.620
2.42	29	3.317	3.041	2.807	2.606	2.432	2.280	2.146	2.027	1.920	1.824	1.737
2.50	30	3.550	3.254	3.004	2.789	2.603	2.440	2.297	2.169	2.055	1.952	1.859
2.58	31	3.790	3.474	3.207	2.978	2.780	2.606	2.453	2.316	2.194	2.085	1.985
2.67	32	4.039	3.702	3.417	3.173	2.962	2.777	2.613	2.468	2.338	2.221	2.116
2.75	33	4.295	3.937	3.634	3.375	3.150	2.953	2.779	2.625	2.487	2.362	2.250
2.83	34	4.559	4.179	3.858	3.582	3.344	3.135	2.950	2.786	2.640	2.508	2.388
2.92	35	4.831	4.429	4.088	3.796	3.543	3.322	3.126	2.953	2.797	2.657	2.531
3.00	36	5.112	4.686	4.325	4.016	3.748	3.514	3.307	3.124	2.959	2.811	2.677
3.08	37	5.399	4.949	4.569	4.242	3.960	3.712	3.494	3.300	3.126	2.970	2.828
3.17	38	5.695	5.221	4.819	4.475	4.177	3.915	3.685	3.480	3.297	3.132	2.983
3.25	39	5.999	5.499	5.076	4.713	4.399	4.124	3.882	3.666	3.473	3.299	3.142
3.33	40	6.311	5.785	5.340	4.958	4.628	4.338	4.083	3.856	3.653	3.471	3.306
3.42	41	6.630	6.077	5.610	5.209	4.862	4.558	4.290	4.052	3.838	3.646	3.473
3.50	42	6.957	6.378	5.887	5.466	5.102	4.783	4.502	4.252	4.028	3.827	3.644
3.58	43	7.293	6.685	6.171	5.730	5.348	5.014	4.719	4.457	4.222	4.011	3.820
3.67	44	7.636	6.999	6.461	5.999	5.600	5.250	4.941	4.666	4.421	4.200	4.000
3.75	45	7.987	7.321	6.758	6.275	5.857	5.491	5.168	4.881	4.624	4.393	4.184
3.83	46	8.346	7.650	7.062	6.557	6.120	5.738	5.400	5.100	4.832	4.590	4.372
3.92	47	8.712	7.986	7.372	6.845	6.389	5.990	5.637	5.324	5.044	4.792	4.564
4.00	48	9.087	8.330	7.689	7.140	6.664	6.247	5.880	5.553	5.261	4.998	4.760
4.08	49	9.470	8.681	8.013	7.440	6.944	6.510	6.127	5.787	5.482	5.208	4.960
4.17	50	9.860	9.038	8.343	7.747	7.231	6.779	6.380	6.026	5.709	5.423	5.165
4.25	51	10.259	9.404	8.680	8.060	7.523	7.053	6.638	6.269	5.939	5.642	5.374
4.33	52	10.665	9.776	9.024	8.379	7.821	7.332	6.901	6.517	6.174	5.866	5.586
4.42	53	11.079	10.156	9.374	8.705	8.125	7.617	7.169	6.770	6.414	6.093	5.803
4.50	54	11.501	10.542	9.732	9.036	8.434	7.907	7.442	7.028	6.658	6.325	6.024
4.58	55	11.931	10.937	10.095	9.374	8.749	8.202	7.720	7.291	6.907	6.562	6.249
4.67	56	12.369	11.338	10.466	9.718	9.070	8.503	8.003	7.559	7.161	6.803	6.479
4.75	57	12.814	11.746	10.843	10.068	9.397	8.810	8.292	7.831	7.419	7.048	6.712
4.83	58	13.268	12.162	11.227	10.425	9.730	9.122	8.585	8.108	7.681	7.297	6.950
4.92	59	13.729	12.585	11.617	10.787	10.068	9.439	8.884	8.390	7.949	7.551	7.192
5.00	60	14.199	13.015	12.014	11.156	10.412	9.762	9.187	8.677	8.220	7.809	7.437

APPENDIX B – COST ESTIMATE

Short Narrative of Assumptions for Cost Estimates

Project Description

At the Bonneville second powerhouse, orifices connect the intake gatewell slots to the downstream migrant channel (DSM). They are part of the juvenile bypass system (JBS). The orifice jet hydraulics are considered biologically undesirable since the orifice jet spreads at many of the orifices. A matrix to rank the possible improvement alternatives considered, showed the top three alternatives to have cost estimates at the 60% review phase. The other alternatives were determined to have unfavorable results and/or performance, which eliminated them from further consideration. The top three alternatives are:

- Alternative 3: Re-core orifice tube to larger size (13-inch orifice rings).
- Alternative 4: Reduce orifice ring size (≤ 12 inches) and open additional orifices as needed to maintain channel design flow.
- Alternative 5: Seasonally increase capacity of DSM, reduce orifice ring size (≤ 12 inches) and open additional orifices as needed to maintain channel design flow.

Additionally, the recommended alternative would also include both Alternative 11, which minimizes overall tube length and Alternative 12, which replaces the orifice ring with a lighted orifice ring.

Basis of Design and Estimates

The general assumptions for the cost estimates are as follows:

a) Use an excel spreadsheet with the same rows of task for all the alternatives.
b) Add Alternatives 11 and 12 to the bottom of each of the main alternatives.
c) Similar crews and task would perform similar tasks for each of the alternatives.
d) Due to the requirements of attaching the light ring orifice, the gate slot must be dewatered.
e) The main units will be dewatered with the existing intake bulkheads, rather than using a caisson.
f) Each main unit will be dewatered to tailwater.
g) Bonneville project personnel and equipment will place and remove the intake bulkheads.
h) Orifice work limited to in-water work period since DSM must be dewatered; thus, JBS is shutdown.
i) Only one main unit can be dewatered at a time due to number of bulkheads and project operating requirements.
j) Only three units maximum can be dewatered per in-water work period due to the duration of work on the orifices, length of time required to dewater each, and system-wide coordination of unit outages.
k) For cost comparison among alternatives on a like-to-like basis, general assumption and adjustments will be used rather than detailing the specifics of overtime (OT), subcontracting, detailed labor rates, etc. To recognize OT, assume six 10-hour days and labor is about 45% of direct costs for 70-hours paid per week for 60 man-hours worked [(70/60) * 0.45) - 0.45 = 7.5% of direct costs is OT cost].
l) All markups are assumed from the rule of thumb of JOOH 15%, HOOH 10%, profit 10%, bond, sales tax, B&O tax 3% and OT of 7.5% for a total markup (running) of 54%.
m) Material costs from engineers UNO.
n) See notes in spreadsheets for production assumptions and other considerations.
o) For alternative comparison purposes, assume 35% contingency until a risk-based analysis is performed to determine a more detailed contingency.

Crews

General Work Crew (GenCrew)
Performs dewatering support, scaffolding install, demolition, general deck support. Includes:

40 T crane	*Misc. power tools*
Flat bed truck	*2 equipment operators*
3 laborers	*1 foreman*

Coring Crew (Core)
Performs coring new orifices. Includes:

2 laborers
Core drill

Structural Installers (StruCr)
Performs installing orifice tubes, grouting (tubes, old light tubes, new orifice rings), chipping/removing concrete. Includes:

3 laborers	*2 pickup trucks*
Misc. power tools	*Small tools*

Mechanical Electrical Installers (MechElCr)
Assumes same cost for millwright and electrician and same cost for their required equipment. Performs installing valves, actuators, light rings, redo piping, sensors, power, and modify dewatering structure. Includes:

2 millwrights	*2 pickup trucks*
Misc. power tools	*Small tools*

Controls (Ctrl)
Performs changing programming of controls. Includes:

Electrical engineer
Small tools

Assumptions for Costs	
Bonneville Second Powerhouse Orifice Improvements 2012	
Preliminary Cost Estimate	
RLR 10/20/2011	
V1	Start worksheet based on Lamprey grating cost estimate worksheet.
	Only Alt 3, 4, & 5 studied for cost (each of these alternatives will include Alt 11 and 12).
	Other alternatives not studied for cost due to unfavorable results and performance likely eliminate those alternatives from further consideration.

Preliminary Cost Estimate Summary

Preliminary Cost Estimate (Rounded to $100,000s)
Prepared by: RLR
10/25/2011
Modified by: KAK 11/23/11

Physical Description	Re-core opening for 18" ID pipe; Minimize overall pipe length; Replace 12 5/8" orifice rings With 13" LED orifice rings.	Minimize overall pipe length; Replace 12 5/8" orifice rings with 12" LED orifice rings; Add gates to currently blind flanged orifices; Operate with additional orifices to maintain current channel operation/flow.	Minimize overall pipe length; Replace 12 5/8" orifice rings with 12" LED orifice rings; Add gates to currently blind flanged orifices; Modify screen velocity criteria for part of fish passage season to operate with additional flow allowing additional orifices to open.	Minimize overall pipe length.	Replace 12 5/8" orifice ring with LED orifice ring.
(Costs rounded to $100,000)	**Alt 3 (42 Orifices Modified)**	**Alt 4 (49 Orifices Modified)**	**Alt 5 (56 Orifices Modified)**	**Alt 11 only (42 Orifices Modified)**	**Alt 12 only (42 Orifices Modified)**
Direct Costs	$4,000,000	$2,100,000	$3,000,000	$900,000	$1,500,000
Markups (Overhead, Profits, Bond, tax, OT)	$2,200,000	$1,100,000	$1,600,000	$500,000	$800,000
SUBTOTAL COSTS	$6,200,000	$3,200,000	$4,600,000	$1,400,000	$2,300,000
CONTINGENCY (35%)	$2,200,000	$1,100,000	$1,600,000	$500,000	$800,000
TOTAL ESTIMATED CONSTRUCTION COST	**$8,400,000**	**$4,300,000**	**$6,200,000**	**$1,900,000**	**$3,100,000**

NOTES

1 Escalation & Inflation NOT included

2 Engineering, Supervision, Admin, etc costs NOT included

3 Alternative 3: Utilizes the 42 existing gated orifices; Provides aerated jets, maintains similar jet flows, reduces opportunity for impingement, increases attraction through light ring.

4 Alternative 4: Utilizes the 42 existing gated orifices; Requires 7 additional gate systems for currently blind flanged orifices; Provides aerated jet maintaining current total channel flow, uses additional orifices increasing opportunity for attraction, reduces probability for jet impingement at lower flows, increases attraction through light ring.

5 Alternative 5: Utilizes the 42 existing gated orifices; Requires 14 additional gate systems for currently blind flanged orifices; Increases DSM system flow with seasonally modified criteria at dewatering screens; Provides aerated jet increasing current total channel flow, uses additional orifices increasing opportunity for attraction, reduces probability for jet impingement at lower forebays, increases attraction through light ring.

6 Alternative 11: Utilizes the 42 existing gated orifices; Reduces probability for jet impingement at lower forebays.

7 Alternative 12: Utilizes the 42 existing gated orifices; Increases attraction through light ring.

8 Cost of Alt 11 & Alt 12 cannot be subtracted from the Other alternatives due to work not being mutually exclusive

9 Cost of "Alt 11" only cannot be added to "Alt 12 only" due to overlapping costs/tasks.

10 Nine Orifice lengths have already have been shortened by concrete mining. Costs in this spreadsheet do not reflect the reduction in cost for these orifices.

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Crews: GenCrew, Core

Green Cells are link/formula

V1 — **Direct Costs Alt 3 - Recore for Larger Tubes & 13" Dia Orifices**

						Production	Labor or Crew or Sub-Bid	Rate	L-Cr-SB	Material	Matl		Quantities per Item						
Location	Line No.	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	Direct Cost Subtotal (Rnd)	$/Unit	Direct Cost Subtotal (Rnd)	Verified	X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt 3 Recore for 13" diameter	1	Mob Demob	See Light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	In addition to Light Ring Below Assume 16 hrs per orifice to accnt for extra for coring & grouting need extra room on schafolding ASSUME 42 orifices	Hrs	672.0	1	GenCrew	$367	$247,000		$0		16	42				672	
	3	Scaffolding Main units	See Calcs for Cost p. 60-10 & 60-11 Is needed at each slot. 8 units with 3 slots per unit plus 4 slots at fish units	ea	24.0	1	See calc.	$7,000	$168,000		$0		8	3				24	
	4	scaffolding at fish units	ditto	ea	4.0	1	See calc	$7,000	$28,000		$0		2	2				4	
	5	Demo existing orifice tube	Assume 3 days (10hrs) each orifice (42) to remove orifice ring, light tube stuff, misc items to access wall to core drill	hr	1,260.0	1	StruCr	$147	$186,000		$0		3	10	42			1260	
	6	Core drill for 13" dia Tube	See Calc 60-12. 6 hrs ea orifice	hr	252.0	1	Core	$1,093	$276,000		$0		6	42				252	
	7	Install 13" Tube	Assume 2 days (10hrs) to install & grout new tubes in. Total of 42	hr	840.0	1	StruCr	$147	$124,000		$0		2	10	42			840	
	8	Matl costs for new tubes	from Struc text in report $100,000/28 is about $3600 ea	ea	42.0	1	n/a		$0	$ 3,600	$152,000		42					42	
	9	Install New Gate	Assume 1 day (10 hrs) ea	hrs	420.0	1	MechElCr	$128	$54,000		$0		1	10	42			420	
	10	Install New Actuator	Assume 12 hrs ea (crew hrs)	hr	504.0	1	MechElCr	$128	$65,000		$0		1	12	42			504	
	11	Matl Cost for Mech	From Mech Text in report	ea	42.0	1	n/a		$0	$ 10,000.00	$420,000		42					42	
	12	Modifiy DSM Grating	Assume 8 hrs ea (crew hrs)	hr	336.0	1	StruCr	$147	$50,000		$0		8	42				336	
	13	Redo Orifice Opening Controls HMI	assume 80 hours to reprogram, test, commission, etc.	hr	80.0	1	Ctrl	$51	$5,000		$0		80					80	
	14	Redo Air Flush System Controls	assume 24 hours to reprogram, test, commission, etc.	hr	24.0	1	Ctrl	$51	$2,000		$0		24					24	
	15	New SS Retainer Ring (alt 4)			-	1			$0		$0							0	
	16				-	1			$0		$0							0	
	17				-	1			$0		$0							0	
	18				-	1			$0		$0							0	
Alt 12 Light Ring	19	* Light Ring	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	*3% Min.*

		B2 Orifice Improvements 2012					Crews GenCrew Core				Green Cells are link/formula	Verified							
		Preliminary Cost Estimate (Rounded to 1000$)																	
		Prepared by: RLR	10/21/2011			Labor or Crew or Sub-Bid				Material			Quantities per Item						
V1		**Direct Costs Alt 3 - Recore for Larger Tubes & 13" Dia Orifices**				Production		Rate	L-Cr-SB		Matl								
Location	Line No.	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	Direct Cost Subtotal (Rnd)	$/Unit	Direct Cost Subtotal (Rnd)		X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt 12 Light Ring	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500	
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	720.0	1	Gen Crew + StruCr	$514	$371,000		$0		3	10	8	3		720	
	23	scaffolding at fish units	ditto	hr	120.0	1	ditto	$514	$62,000		$0		3	10	4			120	
	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	840.0	1	StruCr	$147	$124,000		$0		42	20				840	
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	42.0	1	n/a		$0	$ 650.00	$28,000		42					42	
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	840.0	1	MechElCr	$128	$108,000		$0		42	20				840	
	27	Matl costs mech Elec	From text report	ea	42.0	1			$0	$ 1,500.00	$63,000		42					42	
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	100.8	1			$0	$ 150.00	$16,000		42	2.4				100.8	
	29					1			$0		$0							0	
Alt 11 Reduce Orifice Tube Length	30	** Reduce Orifice Tube Length			-	1			$0		$0							0	
	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	420.0	1	StruCr	$147	$62,000		$0		42	10				420	
	32	Install Structural Frame	Assume 20 hrs ea	hr	840.0	1	StruCr	$147	$124,000		$0		42	20				840	
	33	Matl cost for frame	from rpt text	ea	42.0	1	na/		$0	$ 700.00	$30,000		42					42	
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	840.0	1	MechElCr	$128	$108,000		$0		42	20				840	
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	168.0	1	MechElCr	$128	$22,000		$0		42	4				168	
	36	Install Atuator Valve	Assume 12 hrs each	hr	504.0	1	MechElCr	$128	$65,000		$0		42	12				504	
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	42.0	1	StruCr	$147	$7,000	$ 500.00	$21,000		42					42	
	38	Redo Controls	Assume 120 hrs of Programmer	hr	120.0	1	Ctrl	$51	$7,000		$0		120					120	
	39	Mob Demob if not other alts done			-	1			$0		$0							0	
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0								
	41				-	1			$0		$0							0	
	42	Misc Matl	Say 20% ea Matl	%	146,000.0	1		$0	$0	$ 1.00	$146,000		730,000	0.2				146000	
	43	Misc Labor etc	Say 20%	%	515,400.0	1		$1	$516,000	$ -	$0		2,577,000	0.2				515400	
		Subtotal Direct Cost	$3,969,000						$3,093,000		$876,000								
		Notes: This alternative modifies only those orifice units currently in use: 42 orifice units																	

Crews
GenCrew
Core

		B2 Orifice Improvements 2012									Green Cells are link/formula	Verified							
		Preliminary Cost Estimate (Rounded to 1000$)																	
		Prepared by: RLR	10/21/2011			Labor or Crew or Sub-Bid				Material			Quantities per Item						
V1		Direct Costs Alt A4 Reduce Orifice Ring to 12" Dia and Operate Add'l Orifices				Production		Rate	L-Cr-SB		Matl								
Location	Line No.	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	Direct Cost Subtotal (Rnd)	$/Unit	Direct Cost Subtotal (Rnd)		X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt 4 Reduce Orifice Ring to 12" diameter	1	Mob Demob	See Light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	Included in Light Ring work Below	Hrs	-	1	GenCrew	$367	$0		$0							0	
	3	Scaffolding Main units	Ditto	ea	-	1	See calc.	$7,000	$0		$0							0	
	4	scaffolding at fish units	Ditto	ea	-	1	See calc	$7,000	$0		$0							0	
	5	Demo existing orifice tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	6	Core drill for 13" dia Tube	Ditto	hr	-	1	Core	$1,093	$0		$0							0	
	7	Install 13" Tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	8	Matl costs for new tubes	Ditto	ea	-	1	n/a		$0	$ 3,600	$0							0	
	9	Install New Gate	Ditto	hrs	70.0	1	MechElCr	$128	$9,000		$0		1	10	7			70	
	10	Install New Actuator	Ditto	hr	84.0	1	MechElCr	$128	$11,000		$0		1	12	7			84	
	11	Matl Cost for Mech	Ditto	ea	7.0	1	n/a		$0	$ 10,000.00	$70,000		7					7	
	12	Modifiy DSM Grating	Ditto	hr	56.0	1	StruCr	$147	$9,000		$0		8	7				56	
	13	Redo Orifice Opening Controls HMI	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	14	Redo Air Flush System Controls	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	15	New SS Retainer Ring (alt 4)	from report text	ea	49.0	1			$0	$ 400.00	$20,000		49					49	
	16				-	1			$0	$ 401.00	$0							0	
	17				-	1			$0	$ 402.00	$0							0	
	18				-	1			$0		$0							0	
Alt 12 Light Ring	19	* Light Ring	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	*3% Min.*
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500	
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	720.0	1	Gen Crew + SturCr	$514	$371,000		$0		3	10	8	3		720	

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Crews: GenCrew, Core

Green Cells are link/formula

V1 — Direct Costs Alt A4 Reduce Orifice Ring to 12" Dia and Operate Add'l Orifices

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Crew	Labor or Crew or Sub-Bid: Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item: X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt 12 Light Ring	23	scaffolding at fish units	ditto	hr	120.0	1	ditto	$514	$62,000		$0		3	10	4			120	
	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	980.0	1	StrucCr	$147	$145,000		$0		49	20				980	
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	49.0	1	n/a		$0	$ 650.00	$32,000		49					49	
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	980.0	1	MechElCr	$128	$126,000		$0		49	20				980	
	27	Matl costs mech Elec	From text report	ea	49.0	1			$0	$ 1,500.00	$74,000		49					49	
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	117.6	1			$0	$ 150.00	$18,000		49	2.4				117.6	
	29					1			$0		$0		49					49	
Alt 11 Reduce Orifice Tube Length	30	** Reduce Orifice Tube Length			49.0	1			$0		$0		49					49	
	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	490.0	1	StrucCr	$147	$73,000		$0		49	10				490	
	32	Install Structural Frame	Assume 20 hrs ea	hr	980.0	1	StrucCr	$147	$145,000		$0		49	20				980	
	33	Matl cost for frame	from rpt text	ea	49.0	1	na/		$0	$ 700.00	$35,000		49					49	
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	980.0	1	MechElCr	$128	$126,000		$0		49	20				980	
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	196.0	1	MechElCr	$128	$26,000		$0		49	4				196	
	36	Install Atuator Valve	Assume 12 hrs each	hr	588.0	1	MechElCr	$128	$76,000		$0		49	12				588	
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	49.0	1	StrucCr	$147	$8,000	$ 500.00	$25,000		49					49	
	38	Redo Controls	Assume 120 hrs of Programmer	hr	120.0	1	Ctrl	$51	$7,000		$0		120					120	
	39	Mob Demob if not other alts done			-	1			$0		$0							0	
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0								
	41				-	1			$0		$0							0	
	42	Misc Matl	Say 20% ea Matl	%	54,800.0	1		$0	$0	$ 1.00	$55,000		274,000	0.2				54800	
	43	Misc Labor etc	Say 20%	%	301,200.0	1		$1	$302,000	$ -	$0		1,506,000	0.2				301200	
		Subtotal Direct Cost	$2,137,000						$1,808,000		$329,000								

Note: This alternative modifies orifice units currently in use (42) plus additional units that have been drilled but not gated (7) for a total of 49 working orifices maintaining the current operating flow in the collection channel and dewatering system.

Values in red depict the items that are affected by the additional orifice units included and/or the total quantity of orifice units.

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Crews
GenCrew
Core

Green Cells are link/formula

Prepared by: RLR 10/21/2011

Location	Line No.	Item	RLR Notes	Unit	Quantity	Production Qs/Unit	Labor or Crew or Sub-Bid Crew	Rate $/Unit	L-Cr-SB Direct Cost Subtotal (Rnd)	Material $/Unit	Matl Direct Cost Subtotal (Rnd)	Verified	Quantities per Item X	Y	Z	T	S	Q (product xyzts)	NOTE
V1		Direct Costs Alt 5 - Increase DSM Flow w/ More Open Orifice Mod Criteria																	
Alt A5 Increase DSM Flow w/ more open orifice Mod Criteria	1	Mob Demob	See light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	Included in light ring work below	Hrs	-	1	GenCrew	$367	$0		$0		0	0				0	
	3	Scaffolding Main units	Ditto	ea	-	1	See calc.	$7,000	$0		$0							0	
	4	scaffolding at fish units	Ditto	ea	-	1	See calc	$7,000	$0		$0							0	
	5	Demo existing orifice tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	6	Core drill for 13" dia Tube	Ditto	hr	-	1	Core	$1,093	$0		$0		0	0				0	
	7	Install 13" Tube	Ditto	hr	-	1	StruCr	$147	$0		$0		0	0	0			0	
	8	Matl costs for new tubes	Ditto	ea	-	1	n/a		$0	$ 3,600	$0		0					0	
	9	Install New Gate	Ditto	hrs	140.0	1	MechElCr	$128	$18,000		$0		1	10	14			140	
	10	Install New Actuator	Ditto	hr	168.0	1	MechElCr	$128	$22,000		$0		1	12	14			168	
	11	Matl Cost for Mech	Ditto	ea	18.0	1	n/a		$0	$ 10,000.00	$180,000		18					18	
	12	Modifiy DSM Grating	Ditto	hr	112.0	1	StruCr	$147	$17,000		$0		8	14				112	
	13	Redo Orifice Opening Controls HMI	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	14	Redo Air Flush System Controls	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	15	New SS Retainer Ring (alt 4)	from report text	ea	-	1			$0	$ 400.00	$0							0	
	16	Adjustments to weirs and sensors at dewatering Structure to handle increased flows	Assume 3 weeks of each crew to modify for adjustment of weirs or perf plates or sensors or gates or controls	hr	180.0	1	GenCrew, Core, StruCr, MechElCr, Ctrl	$1,786	$322,000		$0		3	60				180	
	17	Malt for D/W Adjustments	Assume $50000 per year for the 3 years of work		3.0	1			$0	$ 50,000.00	$150,000		3					3	
	18				-	1			$0		$0							0	
Alt 12 Light Ring	19	* Light Ring	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	*3% Min.*
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500	
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	720.0	1	Gen Crew + SturCr	$514	$371,000		$0		3	10	8	3		720	
	23	scaffolding at fish units	ditto	hr	120.0	1	ditto	$514	$62,000		$0		3	10	4			120	

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Crews
GenCrew
Core

Green Cells are link/formula

Verified

		Prepared by: RLR	10/21/2011			Labor or Crew or Sub-Bid				Material			Quantities per Item						
V1		Direct Costs Alt 5 - Increase DSM Flow w/ More Open Orifice Mod Criteria				Production		Rate	L-Cr-SB		Matl								
Location	Line No.	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	Direct Cost Subtotal (Rnd)	$/Unit	Direct Cost Subtotal (Rnd)		X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt 12 Light Ring	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	1,120.0	1	StruCr	$147	$165,000		$0		56	20				1120	
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	56.0	1	n/a		$0	$ 650.00	$37,000		56					56	
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	1,120.0	1	MechElCr	$128	$144,000		$0		56	20				1120	
	27	Matl costs mech Elec	From text report	ea	56.0	1			$0	$ 1,500.00	$84,000		56					56	
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	134.4	1			$0	$ 150.00	$21,000		56	2.4				134.4	
	29					1			$0		$0		56					56	
Alt 11 Reduce Orifice Tube Length	30	** Reduce Orifice Tube Length			56.0	1			$0		$0		56					56	
	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	560.0	1	StruCr	$147	$83,000		$0		56	10				560	
	32	Install Structural Frame	Assume 20 hrs ea	hr	1,120.0	1	StruCr	$147	$165,000		$0		56	20				1120	
	33	Matl cost for frame	from rpt text	ea	56.0	1	na/		$0	$ 700.00	$40,000		56					56	
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	1,120.0	1	MechElCr	$128	$144,000		$0		56	20				1120	
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	224.0	1	MechElCr	$128	$29,000		$0		56	4				224	
	36	Install Atuator Valve	Assume 12 hrs each	hr	672.0	1	MechElCr	$128	$87,000		$0		56	12				672	
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	56.0	1	StruCr	$147	$9,000	$ 500.00	$28,000		56					56	
	38	Redo Controls	Assume 120 hrs of Programmer	hr	120.0	1	Ctrl	$51	$7,000		$0		120					120	
	39	Mob Demob if not other alts done			-	1			$0		$0							0	
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0								
	41				-	1			$0		$0							0	
	42	Misc Matl	Say 20% ea Matl	%	108,000.0	1		$0	$0	$ 1.00	$108,000		540,000	0.2				108000	
	43	Misc Labor etc	Say 20%	%	391,400.0	1		$1	$392,000	$ -	$0		1,957,000	0.2				391400	
		Subtotal Direct Cost	$2,997,000						$2,349,000		$648,000								

Note: This alternative modifies orifice units currently in use (42), plus the maximum number of additional orifice units that have been drilled but not gated (18), plus additional units that need to be drilled and gated for a total of 60 working orifices to operate with an increase in flow of ~100 cfs due to operational changes and increase in allowable screen velocity during a portion of the fish passage season.

Values in red depict the items that are affected by the additional orifice units included and/or the total quantity of orifice units.

		B2 Orifice Improvements 2012					Crews GenCrew Core				Green Cells are link/formula	Verified							
		Preliminary Cost Estimate (Rounded to 1000$)																	
		Prepared by: RLR	10/21/2011			Labor or Crew or Sub-Bid				Material			Quantities per Item						
V1		Direct Costs Alt 11 - Minimize Overall Tube Length				Production		Rate	L-Cr-SB		Matl								
Location	Line No.	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	Direct Cost Subtotal (Rnd)	$/Unit	Direct Cost Subtotal (Rnd)		X	Y	Z	T	S	Q (product xyzts)	NOTE
N/A	1	Mob Demob	See Light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	Included in Light Ring work Below	Hrs	-	1	GenCrew	$367	$0		$0							0	
	3	Scaffolding Main units	Ditto	ea	-	1	See calc.	$7,000	$0		$0							0	
	4	scaffolding at fish units	Ditto	ea	-	1	See calc	$7,000	$0		$0							0	
	5	Demo exiting orifice tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	6	Core drill for 13" dia Tube	Ditto	hr	-	1	Core	$1,093	$0		$0							0	
	7	Install 13" Tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	8	Matl costs for new tubes	Ditto	ea	-	1	n/a		$0	$ 3,600	$0							0	
	9	Install New Gate	Ditto	hrs	-	1	MechElCr	$128	$0		$0							0	
	10	Install New Actuator	Ditto	hr	-	1	MechElCr	$128	$0		$0							0	
	11	Matl Cost for Mech	Ditto	ea	-	1	n/a		$0	$ 10,000.00	$0							0	
	12	Modifiy DSM Grating	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	13	Redo Orifice Opening Controls HMI	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	14	Redo Air Flush System Controls	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	15	New SS Retainer Ring (alt 4)	from report text	ea	-	1			$0	$ 400.00	$0							0	
	16	Adjustments to weirs and sensors at dewatering Structure to handle increased flows	Assume 3 weeks of each crew to modify for adjustment of weirs or perf plates or sensors or gates or controls	hr	-	1	GenCrew, Core, StruCr, MechElCr , Ctrl	$1,786	$0		$0							0	
	17	Malt for D/W Adjustments	Assume $50000 per year for the 3 years of work		-	1			$0	$ 50,000.00	$0							0	
	18				-	1			$0		$0							0	
Alt 12 Light Ring	19	* Light Ring	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	-	1	See calcs	$4,730	$0	$ -	$0								*3% Min.*
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0								
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	-	1	Gen Crew + SturCr	$514	$0		$0								
	23	scaffolding at fish units	ditto	hr	-	1	ditto	$514	$0		$0								

		B2 Orifice Improvements 2012					Crews GenCrew Core				Green Cells are link/formula	Verified						
		Preliminary Cost Estimate (Rounded to 1000$)																
		Prepared by: RLR	10/21/2011			Labor or Crew or Sub-Bid				Material			Quantities per Item					
V1		**Direct Costs Alt 11 - Minimize Overall Tube Length**				Production		Rate	L-Cr-SB		Matl							
Location	Line No.	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	Direct Cost Subtotal (Rnd)	$/Unit	Direct Cost Subtotal (Rnd)		X	Y	Z	T	S	Q (product xyzts)
Alt 12 Light Ring	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	-	1	StruCr	$147	$0		$0							
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	-	1	n/a		$0	$ 650.00	$0							
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	-	1	MechElCr	$128	$0		$0							
	27	Matl costs mech Elec	From text report	ea	-	1			$0	$ 1,500.00	$0							
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	-	1			$0	$ 150.00	$0							
	29					1			$0		$0							0
Alt 11 Reduce Orifice Tube Length	30	** Reduce Orifice Tube Length			-	1			$0		$0							0
	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	420.0	1	StruCr	$147	$62,000		$0		42	10				420
	32	Install Structural Frame	Assume 20 hrs ea	hr	840.0	1	StruCr	$147	$124,000		$0		42	20				840
	33	Matl cost for frame	from rpt text	ea	42.0	1	na/		$0	$ 700.00	$30,000		42					42
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	840.0	1	MechElCr	$128	$108,000		$0		42	20				840
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	168.0	1	MechElCr	$128	$22,000		$0		42	4				168
	36	Install Atuator Valve	Assume 12 hrs each	hr	504.0	1	MechElCr	$128	$65,000		$0		42	12				504
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	42.0	1	StruCr	$147	$7,000	$ 500.00	$21,000		42					42
	38	Redo Controls	Assume 120 hrs of Programmer	hr	120.0	1	Ctrl	$51	$7,000		$0		120					120
	39	Mob Demob if not other alts done	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500
	41				-	1			$0		$0							0
	42	Misc Matl	Say 20% ea Matl	%	10,200.0	1		$0	$0	$ 1.00	$11,000		51,000	0.2				10200
	43	Misc Labor etc	Say 20%	%	141,400.0	1		$1	$142,000	$ -	$0		707,000	0.2				141400
		Subtotal Direct Cost	$911,000						$849,000		$62,000							

Note: This workseet assumes that Alt 11 only is <u>not</u> attached to any other Alternatives and would be implemented only on the existing working orifice units (42).

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Prepared by: RLR 10/21/2011

Crews
GenCrew
Core

Green Cells are link/formula

V1		Direct Costs Alt 12 - Replace Orifice Ring w/ LED Orifice Ring				Labor or Crew or Sub-Bid				Material		Verified	Quantities per Item						
						Production		Rate	L-Cr-SB		Matl								
Location	Line No.	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	Direct Cost Subtotal (Rnd)	$/Unit	Direct Cost Subtotal (Rnd)		X	Y	Z	T	S	Q (product xyzts)	NOTE
Alt A5 Increase DSM Flow w/ more open orifice Mod Criteria	1	Mob Demob	See Light ring below	LS	-	1	See calcs	$4,730	$0	$ -	$0							0	
	2	Dewater & Prep	Included in Light Ring work Below	Hrs	-	1	GenCrew	$367	$0		$0							0	
	3	Scaffolding Main units	Ditto	ea	-	1	See calc.	$7,000	$0		$0							0	
	4	scaffolding at fish units	Ditto	ea	-	1	See calc	$7,000	$0		$0							0	
	5	Demo exiting orifice tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	6	Core drill for 13" dia Tube	Ditto	hr	-	1	Core	$1,093	$0		$0							0	
	7	Install 13" Tube	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	8	Matl costs for new tubes	Ditto	ea	-	1	n/a		$0	$ 3,600	$0							0	
	9	Install New Gate	Ditto	hrs	-	1	MechElCr	$128	$0		$0							0	
	10	Install New Actuator	Ditto	hr	-	1	MechElCr	$128	$0		$0							0	
	11	Matl Cost for Mech	Ditto	ea	-	1	n/a		$0	$ 10,000.00	$0							0	
	12	Modifiy DSM Grating	Ditto	hr	-	1	StruCr	$147	$0		$0							0	
	13	Redo Orifice Opening Controls HMI	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	14	Redo Air Flush System Controls	Ditto	hr	-	1	Ctrl	$51	$0		$0							0	
	15	New SS Retainer Ring (alt 4)	from report text	ea	-	1			$0	$ 400.00	$0							0	
	16	Adjustments to weirs and sensors at dewatering Structure to handle increased flows	Assume 3 weeks of each crew to modify for adjustment of weirs or perf plates or sensors or gates or controls	hr	-	1	GenCrew, Core, StruCr, MechElCr, Ctrl	$1,786	$0		$0							0	
	17	Malt for D/W Adjustments	Assume $50000 per year for the 3 years of work		-	1			$0	$ 50,000.00	$0							0	
	18				-	1			$0		$0							0	
Alt 12 Light Ring	19	* Light Ring	LEDs		-	1			$0		$0							0	
	20	Mob Demob	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	*3% Min.*
	21	Dewater & Prep	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	500.0	1	GenCrew	$367	$184,000		$0		5	10	10			500	
	22	Scaffolding Main units	Assume 2 days to install 1 day remove (10 hr days) 8 units with 3 slots per unit plus 4 slots at fish units	hr	720.0	1	Gen Crew + SturCr	$514	$371,000		$0		3	10	8	3		720	
	23	scaffolding at fish units	ditto	hr	120.0	1	ditto	$514	$62,000		$0		3	10	4			120	

B2 Orifice Improvements 2012

Preliminary Cost Estimate (Rounded to 1000$)

Crews
GenCrew
Core

Green Cells are link/formula

Prepared by: RLR 10/21/2011

Location	Line No.	Item	RLR Notes	Unit	Quantity	Qs/Unit	Crew	$/Unit	Direct Cost Subtotal (Rnd)	$/Unit	Direct Cost Subtotal (Rnd)	Verified	X	Y	Z	T	S	Q (product xyzts)	NOTE
						Labor or Crew or Sub-Bid				Material			Quantities per Item						
V1		Direct Costs Alt 12 - Replace Orifice Ring w/ LED Orifice Ring				Production		Rate	L-Cr-SB		Matl								
Alt 12 Light Ring	24	Chip Gatewell Face for flush fit, install ring, grout smooth	Assume Struc Crew 20 hrs each	hr	840.0	1	StruCr	$147	$124,000		$0		42	20				840	
	25	Matl Struc Costs for Light ring work	Matl Struc Costs from report text for anchors, patching, etc	ea	42.0	1	n/a		$0	$ 650.00	$28,000		42					42	
	26	Install Power through Light tube	Assume 20 hrs to install, connect power, secure, test, trouble shoot, transformer etc.	hr	840.0	1	MechElCr	$128	$108,000		$0		42	20				840	
	27	Matl costs mech Elec	From text report	ea	42.0	1			$0	$ 1,500.00	$63,000		42					42	
	28	Grout Old Light Tube Closes	Assume 6" dia x 6 ft each 2 per orifice for 2.4cf per orifice at 150$/cf	cf	100.8	1			$0	$ 150.00	$16,000		42	2.4				100.8	
	29					1			$0		$0							0	
Alt 11 Reduce Orifice Tube Length	30	** Reduce Orifice Tube Length			-	1			$0		$0							0	
	31	Chip Face @ valve	Assume 10 hrs per orifice	hr	-	1	StruCr	$147	$0		$0							0	
	32	Install Structural Frame	Assume 20 hrs ea	hr	-	1	StruCr	$147	$0		$0							0	
	33	Matl cost for frame	from rpt text	ea	-	1	na/		$0	$ 700.00	$0							0	
	34	Redo Piping to Acturator	Assume 20 hrs to customize at each	hr	-	1	MechElCr	$128	$0		$0							0	
	35	Remove Actuator Valve	Assume 4 hrs to remove & save ea	hr	-	1	MechElCr	$128	$0		$0							0	
	36	Install Atuator Valve	Assume 12 hrs each	hr	-	1	MechElCr	$128	$0		$0							0	
	37	Misc part that could not be reused	Assume average of $500 per Orifice	ea	-	1	StruCr	$147	$0	$ 500.00	$0							0	
	38	Redo Controls	Assume 120 hrs of Programmer	hr	-	1	Ctrl	$51	$0		$0							0	
	39	Mob Demob if not other alts done	Assume trips 1 crane, 1 access/skiffs, 2 office/storage, 2 sm equip, 3 misc needs to be done 3 times (3 years)	LS	27.0	1	See calcs	$4,730	$128,000	$ -	$0		9	3				27	
	40	Dewater & Prep (If Alt 11 Only)	Assume 5 days (10 hrs ea) 10 units (8 main, 2 fish)	hr	-	1	GenCrew	$367	$0		$0								
	41				-	1			$0		$0							0	
	42	Misc Matl	Say 20% ea Matl	%	21,400.0	1		$0	$0	$ 1.00	$22,000		107,000	0.2				21400	
	43	Misc Labor etc	Say 20%	%	221,000.0	1		$1	$221,000	$ -	$0		1,105,000	0.2				221000	
		Subtotal Direct Cost	$1,455,000						$1,326,000		$129,000								

Note: This workseet assumes that Alt 12 only is <u>not</u> attached to any other Alternatives and would be implemented only on the existing working orifice units (42).

Assumptions for Costs				
Bonneville Second Powerhouse Orifice Improvments 2012				
Preliminary Cost Estimate				
RLR 10/20/2011				
	Crews_	$/hr	Cellname	NOTE
	GenCrew			GenCrew to perfom Dewatering support, Scaffolding install, Demolition, General Deck Support see calc p. 60-4
	Labor	244		
	Equip	123		
	Total	367	**GenCrew**	
	Coring Crew			Performs: Coring new orifices see calc p. 60-5
	Labor	84		
	Equip	9		
	Wear	1000		
	Total	1093	Core	
	Structural Installers Crew			Performs: Installing Orifice Tubes, Grouting (tubes, old light tubes, new orifice rings., Chipping/removing concrete. See calc p. 60-6
	Labor	114		
	Equip	33		
	Total	147	StruCr	
	MECH ELECTRICAL INSTALLERS			(MechElCr) Assumes same cost for millwright and electrician and same cost for their required equipment. Performs: Installing Valves, Actuators, Light Rings, Redo Piping, sensors, power. Modify Dewatering Structure See Calc p. 60-7
	Labor	95		
	Equip	33		
	Total	128	MechElCr	
	Controllers			Performs: Changing programming of controls. See Calc p. 60-8
	Labor	49		
	Equip	2		
	Total	51	Ctrl	

APPENDIX C – REGIONAL COORDINATION

Comments on 60% EDR from National Marine Fisheries Service

February 1, 2012 F/NWR-5

FILE MEMORANDUM

FROM: Gary Fredricks, Ed Meyer and Trevor Conder

SUBJECT: Comments on the 60% Orifice Improvements Report

These comments are regarding the Bonneville Second Powerhouse Orifice Improvements Study Engineering Documentation 60% Draft Report – November 2011.

1. The goals of this project should be clearly stated as improvements to the collection system that will reduce injury and delay to migrating fish species. These improvements should address three specific issues:
   a. Improve the ability for the project operators to detect debris plugs in the orifice,
   b. Reduce the likelihood of fish impingement due to misalignment of orifice flow, and
   c. Improve gatewell egress times with improved orifice lighting.

2. As we mentioned in our recent memo regarding the FGE Alternatives Report, we do not support alternatives (e.g., A4) that alter the original design goals of this collection channel as outlined in sections 6.1 and 6.2. Nor do we support alternatives that relax NOAA screen criteria (e.g., Alt A5) for any portion of the fish passage season.

3. Additionally, we do not support reducing the orifice ring size (Alt A4) from the current size due to concerns for injury to fallback adult salmon and steelhead.

4. Acceptable alternatives should allow for daily (or more frequent) inspection of the orifice to assure against debris plugging. Alternative A6 would be impractical for this inspection frequency.

5. Alternative A7 has been tried in the past (at PH1) with poor results. The electronic pressure sensors just didn't do well in this gatewell environment. How would these be tested on a daily basis and would the project know if they have failed? Reliability and O&M may be a serious impediment to this design.

6. Alternative A8 has similar reliability and O&M concerns as alternative A7.

7. We support alternative A12 (and elimination of the current incandescent lights and light tubes), however, there should be some provision for determining when these lights are working correctly (lit or not).

8. Summary Comment. Of the alternatives selected as final by the Corps Development Team, we would not support A4 and A5 for reasons mentioned above. Alternative A3, while acceptable, is likely cost prohibitive as written, given the region's current appetite for bypass systems. We recommend looking closely at steps to reduce the costs for Alternative A3 while maintaining its intent of maintaining minimum orifice dimensions and eliminating jet impingement. We suggest further investigation into a cost effective alternative that works to increase the size and or shape of the exit orifice ring so impingement is not possible under any forebay level. This alternative in addition to either alternatives A1 and A2 may provide enough air to support the jet, and possibly eliminate obstruction to the jet that could potentially injure fish. We would appreciate further discussion of these issues in the next Portland District FFDRWG meeting.

Comments on 60% EDR from National Marine Fisheries Service with Responses in Blue

May 3, 2012 F/NWR-5

FILE MEMORANDUM

FROM: Gary Fredricks, Ed Meyer and Trevor Conder

SUBJECT: Comments on the 60% Orifice Improvements Report

These comments are regarding the Bonneville Second Powerhouse Orifice Improvements Study Engineering Documentation 60% Draft Report – November 2011.

1. The goals of this project should be clearly stated as improvements to the collection system that will reduce injury and delay to migrating fish species. These improvements should address three specific issues:
   a. Improve the ability for the project operators to detect debris plugs in the orifice,
   b. Reduce the likelihood of fish impingement due to misalignment of orifice flow, and
   c. Improve gatewell egress times with improved orifice lighting.

   - **Concur. Plan to clarify in 90% Engineering Document Report.**

2. As we mentioned in our recent memo regarding the FGE Alternatives Report, we do not support alternatives (e.g., A4) that alter the original design goals of this collection channel as outlined in sections 6.1 and 6.2. Nor do we support alternatives that relax NOAA screen criteria (e.g., Alt A5) for any portion of the fish passage season.

   - **Concur. We understand the reluctance to relax NOAA screen criteria and alter the original design goals. We will continue the investigation of alternatives that meet these concerns.**

3. Additionally, we do not support reducing the orifice ring size (Alt A4) from the current size due to concerns for injury to fallback adult salmon and steelhead.

   - **There is uncertainty, due to insufficient data, to show that reducing orifice ring size from 12 5/8 inch to the original 12 inch design criteria would provide a measureable benefit to fallback adult salmon and steelhead.**

4. Acceptable alternatives should allow for daily (or more frequent) inspection of the orifice to assure against debris plugging. Alternative A6 would be impractical for this inspection frequency.

   - **Concur. This alternative did not score high enough to be selected in the top three alternatives and was not carried forward.**

5. Alternative A7 has been tried in the past (at PH1) with poor results. The electronic pressure sensors just didn't do well in this gatewell environment. How would these be tested on a daily basis and would the project know if they have failed? Reliability and O&M may be a serious impediment to this design.

   - **Concur. This alternative did not score high enough to be selected in the top three alternatives and was not carried forward.**

6. Alternative A8 has similar reliability and O&M concerns as alternative A7.

   - **Concur. This alternative did not score high enough to be selected in the top three alternatives and was not carried forward.**

7. We support alternative A12 (and elimination of the current incandescent lights and light tubes), however, there should be some provision for determining when these lights are working correctly (lit or not).

   - **Concur. Electronic system proposed to address this concern and there are plans to investigate since this alternative scored high in the alternatives matrix.**

8. Summary Comment. Of the alternatives selected as final by the Corps Development Team, we would not support A4 and A5 for reasons mentioned above. Alternative A3, while acceptable, is likely cost prohibitive as written, given the region's current appetite for bypass systems. We recommend looking closely at steps to reduce the costs for Alternative A3 while maintaining its intent of maintaining minimum orifice dimensions and eliminating jet impingement. We suggest further investigation into a cost effective alternative that works to increase the size and or shape of the exit orifice ring so impingement is not possible under any forebay level. This alternative in addition to either alternatives A1 and A2 may provide enough air to support the jet, and possibly eliminate obstruction to the jet that could potentially injure fish. We would appreciate further discussion of these issues in the next Portland District FFDRWG meeting.

   - **Alternative A3 (Re-Core Orifice Tube to Larger Size, Install Larger I.D. Transport Pipe of 18", Replace 12 5/8" Orifice Ring with 13" Orifice Ring) will no longer be considered based on insufficient supporting biological data and the large cost of $8.4M compared to alternative A4 (Reduce Orifice Ring Size to 12" and Open Additional Orifices as Needed to Maintain Channel Design Flow and Velocities) at $4.3M.**

   - **Alternatives A1 (Add Compressed Air to Orifice Tube with 13" Orifice Rings) and A2 (Vent Orifice tube Using Existing Light Tube Ports with 13" Orifice Rings) did not rank high enough in the Alternatives Matrix to make the top three alternatives and will no longer be considered.**

- **Alternative A5 (Seasonally Increase Capacity of DSM2, Reduce Orifice Ring Size to 12" and Open Additional Orifices as Needed to Maintain Channel Design Flow and Velocities) will no longer be considered due to the strong concern for relaxing the dewatering screen velocity criteria for part of the fish passage season.**

- **For all major alternatives considered, alternatives A11 (Minimize Overall Length of Pipe and Mounting Flange) and A12 (Replace Existing Orifice Ring with Lighted Orifice Ring) are assumed to be included as part of the Alternatives Evaluation.**

- **Alternative A4 has ranked high in the Alternatives Matrix and is being investigated to determine if the goals as outlined in the EDR can be met, as well as the concerns to not change velocity in the DSM2 channel and existing screen criteria at the dewatering structure. Operations are being investigated to link these improvements to maximize benefits to the Fish Guidance Efficiency Program. We look forward to your collaboration in further discussion.**

Special FFDRWG Bonneville FGE and B2 Orifice – Minutes

CENWP-PM-E 30 April 2012

MEMORANDUM FOR THE RECORD

Subject: DRAFT minutes for the 30 April 2012 Special FFDRWG BON FGE meeting.

The meeting was held in Room 3E at Portland District RDP. In attendance:

Last	First	Agency	Office/Mobile	Email
Conder	Trevor	NOAA	503-231-2306	Trevor.conder@noaa.gov
Fredricks	Gary	NOAA	503-231-6855	Gary.fredricks@noaa.gov
Kruger	Rick	ODFW	971-673-6012	Rick.kruger@coho2.dfw.state.or.us
Kuhn	Karen	USACE-NWP	808-503-4897	Karen.a.kuhn@usace.army.mil
Lee	Randy	USACE-NWP	503-808-4876	Randall.t.lee@usace.army.mil
Lorz	Tom	CRITFC	503-238-3574	lort@critfc.org
Mackey	Tammy	USACE-NWP	503-961-5733	Tammy.m.mackey@usace.army.mil
Medina	George	USACE-NWP	503-808-4753	George.J.Medina@usace.army.mil
Meyer	Ed	NOAA	503-230-5411	Ed.meyer@noaa.gov
Petersen	Christine	BPA		chpetersen@bpa.gov
Rerecich	Jon	USACE-PM-E	503-808-4779	Jonathan.g.rerecich@usace.army.mil
Schneider	Carolyn	USACE-NWP	503-808-4970	Carolyn.b.schneider@usace.army.mil
Skidmore	John	BPA		jtskidmore@bpa.gov
Weiland	Mark	PNNL	509-427-5923	Mark.weiland@pnnl.gov
Wills	David	USFWS	360-604-2500	David_wills@fws.gov

Lorz called in.

1. Finalized results from this meeting.

1.1. Alternatives that require de-rating the units is not supported by NOAA Fisheries.

1.2. Medina, in an effort to wrap up the FGE component of the meeting, suggested looking at Alternatives 1 and 8. The report would be completed around late June with looking at the model in FY13. These two alternatives would be modeled, followed by detailed reports. **Due to the fabrication of the slot filler and the Gantry 7 outage, the U14 A-slot slot filler won't be tested until early Spring 2013.**

1.3. For orifices, improve the lighting and improve the inspection ability. Provide air to clean the jet while inspecting and convert the existing light tubes to an inspection port. **In summary- LED orifice at 12 5/8", reduce distance by embedding actuators and provide inspection port through old light tube with a push button flusher.**

2. The following documents were provided or discussed. Documents may be found at www.nwd-wc.usace.army.mil/tmt/documents/FPOM/2010/FFDRWG/BON%20PH2%20FGE%20and%20orifice%20improvements/

2.1. *120430 Special FFDRWG meeting agenda_B2FGE_B2Orifice _30APR2012 (3).doc*

2.2. *120430 B2FGE Alt Eval Matrix Final.pdf*

2.3. *120430 B2FGE Eval of Alt Narrative.pdf*

2.4. *120430 B2OrificeImprov_90%EDR (1).pdf*

2.5. *120430 B2OrificeImprov_90%EDR (2).pdf*

3. Action Items

4. **B2 FGE and B2 Orifice Background.** Now attempting to combine the two PDTs since they are so closely intertwined.

5. **B2 FGE.** R. Lee provided some background.

5.1. Operating assumptions and constraints. Fredricks and Wills talked about the need to get this project implemented due to the push to de-rate the PH2 units for the safety of fish. They recognize the complexities involved in balancing operations for fish, TDG, and power at BON, but operating those units at the upper end kills not only Spring Creek fish but also run of the river fish.

5.2. How B2 FGE alternatives are weighed. Lee went through the matrix and explained each factor and the weight given. There were questions about the weighted scores. Biological factors were weighted higher than other factors. Baseline was given a 4. Higher cost scores are better benefits/lower impacts, lower cost scores are reduced benefits. There were questions about the weighted scores. Biological factors were weighted higher than other factors. Conder asked why the two orifices option was rated better than de-rating the unit. Based on Lyle Gilbreath's report, de-rating the unit increased survival five-fold. There were more questions about rating. Fredricks said it doesn't matter because we are going to evaluate the alternatives based on what they do. He does want to explore the O&M tail because that can be a serious problem.

5.3. Matrix overview. Medina suggested focusing on the top three alternatives at this time. Kruger noted that if the scores were adjusted, then the top three alternatives may change. Everyone agreed that building a new bypass was off the table due to cost. Fredricks also suggested that Alt. 5 is off the table since de-rating the unit isn't a good option. He also felt that very little qualitative information is available for that option right now. He would like to see the best geometry further explored at PH1. We need to consider what works best for the unit as well as for fish.

5.3.1. Wills asked for clarification about 1% efficiency range and open geometry. He wants to know where they came from and where do the ranges overlap. Fredricks and Meyer said it depends on each unit and 1% may or may not result in the best biological effects and may not even be the best efficiency for the units.

5.3.2. Meyer explained that turbines have a best operating point chart. He went through how the curves are developed for generating power. All the points on the curve are based on head and flow. The 1% comes off that peak. The 1% is for power.

5.3.3. Cavitation occurs when the unit blades are misaligned. Cavitation and turbulence is what kills fish at the lower end of the 1% curve. At the upper end, cavitation occurs when too much flow is put through the unit.

5.3.4. Best geometry is when the stay vanes, wicket gates, etc are all in alignment and provides for the best flow path. Open geometry is determined based on physical alignment. It often results in greater power efficiency and greater survival for fish. Meyer explained that in some units the wicket gates and stay vanes are in line but in others, they are offset so best geometry differs for each unit.

5.3.5. Kristine asked about the episodic debris issues. Meyer explained that during those high flows, which coincides with the debris, water is pushed through the unit but with high tailwater, the unit shouldn't reach cavitation.

5.4. Cleaning the VBSs without the backer screen takes about 20 minutes. Adding a second crane and crew may handle the debris issues during the high flow and high debris times of year. Fredricks agreed this option should be on the table.

5.5. Alternatives to be carried forward include a flow control device, slot fillers and operational changes (second crane and crew). Rerecich clarified that the Region is willing to take a hit on FGE.

5.5.1. The flow control (louver) will likely be adjustable rather than fixed. May require a physical model. O&M costs may be high, depending on final design. Fredricks stressed that the VBS must be balanced to reduce hot spots. Wills asked if the individual louvers should be adjustable to best balance the VBS. Conder suggested the louver would be most beneficial at the upper 1%. Medina wanted to clarify that the team should move forward with the louvers even though it will likely reduce FGE. Meyer said he is looking at it as pulling forward a flow control device alternative. The slot filler may work but there should be at least one flow control device as an option. Fredricks said they are willing to look at it and test it to see what would happen to FGE. He also noted that we need to determine what the overall goal for the gatewell will be.

5.5.2. Medina, in an effort to wrap up the meeting, suggested looking at Alternatives 1 and 8. The report would be completed around late June with looking at the model in FY13. These two alternatives would be modeled, followed by detailed reports. **Due to the fabrication of the slot filler and the Gantry 7 outage, the U14 A-slot slot filler won't be tested until early Spring 2013.**

6. **B2 Orifice Improvements. Kuhn provided some background, operating assumptions and constraints, and how B2 orifice improvement alternatives are weighed.** It was noted that there was little support for returning to the 12" orifice rings. Opening additional orifices at the north units may not work because the channel is balanced. Rerecich noticed that Unit 18 operating at the lower end of 1% showed clean jets in B and C slots but A was disturbed. Rerecich noted that there are a lot of factors contributing to the condition of the orifice jets.

6.1. Fredricks said, years ago, when the units were not running, the jets were perfect; operating units usually had a different shaped jet but still intact. Once the channel was re-designed, the orifice jets didn't remain intact as often as before. He noted that he didn't want the correction to be smaller orifices due to fish size and to debris. NOAA Fisheries said they would rather see 14" orifices but that won't work because of the volume of water. Fredricks stressed that the clear jets are needed to show the orifices are clean; that is the primary reason for clearing up the jets. He also noted, it would be good to know how often the orifices are truly blocked. Maybe it doesn't happen that often.

6.2. Rerecich asked about the benefit of having a regulating orifice in A-slots to reduce gatewell retention time, units 11-18, but removing them in C-slots. The A-slots are the orifices with the messiest jets most often. C-slots tend to be clear most often. Fredricks asked about the channel hydraulics. Rerecich had some information based on CFD models. He said he would like to have this option available to look at. He also said the orifices will be set into the wall and the ring will be shaped. Those two actions are going to happen because there is a high likelihood of a benefit and little to no risk. Kuhn noted that the orifice ring being smooth is for the adult fish; if you were looking for a spring for the jet, you would have a sharp edged orifice ring.

6.3. After further discussion, Fredricks decided we should be back at vertical slot orifices. Rerecich noted that this is why the FGE and Orifices PDTs are intertwined. Vertical slots are likely cost prohibitive. After further discussion, Fredricks suggested that if you could see the orifice through the light tube, then you could see if there was debris. In addition, an easy push button for flushing if there was debris, may provide a system that meets the needs. The light tube would be useable because the lights would not be at the light tube, they would be built into the orifice. The lenses would remain cleaner with no light cooking on river and bug gunk. **Provide air to clean the jet while inspecting and convert the existing light tubes to an inspection port.**

6.4. Conder suggested getting as big an actuator as possible and as close to the wall as possible. The reduction in tube length should help. Fredricks suggested going to an oil actuator rather than an air actuator. Can we look at flattening the cylinder. The misalignment of the actuator, gate and orifice rings and tubes may contribute to the impingement issues. Rerecich said the longer tubes are resulting in the jet collapsing before it reaches the end of the tubes.

6.5. In summary- LED orifice at 12 5/8", reduce distance by embedding actuators and provide inspection port through old light tube with a push button flusher. NOAA recommends testing this orifice by orifice not just a blanket design. More discussion occurred around the orifice shape. Meyer suggested changing the exiting edge of the orifice tube to help the jet get over the edge.

6.6. Matrix Overview

- **6.6.1.** Orifice lighting and ring improvements
- **6.6.2.** Reduction of overall tube length

Comments on 90% EDR from National Marine Fisheries Service

May 9, 2012 F/NWR-5

FILE MEMORANDUM

FROM: Gary Fredricks, Ed Meyer and Trevor Conder

SUBJECT: Bonneville Dam PH2 Orifice Improvements Study 90% Engineering Documentation Report (EDR)

The following comments pertain to the subject report dated March 2012. We previously submitted comments on the 60% report on February 1, 2012. We also verbally commented on elements of the 90% report at an April 30, 2012, ad hoc Fish Facility Design Review Work Group meeting.

In reviewing the current EDR, we note that some of our comments from our February 1 memo were adopted and some were not. We appreciate the clarification added to the purpose and scope of the program and the elimination from further consideration of several of the alternatives that were a concern to us. However, we do note that one of our primary concerns (reduction in orifice ring size) was actually adopted as part of the preferred alternative. We remain concerned that any reduction in gatewell orifice size is a negative step for a system that passes a large number of adult salmon and steelhead. We also expressed this concern again at the April 30 meeting along with a few new comments and thoughts which included:

1. Completely achieving all the stated goals of this project may not be practical given the expense associated with re-coring the orifices or the need to accept the biological consequences associated with some of the other alternatives. We do, however, believe that achieving ease of inspection and improved gatewell orifice lighting is possible and that some improvement in orifice jet is possible through less intrusive and expensive methods.
2. Replacing the current orifice lighting with LED rings (with a failure warning system) as described in Alternative A12 will achieve the lighting objective.
3. Improved orifice inspection could be achieved by improving the view the current light tubes give of the back side of the orifice. We already use these light tubes to view the orifice for plugs but the light fixture is difficult to move out of the way and the light tube lens is difficult to see through. An improved observation system should be combined with an improved air flush system (something easier and more positive to use than the current valves) to allow a better, albeit temporary, orifice jet condition for viewing.
4. Improvements in the orifice jet can be achieved through the implementation of Alternative A11 (minimizing overall length of pipe and mounting flanges) combined with the second component of Alternative A4 (mining out concrete in the collection channel). We recognize that these improvements will be unlikely to result in perfect jets for all the orifices and forebay levels, but they should result in a significant improvement over the existing condition.

We look forward to working with the Corps in pulling these thoughts together into a final regionally preferred alternative for this project.

Comments on 90% EDR from National Marine Fisheries Service with Responses in Blue

May 9, 2012 F/NWR-5

FILE MEMORANDUM

FROM: Gary Fredricks, Ed Meyer and Trevor Conder

SUBJECT: Bonneville Dam PH2 Orifice Improvements Study 90% Engineering Documentation Report (EDR)

The following comments pertain to the subject report dated March 2012. We previously submitted comments on the 60% report on February 1, 2012. We also verbally commented on elements of the 90% report at an April 30, 2012, ad hoc Fish Facility Design Review Work Group meeting.

In reviewing the current EDR, we note that some of our comments from our February 1 memo were adopted and some were not. We appreciate the clarification added to the purpose and scope of the program and the elimination from further consideration of several of the alternatives that were a concern to us. However, we do note that one of our primary concerns (reduction in orifice ring size) was actually adopted as part of the preferred alternative. We remain concerned that any reduction in gatewell orifice size is a negative step for a system that passes a large number of adult salmon and steelhead. We also expressed this concern again at the April 30 meeting along with a few new comments and thoughts which included:

1. Completely achieving all the stated goals of this project may not be practical given the expense associated with re-coring the orifices or the need to accept the biological consequences associated with some of the other alternatives. We do, however, believe that achieving ease of inspection and improved gatewell orifice lighting is possible and that some improvement in orifice jet is possible through less intrusive and expensive methods.

    - **Many FFDRWG members expressed strong reluctance to a reduction of orifice ring size (Alternative A4) from the current 12 5/8 inch orifice to the original design specification of 12 inch. This was due to a possible biological risk to adult fish that pass through the orifices. A reduction to a 12 inch orifice ring, with the ability to operate more orifices, is linked to the FGE program and the ongoing investigation to reduce gatewell residence time. The 100% EDR will recommend a phased approach to implementing alternatives to improve jet quality. Orifice ring size reduction will be the final phase. Future examination of alternatives in the Design Documentation Report (DDR) of the orifice system to enhance jet cohesiveness, inspection efficiency, and orifice lighting is expected to contribute to overall improved jet quality at the Second Powerhouse. The FGE program is examining alternatives to improve the gatewell hydraulics and the FGE program's preferred alternative may be a contributing factor to achieving jet cohesiveness.**

2. Replacing the current orifice lighting with LED rings (with a failure warning system) as described in Alternative A12 will achieve the lighting objective.

- **Concur. Plans are in progress to test a low profile light ring with a 12 5/8 inch orifice diameter in spring 2013. Design refinement will be conducted in the DDR.**

3. Improved orifice inspection could be achieved by improving the view the current light tubes give of the back side of the orifice. We already use these light tubes to view the orifice for plugs but the light fixture is difficult to move out of the way and the light tube lens is difficult to see through. An improved observation system should be combined with an improved air flush system (something easier and more positive to use than the current valves) to allow a better, albeit temporary, orifice jet condition for viewing.

- **We anticipate lighting improvements with an orifice ring will help illuminate the orifice jet providing ease to the inspection. Eliminating primary use of the halogen lights could significantly reduce the water scale on the orifice lens and enhance the visual inspection of the orifice for debris. Installation of a local manual control switch to eliminate manually overriding the solenoid valves will be further investigated in the DDR.**

4. Improvements in the orifice jet can be achieved through the implementation of Alternative A11 (minimizing overall length of pipe and mounting flanges) combined with the second component of Alternative A4 (mining out concrete in the collection channel). We recognize that these improvements will be unlikely to result in perfect jets for all the orifices and forebay levels, but they should result in a significant improvement over the existing condition.

- **Concur. Alternatives A11 – Minimize Overall Pipe Length and Mounting Flange and A12 – Replace Existing Orifice Ring with Lighted Orifice Ring will be carried to the DDR.**

We look forward to working with the Corps in pulling these thoughts together into a final regionally preferred alternative for this project.

Thank you for your comments.

USACE Portland District (NWP) FFDRWG Update Form
October 20, 2016

PROJECT INFORMATION

Project Title	Bonneville Second Powerhouse JBS Orifice Improvements
SCT Reference Number	
Project Manager (PM)	George Medina (NWP, 503-808-4753)
Technical Lead (TL)	Karen Kuhn (NWP, 503-808-4897)
Biologist/Coordination	Jon Rerecich (NWP, 503-808-4779)

PROJECT DESCRIPTION

An engineering investigation was initiated to provide a recommended design to improve Bonneville Second Powerhouse juvenile fish passage for the downstream migrant (DSM) system from the gatewell to the primary dewatering system. Study goals were focused on improvements to reduce injury and delay to migrating fish species that include:

- Improving the ability for the project operators to detect debris plugs at the orifice;
- Reducing the likelihood of fish impingement due to alignment of orifice flow; and
- Improving gatewell egress times with improved lighting.

Because of its ability to meet all study goals at a reasonable estimated cost the Engineering Documentation Report (EDR) Alternative 4 was selected as the recommended alternative. Alternative 4 would reduce the orifice ring size from 12 5/8 inches to its original design diameter of 12 inches and open additional orifices as needed, to maintain channel design flow and velocities. In addition, both Alternative 11 (minimizes overall tube length) and Alternative 12 (uses lighted orifice ring) would be included.

PROGRESS AND KEY ISSUES

NOAA provided review comments through the FFDRWG process and did not support reducing the orifice ring size. This was due to possible biological risk to adult fish that pass through the orifices. The reduction to a 12 inch orifice ring, with the ability to operate more orifices, was linked to the FGE program and the ongoing investigation to reduce gatewell residence time. Continued discussion through FFDRWG resulted in many members reluctant to reduce orifice ring size. The PDT accepted this concern and the EDR suggests a phased approach for implementing alternative measures, and recommending that a reduction in orifice ring size would be the lowest priority alternative measure for implementation. The phased approach would test the performance of each measure following their implementation before additional measures are considered. The EDR also recommends activities associated with the B2 FGE program that included research and development including:

"*Incorporate observations and conclusions from scheduled testing of the gatewell turbulence reduction device in the B2 FGE program in FY13. Continue to collect information if other alternatives are tested in the B2 FGE program.*"

This project was originally tied to the B2FGE program on a parallel track. Hydraulic and biological testing through the B2FGE program in 2008, 2009, 2013, 2014, and 2015 has provided a better understanding of the mechanisms of mortality in the JBS. The primary sources have been identified and include undesirable gatewell hydraulic conditions and excessive through-screen velocities on the two uppermost panels of the VBS during turbine operations in the upper 1% range. An alternative has been tested with full powerhouse implementation scheduled for fall and winter of 2016/2017.

Based on FGE test data and fish condition data collected through the Smolt Monitoring Program, there appears to be little biological benefit for making adjustments to minimize overall orifice pipe length (Alt. 11) and installation of orifice light rings to improve gatewell egress times (Alt. 12). Given the high cost, substantial O&M and low biological benefit the light ring alternative is not being pursued. However, improving the ability for the project personnel to detect debris plugs at the orifice continues to be a FFDRWG concern. Providing a cohesive jet through re-coring the tube to a larger 18" diameter and minimizing overall pipe length by moving the actuators that have a longer distance to the orifice ring are the highest ranked EDR (CRFM) based alternatives to achieve this objective.

The B2 DSM PLC program operation has a continuous orifice flush cycle for debris removal that takes approximately 3.8 hours to complete for 40 orifices. The cycle then repeats until it is stopped. The other mode of operation is manual, allowing individual control of the slide gate and can be done from a computer touch screen in the control room or at the PLC cabinet in the electrical building on elevation +90 of the intake deck. Another method for manual operation is at the orifice in the DSM channel.

There has been interest expressed to investigate the inspection benefit of installing a local manual control switch to eliminate manually overriding the solenoid valves at the orifice during the inspection. This was included as a recommendation in the EDR. NOAA provided comments during 90% EDR review including – "*Improved orifice inspection could be achieved by improving the view the current light tubes give of the back side of the orifice. We already use these light tubes to view the orifice for plugs but the light fixture is difficult to move out of the way and the light tube lens is difficult to see through. An improved observation system should be combined with an improved air flush system (something easier and more positive to use than the current valves) to allow a better, albeit temporary, orifice jet condition for viewing.*"

Maintenance of the orifices and flush system is critical for its optimal operation and performance. Due to the existing frequency of auto flushing, daily system inspections by personnel, very infrequent observations of orifice debris plugging over many years, and the structural crew's ability to maintain removal of debris in gatewells when it is at or near criteria it, is recommended that resources to implement any modifications be conducted through O&M. The COE and FFDRWG members have been in discussion regarding ideas that are expected to help improve the reliability of the system. Two PLC modifications are being investigated:

1. Adding an air burst to the end of the flush cycle after the gate opens providing air support to reinitiate a cohesive jet.
2. Adding another auto flush cycle to the increase the cycling frequency for each orifice to approximately 2 hours.

The COE reported at the December 2015 and June 2016 FFDRWG that other LED light sources with higher luminance values had been investigated by the project through O&M and there were no plans for the PDT to move forward with the EDR recommendations for structural improvements or lighting improvements.

CURRENT SCHEDULE

Schedule for ATR completion will be determined based on ATR participants' availability followed by incorporation of agreed upon changes through the FFDRWG process.

FFDRWG REVIEW NEEDED AT MEETING? (If YES, list discussion topics below)

Updated EDR Recommendation to improve jet quality, inspection capability, align with ranked alternatives, and address FFDRWG concerns:

1. Modified alternative 3: Re-core orifice tube to a larger size (18 inch inside diameter) and maintain existing 12 5/8 inch orifice ring size.

2. Alternative 11: Minimize overall pipe length.

3. Eliminate orifice light ring alternative 12. Conduct lighting improvement on existing system through O&M.

Recommend prototype testing new configuration on poorest performing orifice(s) if necessary following B2FGE program gatewell modifications and O&M program improvements

O&M recommendations:

1. Rehab all orifices and air system for the function in auto and manual.
   Update ***– BON will be able to overhaul all orifices as time and money allow, starting at the south end of the DSM and working north. This IWW period the Project will rehab orifices 11A-S and 11A-N. This effort will continue each IWW, and includes complete replumbing (fittings, valves, and tubing).***

2. Two air burst cycle PLC modifications to investigate:
   a. Increase the frequency of orifice auto-flush from 4 hour cycle to 2 hour cycle
   b. Add an air burst to the end of the cycle.

   Update ***- BON is not willing to support this item due to high cost (in labor) and the observation that the orifice jets return to their original state shortly after manually supplying an air burst; BON would rather spend tight O&M dollars on items that have a clear benefit (e.g. orifice rehab).***

3. Clean light tubes to improve the view of the base of the jet. The light tubes lose Their luminescence due to algae, mold, water deposits on the lenses and spider habitat. The lenses are cleaned or replaced annually but each year the view capability diminishes through the season. The tubes must be cleaned out and have lights which seal tightly against the lens to eliminate spider webs and droppings. A possible solution to the water deposits is to wax the lenses and/or extend the tubes and lights further away from the water. A possible solution to providing long term reflective quality in the tube is to install a PVC white liner.

   Update ***- A light tube extension was tested on unit 18 in the DSM and did not prevent scum build-up on the glass view lens. Therefore this option is deemed unsuccessful. The project is looking into best options for cleaning the view port tubes.***

4. New higher luminance and cooler LED lights to reduce water scale buildup.

   Update ***– New LED lights have been installed on all orifices.***

5. New light hardware to allow unobstructed movement of light for observation of the base of the jet.

   Update ***– New light shrouds have been installed on all orifices and are movable.***

6. Increase frequency of changing out clean lenses. Increase from once per year to twice per year by adding a mid-season change out.

   Update ***- Cleaning lenses vs. replacement with new being evaluated. BON has a method to clean lenses. BON will add mid season lens change, increasing the frequency of lens cleaning/replacement.***