US Army Corps of Engineers ®
Portland District

John Day Lock and Dam Configuration and Operation Plan

April 2007

CENWP-EC-DS (1110-2-1150a)

2 JUL 2007

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: John Day Configuration and Operation Plan, April 2007

1. The John Day Configuration and Operation Plan April 2007 for the John Day Project has been completed and is enclosed for your information. If you wish to view the Report, it is located at the following link:
<file:///\\nwd\nwp\etds\Columbia\JohnDay\Config_Study\Decision_Document\Report\Final_Edit\FINAL_JDA_Config_Main_Report_5-29-07&ITR.pdf>

2. An Independent Technical Review has been performed that is appropriate for the level of risk and complexity of the project. All comments resulting from the Technical Review have been resolved. The project will proceed to implementation of the Strategic Plan outlined in the Report. Periodic updates of the Strategic Plan will be provided as new information is obtained.

3. If you have any questions, please contact Matt Hanson, CENWP-EC-DS, 503-808-4934.

Encl

KEVIN J. BRICE
Deputy District Engineer for Project Management

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DESIGN/STUDY REPORTS
INDEPENDENT TECHNICAL REVIEW CERTIFICATION
John Day Lock and Dam Configuration and Operation Plan

CERTIFICATION OF INDEPENDENT TECHNICAL REVIEW

The District has completed the **John Day Lock and Dam Configuration and Operation Plan for the John Day Lock and Dam.** Notice is hereby given that an independent technical review, that is appropriate to the level of risk and complexity inherent in the project, has been conducted as defined in the Project Management Plan. During the independent technical review, compliance with established policy and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level obtained; and reasonableness of the result, including whether the product meets the customer's needs consistent with law and existing Corps policy. The independent technical review was accomplished by an independent team. All comments resulting from ITR have been resolved in accordance with EC 1110-1-105.		
Significant concerns and the explanation of the resolution are as follows: All issues with the current document have been resolved. Further changes to the document will be made when the Configuration and Operation Plan is updated.		
Mike Langeslay, CENWP-PM-E	Signature ► [signature]	Date ► 5/30/07
ITR Team Members & Disciplines: Lynn Reese, Hydraulics Martin Ahmann, Hydraulics Laurie Ebner, Hydraulics Mike Langeslay, Biology Blaine Ebberts, Biology Jeff Hurt, Structures		
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ABBREVIATIONS AND ACRONYMS

BGS	behavioral guidance system
BiOp	Biological Opinion
BPA	Bonneville Power Administration
COP	Configuration and Operation Plan
Corps	U.S. Army Corps of Engineers
cfs	cubic feet per second
ESBS	extended-length submersible bar screen
ESU	Evolutionarily Significant Unit
FDM	Feature Design Memorandum
FCRPS	federal Columbia River power system
FGE	fish guidance efficiency
FPE	fish passage efficiency
HAC	Hydropower Analysis Center
JDA	John Day Lock and Dam
JBS	juvenile bypass system
MSL	mean sea level
MCDA	Multi-criteria Decision Analysis
MWh	megawatt hour
NMFS	National Marine Fisheries Service
O&M	operation and maintenance
RSW	removable spillway weir
SAR	smolt-to-adult return rate
SIMPAS	Simulated Passage Model
SPE	spill passage efficiency
SFSB	surface flow at skeleton bays
SFSP	surface flow at spillway
TDG	total dissolved gas
TSP	Turbine Survival Program
TSW	top spillway weir
VBS	vertical barrier screen
WMD	Water Management Division

English to Metric Conversion Factors

To Convert From	To	Multiply by
feet (ft)	meters	0.3048
miles	kilometers (km)	1.6093
acres	hectares (ha)	0.4047
acres	square meters (m^2)	4047
square miles (mi^2)	square kilometers (km^2)	2.590
acre-feet	hectare-meters	0.1234
acre-feet	cubic meters (m^3)	1234
cubic feet (ft^3)	cubic meters (m^3)	0.02832
feet/mile	meters/kilometer (m/km)	0.1894
cubic feet/second (cfs or ft^3/s)	cubic meters/second (m^3/s)	0.02832
degrees Fahrenheit (°F)	degrees Celsius (°C)	(Deg F - 32) x (5/9)

EXECUTIVE SUMMARY

This Configuration and Operation Plan (COP) documents the results of a Configuration Study conducted at the John Day Lock and Dam (JDA). The purpose of the JDA COP is to: (1) summarize knowledge regarding passage of anadromous fish at JDA; (2) develop a Decision Analysis Framework from which to select potential fish passage alternatives; and (3) develop a long-term Strategic Plan to improve the survival of salmonids passing JDA. The targeted goal is to meet performance standards set forth in the National Marine Fisheries Service's Remanded 2004 Biological Opinion by achieving a 96% total dam passage survival rate for ESA-listed anadromous fish passing JDA.

Current operations at JDA were selected with agreement from regional salmon managers. Operations are based on multiple years of fish behavior, passage distribution, and survival research. Research identified key biological issues affecting fish passage and survival at JDA. These issues include, but are not limited to delay associated with forebay residence times, individual passage route survival rates, and delay and predation associated with egress through tailrace areas.

A multi-criteria decision model was used to derive a list of potential fish passage alternatives. Some cost-effective alternatives with high probabilities of meeting or exceeding performance standards are shown below. The criteria used in the model to develop the alternatives were weighted based on agreed upon biotic parameters and issues. Alternative development was divided into two phases to imbed critical decision points within the implementation process. Phase I was developed to identify and implement successful surface passage alternatives through the forebay and tailrace. Phase II will optimize, if necessary, the passage alternative(s) with a behavioral guidance system or other measures not yet identified.

Potential Phase I Alternatives	*Survival Benefit Range	Average Annual Life-cycle Costs (35 yrs)
Surface flow at spillway (SFSP) & tailrace modifications	1.5% to 6.3%	$4,516,841
Surface flow at skeleton bays (SFSB) & tailrace modifications	1.5% to 6.3%	$8,812,075

* Note: Phase I survival benefits show the range of increase in survival rates, for all species, between baseline 30/30 day/night spill and the implemented alternative(s) at the same spill level.

Data gaps will be addressed during Phase I alternative implementation. For example, the potential to reduce powerhouse passage through developing spillway surface flow bypass (via top spillway weirs) and improve egress through tailrace modifications will be evaluated. Biological evaluations will determine whether surface flow at the spillway reduces powerhouse passage and increases survival rates. Concurrently, evaluation of tailrace egress with spillway surface flow operations will help determine favorable spillway configurations (i.e., top spillway weir placement).

Prior to Phase II, biological evaluations will show if performance standards are not being met, and whether additional forebay and/or tailrace alternatives are needed to meet targeted survival rates. Some potential Phase II alternatives include a behavioral guidance system, juvenile bypass system outfall relocation, and/or other structural or tailrace improvements. A summary of these and other alternatives; including, survival and cost benefits are found in Sections 4, 5, and 6 of this report.

The Strategic Plan developed from the Decision Analysis Framework consists of the following implementation stages: (1) two phase feasibility study to recommend alternative(s) for implementation; (2) detailed design report(s) for selected alternative(s); (3) plans and specifications for construction of prototype(s) and/or the final alternative(s); and (4) multiple years of biological testing to verify dam passage survival rates for the fish species and life stages passing JDA. Decision points are imbedded to allow direction from Portland District and regional fish managers.

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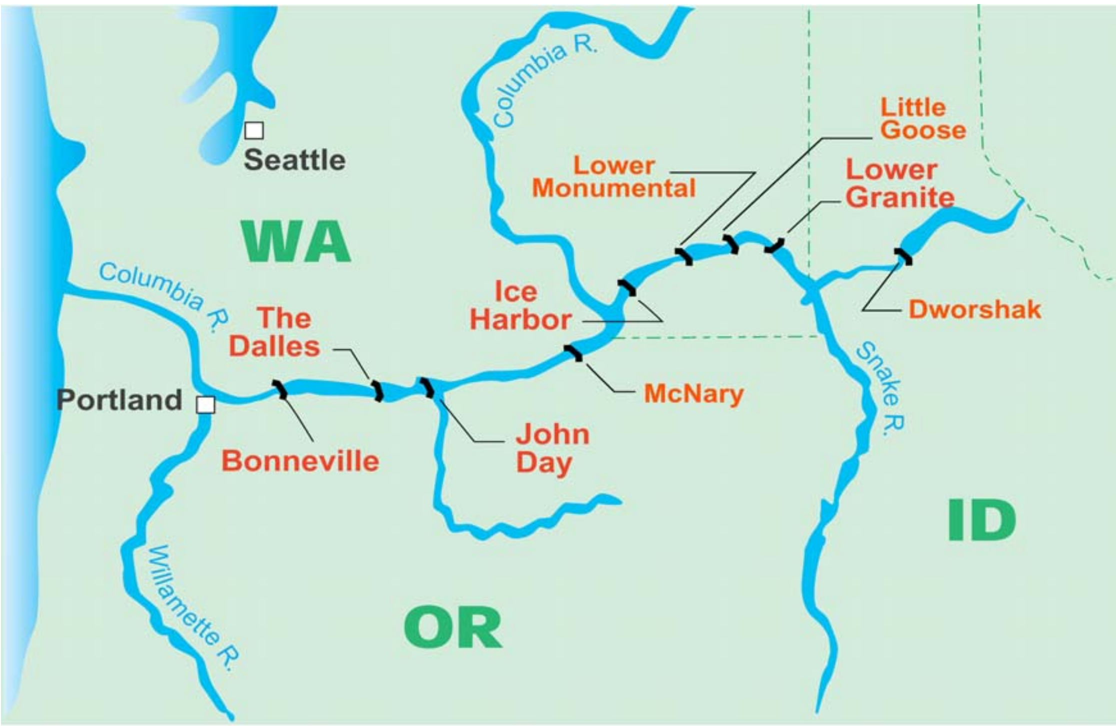
1. INTRODUCTION

This report documents the results of a Configuration Study conducted to develop a long-term Strategic Plan to improve the survival of juvenile salmonids passing the U.S. Army Corps of Engineers' (Corps') John Day Lock and Dam (JDA). John Day Dam is located at the head of Lake Celilo, 216 miles upstream from the mouth of the Columbia River. The dam crosses the river near Rufus, Oregon, about 25 miles upstream from The Dalles and just below the mouth of the John Day River (Figure 1-1). Lake Umatilla, impounded by JDA, extends about 76 miles up to McNary Dam.

Figure 1-1. Location of John Day Lock and Dam



1.1. PURPOSE AND NEED

The purpose of the Configuration Study is to determine how fish passage survival at JDA can be improved. The study will: (1) summarize the current knowledge about anadromous fish passage at JDA; (2) develop a Decision Analysis Framework from which to select potential fish passage alternatives; and (3) develop a long-term Strategic Plan to improve the survival of Endangered Species Act (ESA)-listed salmonids passing JDA. Specific study objectives include:

- Define baseline condition for ESA-listed anadromous fish and species of interest passing JDA.
- Identify and prioritize the fish passage alternatives to be evaluated.
- Develop a Decision Analysis Framework from which alternatives will be evaluated.
- Identify critical information gaps needed to make decisions on biological and/or hydraulic information for future fish passage improvements.
- Provide a Strategic Plan (to be updated annually) and an estimated schedule for implementation of a recommended plan for fish passage improvements at JDA.

As new data is gathered, the Strategic Plan will be modified to reflect the new information. Reports documenting findings over the previous year and the direction of the program the following year will be evaluated and the Strategic Plan updated as new information becomes available.

In the 2000 and 2004 Biological Opinion (BiOp) for the federal Columbia River power system (FCRPS), the National Marine Fisheries Service (NMFS) established juvenile and adult fish survival goals for fish passing through the hydrosystem (NMFS 2000, 2004). The overarching goal of this study is to develop a strategic plan to improve dam passage survival for juvenile salmon and steelhead passing JDA. The goal set by this team for the alternative(s) evaluation for fish survival at JDA is to achieve 96% (or greater) dam passage survival for juvenile salmonids passing the dam. Dam passage survival includes passage through all routes of passage [turbine, spillway, and juvenile bypass system (JBS)] and through the immediate tailrace to approximately 0.5 mile below the dam (Peven et al., 2005). While this study is using 96% as the targeted survival rate for modeling purposes, performance or survival standards for FCRPS projects are being established via the remand process for the BiOp.

Current operations at JDA were designed to provide the safest and most efficient means of passage for ESA-listed fish species under the logistical constraints imposed by power generation, navigation, and state and federal water quality standards. These operations were selected with input and agreement from regional salmon managers based on multiple years of passage behavior and survival research at different operational scenarios. However, under these operations the project does not currently meet the targeted survival rate for all species and life stages passing JDA.

1.2. DECISION ANALYSIS FRAMEWORK

The Decision Analysis Framework describes the criteria, tools, and considerations that were used to evaluate passage improvement alternatives at JDA. These evaluation factors include juvenile fish survival, effects on other species and life stages, costs [capital and operation and maintenance (O&M)], economic impacts, total dissolved gas (TDG), implementation timing, and data uncertainty.

1.3. FISH SURVIVAL MODELING

Studies conducted at JDA to date have provided passage behavior and survival estimates for all routes of passage as well as for the dam as a whole over a range of project operations with a special focus on spillway operations. These studies have provided good information for the current configuration and operations at JDA. However, for the purposes of this configuration and operation plan study it was necessary to use another tool to model passage behavior and survival under each of the proposed alternatives.

The model used for this purpose was the Simulated Passage Model (SIMPAS). This spreadsheet model was developed by the NMFS and was used in the 2004 BiOp (NMFS 2004). Only the JDA portion of SIMPAS was used for comparing alternatives in this study. As with all models, the results are only as good as the input parameters. Therefore, a key part of the Decision Analysis Framework was obtaining and using regionally agreed-upon input parameters for SIMPAS. In addition to SIMPAS modeling, other effects on juvenile fish passage were considered as they may influence fish survival in ways that cannot or have not been measured. These include forebay behavior, tailrace egress, passage times (through conveyance), and smolt-to-adult return rate (SAR).

2. PROJECT DESCRIPTION

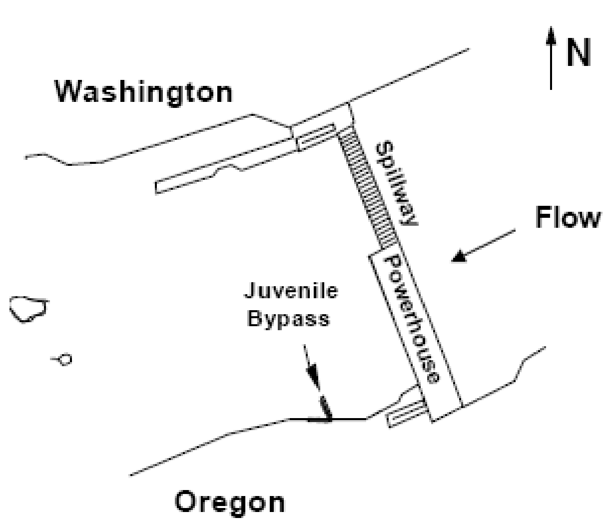
2.1. PROJECT AUTHORIZATION

John Day Lock and Dam was originally authorized for hydropower production and navigation in the Flood Control Act of 1950, and generally conforms to plans contained in the review report on the Columbia River and tributaries published as House Document 531, 81st Congress, 2nd Session. That document provided for a dam, power plant, navigation lock, fish passage facilities, and a slack-water lake extending upstream to McNary Dam. A subsequent restudy resulted in a reauthorized project to reduce flood control storage to 500,000 acre-feet. Reauthorization was recommended and the revision was adopted by the Public Works Committee of the Senate and House by letters dated April 22, 1957, and December 12, 1957, respectively. Authority to modify and update the fish passage facilities was contained in the Fish and Wildlife Coordination Act of 1958, as amended (Public Law 85-624, 72 Stat. 563, 16 U.S.C. §661 *et seq.*) and in the original project authorization. The project authority was again modified for development of waterfowl management areas by the Flood Control Act of 1965 in accordance with the Report of the Chief of Engineers in Senate Document 28, 89th Congress, 1st Session.

2.2. MAJOR PROJECT FEATURES

The JDA project includes a powerhouse, spillway, navigation lock, and fish passage facilities (Figure 2-1). The structure is primarily a concrete gravity dam with a north abutment embankment section. It is a storage project and the dam can be manipulated to provide additional flood control for the lower river. The normal operating pool elevation during fish passage season typically fluctuates from elevation 262 to 265 feet mean sea level (MSL). The operating range of the project varies from elevation 257 to 268 feet MSL.

Figure 2-1 John Day Lock and Dam



2.2.1. Powerhouse

The powerhouse is 1,975-feet long and contains 16 main generating units. An additional 4 units were not constructed (referred to as skeleton bays), leaving an unimproved powerhouse section of approximately 400 feet between the powerhouse and spillway. At peak production, the powerhouse is capable of producing 2.2 million kilowatts. Each generating unit has three 20-foot-wide intakes with the ceiling elevation located approximately 52 feet below normal pool, at elevation 210 feet MSL. The units have a capacity of up to 155 megawatts at approximately 20,000 cubic feet per second (cfs) of discharge. The total hydraulic capacity of the powerhouse is greater than 320,000 cfs.

The powerhouse was originally designed with a capacity of up to 20 turbine units. Currently 16 turbines are installed. No turbines are installed in skeleton bays 17, 18, 19, and 20 at the north end of the powerhouse. The skeleton bays consist of intakes with bulkheads installed on the forebay side, and draft tube stoplogs and a void where the scroll casing for a unit would be installed. All of the powerhouse enclosure structure exists, upstream galleries, downstream galleries, although only minimal structural components were installed under the original construction contract. Any modification of this area would require using the existing powerhouse intakes and outlets, or dewatering in the forebay or tailrace would be required.

2.2.2. Spillway

The spillway is located adjacent to the powerhouse and abuts the navigation lock on the Washington shore. It has twenty 50-foot wide spillway bays each capable of discharging up to 50,000 cfs under normal pool elevations. In a flood event, the total spillway discharge capacity is approximately 2,250,000 cfs. The ogee crest is located at elevation 210 feet MSL, approximately 52 feet below normal pool. Flow through each bay is regulated with a radial (tainter) gate. The spillway stilling basin is relatively deep and with a discharge in excess of 3,200 cfs per spillway bay, the TDG percentage increases to above 120% of atmospheric pressure. When total spill discharge is maintained at or below 64,000 cfs (under Regionally coordinated FPP spill patterns) TDG requirements can typically be met downstream.

2.2.3. Navigation Lock

The navigation lock was constructed on the north side of the spillway dam (Washington shore), and is 86-feet wide, 675-feet long, and provides 15 feet of water depth over the sills. The upstream approach channel for the navigation lock includes a floating guidewall, which has approximately 15 feet of draft and extends approximately 800 feet upstream of the spillway dam. The upstream approach channel is adjacent to the north fish ladder exit section. The downstream approach channel entrance extends approximately 2,000 feet downstream of the spillway and north fishway entrance.

2.2.4. Fish Passage Facilities

Four species of Pacific salmon annually migrate past JDA: Chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*O. mykiss*), coho salmon (*O. kisutch*), and sockeye salmon (*O. nerka*). Downstream migrants, including yearling and subyearling Chinook salmon, steelhead, sockeye salmon, and coho salmon pass JDA from mid-April though early June. Subyearling fall Chinook salmon outmigrants typically pass the dam from mid-June through August. Roughly, half of all juvenile salmon passing JDA during a migration season are currently estimated to be subyearling Chinook salmon. Adult upstream migration occurs throughout the year, although passage during the winter months is relatively light. Fish counting normally extends from April 1 through October 31.

Fish passage facilities include two adult fish ladders and a screened JBS. The north adult fish ladder has two main entrances located adjacent to spillway bay one and exits upstream along the Washington shore. The south adult fishway has three main entrances, one at the south end of the powerhouse and two smaller entrances at the north end of the powerhouse. Also, ten floating orifice-type entrances are distributed across the downstream powerhouse face. The south fish ladder exits upstream adjacent to the Oregon shore.

The JBS has undergone several modifications in the last 25 years. Currently each main unit intake has a 20-foot submersible traveling screen that diverts approximately 200 cfs of flow up into a dewatering gate slot. A vertical barrier screen (VBS) located between the dewatering gate slot and the operating gate slot removes all but 14 cfs of this flow. The remaining 14 cfs of water and guided fish are discharged through a 14-inch orifice into a collection channel, and eventually released approximately 600 feet downstream of the powerhouse through an outfall adjacent to the Oregon shore. The JBS also includes a juvenile smolt monitoring facility that was put into operation in 2000.

2.3. Project Operations

A strict operational plan is used when operating JDA to maintain acceptable tailrace conditions for downstream migrant fish. As the total river flow increases, the amount of discharge released from the powerhouse must increase relative to the spillway discharge. If the powerhouse discharge is too high, a large eddy forms downstream of the spillway, which results in a large percentage of the flow returning into the stilling basin. If the spillway discharge is too high, a large eddy is formed downstream of the powerhouse. As a result of these conditions, spillway and powerhouse operations are coordinated to provide hydraulic conditions deemed optimal for egress of migrating salmonids through the tailrace.

Flow distribution and operational guidelines for JDA, as described in the 2004 FCRPS BiOp (NMFS 2004) and in the annual Fish Passage Plan developed by the Corps' Northwestern Division, are based upon many different factors that affect juvenile and adult passage at the dam. Requirements include seasonal operation, turbine unit restrictions for tailrace patterns, turbine unit operation priority, turbine operation within 1% of peak efficiency, minimum and maximum turbine operation, Bonneville Power Administration (BPA) power requirements, spillway gate operation pattern, scheduled maintenance, unplanned outages, and others. All of these factors play a role in the operation of JDA in consideration of juvenile and adult fish migration. These factors are not variables within the context of this study and are assumed to be a part of the project operation. The current Fish Passage Plan is the approved method of operation of JDA.

2.3.1. River Flows at JDA

Table 2-1 shows the spring and summer flows at JDA that have occurred during the primary downstream fish passage seasons. In a typical flow year, total river discharge at the dam averages approximately 300,000 cfs from April through June. By the end of August, river flows decrease to approximately 180,000 cfs.

Figure 2-2 Hydrograph for the Columbia River at The Dalles

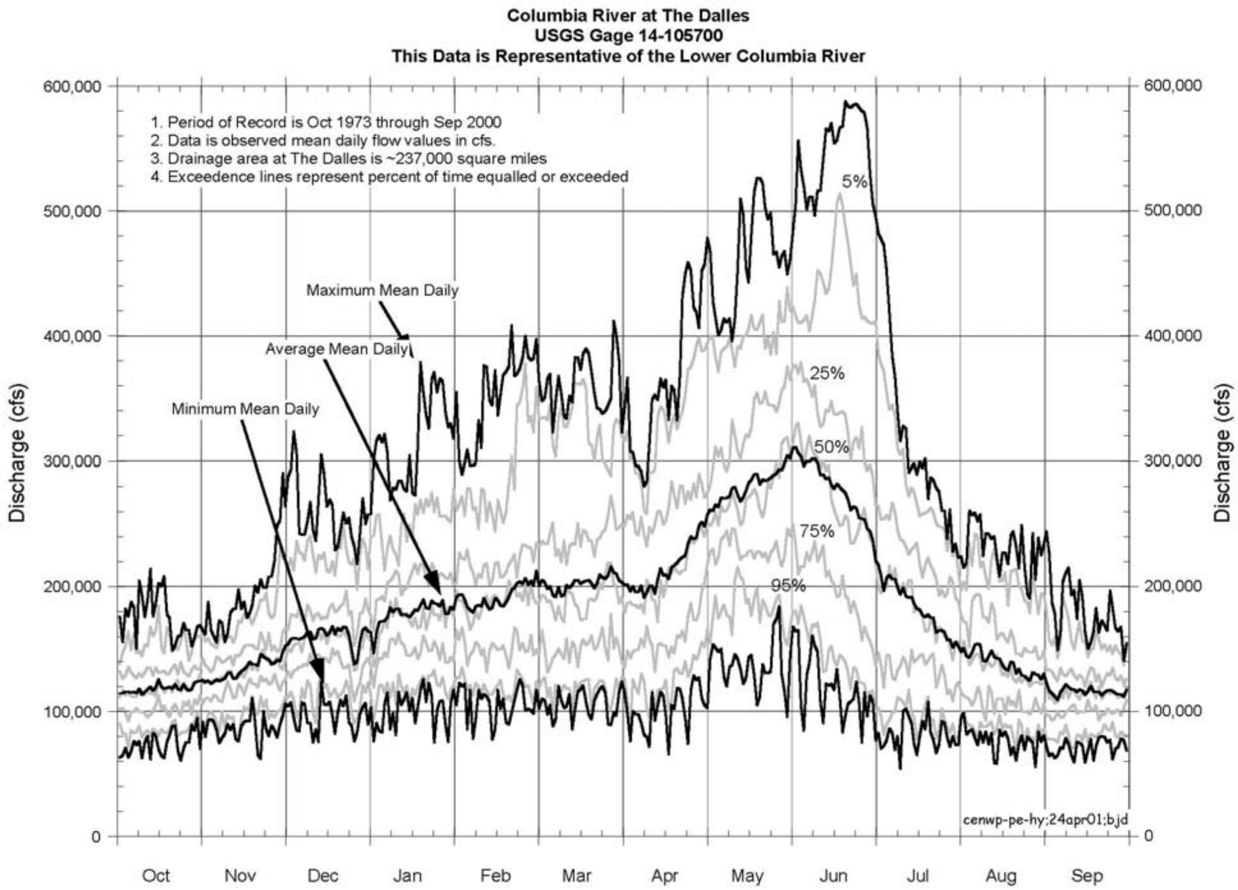


Table 2-1. Spring and Summer Flows at JDA

Season	Duration	Total River Discharge [1] (cfs)	Tailwater Elevation [2] (feet MSL)
Spring Flows (30 April - 30 June)	Minimum Daily	120,000	159.00
	Average Daily	300,000	163.00
	Maximum Daily	450,000	168.00
Season	**Duration**	**Total River Discharge [1] (cfs)**	**Tailwater Elevation [2] (feet MSL)**
Summer Flows (30 June - 30 September)	Minimum Daily	70,000	158.40
	Average Daily	120,000	159.00
	Maximum Daily	200,000	160.50

[1] Based on The Dalles hydrograph.
[2] Assuming The Dalles forebay is at elevation 158 feet MSL, the typical operating pool elevation.

2.3.2. Tailrace Conditions

The JDA tailrace has a number of areas that influence tailrace egress from the project. Downstream of both the powerhouse and spillway, river thalwegs (e.g., channels), are separated by shallows in the near dam tailrace area and islands further downstream. These areas compose bathymetric obstacles to smooth tailrace egress. In addition, the contraction of the south shore in and around the area near the JBS outfall area acts to force flow from turbine units 1 through 4 on a northern trajectory. These areas, in concert with spillway and powerhouse operations, act to form a variety of flow patterns and eddies that are non-conducive to rapid downstream egress. Such flow patterns and eddies move either clockwise or counter-clockwise depending on project operations. As a result, tailrace flow patterns vary considerably, depending upon tailrace water elevations and flow levels from the spillway and powerhouse. For this reason, attaining reasonable tailrace egress conditions depends on maintaining balanced flow levels between the powerhouse and spillway. In addition to tailrace bathymetry, the presence of four skeleton bays between the powerhouse and the spillway provides a gap in water flow where juvenile salmonid predator species can reside. This gap creates either a localized eddy just down stream of the skeleton bays or a significant stagnant region in the same area, depending upon project operations. The tailrace and its affect on juvenile fish egress are discussed in more detail in Section 3 of this report.

2.3.3. Total Dissolved Gas

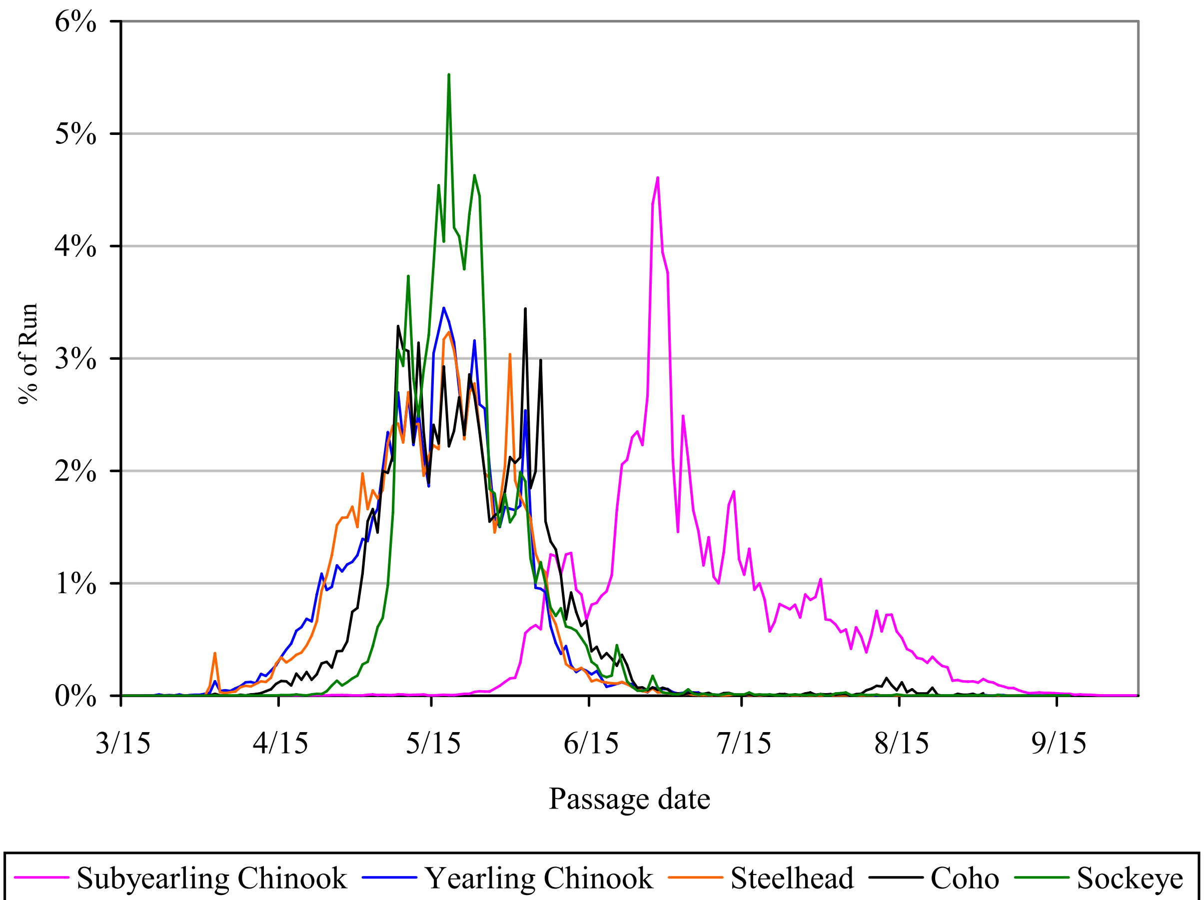
Total dissolved gas supersaturation results when spillway discharge and entrained air plunge to depth in the stilling basin. Research shows that prolonged exposure to TDG levels above 120% is harmful to juvenile salmonids and other aquatic organisms. Currently, state and federal water quality criteria limit the saturation of TDG to 110% of atmospheric pressure. Oregon and Washington grant waivers applied for by NMFS that allow the Corps to exceed this limitation at JDA up to a TDG level of 120% below the dam and 115% in the forebay of the downstream dam (The Dalles). Due to these limits, JDA is generally limited to 24-hour spill levels of 30% to 40% of total project outflow during spring and summer juvenile salmonid migration.

3. CURRENT PASSAGE CONDITIONS

3.1. JUVENILE SALMON RUN TIMING

Several species of Pacific salmon migrate past JDA annually including yearling (stream-type) and sub-yearling (ocean-type) Chinook salmon, steelhead trout, coho salmon, and sockeye salmon. All species, except ocean-type Chinook salmon, rear in freshwater for at least one year prior to migrating to the ocean. The 10-year average (1995-2004) of the juvenile salmonid run timing distribution at JDA is shown in Figure 3-1 (expressed as the percent of the total run). The run-timing distribution of these "yearling" fish typically begins in early April and lasts into September with the bulk of the run passing JDA by the end of May. Ocean-type Chinook salmon begin their seaward migration as "subyearlings," rearing as they migrate downstream. The bulk of these fish pass JDA by early August.

Figure 3-1. Juvenile Salmonid Run Timing, 10-year Average (1995-2004)



3.2. Diel Passage Distribution

Diel passage distribution of juvenile salmonids is typically a function of both fish behavior and operation of JDA. Current operations call for no spill during the day and 60% (of total river discharge) spill at night during the spring. During the summer migration of subyearling or 'ocean-type' Chinook salmon, the project operates under a 30% spill level for 24 hours per day. During the spring day operation, the majority of fish that enter the forebay of the dam tend to mill around in the forebay. When spill begins in the early evening (~ 6:00 p.m.), these fish almost immediately pass through the spillway (Moursund et al., 2003). Night passage continues to be high until the early morning hours, after which the spillway is closed. During a 24-hour spill treatment, diel passage distribution remains relatively consistent throughout the day, which indicates that fish passed soon after they entered the forebay. Additionally, a 2003 study by Hansel and others (2004) to evaluate passage and survival of yearling Chinook released 1,389 radio-tagged fish approximately 14 miles upstream of JDA; half the fish were released at 9:00 a.m. and half at 9:00 p.m. Based on detections at JDA, 31% of these fish passed the dam during day operations while 69% passed during the night (Hansel et al., 2004).

3.3. Passage Route Distribution

The location where juvenile salmonids pass JDA also is largely dependent upon project operations. In general, as spill levels increase at JDA, the number of migrating salmon passing through that route also increases. Both radio-tag and hydro-acoustic studies at projects throughout the FCRPS have confirmed this result. Spill passage efficiency (SPE) is the metric used to measure the proportion of fish passing the dam via the spillway relative to the entire population passing the dam. Fish passage efficiency (FPE) is the metric used to describe the proportion of fish passing through non-turbine routes (JBS and spillway) relative to total dam passage. Studies of radio-tagged yearling and subyearling Chinook and steelhead have continued to show that FPE is generally higher with spill. However, tests of 12-hour versus 24-hour spill operations found that estimates of FPE were commonly not statistically different (Table 3-1).

Table 3-1. Estimated Percent Fish Passage Efficiency, 1999-2003

Year	Spill Treatment % spill day/night	Yearling Chinook	Juvenile Steelhead	Subyearling Chinook
1999	12-hr 0/45	82.5 (75.5, 88.1)[1]	94.2 (88.9, 97.5)	---
	24-hr 30/45	87.5 (81.4, 92.2)	90.4 (84.6, 94.5)	---
2000	12-hr 0/53	84.6 (74.8, 91.8)	93.0 (89.0, 96.0)	**78.7 (71.5, 84.9)**
	24-hr 30/53	91.3 (83.7, 96.2)	91.3 (87.2, 94.5)	**91.1 (86.0, 94.9)**
2002	12-hr 0/54	84.1 (79.8, 87.9)	85.2 (77.8, 90.9)	71.8 (67.8, 75.6)
	24-hr 30/30	79.9 (75.3, 84.1)	89.9 (82.2, 95.2)	70.4 (66.6, 74.0)
2003	12-hr 0/60	85.7 (83.0, 88.2)	---	70.7 (64.7, 76.4)
	12-hr 0/45	83.6 (80.6, 86.4)	---	---
	24-hr 30/30	---	---	74.8 (69.5, 79.7)

[1] Estimated percent fish passage efficiency at varying spill operation tests for radio-tagged fish passing John Day Dam. The 95% confidence intervals are in parentheses following the point estimates. Bolded estimates for 2000 subyearling Chinook salmon are significantly different.

This artifact of fish passage may be related to fish behavior rather than project operations. As spill levels and SPE increase, fish guidance efficiency (FGE, the proportion of fish that are guided out of turbine unit intakes via screens and passed into the juvenile bypass system) tends to decrease. These data suggest that fish "destined" for bypass system passage – in the absence of spill – will better guide to the spillway in the presence of spill. Conversely, fish guided to the spillway will likely pass through the JBS in the absence of spill (Moursund et al., 2003; Hansel et al., 2004). The result is a similar FPE estimate under both operations.

3.4. JUVENILE FISH SURVIVAL

Using radio-telemetry techniques, survival for juvenile salmonids passing JDA was estimated from 1999 through 2003. During this period, methods of survival estimation, species evaluated, and project operations were varied to answer specific questions relevant to the operation of JDA. Two models of survival estimation were used: the paired release-recapture model of Burnham and others (1987) and the route-specific survival model of Skalski and others (2002). In each of these studies, the survival estimates reported represent survival from the point of release or detection at a passage route to the release point of the reference group. Passage distribution and survival estimates under the varying operational tests are shown in Tables 3-2, 3-3, and 3-4 for yearling and subyearling Chinook salmon and juvenile steelhead, respectively.

Table 3-2. Estimated Passage Distribution and Survival for Yearling Chinook Salmon

Year	Spill Treatment % spill day/night	Spillway		Juvenile Bypass		Turbine		Dam Passage Survival
		Passage	Survival	Passage	Survival	Passage	Survival	
1999	12-hr 0/45	52.6	---	29.9	---	17.5	---	---
	24-hr 30/45	65.6	---	21.9	---	12.5	---	---
2000	12-hr 0/53	75.1	98.6 (92.5, 104.7)[a]	14.6	---	10.3	---	97.6 (90.9, 104.3)[a]
	24-hr 30/53	85.8	93.7 (87.6, 99.8)[a]	6.0	---	8.2	---	93.5 (87.8, 99.2)[a]
2001	12-hr 0/30	---	---	---	93.2 (89.0, 97.4)[a]	---	---	---
2002	12-hr 0/54	48.1	99.3 (95.8, 103.0)	36.0	91.1 (85.7, 95.9)[a]	15.9	77.8 (67.3, 87.0)	92.9 (89.5, 96.3)
	24-hr 30/30	53.1	100.0 (96.5, 104.0)	26.7	99.1 (94.0, 103.0)[a]	20.2	83.2 (74.4, 90.9)	96.3 (93.0, 99.6)
2003	12-hr 0/60	56.7	93.4 (90.0, 96.3)	29.0	101.9 (99.6, 103.6)	14.3	89.1 (82.9, 95.3)[b]	92.2 (87.5, 96.9)
	12-hr 0/45	47.4	93.9 (90.3, 96.7)	36.2	98.8 (95.9, 100.8)	16.4	80.7 (77.2, 84.2)[c]	94.0 (89.9, 98.1)

Passage distribution is the percentage of all study fish passing JDA. The 95% confidence intervals are in parentheses. Survival estimated using the route-specific survival model, unless otherwise noted.
[a] Survival estimated using the paired release-recapture model.
[b] Estimated turbine survival for fish released directly into turbine intake during the day/no spillway operations.
[c] Estimated turbine survival for fish released directly into the turbine intake at night during 45% spill.

Table 3-3. Estimated Passage Distribution and Survival for Subyearling Chinook Salmon

Year	Spill Treatment % spill day/night	Spillway		Juvenile Bypass		Turbine		Dam Passage Survival
		Passage	Survival	Passage	Survival	Passage	Survival	
1999	12-hr 0/25	44.0	---	---	---	---	---	---
	12-hr 0/51	50.0	---	---	---	---	---	---
	24-hr 28/51	78.0	---	---	---	---	---	---
	24-hr 21/25	58.0	---	---	---	---	---	---
2000	12-hr 0/59	53.9	---	24.8	---	21.3	---	---
	24-hr 30/59	81.5	---	9.6	---	8.9	---	---
2001	24-hr 0/0	---	---	---	86.8 (78.4, 95.2)[a]	---	---	---
2002	12-hr 0/54	41.7	98.5 (93.4, 102.3)	28.9	---	29.4	86.6 (79.5, 92.8)[b]	92.8 (88.5, 97.1)
	24-hr 30/30	57.1	100.3 (98.3, 107.8)	13.1	---	29.8	96.6 (88.5, 103.1)[b]	99.2 (94.1, 104.3)
2003	12-hr 0/60	48.1	90.1 (87.7, 92.2)	22.6	89.2 (85.5, 92.4)	29.3	71.9 (67.1, 76.4)	84.5 (81.4, 87.6)
	24-hr 30/30	61.7	95.5 (93.8, 97.0)	13.1	92.1 (87.7, 95.5)	25.2	72.2 (67.3, 76.7)	88.6 (85.6, 91.6)

Passage distribution is the percentage of all study fish passing the project. The 95% confidence intervals are in parentheses. Survival estimated using the route-specific survival model, unless otherwise noted.

[a] Survival estimated using the paired release-recapture model.

[b] Estimate represents total powerhouse passage survival (turbine- and JBS-passed fish combined).

Table 3-4. Estimated Passage Distribution and Survival for Juvenile Steelhead

Year	Spill Treatment % spill day/night	Spillway		Juvenile Bypass		Turbine		Dam Passage Survival
		Passage	Survival	Passage	Survival	Passage	Survival	
1999	12-hr 0/45	44.9	---	49.3	---	5.8	---	---
	24-hr 30/45	52.6	---	37.8	---	9.6	---	---
2000	12-hr 0/53	68.8	98.8 (96.1, 101.5)[a]	24.2[d]	---	7.0[d]	---	95.7 (91.6, 99.8)[d]
	24-hr 30/53	76.0	90.5 (84.0, 97.0)[a]	15.3[d]	---	8.7[d]	---	90.4 (83.7, 97.1)[d]
2001	12-hr 0/30	---	---	---	91.7 (87.7, 95.7)[a]	---	---	---
2002	12-hr 0/54	57.2	95.8 (89.9, 100.0)	28.0	88.2 (82.2, 94.2)[b]	14.8	93.0 (84.7, 99.5)[c]	94.0 (88.7, 99.3)
	24-hr 30/30	55.3	93.2 (85.7, 98.8)	34.6	92.6 (85.9, 99.3)[b]	10.1	89.9 (80.7, 96.7)[c]	91.5 (86.2, 96.8)

Passage distribution is the percentage of all study fish passing the project. The 95% confidence intervals are in parentheses. Survival estimated using the route-specific survival model, unless otherwise noted.

[a] Survival estimated using the paired release-recapture model.

[b] Estimated survival for fish released directly into the JBS during night spill operations.

[c] Estimated total powerhouse passage survival (turbine- and JBS-passed fish combined due to lower numbers of fish passing either route).

[d] Estimated passage efficiency through turbines and the JBS were calculated using the SPE and FPE estimates (FPE-SPE = JBS passage and 1-FPE = turbine passage).

The period of time from dam passage to successfully navigating through and exiting dam tailrace areas can affect the survival rates of fish. Slow or delayed egress due to poor flow conditions results in a longer temporal availability of passing fish to opportunistic predators residing around irregular bathymetric areas in the JDA tailrace. In 2000 and 2002, tailrace egress times were evaluated using radio telemetry. Median travel times of yearling Chinook, steelhead, and subyearling Chinook from different release points on the spillway to an exit location 5.3 kilometers downstream have been synthesized on Tables 3-5, 3-6, and 3-7 for different spill treatments [% spill during day (D) or night (N)]. Survival estimates from direct releases of radio-tagged fish into the JBS during night spillway operations (30% and 60% spill) can be observed under 2002 studies (below).

Table 3-5. Median Travel Time of Radio-tagged Yearling Chinook during Different Spill Treatments

Year	Spill Treatment	Spillway Release Site	Sample Size	Median Time (min.)	Range
2002	30D	North	33	68.6	48.1-172.6
	30N	North	31	63.0	44.2-228.5
	60N	North	43	53.3	7.5-84.1
	30D	South	38	64.9	8.6-164.2
	30N	South	36	63.4	44.8-257.6
	60N	South	80	65.7	43.7-153.4
2000	30D	North	8	63.0	
	60N	North	18	70.1	
	30D	Middle	12	63.5	
	60N	Middle	14	59.9	
	30D	South	3	83.8	
	60N	South	8	75.9	

Table 3-6. Median Travel Time of Radio-tagged Steelhead during Different Spill Treatments

Year	Spill Treatment	Spillway Release Site	Sample Size	Median Time (min.)	Range
2002	30D	North	23	53.0	6.6-222.6
	30N	North	24	54.1	37.1-141.7
	60N	North	24	48.8	10.7-81.7
	30D	South	12	61.8	7.2-126
	30N	South	21	60.1	38-107.2
	60N	South	44	59.3	13.9-150.2
2000	30D	North	15	63.8	
	60N	North	3	84.3	
	30D	Middle	15	67.0	
	60N	Middle	10	58.0	
	30D	South	7	87.2	
	60N	South	8	73.9	

Table 3-7. Median Travel Time of Radio-tagged Subyearling Chinook during Different Spill Treatments

Year	Spill Treatment	Spillway Release Site	Sample Size	Median Time (min.)	Range
2002	30D	North	23	55.9	41.1-149.6
	30N	North	40	51.8	37.8-121.8
	60N	North	33	56.2	34.6-193.6
	30D	South	18	59.5	37.6-89.7
	30N	South	41	55.5	39.8-99.1
	60N	South	71	51.9	16.2-127.7
2000	30D	North	20	90.9	
	60N	North	18	82.3	
	30D	Middle	17	96.3	
	60N	Middle	17	94.5	
	30D	South			
	60N	South	17	101.2	

1999

During spring outmigration, passage behavior at JDA was evaluated for radio-tagged yearling Chinook and steelhead. The primary objective was to evaluate and compare passage metrics (SPE, FPE and FGE) for each species using 12-hour and 24-hour spill treatments. The 12-hour spill treatment consisted of zero day spill combined with 45% spill at night. The 24-hour spill treatment consisted of 30% day spill and 45% night spill. A 60% night spill was initially planned for both treatments; however, TDG levels limited the amount of night spill to an average of 45%. During the last block of the 24-hour treatment, night spill was limited to 30% of total project discharge.

Results show that steelhead smolts spent significantly more time in the forebay during both the zero and 30% day spill treatments as compared to the 45% night spill (Hansel et al., 2000). Radio-tagged Chinook salmon also exhibited significantly longer forebay residence times between the zero day spill treatment and the 45% night spill. No differences were detected between the 30% day and 45% night spill. For both species, fish that arrived at JDA during the 12-hour spill milled about the forebay until the beginning of night spill. This behavior also was evident for steelhead that arrived during the daytime 24-hour spill treatment. Overall FPE estimates were not significantly different between spill treatments for both yearling Chinook salmon and steelhead. Estimates of SPE also were not significantly different between treatments for steelhead. However, for yearling Chinook salmon, the SPE was significantly higher during the 24-hour spill treatment (66%) as compared to the 12-hour treatment. For steelhead, the estimates of FGE were empirically higher during both night and 0% spill as compared to 30% day spill. For yearling Chinook, the estimates of FGE were higher during the zero and 30% day spill as compared to a 45% day spill.

2000

For testing purposes, the project was operated under two operations: a 12-hour spill treatment of 0% day spill and 53% night spill and a 24-hour spill treatment of 30% day and 45% night spill. The paired release-recapture model (Burnham et al., 1987) was used to estimate survival for fish passing through the spillway and passing the entire project ("dam passage survival"). The zone of inference for spillway survival was from detection at the upstream side of the spill gates to the release point of the tailrace reference group. For dam passage survival, the zone of inference was from detection in all passage routes to the release point of the tailrace reference group. A significant difference in spillway passage survival was detected between treatments for radio-tagged steelhead where survival was lower during the 24-hour spill treatment (Counihan et al., 2002). A similar trend was noted for hatchery yearling Chinook; however, the differences were not statistically significant. Differences in dam passage survival for both species also were not significantly different between treatments.

2001

During the juvenile salmonid outmigration in 2001, spill operations within the FCRPS were curtailed due to drought conditions. Survival studies planned for JDA were changed to evaluate survival rates of fish passing through and exiting the JBS by direct release of fish into the JBS. The zone of inference for these estimates was from the release point in the JBS to the release point of the tailrace reference group just downstream of the dredge islands. Passage survival was estimated for yearling and subyearling Chinook and steelhead during both day and night operations. Results showed no significant difference in survival between day and night release groups for yearling Chinook salmon and steelhead (Counihan et al., 2005). However, a significant relationship was detected for subyearling Chinook between day and night release groups. A significant relationship also was found between survival and total project discharge for both yearling and subyearling Chinook; survival was higher when total discharge at the project was higher. It was suggested that these significant relationships may be due to predation in the tailrace; a change in operations from day to night (typically a result of power peaking needs) creates different hydraulic conditions in the tailrace that may guide migrating juvenile salmonids through areas with high predator densities.

2002

During the spring and summer juvenile salmonid out-migration, passage behavior, timing, and survival at JDA were evaluated for radio-tagged yearling and subyearling Chinook salmon and wild steelhead trout. Primary objectives included evaluating the effects of two spillway operation scenarios on passage timing and behavior both at the dam and through the tailrace immediately below the dam. Also, estimating route-specific survival probabilities using the route-specific survival model for the three species was a primary objective. Similar to past studies, the zone of inference was about 328 feet upstream of the dam to about 0.6 mile below the dam. All passage and survival numbers are presented in Tables 3-2, 3-3 and 3-4.

For both the spring and summer testing periods, JDA was operated under two test conditions: a 12-hour spill of 0% day and 60% night and a 30% spill for 24-hours. For radio-tagged yearling Chinook salmon, the 12-hour spill treatment resulted in higher FPE than the 24-hour treatment although the difference was not statistically significant (Beeman et al., 2006). Forebay residence times were longer during the day under both treatments when compared to night. Dam passage survival, although not significantly different, was higher during the 24-hour treatment. Similar to hatchery Chinook salmon, FPE for wild steelhead was empirically higher during the 12-hour treatment when compared to the 24-hour treatment. Forebay residence times were significantly higher during the day for both treatments. Wild steelhead that arrived during the day typically waited until night to pass during both spill treatments. Dam passage survival was empirically higher during 12-hour spill; however, differences between treatments were not statistically significant (Counihan et al., 2003). During the summer study period, results showed that FPE for subyearling Chinook was slightly higher during the 12-hour spill. Forebay residence times were significantly longer during the 24-hour spill treatment; unlike spring migrants, there was little difference in timing between day and night during either treatment.

Another study conducted in 2002 dealt with direct releases of radio-tagged fish into the JBS during night spillway operations (30% and 60% spill). For all three species tested, estimates of survival were lower during the 60% spill treatment (Counihan et al., 2003) A concurrent study to evaluate tailrace egress timing from exit at the JBS to detection lines downstream resulted in both radio-tagged yearling Chinook salmon and steelhead trout having longer travel times during the 60% spill than the 30% spill (Smith et al., 2004). Additionally, results showed that fish exiting the JBS during 60% spill traveled upstream of the JBS outfall pipe toward the powerhouse.

2003

During the spring and summer juvenile salmonid outmigration, passage behavior, timing, and survival at JDA were evaluated for radio-tagged yearling and subyearling Chinook salmon. Primary objectives included evaluating the effects of two spillway operation scenarios on passage timing and behavior both at the dam and through the tailrace immediately below the dam. Also, estimating route-specific survival probabilities for radio-tagged fish and for each spill operation test was a primary objective. For passage survival probabilities, the zone of inference was from about 328 feet upstream of the dam to about 0.6 mile below the dam. Passage and survival estimates for yearling and subyearling Chinook salmon are presented in Tables 3-2 and 3-3, respectively.

For the spring test period, JDA was operated under two 12-hour spill test conditions, a 0% day and 45% night spill (0/45), and 0% day and 60% night spill (0/60). For radio-tagged yearling Chinook salmon, no significant differences were detected in FPE between the two treatments (Hansel et al., 2004). Empirical differences were noted between treatments in estimates of SPE and JBS passage efficiency where the 0/45 spill had higher passage rates through the JBS than did the 0/60 spill. Conversely, the 0/60 spill had higher estimates of SPE than the 0/45 spill. Similar to 2002 results, forebay residence times were longer during the day under both treatments when compared to night. Median residence times were similar between treatments during night spill operations; however, during the day median residence time was nearly twice as long during the 0/45 spill than during 0/60 spill. Dam passage survival, although not significantly different, was slightly higher during the 0/45 spill (see Table 3-2; Counihan et al., 2003). Direct releases of radio-tagged yearling Chinook were used to estimate turbine passage survival between a 0% spill (day) and a 45% spill (night). The results show that turbine passage survival is higher during 0% spill than during a 45% night spill.

For the summer study period, JDA was operated under the same operations as 2002, a 12-hour spill (0% day and 60% night) and a 24-hour spill (30% spill; Hansel et al. 2004). For radio-tagged subyearling Chinook salmon, no significant differences were detected between treatments in overall FPE (day and night results combined). However, significant differences were detected between treatments in estimates of SPE and JBS passage efficiency where the 24-hour spill had higher SPE than the 12-hour spill. Conversely, the 12-hour spill had significantly higher passage through the JBS than the 24-hour spill. Dam passage survival, although not significantly different, was slightly higher during the 24-hour spill. Forebay residence times were significantly longer during the day time for 12-hour spill compared to the 24-hour spill. No significant differences were detected between treatments during the night.

A concurrent study was conducted to evaluate tailrace egress timing for radio-tagged fish exiting the JBS during night operations of 45% and 60% spill. Results show that for yearling Chinook salmon exiting the outfall during 45% spill, travel time to the first detection line (0.7 kilometer downstream) was two times faster than those released during 60% spill (Daniel et al., 2003a). Significant differences in travel time between treatments were detected at detection lines up to 14 miles downstream of JDA. Releases of drogues at the exit of the JBS also yielded significantly different and nearly 3 times shorter tailrace residence times at a 45% spill when compared to a 60% spill.

A similar study was conducted using radio-tagged subyearling Chinook salmon and yielded similar results (Daniel et al., 2003b). Treatments tested were time 30% spill and 60% spill where all tests were conducted at night. Travel times for radio-tagged fish from release to each of three exit lines up to 2 miles downstream of JDA.

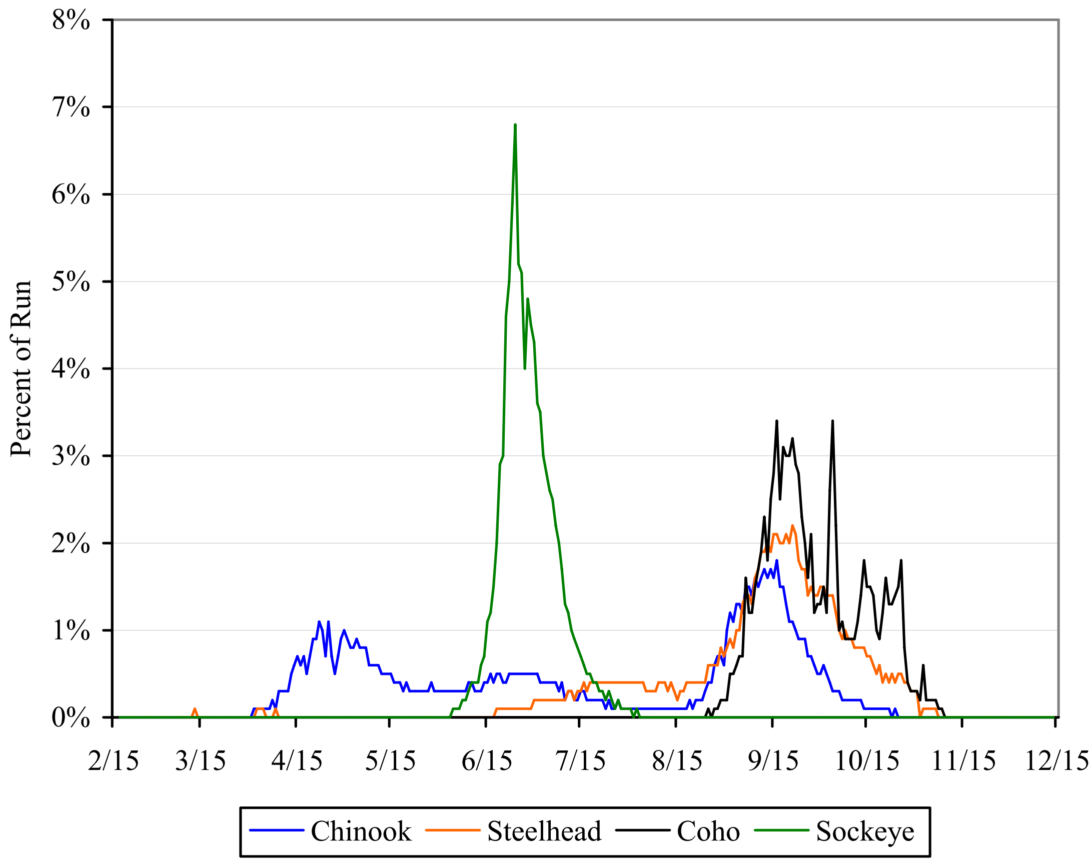
2004

Studies to evaluate the effectiveness of extended-length bar screens (ESBS) and a prototype vertical-barrier screen deployed in a turbine intake with the goal of increasing FGE for migrating juvenile salmonids was conducted. Results show that high flows in the gatewell due to the deployment of the ESBS led to higher descaling and mortality of yearling Chinook salmon (Brege et al., 2005).

3.5. ADULT FISH

Run timing at JDA for adult salmonids begins in early to mid-March with the arrival of summer steelhead (Figure 3-2). Due to complex life history characteristics and behaviors, steelhead that overwintered in the hydrosystem below JDA and fresh migrants from the Pacific Ocean both pass during spring.

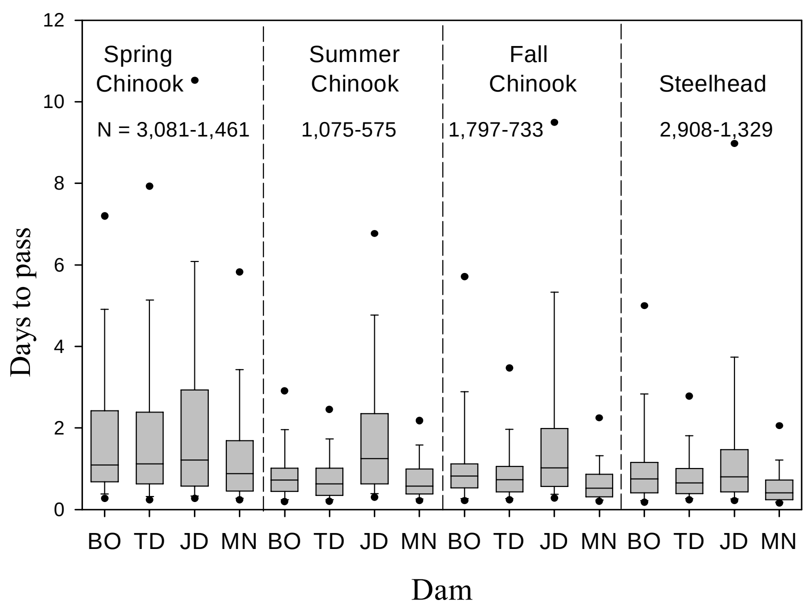
Figure 3-2. Adult Salmonid Run-timing Distribution, 10-year Average (1996-2005)



Based on the most recent 10-year average (1996-2005), spring-run or stream-type Chinook salmon begin to arrive in late March; peak passage of these early fish typically occurs in late April and continues into early June as summer-run Chinook begins. Summer-run Chinook peaks in late June. The fall run or ocean-type Chinook begin to arrive in late summer, typically in early August with numbers peaking by mid-September. Sockeye salmon passage occurs between early June and the end of July with the 10-year average peak in late June. Along with sockeye, the majority of steelhead trout pass JDA from mid-June through October with the peak occurring in mid-September. Coho salmon pass from mid-August to early November, peaking in mid-September. Bull trout are rarely observed passing upstream at JDA.

The majority of research on adult salmonid behavior at JDA has been conducted using radio-tagged Chinook salmon and steelhead collected, tagged, and released at Bonneville Dam. The primary objective of this research has been to calculate timing and behavior of these fish associated with passage through the adult fishway systems at all lower Columbia River mainstem projects. A synthesis of the results from 1996 through 2001 show that median passage times for adult salmonids passing JDA are some of the longest of the four lower Columbia River dams, with Bonneville having the longest (Figure 3-3 and Table 3-8; Keefer et al., 2005).

Figure 3-3. Median Passage Times by Fish Species and Dam, 1996-2001



Key: BO = Bonneville; TD = The Dalles; JD = John Day; MN = Monumental.

Table 3-8. Travel Time of Radio-tagged Fish from First Detection on Tailrace Receivers to First Detection on Fishway Entry Receivers, 1996-2002

Study Year	# Fish	Travel Time Distribution (hours)				
		5%	25%	50%	75%	95%
Spring/Summer Chinook Salmon						
1997	414	1.8	3.9	8.6	29.7	209.4
1998	440	1.3	2.9	6.1	16.6	84.1
2000	414	1.2	2.5	4.7	9.6	58.0
2001	598	1.2	2.4	4.8	10.4	48.4
2002	648	1.6	3.5	7.0	13.7	59.7
Steelhead Trout						
1997	351	1.3	2.0	3.4	7.7	22.4
2000	442	1.1	1.9	3.8	9.9	25.9
2001	438	1.2	1.7	2.8	6.0	17.1
2002	641	1.3	2.0	3.7	9.6	33.4
Fall Chinook Salmon						
1998	238	0.9	1.5	2.6	6.3	15.0
2000	221	1.2	1.8	3.2	7.2	17.7
2001	205	0.8	1.4	2.4	5.4	10.4
2002	333	0.9	1.5	2.4	5.5	11.6
Sockeye Salmon						
1997	309	0.9	1.2	1.9	3.3	11.4

Note: Telemetry coverage of fishway entrances varied between years.

Similar to other projects within the FCRPS, fallback of upstream migrating adult salmonids (passing back downstream following successful passage upstream) at JDA has been an area of concern. Through operational changes, an overall reduction in fallback rates has been realized since 1996 (Figure 3-4). An analysis of fall back numbers for Chinook salmon in 2000 and 2002 during spill treatment tests for juvenile salmonids showed that fallback rates were 2% higher (although no significant differences were detected) during the day spill treatment (letter report to David Clugston, U.S. Army Corps of Engineers, from Dr. Chris Peery, University of Idaho, October 27, 2003). Currently adult downstream passage is included in the Decision Model combined under the downstream migrants, kelts, and overshoots.

3.6. OTHER MIGRATORY FISH

3.6.1. Steelhead Kelts

Like juvenile salmonids, steelhead kelts (i.e., post-spawn fish that are potential repeat spawners) undergo a mass migration to the Pacific Ocean from April through June of each spring. For example, an estimated 60% of the entire Snake River steelhead Evolutionarily Significant Unit (ESU) attempted sea-ward migration as kelts following spawning in spring 2000 (Evans and Beaty 2001). Studies to evaluate steelhead kelt passage in relation to FCRPS operations were conducted from 2001 to 2004 (Wertheimer and Evans 2005). Results from these studies indicate high FPE numbers for steelhead kelts passing JDA with the majority of fish passing through the spillway (Table 3-9). Data indicate that improvements being implemented at FCRPS projects for juvenile salmonids, particularly surface flow bypass systems, provide the optimal passage route and should enhance the return rates from steelhead kelts (Wertheimer 2007).

Figure 3-4. Fallback Percent by Fish Species, 1996-2003

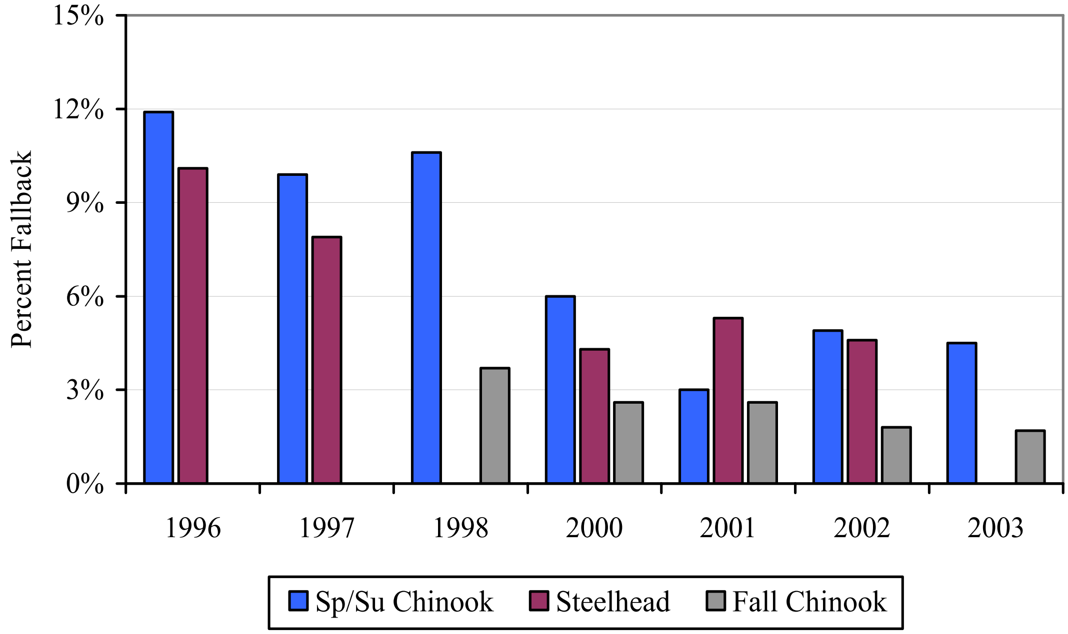


Table 3-9. Passage Efficiency Metrics for Steelhead Kelts, 2002

Percent Spill (day/night)	# Fish	Spillway Passage Efficiency	Fish Guidance Efficiency	Fish Passage Efficiency
0/54	58	79%	50%	90%
30/30	97	88%	58%	95%
N/A	209	87%	46%	93%

3.6.2. Lamprey

Based on the average of adult ladder counts from 2000 through 2005, run-timing of adult lamprey at JDA occurs from late April to late November and typically peaks by mid-July (Figure 3-5). Research conducted on radio-tagged adult lamprey from 1997 through 2000 indicated that passage efficiency for these fish was relatively poor at JDA. Moser and others (2002) reported significant differences in passage efficiency between John Day, The Dalles, and Bonneville dams (Figure 3-6). These low efficiency numbers have been attributed to hydraulic conditions within the ladders and fishways that are unsuitable for effective lamprey passage.

Little is known regarding the downstream migratory behaviors of juvenile Pacific lamprey passing FCRPS projects. Most juvenile lamprey are believed to travel deep in the water column; thus, being readily available to pass via both turbine units and spill (Brege et al., 2001). Because some juvenile lamprey are known to enter turbine intakes the potential effects of turbine passage and turbine intake screen diversion on juvenile lamprey were assessed (Moursund et al., 2003). Evaluation of lamprey exposure to intake screens suggested that the plastic mesh and bar screens commonly used in FCRPS turbine intake bypass systems caused a proportion of lamprey to become stuck in the screen material, a condition that ultimately lead to death for fish impinged upon screen systems.

Figure 3-5. Passage Efficiency of Radio-tagged Adult Lamprey at Bonneville (BON), The Dalles (TDA), and John Day (JDA) Dams, 1997-2000

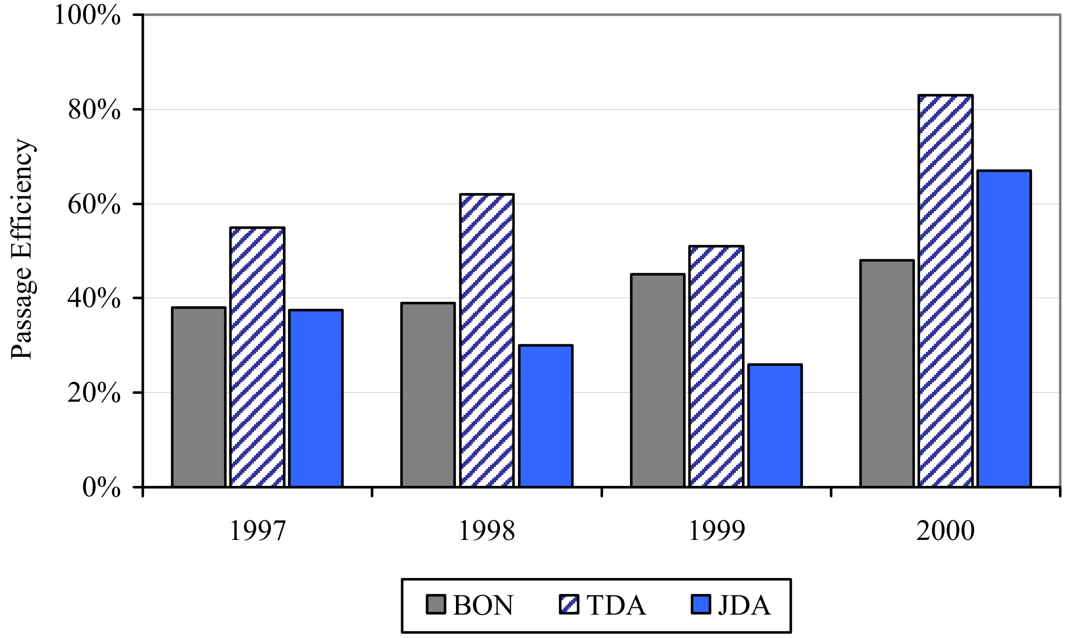
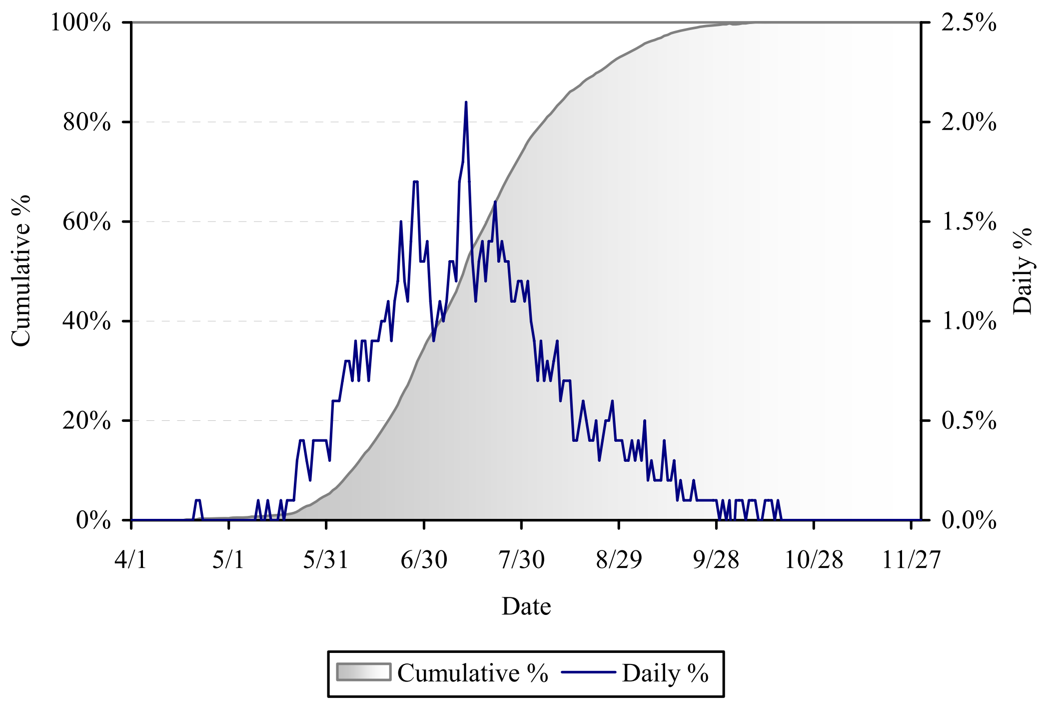


Figure 3-6. Daily Average and Cumulative Percent Passage Indices for Adult Lamprey Passing JDA, 2000-2005



3.7. CONCLUSIONS

The passage and survival data for juvenile salmonids presented in this section represents one of the most comprehensive data sets of its kind for a single project. This data set contains data collected across multiple years and compares different spillway operations within years. Based on these data, the following conclusions were made.

Forebay Residence Time

For both spring and summer migrants, forebay residence time was a direct function of spill level and time of arrival for radio-tagged fish. Fish that arrived at the dam during 0% day spill treatments milled about the forebay until night spill began. Forebay residence times were longer during the day under both treatments (i.e., 0/60 day/night vs. 30/30 day/night) when compared to night. Conversely, all species tested that arrived at JDA during night spill operations (and 30% day spill for yearling and subyearling Chinook salmon) quickly passed through the forebay and dam. Data indicate residence times, particularly during daylight hours, will be reduced with the presence of surface flow bypass.

Fish Passage Efficiency

For yearling Chinook salmon and steelhead, 24-hour spill had no significant effect on FPE in all years tested. For these spring migrants, spill was not effective in reducing turbine entrainment; instead it reduced the number of fish passing through the JBS. For subyearling Chinook salmon, however, there was a significant increase in FPE under the 24-hour spill treatment in 2000. In other study years, results for subyearling Chinook salmon were similar to the spring migrants where increase spill only reduced JBS passage efficiency.

Passage Survival

For yearling Chinook salmon, no significant difference and no overall benefit has been detected for a 24-hour spill treatment when compared to a 12-hour treatment. However for steelhead trout, both spillway and dam passage survival was consistently lower (and significantly different) during 24-hour spill treatments when compared to the 12-hour spill treatments. For subyearling Chinook salmon, significant differences were between treatments were detected where 24-hour, 30% spill yielded higher passage survival. Survival probabilities for turbine passed fish and for all species tested have been some of the lowest observed in the FCRPS.

Tailrace Egress

For radio-tagged fish (all species tested) released through the JBS outfall, travel times from release to exit from the immediate tailrace were 2 to 3 times longer during 60% spill treatments as compared to 30% or 45% spill. During 60% spill, fish exiting the JBS outfall traveled upstream and northward toward the spillway. Many of these fish spent time in the large eddy that forms in the area immediately downstream of the skeleton bays area between the spillway and powerhouse. These delays in the tailrace are likely leading to increased vulnerability to predators. Estimates of survival for fish passing through the JBS during 60% spill were lower as compared to fish passing during 30% spill. This information suggests that lower turbine survival also may be due to this same hydraulic condition.

Adult Passage

Passage efficiency improvement efforts are continuing with currently proposed structural modifications to the north ladder. Similar to changes in the south ladder, these changes should eliminate fish mortalities associated with jumping, reduce travel time through the ladder, and increase total passage efficiency for adult salmonids migrating past JDA. Day-time spill for juvenile salmon does increase fallback rates for adult salmon at JDA (~2% increase) although significant differences were not detected and the majority of fallback events occurred during the spring.

The above studies of fish passage behavior and survival have enabled regional salmon managers to provide improved operations under JDA's current configuration, though such operations continue to be refined. These data have also identified where the Corps and regional managers should focus efforts in order to achieve the targeted 96% dam passage survival for juvenile salmonids.

4. FISH PASSAGE ALTERNATIVES

4.1. ALTERNATIVES CONSIDERED

In this section, the primary component of each fish passage alternative considered in the Configuration Study is briefly described and an estimated total cost is provided. Existing studies and reports were used to determine the features, costs, and schedules for each alternative. The benefits of each alternative were estimated and included survival improvements, total dissolved gas (TDG) improvements, fish guidance efficiency (FGE) improvements, and reduced residence times in the forebay and the tailrace. At the end of this section, an estimated schedule for implementation is shown to allow comparison of all the alternatives. Additional information for each alternative and a more detailed cost estimate is included in the Fact Sheets located in Appendix A.

The cost estimates from the unranked list of alternatives provided below were taken from various sources. Some cost estimates were from previous studies while other estimates were adapted from similar construction contracts for similar types of work. The total cost for implementing each alternative was developed using three primary cost calculations: (1) the design development work that includes model studies, biological testing, and engineering design; (2) the construction phase which includes costs to develop plans and specifications, construction contract supervision and administration, and engineering during construction (these costs are estimated from percentages of the construction contract and vary based upon the complexity, duration, and unknowns of the job); and (3) operation and maintenance (O&M) and post-construction monitoring costs, which includes biological testing costs to determine and confirm acceptable project operation. The total cost for implementation of each alternative was developed to a similar level of detail and were used as inputs into the multi-criteria decision model (see Section 5).

4.2. ALTERNATIVE 1: EXTENDED-LENGTH SUBMERSIBLE BAR SCREENS (ESBS)

A screened juvenile bypass system (JBS) diverts a proportion of fish passing through turbine intakes into a collection channel, which then routes and releases the fish downstream of the dam. The objective is to increase FGE over the existing JBS by incrementally reducing the proportion of turbine entrained fish and releasing collected fish in a tailrace location that provides the lowest opportunity for smolts to encounter predators. The expected estimated increase in FGE, as stated in Feature Design Memorandum (FDM) No. 51 (November 1997), would be approximately 7-9% for spring outmigrants and 30% for subyearling Chinook salmon. New screens do not necessarily increase survival over the current JBS operation because of increased gatewell turbulence. The primary goal is to increase fish guidance and pass the fish downstream to a benign outfall. Main features of the system are extended-length submersible bar screens (ESBS) and new vertical barrier screens (VBS). Final design studies would resolve issues such as VBS final design for gatewell flow distribution, gatewell debris studies, VBS cleaning device, and the decision on bar screens versus polyester mesh screens. Existing components such as the orifices, collection channel, transportation flume, and outfall are a part of the current JBS system and would not change. The current ESBS and VBS designs use bar screen panels with 1.75 millimeter wire spacing, which is the approved wire gap used for fry and lamprey on the Columbia River. Moving the JBS outfall would likely improve passage survival; however, this is kept as a separate alternative to be evaluated with the existing JBS. The total costs for design and construction of this alternative are estimated at $76.2 million. The O&M costs are estimated at $810,000 annually. Post-construction monitoring costs are estimated at $8 million.

4.3. ALTERNATIVE 2: SURFACE FLOW AT SPILLWAY (SFSP)

This alternative was taken directly from the work for a removable spillway weir (RSW) at JDA. Because final design of a surface flow outlet at the spillway has not occurred, two RSWs were used as a surrogate to estimate costs, passage discharge, benefits, etc. The primary function of a surface-oriented outlet at the spillway is to improve FPE by shifting fish passage distribution from the powerhouse to the spillway to improve FPE (non-turbine passage). The second benefit is to reduce the amount of migration delay associated with discovering a dam passage route (i.e., forebay residence time). A surface flow outlet at the spillway would be similar in concept to an RSW and would likely be a benign overflow-type weir with no spillway regulation to provide an unobstructed surface passage route at the spillway. The alternative evaluated considers the construction of several surface flow outlets. Due to the large forebay at JDA, it was assumed that one outlet would not be sufficient; two RSWs reflect the type of design, modeling, and biological effort that would be required in design and construct a surface flow outlet at the spillway. This alternative was modeled by taking 50% of the powerhouse fish and passing them through the spillway. The total costs for design and construction of this alternative are estimated at $45.9 million. The O&M costs are estimated at $400,000 annually. Post-construction monitoring costs are estimated at $6 million.

4.4. ALTERNATIVE 3: SURFACE FLOW AT SKELETON BAYS (SFSB)

Surface collection success at other hydroelectric projects generated interest in surface collection studies at Corps' projects. The Portland District evaluated surface collection for JDA and completed a FDM on a recommended alternative in 1998 (FDM No. 52). The recommended alternative converts two skeleton bays on the north end of the powerhouse into six 21-foot-wide overflow spillway chutes. The crest elevation of the spillway is at elevation 242.5 MSL. The chutes discharge into the tailrace at different elevations to optimize tailrace conditions for dissolved gas. Overflow discharge from each chute is approximately 6,000 cfs for a total potential discharge of 36,000 cfs. The design of the system enables a much higher flow to dissolved gas ratio than the existing spillway bays. Additional spill capacity of approximately 36,000 cfs during the spring outmigration may enable project operations to stay within water quality parameters during a 10-year flood event. Preliminary general model investigations identified that in order to channel surface bypass flow downstream and avoid large tailwater eddies, a maximum spill level of about 40% is needed when total river discharge is 300,000 cfs. At 200,000 cfs, the maximum recommended spill level is about 28%. It is assumed that spill will occur 24 hours per day. For modeling purposes, this alternative assumed to pull 50% of powerhouse fish into the spillway.

This alternative provides several biological benefits similar to Alternative 2. These benefits include shifting fish passage distribution from the powerhouse to the spillway to improve non-turbine passage and reducing forebay residence time by providing a normative passage route with a benign over flow type weir with no spillway regulation to provide an unobstructed surface passage route at the spillway. Also, this alternative would benefit the tailrace residence time in that it would be operated with additional spillway flow to provide good tailrace egress, as well as diminishing the dead area that currently exists downstream of the skeleton bays. The total costs for design and construction of this alternative are estimated at $129.2 million. The O&M costs are estimated at $170,000 annually. Post-construction monitoring costs are estimated at $6 million.

4.5. ALTERNATIVE 4: POWERHOUSE HYDROCOMBINE

A hydrocombine option was considered because it is similar to the "Wells intake" which was the initial impetus for the Surface Collection Program. The benefit of a hydrocombine is that the spillway bay is located over the powerhouse unit such that as flow moves toward the powerhouse, it would be drawn down into the intake. Generally, juvenile fish tend to move upward in the water column as the flow dives. A horizontal spillway ogee would be placed above the hydrocombine intake which would split the flow horizontally and provide an outlet for fish being drawn into the intake. This outlet would be open to the surface so it would intercept both diving juvenile fish and those seeking a surface outlet at the powerhouse. This alternative has the benefit that the powerhouse unit must be operating to draw the most fish to the unit. It is anticipated that the direct passage of surface water would provide greater juvenile attraction and higher survival by keeping juvenile fish from diving 40 feet to go under the tainter gate during downstream passage. This alternative has a benefit similar to the other spillway alternatives in that it is expected to reduce forebay residence time; with appropriate spillway flow, it also would reduce tailrace residence time. Future configuration study updates will incorporate recent turbine survival estimates.

A blank skeleton bay lends itself to an unrestricted design of the turbine. It is not unreasonable to expect that new turbines could be designed and operated with fish survival rates near the targeted 96%, the goal for juvenile survival at JDA. In addition, if the high volume of flow currently discharged over the spillway could be passed through "high survival" turbines installed in the skeleton bays, then egress conditions also would improve. The total costs for design and construction of this alternative are estimated at $256 million. The O&M costs are estimated at $304,000 annually. Post-construction monitoring costs are estimated at $8 million. Although this alternative currently does not have an acceptable cost-benefit ratio, it could become more attractive in the future as the demand for regional power increases.

4.6. Alternative 5: Behavioral Guidance System (BGS)

For this alternative, a BGS would be placed in the forebay to maximize juvenile guidance to the spillway for the amount of spillway discharge. There are two primary objectives: (1) increase dam passage survival for juvenile salmonids, and (2) increase the cost-effectiveness of operating the spillway as a bypass system. Since most fish are in the top portion of the water column, current design concepts all revolve around a floating structure with a curtain hanging down into the water that alters the hydraulic characteristics and guides fish away from the powerhouse to the spillway. This alternative also has the potential to reduce forebay residence time and enhance FPE, as well as having the potential to reduce spillway flow (the alternative was evaluated in this study with the current spillway flow volumes). The total costs for design and construction of this alternative are estimated at $61.1 million. The O&M costs are estimated at $115,000 annually. Post-construction monitoring costs are estimated at $6 million.

4.7. Alternative 6: Tailrace Improvements

To divide the flow in the stilling basin to a smaller area to control and to allow better guidance of outmigrants in the JDA tailrace, a spillwall could be constructed similar to the training wall constructed at The Dalles in 2004. Although it is not known where the location of a spillwall would be most effective, the wall would extend from approximately 2 feet above normal high tailwater to the stilling basin floor. The length of a wall from the vertical face of the existing spillway piers to the end sill would be approximately 232 feet. The thickness of the spillwall would be 12 feet to match the existing pier thickness. With normal tailwater elevation of approximately 160 MSL, the wall would be approximately 48 feet high (the stilling basin elevation is elevation 114 MSL with the end sill at elevation 127 MSL). Most importantly, the depth from normal tailwater (elevation 160 MSL) to the bottom of the stilling basin is 46 feet. The estimated volume of concrete for this type of wall would be about 5,000 cubic yards. Installation of this wall also would include the removal of one or two baffle blocks in the stilling basin and the use of high-capacity, post-tensioned anchors.

An advantage of a spillwall separating the powerhouse from the spillway is that it eliminates the entrainment of powerhouse flow into the stilling basin and prevents the circulation of flow below the powerhouse. This confines the spill flow as mentioned but also improves egress conditions for turbine and bypassed fish. In addition, it has the potential to reduce TDG saturation by preventing entrained powerhouse flows from becoming saturated within the stilling basin. This alternative would greatly improve tailrace egress. The total costs for design and construction of this alternative are estimated at $20 million. The O&M costs are estimated at $16,500 annually. Post-construction monitoring costs are estimated at $6 million.

4.8. Alternative 7: Tailrace Improvements – JBS Outfall Relocation

Improvements to the JBS outfall may produce additional juvenile fish survival benefits. This alternative would optimize the location of the outfall further downstream and further out in the river. The current JBS outfall could be located in an area such that river velocities and flow conditions at the outfall minimize predation and maximize fish movement downstream. The total costs for design and construction of this alternative are estimated at $16.8 million. The O&M costs are estimated at $16,500 annually. Post-construction monitoring costs are estimated at $4 million.

4.9. Alternative 8: Turbine Improvements

The purpose of this alternative is to determine and upgrade the generating units at JDA to increase juvenile fish survival and decrease mortality in powerhouse flow. The features that most likely would be made for improving fish passage include new runners, modified stay-vane and wicket gates, and draft-tube modifications. Costs associated with other improvements, such as new windings, were not included in this alternative. No specific improvements have yet been identified, but the modifications are expected to increase survival and efficiency over the existing powerhouse units. Previous model investigations of stay-vane, wicket gate, and draft-tube modifications have shown a 1% to 2% increase in turbine efficiency. The total costs for design and construction of this alternative are estimated at $203.6 million. The O&M costs for this alternative would be no different than for the existing units because the same number of units would be operating. Post-construction monitoring costs are estimated at $8 million.

4.10. Alternative 9: Powerhouse Surface Collection

Powerhouse surface collection alternatives were investigated by Harza Engineering (1994; design and results of the investigation are included in their report). The final selected alternative was a steel structure attached to the face of the powerhouse with an open channel, flow outlet channel that crossed the face of powerhouse units 1-16 and was extended to the tailrace. This alternative has the benefit of only spilling water in excess of powerhouse capacity or in excess of powerhouse demand. The premise of this alternative would be that fish would be attracted to the powerhouse with flow to the turbines. Surface outlets would be provided above each generating unit to allow fish to pass downstream through an open channel. Benefits from this alternative include reduced forebay residence time and reduced spillway flow. The total costs for design and construction of this alternative are estimated at $288.2 million. The O&M costs are estimated at $2.1 million annually. Post-construction monitoring costs are estimated at $12 million. This alternative is represented in the Decision Model as the Hydrocombine because costs and benefits are similar to the Hydrocombine alternative.

4.11. ALTERNATIVE COMBINATIONS

It is likely that no single alternative has the capacity to achieve the targeted project survival goal due to the complex criteria that all alternatives are measured against. Therefore, alternatives were combined to try and optimize the benefits of each alternative. To compare the alternatives, they were evaluated under a range of total river discharge, spillway flow, and powerhouse operations to simulate project operation. The alternatives were combined to compliment the benefits of each alternative and were selected by the Project Delivery Team and from professional experience to best achieve the fish passage goal.

5. MULTI-CRITERIA DECISION MODEL

5.1. MULTI-CRITERIA DECISIONS

Decision-making for environmental projects is typically a complex exercise, characterized by trade-offs between socio-political, environmental, and economic impacts with significant uncertainties within many decision factors. Such problems have been described by Yoe (2002) as, "…problems that do not have a right or wrong answer but only answers that are better or worse." Most people, when confronted with such a problem, attempt to use intuitive or heuristic approaches to simplify the more complex sections until the problem seems more manageable. In this "taming" process, important information may be lost, opposing points of view may be discarded, and elements of uncertainty may be ignored. In short, there are many reasons to expect that, on their own, individuals (either lay or expert) will often experience difficulty making informed, thoughtful choices about complex issues involving uncertainties and value tradeoffs (McDaniels et al., 1999).

Decision analytical frameworks such as Multi-criteria Decision Analysis (MCDA) can provide a systematic approach for integrating risk levels, uncertainty, and valuation. A detailed analysis of the theoretical foundations of these decision methods and their comparative strengths and weaknesses is presented in Belton and Stewart (2002) while a review of their use for environmental decision making by various governmental agencies is presented in Kiker and others (2005). The common purpose of MCDA methods is to evaluate and choose among alternatives based on multiple criteria using systematic analysis that overcomes the limitations of unstructured individual or group decision-making. For individual decision-makers, decision analysis can help to integrate risk and uncertainty concerns, to quantify value judgments, to score different project alternatives on the criteria of interest and to facilitate the selection of a preferred course of action. For group problems, the process of quantifying stakeholder preferences may be more intensive, often incorporating aspects of group decision-making. One of the advantages of an MCDA approach in group decision-making is the capacity for calling attention to similarities or potential areas of conflict between stakeholders with different views which can result in a more complete understanding of the values held by others.

The Corps currently uses a variety of mechanistic/deterministic fate and transport models to provide information in quantifying the various economic development/ecological restoration accounting requirements as required by procedures in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* issued by the U.S. Water Resources Council. The complexity and scope of these models are determined by the various planning teams. Issues such as uncertainty and risk also are addressed through formulation at the individual project management level. As an integration mechanism, the National Research Council (1999) review recommended that further decision analysis tools be implemented to aid in the comparison and quantification of environmental benefits from restoration, flood damage reduction, and navigation projects.

Criterium DecisionPlus© by InfoHarvest is a multi-decision criteria analysis software package selected for use for this study. The package is one of the packages recommended in Yoe (2002) for use in Corps' projects. The impact of different value systems can quickly be seen and discussed by stakeholders.

5.2. MODEL INPUT/CRITERIA

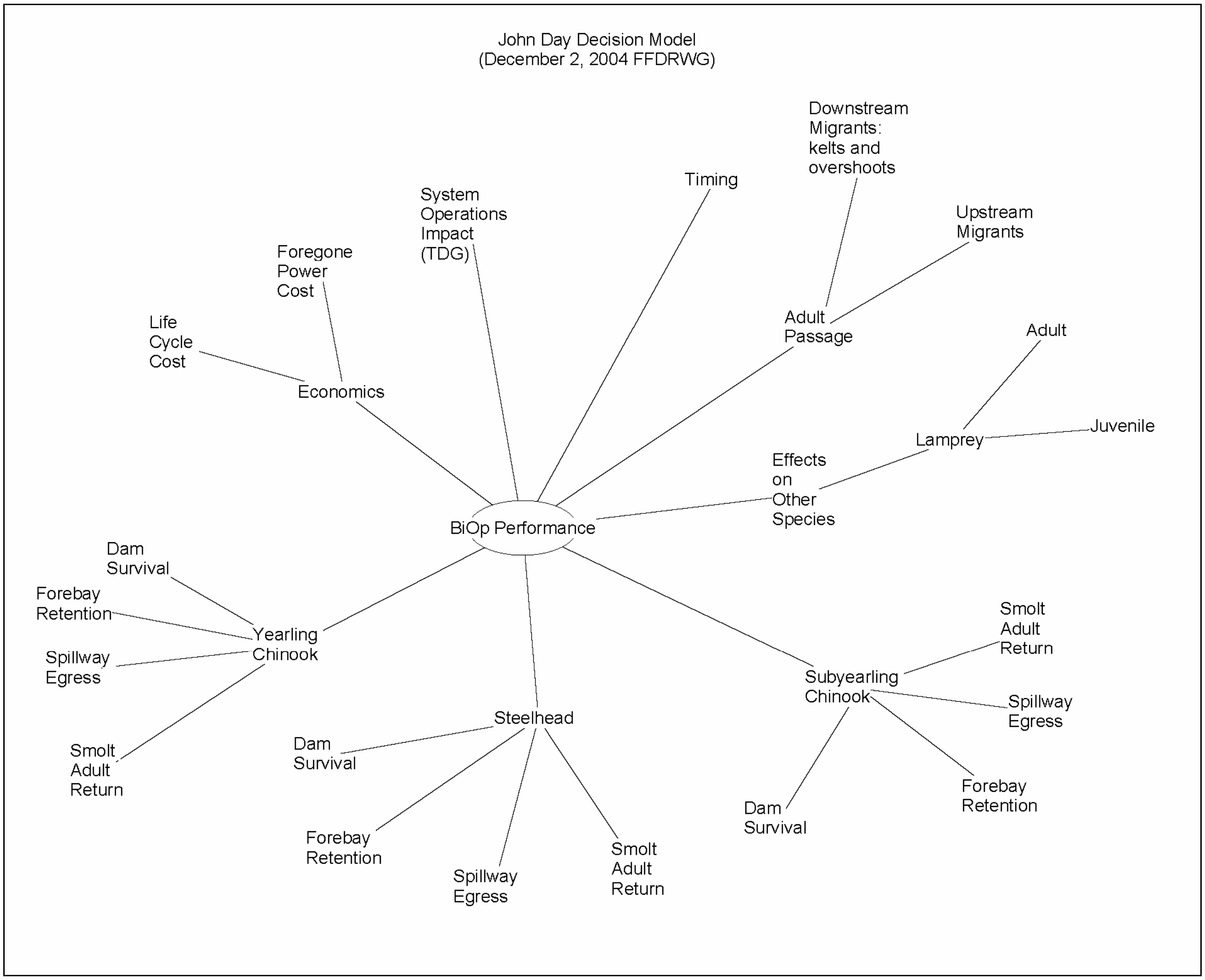
The goal of the model was to identify alternatives that would most likely provide passage and/or survival improvements to meet the biological performance requirements as provided in the 2004 FCRPS BiOp (NMFS 2004).

- Yearling Chinook
  - Dam passage survival
  - Forebay retention
  - Tailrace egress
  - Smolt-to-adult return rate (SAR)
- Subyearling Chinook
  - Dam passage survival
  - Forebay retention
  - Tailrace egress
  - SAR
- Steelhead
  - Dam passage survival
  - Forebay retention
  - Tailrace egress
  - SAR
- Effects on Other Species and Life Stages
  - Pacific Lamprey (*Lampetra tridentata*)
    - Adult
    - Juvenile
- Adult Passage
  - Downstream migrants – kelts and overshoots
  - Upstream migrants
- Economics
  - Life cycle cost
  - Foregone power
- System Operations Impact (TDG)
- Timing

The decision model software provides the tools to build the multi-criteria decision model. The model is built using the brainstorming tool. Figure 5-1 is the preliminary model framework that the Portland District developed. During regional discussions, the preliminary model was modified to its current form (Figure 5-2). The preliminary model was used to test the software and its application to this study.

Weights were applied to the criteria to describe the relative importance of each one with respect to the others (Table 5-1). The JDA model started at the goal (BiOp performance), relatively weighted each of the criteria directly beneath the goal (Level 1), and then repeated this for every criterion with sub-criteria (Level 2 and Level 3). Weights were determined quantitatively where possible, and qualitatively where no data existed, relying on “professional judgment”. Preliminary weights were established and these values were input into the preliminary model. Criteria with differing scales were normalized. Normalization of data provides data of differing scales to be handled on an equal footing.

Figure 5-1. Preliminary Model Framework



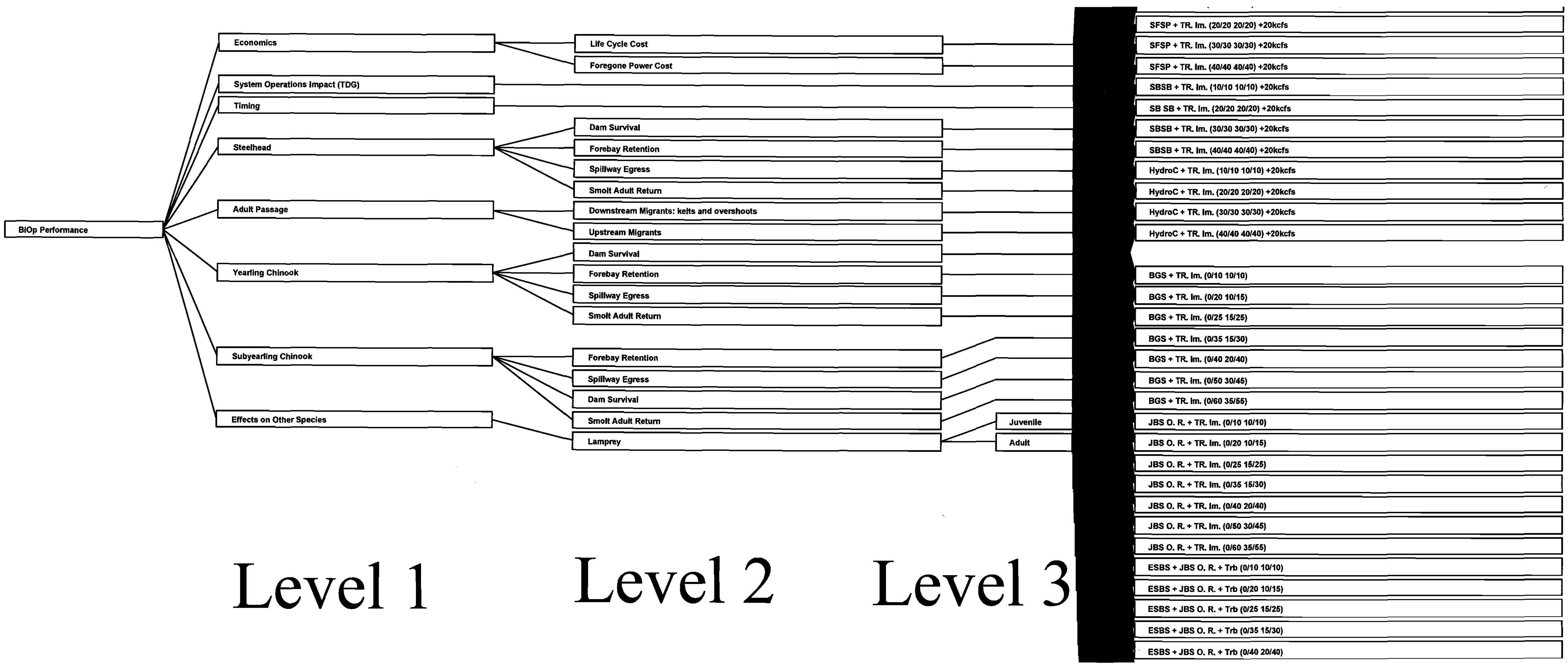


Figure 5-2 Preliminary Model Hierarchy

Table 5-1. Preliminary Model Criteria Weights

Model Criteria Weights (preliminary)				
Level 1 wts.	**Criteria**	**Level 2 wts.**	**Criteria**	**Level 3 wts.**
100	Yearling Chinook	100	Dam Survival	n/a
		50	Forebay Retention	n/a
		75	Tailrace Egress	n/a
		25	SAR	n/a
100	Steelhead	100	Dam Survival	n/a
		50	Forebay Retention	n/a
		75	Tailrace Egress	n/a
		25	SAR	n/a
100	Subyearling Chinook	100	Dam Survival	n/a
		50	Forebay Retention	n/a
		75	Tailrace Egress	n/a
		25	SAR	n/a
75	Adults	100	Downstream migrants	n/a
		50	Upstream migrants	n/a
30	Timing	n/a		
50	Effects on other species and life stages	100	Lamprey	
			Adult	100
			Juvenile	100
50	Economics	100	Life cycle cost	n/a
		100	Foregone power	n/a
25	Total Dissolved Gas	n/a		

Thirty-five structural alternatives combined with the various spill conditions resulted in a total of 237 possible alternatives that could be considered for evaluation in the decision model. Evaluating all possible alternatives would be cumbersome and unmanageable. A screening exercise was conducted with the intent of reducing the number of alternatives to evaluate in the decision model. In general, the exercise was based on comparing the dam survival estimates for each of the juvenile fish species (steelhead, yearling and subyearling Chinook) for the alternative to be considered against the corresponding species dam survival estimates for the current operation. If all three dam survival estimates for the alternative to be considered showed a benefit (dam survival estimates exceeded the dam survival estimates for the current operation), the alternative was kept for evaluation in the decision model. Any alternative that did not result in project survival meeting or exceeding the current project survival for all three species, was eliminated from further consideration. The screening exercise resulted in 162 alternatives to consider for evaluation in the decision model (Appendix C contains a table that summarizes the inputs for the model).

5.2.1. Dam Passage Survival

Dam passage survival is defined as the combined probability of survival though each route available to migrating juvenile salmonids weighted by the probability of passage through each route. It is calculated by summing the products of survival and passage efficiency probabilities through individual routes. The zone of inference for dam passage survival is from detection immediately upstream of the route of passage to the release point of the tailrace reference group, typically 0.5 to 1 mile downstream of the dam. By definition these estimates of survival or mortality (1-survival) include any direct mortality (e.g., strike on a turbine runner or a spillway flow deflector) and the indirect mortality (e.g., predation by other fish or birds within the immediate tailrace) that occurs as a result of choosing a particular passage route.

For modeling purposes, a baseline dam passage survival probability was calculated for yearling and subyearling Chinook salmon and steelhead trout at JDA (Table 5-2). Estimates of route-specific passage and survival probabilities for each species were provided in the 2004 BiOp (NMFS 2004) and confirmed through discussion with regional salmon managers. Estimates included spill passage efficiency (SPE, the proportion of fish passing through the spillway relative to all routes combined), fish guidance efficiency [FGE, the proportion of fish entering turbine intakes (1-SPE) and guided into the JBS], and route-specific survival through the spillway, turbine, and JBS. Because SPE changes with spill volume, the SIMPAS model was used to generate SPE over the range of spillway operations modeled for each alternative. Passage through the JBS was calculated as (1-SPE)*FGE while turbine passage was calculated as (1-SPE)*(1-FGE). Further, dam passage survival was computed for each alternative and at each operation using a Monte Carlo version of SIMPAS (to incorporate risk and uncertainty in the data). See Tables 5-3 to 5-5 for the SIMPAS inputs for the different alternatives and fish species. Details on the Monte Carlo simulations and all of the SIMPAS inputs are found in Appendix C.

Table 5-2. Baseline Passage and Survival Probabilities Assigned to Yearling and Subyearling Chinook Salmon and Steelhead

Species	Passage Metrics		Passage Route Survival			
	SPE*	FGE	Spillway	Turbine	Bypass	Project Survival
Yearling Chinook	Day: $y = 1.9955x^3 - 4.7235x^2 + 3.7249x$ Night: $y = -0.8593x^2 + 1.867x$	0.73	0.98	0.82	0.95	0.96
Steelhead	Day: $y = 1.7294x^3 - 3.986x^2 + 3.2595x$ Night: $y = -0.7279x^2 + 1.7345x$	0.85	0.98	0.82	0.95	0.96
Subyearling Chinook	Day: $y = 2.165x^3 - 4.8737x2 + 3.7067x$ Night: $y = -0.9307x^2 + 1.9312x$	0.32	0.98	0.72	0.92	0.89

* “y” = proportion of fish passing through the spillway; “x” = proportion of spillway discharge
Note: Inputs used for modeling purposes will be revised to reflect regionally agreed upon estimates used for COMPASS in the next COP update.

Table 5-3. Estimated Change in Dam Passage Survival for Yearling Chinook from Estimated Baseline of 94% (2005 current project operation)

Alternative	Project Operations (0/10 = 0% spill during the day and 10% spill at night)												
	0/0	**0/5**	**0/10**	**10/10**	**0/20**	**20/20**	**0/25**	**0/35**	**30/30**	**0/40**	**40/40**	**0/50**	**0/60**
Current Project	-4.2	-3.8	-3.3	--	-2.5	--	-2.2	-1.4	--	-1.1	--	-0.5	0.0
BGS	-4.3	-3.8	-3.3	--	-2.5	--	-2.1	-1.4	--	-1.1	--	-0.5	0.0
BGS+TI	-3.4	-3.0	-2.6	--	-1.9	--	-1.6	-1.0	--	-0.7	--	-0.2	0.3
BGS+TRI	0.1	0.2	0.4	--	0.7	--	0.8	1.0	--	1.1	--	1.3	1.5
BGS+TI+TRI	0.1	0.3	0.4	--	0.7	--	0.8	1.0	--	1.1	--	1.3	1.5
ESBS	-3.3	-3.0	-2.5	--	-1.8	--	-1.5	-0.9	--	-0.6	--	-0.1	0.3
ESBS+TI	-2.7	-2.4	-2.0	--	-1.4	--	-1.1	-0.6	--	-0.3	--	0.1	0.5
ESBS+TRI	0.7	0.8	0.9	--	1.1	--	1.2	1.4	--	1.4	--	1.6	1.7
ESBS+TI+TRI	0.7	0.7	0.9	--	1.1	--	1.2	1.3	--	1.4	--	1.6	1.7
ESBS+JBS	-0.9	-0.7	-0.5	--	-0.1	--	0.1	0.5	--	0.6	--	0.9	1.1
ESBS+JBS+TRI	0.7	0.8	0.9	--	1.1	--	1.2	1.4	--	1.4	--	1.6	1.7
ESBS+JBS+TI	-0.4	-0.2	0.0	--	0.4	--	0.5	0.8	--	0.9	--	1.1	1.3
ESBS+JBS+TI+TRI	0.7	0.8	0.9	--	1.1	--	1.2	1.3	--	1.4	--	1.6	1.7
HC	--	--	--	-0.4	--	0.2	--	--	0.7	--	1.1	--	--
HC+TI	--	--	--	-0.4	--	0.2	--	--	0.7	--	1.1	--	--
HC+TRI	--	--	--	1.4	--	1.6	--	--	1.7	--	1.9	--	--
HC+TI+TRI	1.2	--	--	1.4	--	1.6	--	--	1.7	--	1.8	--	--
HC+BGS+TRI	1.1	--	--	1.4	--	1.6	--	--	1.8	--	1.9	--	--
JBS	-2.1	-1.8	-1.5	--	-0.9	--	-0.6	-0.2	--	0.1	--	0.4	0.7
JBS+TI	-1.2	-1.0	-0.8	--	-0.3	--	-0.1	0.3	--	0.4	--	0.7	1.0
JBS+TRI	0.1	0.3	0.4	--	0.7	--	0.8	1.0	--	1.1	--	1.3	1.5
JBS+TI+TRI	0.1	0.2	0.4	--	0.6	--	0.8	1.0	--	1.2	--	1.3	1.5
SFSP*	--	--	--	-1.2	--	-0.4	--	--	0.2	--	0.8	--	--
SFSP+TI	--	--	--	-0.9	--	-0.2	--	--	0.4	--	0.9	--	--
SFSP+TRI	--	--	--	1.4	--	1.6	--	--	1.7	--	1.9	--	--
SFSP+TI+TRI	1.1	--	--	1.4	--	1.6	--	--	1.7	--	1.8	--	--
SFSP+BGS+TRI	1.2	--	--	1.4	--	1.6	--	--	1.8	--	1.9	--	--
SFSB	--	--	--	1.4	--	1.6	--	--	1.8	--	1.9	--	--
SFSB+TI	--	--	--	1.4	--	1.6	--	--	1.8	--	1.8	--	--
SFSB+TRI	--	--	--	1.4	--	1.6	--	--	1.7	--	1.8	--	--
SFSB+TI+TRI	1.2	--	--	1.4	--	1.6	--	--	1.8	--	1.9	--	--
SFSB+BGS+TRI	1.1	--	--	1.4	--	1.6	--	--	1.7	--	1.9	--	--
TRI	0.1	0.3	0.4	--	0.7	--	0.8	1.0	--	1.1	--	1.3	1.5
TRI+TI	0.1	0.2	0.3	--	0.7	--	0.8	1.0	--	1.2	--	1.3	1.5
TI	-3.5	-3.0	-2.6	--	-1.9	--	-1.5	-0.9	--	-0.7	--	-0.2	0.3

BGS = Behavioral Guidance Structure
TI = Turbine Improvements
TRI = Tailrace Improvements
ESBS = Extended-length Submersible Bar Screen
JBS = Relocation of juvenile bypass system outfall
HC = Install hydrocombines in the skeleton bays
SFSP = Surface flow at spillway
SFSB = Surface flow at skeleton bays

Note: Monte Carlo simulations were used to estimate passage and survival based on assumed benefits provided by each alternative. Alternatives in bold are "surface flow" routes and include 20,000 cfs of additional flow.

Table 5-4. Estimated Change in Dam Passage Survival for Subyearling Chinook from Estimated Baseline of 90% (2005 current project operation)

Alternative	Project Operations (10/10 = 10% spill during the day and 10% spill at night)											
	0/0	5/5	10/10	10/15	20/20	15/25	15/30	30/30	20/40	40/40	30/45	35/55
Current Project	-10.7	-8.5	-6.5	-5.2	--	-2.2	-1.1	--	1.3	--	2.9	4.7
BGS	-10.7	-8.5	-6.5	-5.2	--	-2.2	-1.1	--	1.3	--	2.8	4.7
BGS+TI	-3.2	-1.8	-0.6	0.2	--	2.0	2.7	--	4.2	--	5.2	6.3
BGS+TRI	-1.9	-0.7	0.4	1.1	--	2.8	3.4	--	4.7	--	5.6	6.6
BGS+TI+TRI	-1.9	-0.8	0.4	1.2	--	2.8	3.4	--	4.7	--	5.6	6.6
ESBS	-4.7	-3.2	-1.8	-0.9	--	1.2	2.0	--	3.7	--	4.7	6.0
ESBS+TI	-0.5	0.5	1.5	2.2	--	3.6	4.1	--	5.3	--	6.0	6.9
ESBS+TRI	2.0	2.8	3.5	3.9	--	5.0	5.4	--	6.2	--	6.8	7.4
ESBS+TI+TRI	2.0	2.7	3.5	3.9	--	5.0	5.4	--	6.2	--	6.8	7.4
ESBS+JBS	-2.2	-1.0	0.2	0.9	--	2.6	3.2	--	4.6	--	5.5	6.5
ESBS+JBS+TRI	2.0	2.7	3.5	3.9	--	5.0	5.4	--	6.2	--	6.8	7.4
ESBS+JBS+TI	2.0	2.7	3.5	3.9	--	5.0	5.4	--	6.2	--	6.8	7.5
ESBS+JBS+TI+TRI	2.0	2.7	3.5	3.9	--	5.0	5.4	--	6.2	--	6.8	7.4
HC	--	--	3.4	--	4.7	--	--	5.7	--	6.6	--	--
HC+TI	--	--	3.4	--	4.7	--	--	5.7	--	6.6	--	--
HC+TRI	--	--	4.4	--	5.5	--	--	6.3	--	7.0	--	--
HC+TI+TRI	3.2	-	4.4	--	5.4	--	--	6.3	--	7.0	--	--
HC+BGS+TRI	3.2	-	4.4	--	5.5	--	--	6.3	--	7.0	--	--
JBS	-9.4	-7.4	-5.5	-4.3	--	-1.5	-0.4	--	1.8	--	3.3	5.0
JBS+TI	-1.9	-0.7	0.4	1.1	--	2.7	3.4	--	4.7	--	5.6	6.6
JBS+TRI	-1.9	-0.7	0.4	1.1	--	2.8	3.4	--	4.7	--	5.6	6.6
JBS+TI+TRI	-1.9	-0.7	0.4	1.1	--	2.8	3.4	--	4.7	--	5.6	6.6
SFSP	--	-	0.4	--	2.4	--	--	4.0	-	5.4	--	--
SFSP+TI	--	--	3.4	--	4.7	--	--	5.7	--	6.6	--	--
SFSP+TRI	--	--	4.4	--	5.5	--	--	6.3	--	7.0	--	--
SFSP+TI+TRI	3.2	--	4.4	--	5.5	--	--	6.3	--	7.0	--	--
SFSP+BGS+TRI	3.2	--	4.4	--	5.5	--	--	6.3	--	7.0	--	--
SFSB	--	--	4.4	--	5.4	--	--	6.3	--	7.0	--	--
SFSB+TI	--	--	4.4	--	5.4	--	--	6.3	--	7.0	--	--
SFSB+TRI	--	--	4.4	--	5.4	--	--	6.3	--	7.1	--	--
SFSB+TI+TRI	3.2	--	4.4	--	5.4	--	--	6.3	--	7.0	--	--
SFSB+BGS+TRI	3.2	-	4.4	--	5.4	--	--	6.3	--	7.0	--	--
TRI	-1.9	-0.7	0.4	1.1	--	2.7	3.4	--	4.7	--	5.6	6.6
TRI+TI	-1.9	-0.7	0.4	1.1	--	2.8	3.4	--	4.7	--	5.6	6.6
TI	-3.2	-1.8	-0.6	0.2	--	2.0	2.7	--	4.2	--	5.2	6.3

BGS = Behavioral Guidance Structure
TI = Turbine Improvements
TRI = Tailrace Improvements
ESBS = Extended-length Submersible Bar Screen
JBS = Relocation of juvenile bypass system outfall
HC = Install hydrocombines in the skeleton bays
SFSP = Surface flow at spillway
SFSB = Surface flow at skeleton bays

Note: Monte Carlo simulations were used to estimate passage and survival based on assumed benefits provided by each alternative. Alternatives in bold are “surface flow” routes and include 20,000 cfs of additional flow.

Table 5-5. Estimated Change in Dam Passage Survival for Steelhead from Estimated Baseline of 91% (2005 current project operation)

Alternative	Project Operations (0/10 = 0% spill during the day and 10% spill at night)												
	0/0	**0/5**	**0/10**	**10/10**	**0/20**	**20/20**	**0/25**	**0/35**	**30/30**	**0/40**	**40/40**	**0/50**	**0/60**
Current Project	-3.1	-2.8	-2.4	--	-1.9	--	-1.6	-1.0	--	-0.8	--	-0.4	0.0
BGS	-3.1	-2.8	-2.5	--	-1.8	--	-1.5	-1.0	--	-0.8	--	-0.4	0.0
BGS+TI	-2.7	-2.4	-2.0	--	-1.5	--	-1.3	-0.8	--	-0.6	--	-0.2	0.2
BGS+TRI	0.7	0.7	0.8	--	1.0	--	1.1	1.2	--	1.2	--	1.3	1.4
BGS+TI+TRI	0.7	0.7	0.8	--	1.0	--	1.0	1.2	--	1.2	--	1.3	1.4
ESBS	-1.9	-1.7	-1.4	--	-1.0	--	-0.7	-0.4	--	-0.2	--	0.1	0.4
ESBS+TI	-1.8	-1.5	-1.2	--	-0.8	--	-0.6	-0.3	--	-0.1	--	0.3	0.5
ESBS+TRI	1.3	1.3	1.5	--	1.5	--	1.5	1.6	--	1.6	--	1.7	1.6
ESBS+TI+TRI	1.4	1.4	1.4	--	1.5	--	1.5	1.6	--	1.6	--	1.6	1.6
ESBS+JBS	0.9	1.0	1.0	--	1.2	--	1.2	1.3	--	1.3	--	1.4	1.5
ESBS+JBS+TRI	1.4	1.4	1.4	--	1.5	--	1.5	1.6	--	1.6	--	1.6	1.7
ESBS+JBS+TI	1.0	1.1	1.2	--	1.2	--	1.3	1.4	--	1.4	--	1.5	1.6
ESBS+JBS+TI+TRI	1.4	1.4	1.4	--	1.5	--	1.5	1.6	--	1.6	--	1.6	1.7
HC	--	--	--	-0.7	--	-0.1	--	--	0.3	--	0.6	--	--
HC+TI	--	--	--	-0.7	--	-0.2	--	--	0.3	--	0.7	--	--
HC+TRI	--	--	--	1.3	--	1.4	--	--	1.5	--	1.6	--	--
HC+TI+TRI	1.2	--	--	1.3	--	1.4	--	--	1.6	--	1.6	--	--
HC+BGS+TRI	1.3	--	--	1.3	--	1.5	--	--	1.5	--	1.6	--	--
JBS	-0.5	-0.4	-0.2	--	0.1	--	0.2	0.5	--	0.5	--	0.8	0.9
JBS+TI	-0.1	0.0	0.2	--	0.4	--	0.5	0.7	--	0.8	--	1.0	1.2
JBS+TRI	0.6	0.7	0.8	--	1.0	--	1.0	1.1	--	1.2	--	1.3	1.5
JBS+TI+TRI	0.6	0.7	0.8	--	1.0	--	1.0	1.2	--	1.2	--	1.3	1.4
SFSP	--	--	--	-1.2	--	-0.6	--	--	-0.1	--	0.4	--	--
SFSP+TI	--	--	--	-1.0	--	-0.4	--	--	0.1	--	0.5	--	--
SFSP+TRI	--	--	--	1.4	--	1.5	--	--	1.5	--	1.6	--	--
SFSP+TI+TRI	1.2	--	--	1.4	--	1.5	--	--	1.5	--	1.6	--	--
SFSP+BGS+TRI	1.3	--	--	1.4	--	1.5	--	--	1.6	--	1.6	--	--
SFSB	--	--	--	1.4	--	1.5	--	--	1.5	--	1.6	--	--
SFSB+TI	--	--	--	1.3	--	1.5	--	--	1.5	--	1.6	--	--
SFSB+TRI	--	--	--	1.4	--	1.5	--	--	1.5	--	1.6	--	--
SFSB+TI+TRI	1.3	--	--	1.4	--	1.5	--	--	1.6	--	1.6	--	--
SFSB+BGS+TRI	1.3	--	--	1.3	--	1.4	--	--	1.5	--	1.6	--	--
TRI	0.7	0.8	0.8	--	0.9	--	1.0	1.1	--	1.2	--	1.3	1.4
TRI+TI	0.7	0.7	0.8	--	1.0	--	1.1	1.2	--	1.2	--	1.3	1.4
TI	-2.7	-2.4	-2.1	--	-1.5	--	-1.3	-0.8	--	-0.6	--	-0.2	0.1

BGS = Behavioral Guidance Structure

TI = Turbine Improvements

TRI = Tailrace Improvements

ESBS = Extended-length Submersible Bar Screen

JBS = Relocation of juvenile bypass system outfall

HC = Install hydrocombines in the skeleton bays

SFSP = Surface flow at spillway

SFSB = Surface flow at skeleton bays

Note: Monte Carlo simulations were used to estimate passage and survival based on assumed benefits provided by each alternative. Alternatives in bold are "surface flow" routes and include 20,000 cfs of additional flow.

5.2.2. Forebay Retention

In recent radio-telemetry studies at JDA, forebay retention has been defined as the amount of time a fish spends in the near-dam area upstream of the dam prior to passage. These studies found a direct correlation of spill volume to forebay retention time for both yearling and subyearling Chinook salmon; a higher the spill volume means a shorter forebay retention time (see Section 3.4). For spill levels higher than 30%, this was also true of radio-tagged steelhead trout. To apply qualitative criteria based on this data, an overall ranking value (0 being the worst and 1 being the best) was assigned to each alternative over the range of spill volumes. Beginning with a baseline value of 0.5, Table 5-6 shows the changes to the baseline ranking based on spillway operation.

Table 5-6. Ranking Values for Forebay Retention

Spill Volume [1] (% spill)	Yearling Chinook	Steelhead	Subyearling Chinook
0/0, 0/0	-0.2	-0.2	-0.2
0/5, 5/5	-0.2	-0.2	-0.2
0/10, 10/10	-0.2	-0.2	-0.2
0/20, 10/15	-0.1	-0.1	-0.2
0/25, 15/25	-0.1	-0.1	-0.1
0/35, 15/30	-0.1	-0.1	-0.1
0/40, 20/40	-0.1	-0.1	0.0
0/50, 30/45	0.0	0.0	0.0
0/60, 35/55	0.0	0.0	+0.1

[1] Percent spill as spring-day/spring-night, summer-day/summer-night

For surface flow bypass alternatives, a value of 0.2 was added to all conditions; where training spill was included, the ranking value was changed as follows: 0 to 20% = -0.1, 20 to 40% = 0.0, and ≥ 40% = +0.1. Additionally, the presence of a BGS adds 0.1 to the overall ranking value.

5.2.3. Tailrace Egress

Tailrace egress is defined as the elapsed time from passage through a given route to exit from the tailrace at some predefined point (see Section 3.4). In recent radio-telemetry studies, detection transects were located at the end of the navigation lock wing wall, at the dredge island about 1 mile downstream, and about 3 miles downstream of the dam (Duran et al., 2002). Results indicated that spill volume affected tailrace egress time, primarily for turbine and JBS-passed fish, where higher spill volumes increased the amount of time fish stayed in the near-dam tailrace area. Based on these results and beginning with a base value of 0.5, the following ranking values were assigned (Table 5-7).

Table 5-7. Ranking Values for Tailrace Egress

Spill Volume [1] (% spill)	Yearling Chinook	Steelhead	Subyearling Chinook
0/0, 0/0	+0.2	+0.2	+0.1
0/5, 5/5	+0.2	+0.2	+0.1
0/10, 10/10	+0.2	+0.2	+0.1
0/20, 10/15	+0.1	+0.1	+0.1
0/25, 15/25	+0.1	+0.1	0.0
0/35, 15/30	+0.1	+0.1	0.0
0/40, 20/40	+0.1	+0.1	0.0
0/50, 30/45	0.0	0.0	-0.1
0/60, 35/55	0.0	0.0	-0.1

[1] Percent spill as spring-day/spring-night and summer-day/summer-night

5.2.4. Smolt-to-Adult Return Rates

Research on hatchery yearling Chinook salmon migrating through the Lower Snake River has shown that smolt-to-adult return rates (SAR) are significantly lower for fish passing through juvenile bypass systems (detected) when compared to fish passing through other routes (undetected). To rank alternatives based on this assumption, juvenile bypass passage efficiency was calculated (see Section 5.2.1) and multiplied by species specific SAR data for detected and undetected fish, respectively. These two numbers were generated for each alternative at each operation and were then added together to provide an overall ranking value for this category.

The Monte Carlo simulations output the distribution of juvenile fish routed through the JBS and those through undetected routes. The relationships identified above are then used to develop a SAR FPE number. The percent of juvenile fish routed through the JBS are multiplied by the SAR for the bypass routes and the percent of juvenile fish routed through undetected routes (excluding turbine passed fish) are multiplied by 1.0; the two numbers are then added together to get an estimate of the JDA smolt-to-adult return rate FPE.

5.2.5. Effects on Other Fish Species/Life Stages

The following fish species/life stages also will be included in the analysis: white sturgeon (*Acipenser transmontanus*), adult Pacific lamprey, juvenile lamprey and sockeye. Bull trout are not included in the model because their presence in the lower river is negligible. Sturgeon, lamprey, and sockeye are included in a qualitative sense. Each alternative is rated assuming no change, an improvement, or degradation over base case (the qualitative rating assumes 0 is the worst and 1 is the best). Spill percentage is a key factor in the qualitative rating; the ratings used in the model can be found in Appendix C.

<u>Juvenile Pacific Lamprey.</u> Similar to juvenile salmonids, it has been hypothesized that spill provides a survival benefit for juvenile lamprey. Passage through turbine intakes, whether the fish pass through the turbines or are guided by screens (designed for juvenile salmonids) can be detrimental for lamprey survival. Based on this premise and beginning with a baseline ranking value of 0.5, a value of 0.1 is added for all alternatives at spill levels above 50% in the spring and above 40% in the summer. A value of 0.1 is subtracted from the baseline ranking value for spill conditions less than 25% spill.

Adult Pacific Lamprey. Where higher spill volumes provide a benefit to juvenile lamprey, they can cause passage delays for the adult life stage of this species. Based on this information, ranking values are assigned to the alternatives as shown in Table 5-8.

Table 5-8. Ranking Values for Adult Pacific Lamprey

Spill Volume	Added to Baseline Ranking Value (0.5)
0%	0.5
<10%	0.4
<20%	0.3
<30%	0.2
<50%	0.1
>50%	0.0

5.2.6. Adult Passage Criteria

Downstream Migrants and Overshoots. It has been found in recent steelhead kelt radio-telemetry studies that surface flow bypass systems provide a more benign option than other routes of dam passage (Wertheimer 2007). Based on these data, a value of 0.2 was added to a baseline value (0.5) for all surface flow alternatives and a value of 0.1 was added for the BGS alternative.

Upstream Migrants. Radio-telemetry studies on adult salmon and steelhead have shown that higher spill volumes can increase delays in the tailrace and increase the probability of fallback events once a fish has successfully passed the dam. Based on this information, a value of 0.1 was subtracted from 0.5 baseline ranking value for day-time spill above 50% and for the BGS alternative. A value of 0.1 was added to the baseline value for all surface flow outlets and for the ESBS alternative because both alternatives can provide safer passage in fallback events.

The ratings are qualitative and assume the highest rating is one and the lowest is zero. Spill percentage is a key factor and all of the ratings used in the model can be found in Appendix C.

5.2.7. Economics

Economic impacts were estimated for use in the multi-criteria decision model for the range of structural alternatives and percent spill configurations identified as potentially improving fish passage survival at JDA. There are two major economic categories: (1) change in hydropower production with different spill configurations and structural alternatives; and (2) life-cycle costs (planning, design, construction, and operation and maintenance costs) associated with the different structural alternatives.

5.2.8. Hydropower

Hydropower impacts were estimated by the Corps' Water Management Division (WMD) and the Hydropower Analysis Center (HAC). The WMD assessed the change in monthly hydropower generation due to various spill options and reduced turbine efficiency of 5% at JDA using the Corps' HYSSR model. The HAC used the change in monthly hydropower generation data to determine the economic impact for each spill scenario. Annual energy benefits for the 35-year evaluation period are based on monthly average energy prices ($/MWh) for the yearly period October 2009 to September 2010, with prices projected by BPA. Appendix B contains the hydropower analysis.

Forty-four scenarios for John Day were developed. The base case includes 60% spill at night during the spring spill season (April 10th through June 20th) and 30% spill 24-hours per day during the summer spill season (June 21st through August 31st), which is the currently planned operation.

All project operational data for scenarios 1-14 are the same as for the base case except for John Day's spill criteria. Scenarios 11-14 include the spill that is given in percent of the regulated flow plus an additional 20,000 cfs fish spill flow. For scenarios 15-29, an assumption was made that JDA's turbine efficiency would be reduced by 5% if fish bypass screens were placed in the turbine intakes or a fish bypass structure was placed in front of the intakes. Scenarios 15-29 are the same as the base case and scenarios 1-14 except that the generation for JDA was reduced by 5% year-round.

For scenarios 30-44, an assumption was made that turbine efficiency would be increased by 2% if new turbines were installed at JDA. This assumption is based on the increase in efficiency of the new minimum gap runner units installed at Bonneville Dam. Scenarios 30-44 are the same as the base case and scenarios 1 through 14 except that the generation for JDA was increased by 2% year-round.

A summary of the monthly and annual impact on energy benefits for all the scenarios are available in Table 5-9. The scenario with the greatest **positive** impact on annual energy benefits ($74.5 million per year increase) is scenario 31, a scenario that does not include any spill for juvenile fish at JDA. This scenario does include turbine runner replacement, which is assumed to increase generation at the project by 2% year-round.

Conversely, the scenario with the greatest **negative** impact on annual energy benefits ($57.1 million per year decrease) is scenario 29 (Table 5-9). This scenario includes a JDA juvenile fish spill percentage of 40% 24-hours per day plus an additional 20,000 spill for juvenile fish. The additional 20,000 cfs may be spilled through a SFSP, SFSB, or a hydrocombine. This scenario also includes the addition of fish bypass screens in the JDA turbine intakes or a fish bypass structure in front of the intakes, which is assumed to decrease generation at the project by 5% year-round.

Table 5-9. Sixty-year Average Difference in Energy Benefits ($1,000) from Base Case

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	YEAR
Energy Value ($/MWh)	73.55	73.55	46.81	40.04	44.10	44.44	40.95	43.18	42.32	37.51	37.51	33.15	31.40	56.02	
SCENARIO															
1. 0/0 0/0	10565	9490	371	209	508	66	91	116	-94	2134	5375	9743	9178	17047	64799
2. 0/5 5/5	8844	8050	337	149	445	66	91	87	0	1864	4808	9077	8636	14171	56625
3. 0/10 10/10	7149	6496	303	149	381	66	91	87	0	1661	4402	8041	7799	11379	48006
4. 0/20 10/15	6170	5592	270	119	286	66	61	87	0	1283	3390	6166	6579	10128	40197
5. 0/25 15/25	3760	3361	202	89	191	33	61	58	0	1080	2822	5328	5946	5669	28600
6. 0/35 15/30	2727	2231	169	89	159	0	61	58	0	770	2228	3601	4454	4502	21049
7. 0/40 20/40	344	85	101	30	64	0	30	29	0	675	1783	2442	3527	584	9693
8. 0/50 30/45	-2489	-2429	-34	-30	-127	0	-30	-29	0	338	419	937	2215	-3376	-4635
9. 0/60 35/55	-5084	-4124	-101	-209	-318	-33	-61	-87	0	-14	-135	25	1515	-7378	-16003
10. 20 kcfs spill	6699	5479	236	89	254	66	61	58	-94	1350	3768	7054	6895	11462	43379
11. 10% 24-hr + 20 kcfs	3178	2090	101	60	127	0	30	29	-94	-14	1675	3133	3685	5835	19834
12. 20% 24-hr + 20 kcfs	-530	-1017	-67	-89	-95	0	0	-29	-94	-837	-378	-1184	-181	83	-4419
13. 30% 24-hr + 20 kcfs	-3945	-4067	-303	-387	-413	-66	-61	-87	-126	-1013	-1269	-5649	-4341	-3209	-24937
14. 40% 24-hr +20 kcfs	-5190	-5988	-371	-655	-794	-198	-122	-174	-126	-1013	-1472	-9521	-7596	-4668	-37888
15. Basecase - 5%	-1207	-1087	-1048	-1154	-1543	-1803	-2268	-1599	-1790	-908	-892	-1819	-1755	-2259	-21135
16. Scenario 1 - 5%	8857	7948	-677	-946	-1035	-1737	-2177	-1483	-1883	1123	4196	7416	6954	13896	40453
17. Scenario 2 - 5%	7220	6582	-711	-1005	-1099	-1737	-2177	-1512	-1790	863	3659	6784	6438	11170	32686
18. Scenario 3 - 5%	5607	5104	-745	-1005	-1162	-1737	-2177	-1512	-1790	670	3275	5801	5645	8526	24500
19. Scenario 4 - 5%	4678	4245	-779	-1035	-1257	-1737	-2207	-1512	-1790	311	2314	4025	4486	7336	17078
20. Scenario 5 - 5%	2384	2120	-846	-1065	-1353	-1770	-2207	-1541	-1790	118	1777	3229	3885	3118	6059
21. Scenario 6 - 5%	1401	1037	-880	-1065	-1384	-1803	-2207	-1541	-1790	-177	1215	1592	2469	2011	-1123
22. Scenario 7 -5%	-863	-1003	-947	-1125	-1480	-1803	-2238	-1570	-1790	-267	791	492	1588	-1694	-11908
23. Scenario 8 - 5%	-3561	-3395	-1082	-1184	-1669	-1803	-2299	-1628	-1790	-587	-503	-934	345	-5433	-25523
24. Scenario 9 - 5%	-6036	-4995	-1149	-1363	-1859	-1836	-2328	-1686	-1790	-922	-1026	-1796	-318	-9216	-36319
25. Scenario 10 - 5%	5181	4141	-812	-1065	-1289	-1737	-2207	-1541	-1883	379	2678	4870	4786	8601	20101
26. Scenario 11 - 5%	1824	904	-947	-1095	-1416	-1803	-2238	-1570	-1883	-918	693	1153	1738	3274	-2283
27. Scenario 12 - 5%	-1713	-2051	-1116	-1244	-1638	-1805	-2267	-1628	-1883	-1700	-1253	-2939	-1927	-2174	-25337
28. Scenario 13 - 5%	-4964	-4948	-1352	-1540	-1954	-1871	-2328	-1686	-1914	-1867	-2096	-7173	-5876	-5266	-44834
29. Scenario 14 - 5%	-6139	-6755	-1421	-1808	-2335	-2002	-2389	-1773	-1914	-1867	-2286	-10847	-8969	-6615	**-57119**
30. Basecase + 2%	483	435	419	462	617	721	907	640	716	363	357	728	702	904	8454
31. Scenario 1 + 2%	11248	10107	790	670	1125	787	999	756	621	2538	5846	10674	10068	18308	**74538**
32. Scenario 2 + 2%	9494	8637	756	611	1062	787	999	727	716	2264	5267	9994	9515	15372	66200
33. Scenario 3 + 2%	7766	7053	723	611	998	787	999	727	716	2058	4853	8937	8661	12520	57409
34. Scenario 4 + 2%	6767	6131	689	581	903	787	968	727	716	1672	3820	7023	7416	11245	49444
35. Scenario 5 + 2%	4310	3858	622	551	808	754	968	698	716	1465	3241	6167	6770	6689	37617
36. Scenario 6 + 2%	3258	2709	588	551	776	721	968	698	716	1148	2634	4405	5248	5498	29917
37. Scenario 7 + 2%	827	520	520	492	681	721	938	669	716	1052	2179	3222	4302	1495	18333
38. Scenario 8 + 2%	-2060	-2043	386	432	490	721	877	610	716	708	787	1686	2964	-2553	3720
39. Scenario 9 + 2%	-4703	-3775	318	253	299	688	846	552	716	350	221	753	2248	-6642	-7876
40. Scenario 10 + 2%	7307	6015	655	551	871	787	968	698	621	1739	4204	7928	7739	12607	52690
41. Scenario 11 + 2%	3719	2565	520	521	744	721	938	669	621	348	2067	3924	4464	6860	28681
42. Scenario 12 + 2%	-56	-603	352	372	522	722	907	610	621	-492	-28	-482	518	986	3949
43. Scenario 13 + 2%	-3538	-3715	116	74	204	656	846	552	589	-671	-939	-5039	-3727	-2387	-16978
44. Scenario 14+ 2%	-4810	-5681	49	-194	-177	523	785	465	589	-671	-1147	-8991	-7047	-3890	-30196

0/0 0/0 = 0% spring-day/0% spring-night spill flow and 0% summer-day/0% summer-night spill flow.
20 kcfs = 20,000 cfs
There are 14 periods in the HYSSR model, one period for each month except April and August, which are split into half months because of flow differences (AP1 and APR are the first and second half of April; AG1 and AUG are the first and second half of August).

5.2.9. Life-cycle Costs

Life-cycle costs include the planning, design, construction, and operation and maintenance costs associated with each alternative. The life-cycle cost estimates for use in the multi-criteria decision model were developed based on existing data. The primary source of data for estimating the costs for each alternative were existing planning, design and construction studies for proposed and completed work at JDA and other FCRPS projects. The level of cost detail provided in these studies varies widely based on the type of report. The types of reports ranged from preliminary assessments to detailed construction specifications. This variability in the cost information has been incorporated into this analysis by determining expected costs and also estimating a minimum and maximum cost estimate based on the quality of the data. Another important source of information was provided by project staff and other local experts. The stream of life-cycle costs were compiled for each structural alternative and then converted to average annual values based on a 35-year evaluation period using the Fiscal Year 2006 federal discount rate of 5.125% for water resource projects (Table 5-10).

Table 5-10. JDA Decision Model Economic Cost Input

Alternative	Average Annual Life-cycle Costs (35 years)		
	Expected	Minimum	Maximum
ESBS	$4,272,241	$4,058,629	$4,485,853
SFSP	$3,065,979	$2,759,381	$3,832,473
SFSB	$7,361,213	$3,680,607	$9,201,516
Hydrocombine	$14,519,365	$10,889,523	$18,149,206
BGS Spillway	$3,683,895	$2,762,921	$6,446,817
Tailrace Improvements, JBS Outfall	$993,115	$744,836	$1,241,394
Tailrace Improvements, Spillwall	$1,450,862	$1,088,147	$1,813,578
Turbine Improvements	$10,009,432	$9,008,489	$19,518,392
Powerhouse Surface Collection	$17,109,858	$15,398,872	$33,364,224

Note: These costs are shown as average annual costs, which includes planning, design, construction, biological testing, and annual O&M costs.

5.2.10. Total Dissolved Gas

The SYSTDG model has been used to provide a relative comparison of TDG characteristics for the different alternatives. This model has been used to compute the number of hours TDG levels will exceed waiver values in the JDA tailrace and Bonneville tailrace. The maximum number of hours was 673 for 40% spill plus 20,000 cfs RSW condition and the minimum number of hours was 80 for zero spill. The results are presented in Appendix C. The gas weighting factor provides a relative comparison of the likelihood a given alternative will gas the river and either reduce flexibility at other projects to spill to gas cap and or require a more involved design effort to reduce gas levels associated with that alternative. Therefore, the factor is not literally the number of occurrences an alternative is allowed to exceed gas targets, but is a relative measure of the complexity involved in getting a given alternative to meet gas levels. A fundamental assumption therefore is that for each alternative gas targets can be met through operational constraints on the system or through engineering design.

5.2.11. Schedule

The schedule (Figure 5-3) was produced based on starting the work at the beginning of a fiscal year (Fiscal Year 2006 for this study). The schedule includes design, testing, plans and specifications, and an estimate of the time required for construction. These time periods are estimates based upon experience and schedules for similar work.

5.2.12. Uncertainty

Different levels of uncertainty and risk are associated with each alternative. Because some of the alternatives have detailed design work, their cost estimates are fairly reliable. For alternatives that have little or no design work available, the cost estimates are more uncertain. For those alternatives, cost estimates are based on comparative work at other locations. Biological data are key evaluation criteria and may have: (1) significant variation within year and in year-to-year data sets; (2) lack of data and assumptions that an outcome achieved at another project could be achieved at JDA; and (3) lack of data on an untested alternative. Uncertainty and risk is incorporated into the analysis by using Monte Carlo simulations to estimate dam survival. The SIMPAS logic is programmed into the Monte Carlo simulation using Crystal Ball.[1] Different distributions are applied to the inputs to account for uncertainty and risk. For example, a normal distribution was applied for data sets that actually exist. For the economics and schedule rating factors a flat distribution was applied representing an equal likelihood of actual costs and durations falling within the estimated range.

5.3. MODEL RESULTS

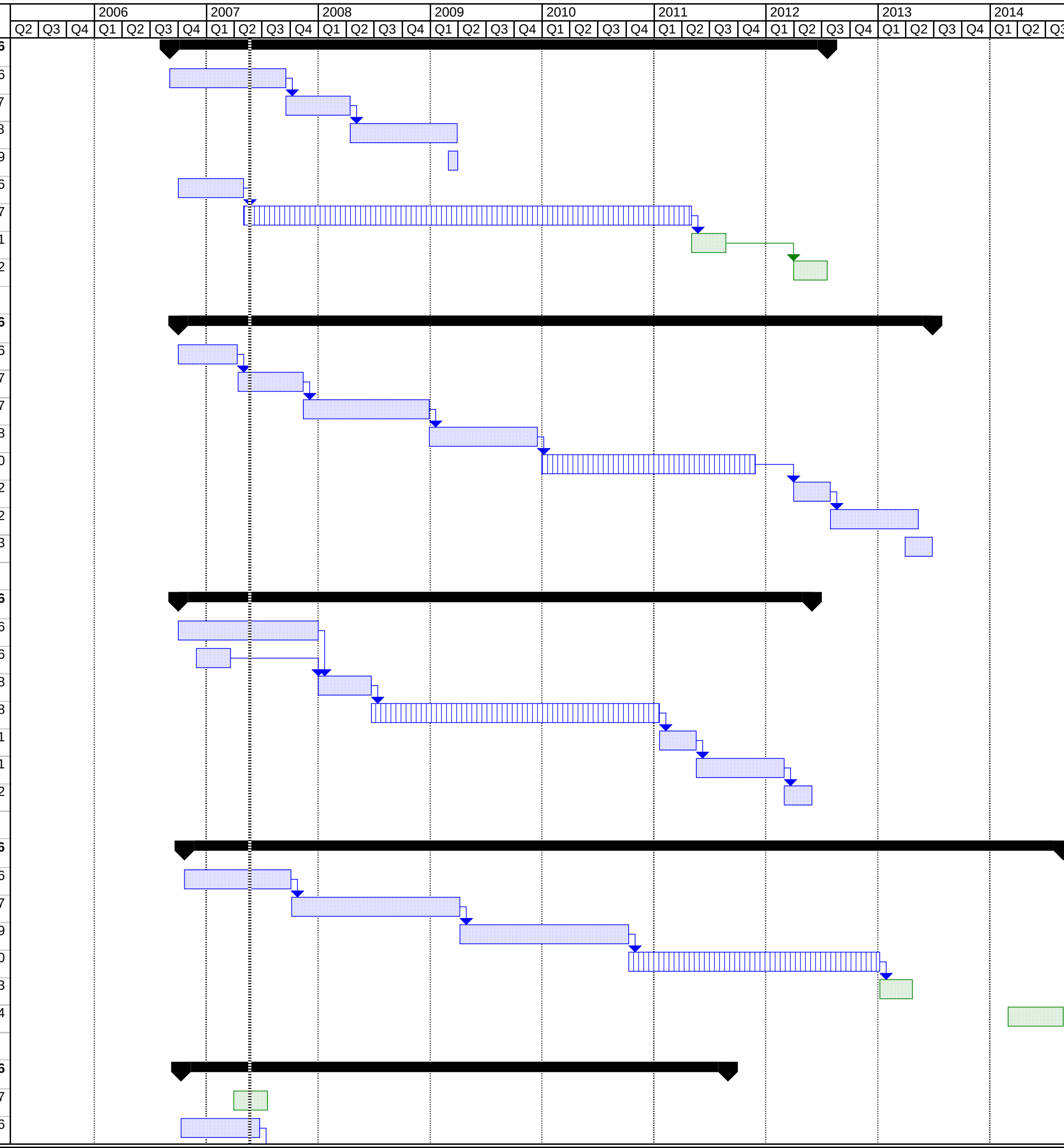
The ranked modeling results are provided for the 10 highest scored alternatives in Table 5-11. The modeled score is a measure of how a given alternative stacks up to other alternatives based on the rating factors and weights discussed previously. A score of 1 would represent an alternative that rated highest in every category used to judge the alternatives while a score of zero would represent an alternative that rated lowest in all categories. The relative tight grouping of the 10 highest scored alternatives in the table suggest that no alternative clearly stands out above the rest though comparison to the current project baseline shows a significant score increase corresponding to significant progress toward meeting the ultimate model performance goal.

When the uncertainty in some of the model inputs is accounted for in the ranking score of alternatives in Table 5-11, the ideal of finding a best alternative is further reduced. The alternative combination of the RSW, tailrace improvement, and BGS has a rather large uncertainty associated with their score value. With uncertainty included, the robustness of the ranking is reduced. Considering the uncertainty, three alternatives are vying for the top ranking: a stand alone RSW (20/20 20/20) +20,000 cfs, and an RSW, BGS, and tailrace improvement alternative at 2 different spill levels (0% training spill and 20% training spill). In the pairwise ranking the combination of RSW, BGS, and tailrace improvements ranks higher than the stand alone RSW 38% of the time at a training spill of 20%, and 20% of the time at a training spill of 0%. From the absolute ranking, the stand alone RSW only ranks highest 15% of the time while the RSW, BGS, and tailrace combination ranks highest of all 30% of the time at a 20% training spill level and 11% of the time at a 0% training spill level. All other alternatives and alternative combinations rank highest less than 5% of the time and beat the best-scored alternative less than 5% of the time.

[1] Crystal Ball is software that automatically calculates Monte Carlo ("what if") cases.

John Day Configuration Study - Alternative Construction Schedules

ID	Task Name	Start
1	**Alt 1 ESBS Implementation**	**Tue 9/5/06**
2	Trash and Debris Concerns DDR	Tue 9/5/06
3	Plans & Specifications	Wed 9/19/07
4	Trash and Debris Measures Construction	Wed 4/16/08
5	Debris Measures Construction Complete	Mon 3/2/09
6	ESBSand VBS P&S	Tue 10/3/06
7	ESBS Construction	Fri 5/4/07
8	1st Year Biological Testing	Thu 5/5/11
9	2nd Year Biological Testing	Mon 4/2/12
10		
11	**Alt 2 Surface Flow Bypass at the Spillway**	**Tue 10/3/06**
12	Feasibility Report	Tue 10/3/06
13	DDR	Mon 4/16/07
14	Plans and Specifications	Thu 11/15/07
15	Bid and Award Process	Tue 12/30/08
16	Construction	Fri 1/1/10
17	First Year Bio Testing	Mon 4/2/12
18	Follow on Improvements	Tue 7/31/12
19	Second Year Bio Testing	Mon 4/1/13
20		
21	**Alt 3 Surface Flow Bypass at Skeleton Bays**	**Tue 10/3/06**
22	Plans and Specifications	Tue 10/3/06
23	Baseline Biological Testing 1st Year	Fri 12/1/06
24	Bid and Award Process	Thu 1/3/08
25	Construction	Tue 6/24/08
26	First Year Bio Testing	Thu 1/20/11
27	Follow on Improvements	Fri 5/20/11
28	Second Year Bio Testing	Fri 3/2/12
29		
30	**Alt 4 Hydrocombine in PH Units**	**Mon 10/23/06**
31	Feasibility Report	Mon 10/23/06
32	DDR	Mon 10/8/07
33	Plans & Specifications	Thu 4/9/09
34	Prototype Construction	Tue 10/12/10
35	Prototype Evaluation	Tue 1/8/13
36	2nd Year Prototype/1st Year Post Construction Evaluation	Mon 3/3/14
37		
38	**Alt 5 Behavioral Guidance System**	**Thu 10/12/06**
39	Baseline Biological Behavior Testing	Mon 4/2/07
40	Feasibility Report	Thu 10/12/06



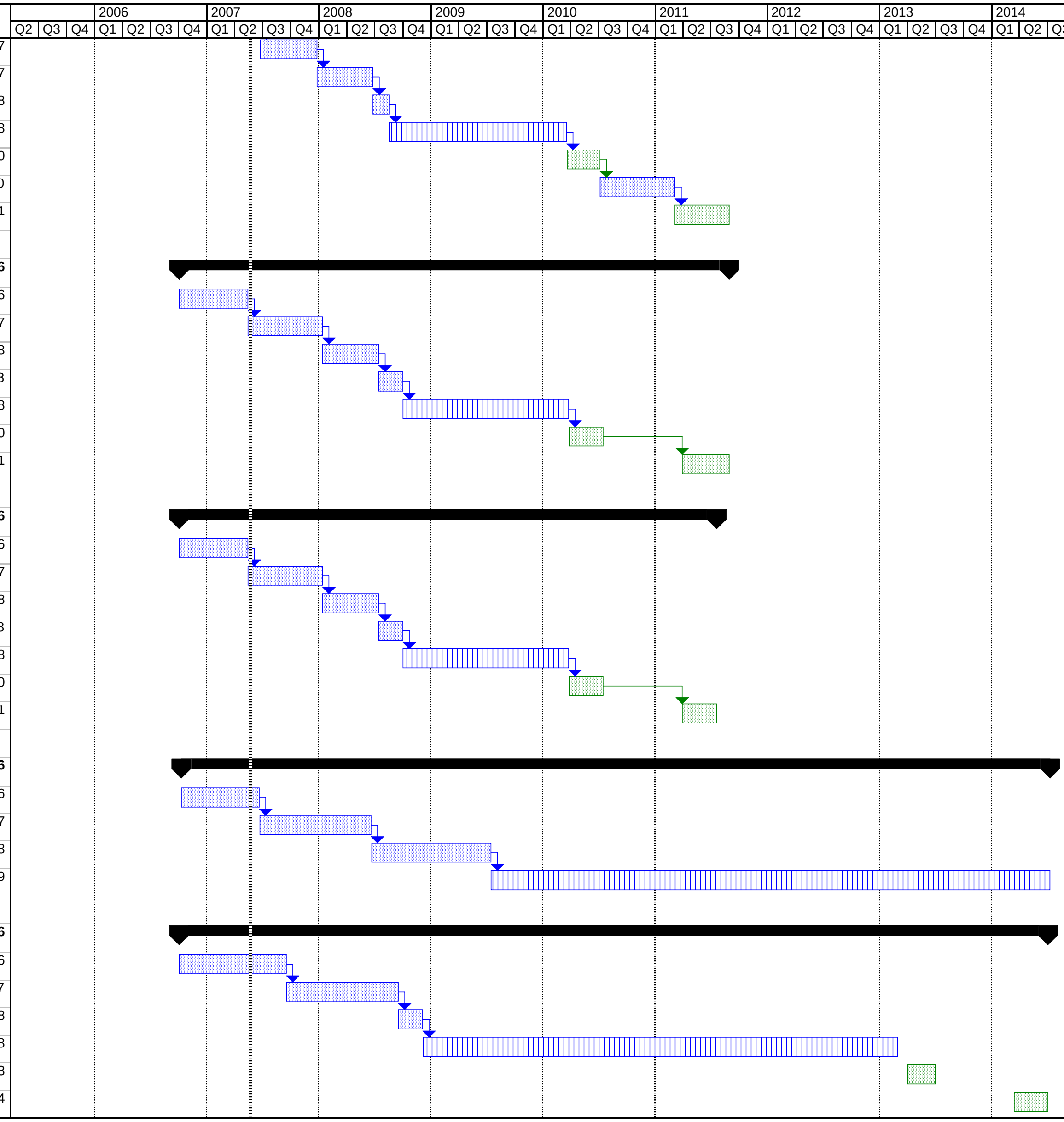
Project: Summary Schedule 06
Date: Mon 5/21/07

Legend: Task; Split; Progress; Milestone; Summary; Rolled Up Task; Rolled Up Split; Rolled Up Milestone; Rolled Up Progress; External Tasks; Project Summary; External Milestone; Deadline

Figure 5-3, Estimated Alternative Schedule

John Day Configuration Study - Alternative Construction Schedules

ID	Task Name	Start
41	DDR	Tue 6/26/07
42	Plans & Specifications	Fri 12/28/07
43	Bid and Award Process	Fri 6/27/08
44	Prototype Construction	Tue 8/19/08
45	Prototype Evaluation	Mon 3/22/10
46	Engineer Follow-on Improvements (Small Contract)	Wed 7/7/10
47	2nd Year Prototype/1st Year Post Construction Evaluation	Tue 3/8/11
48		
49	**Alt 6 Tailrace Improvements - Spillwall**	**Thu 10/5/06**
50	Feasibility Report	Thu 10/5/06
51	DDR	Thu 5/17/07
52	Plans & Specifications	Tue 1/15/08
53	Bid and Award Process	Wed 7/16/08
54	Prototype Construction	Fri 10/3/08
55	1st Year Biological Testing	Mon 3/29/10
56	2nd Year Biological Testing	Fri 4/1/11
57		
58	**Alt 7 Tailrace Improvements - JBS Outfall**	**Thu 10/5/06**
59	Feasibility Report	Thu 10/5/06
60	DDR	Thu 5/17/07
61	Plans & Specifications	Tue 1/15/08
62	Bid and Award Process	Wed 7/16/08
63	Prototype Construction	Fri 10/3/08
64	1st Year Biological Testing	Mon 3/29/10
65	2nd Year Biological Testing	Fri 4/1/11
66		
67	**Alt 8 Turbine Improvements**	**Thu 10/12/06**
68	Feasibility Report	Thu 10/12/06
69	DDR	Mon 6/25/07
70	Plans & Specifications	Mon 6/23/08
71	Prototype Construction	Fri 7/17/09
72		
73	**Alt 9 Powerhouse Surface Collection**	**Thu 10/5/06**
74	Design DDR/Testing	Thu 10/5/06
75	Plans & Specifications	Wed 9/19/07
76	Bid and Award Process	Thu 9/18/08
77	Construction	Mon 12/8/08
78	1st Year Biological Testing	Thu 4/4/13
79	2nd Year Biological Testing	Mon 3/17/14



Project: Summary Schedule 06
Date: Mon 5/21/07

Task | Milestone | Rolled Up Split | External Tasks | Deadline
Split | Summary | Rolled Up Milestone | Project Summary
Progress | Rolled Up Task | Rolled Up Progress | External Milestone

Figure 5-3, Estimated Alternative Schedule

Table 5-11. Decision Model Results for Top 10 Alternatives and Current Project Baseline

Top 10 Alternatives	Modeled Score	Uncertainty			Ranking	
		5 percentile	Mean	95 percentile	Pairwise	Absolute
RSW (20/20 20/20) +20 kcfs	0.737	0.74	0.744	0.745	50%	15%
SBay SBypass (20/20 20/20) +20 kcfs	0.734	0.73	0.738	0.74	<5%	<5%
RSW + TR. Im. (20/20 20/20) +20 kcfs	0.73	0.73	0.737	0.74	<5%	<5%
RSW + BGS + TR. Im. (20/20 20/20) +20 kcfs	0.73	0.73	0.743	0.755	38%	30%
HydroC + BGS + TR. Im. (20/20 20/20) +20 kcfs	0.729	0.725	0.731	0.735	<5%	<5%
HydroC + BGS + TR. Im. (0/0/0/0) +20 kcfs	0.726	0.72	0.725	0.73	<5%	<5%
RSW + BGS + TR. Im. (0/0 0/0) +20 kcfs	0.726	0.725	0.738	0.75	20%	11%
RSW (10/10 10/10) +20 kcfs	0.725	0.72	0.727	0.73	<5%	<5%
SBay SBypass (10/10 10/10) +20 kcfs	0.724	0.72	0.725	0.73	<5%	<5%
SBay SBypass + TR. Im. (20/20 20/20) +20 kcfs	0.722	0.72	0.726	0.73	<5%	<5%
Current Project (0/60 30/30)	0.64	0.65	0.655	0.66	<5%	<5%

Note: Uncertainty represents the range of potential scores for a given alternative when uncertainties in the inputs are considered. The ranking values represent the percent of time that an alternative would rank highest in the case of the absolute ranking and beat the highest ranked alternative in the case of the pairwise ranking. For example due to uncertainty an RSW (10/10 10/10) + 20,000 cfs (20 kcfs)would be the top ranked alternative less than 5% of the time and would beat the best alternative, RSW (20/20 20/20) +20,000 cfs, less than 5% of the time.

5.3.1. Sensitivity

In reviewing the results of the decision model, it is important to consider the sensitivity of the highest ranked alternatives to the rating and weighting factors applied in the model. Considering the stand alone RSW alternative and the two BGS alternatives, the relative ranking of these three alternatives is highly sensitive to timing, economics, and system operation (TDG). For the case of the timing rating factor, a 1.2% decrease in the significance of implementation time would swap the top ranked RSW alternative with one of the alternatives that include RSW, BGS, and tailrace improvements, as well as two hydrocombine and skeleton bay surface bypass alternatives (hydrocombine + BGS + tailrace improvement at 20% training spill and skeleton bay surface bypass + BGS + tailrace improvement at 20% training spill). A 2.5% change in the weighting of economics and a 4.8% change in the weighting the system impacts factor (TDG) would also change which alternative ranked highest. The ranking of the alternatives is relatively insensitive to all other factors requiring greater than a 5% change in that factor to change the ranking results of the model.

5.4. MODEL CONCLUSIONS

The ranking produced by the decision model show that there is a significant amount of uncertainty between three of the 10 highest scored alternatives (stand alone RSW and a combination RSW, BGS, tailrace improvement at 0% and 20% training spill). In addition, even though only three alternative combinations rank highest consistently when uncertainty is considered, the sensitivity of all of the 10 highest scored alternatives to timing, economics, and system operations suggests that the model results are as robust as you would like to throw out a given alternative. It would be ideal at this point to reduce uncertainty in and sensitivity to the economics, timing, and TDG factors before eliminating any of the 10 highest ranked alternatives. The trend seen in 10 highest ranked alternatives is that the best solution for JDA considering all factors includes a cost-effective surface flow route such as the top spillway weir (TSW), tailrace improvements, and behavioral guidance toward the spillway.

6. STRATEGIC PLAN

6.1. INTRODUCTION

The Strategic Plan provides a process for improving the survival of juvenile salmonids passing JDA. The overarching goal of this study is to weigh alternatives based on their potential to achieve the targeted 96% dam passage survival rate for yearling and subyearling Chinook salmon and steelhead trout, in concert with all model criteria factors described in Section 5 of this report. Ultimately, the targets will be established through the BiOp Remand process under regional coordination. For the Strategic Plan to be successful, areas and/or routes of fish passage (i.e., the forebay, the three primary routes of passage, and the tailrace) must be considered as a holistic system that is complex, dynamic, and interdependent. A change to one facet will ultimately have an effect on the others. Therefore, the process leading to a solution for improving juvenile salmonid survival at JDA will need to balance levels of spill and power generation both in the context of fish passage and survival. It is anticipated that the goal will be met through incremental gains from combined changes and adjustments to the existing system, and by incorporating more than one fish passage alternative into the overall system.

As new data is gathered, the Strategic Plan will be modified to reflect the new information. Reports documenting findings over the previous year and the direction of the program the following year will be evaluated and the Strategic Plan updated as new information becomes available.

6.2. ALTERNATIVES

As described in Section 5 of this report, a multi-criteria decision model was used to derive a list of potential fish passage alternatives with the highest potential of meeting the targeted 96% survival rate for juvenile salmonids passing JDA. The variables and criteria used in the model were weighted based on their relative importance (e.g., the cost of a given alternative, the economics of foregone power, the type of fish species, spill rate, and time of year). Regional fish managers and the JDA configuration team provided input and were involved in selection of the final list of alternatives.

Following execution and including sensitivity testing, the decision model produced the following list of alternatives (both stand alone and in combination) with the highest potential to provide the largest benefit for dam passage survival at JDA considering all factors included in the decision model.

- Surface flow at spillway (SFSP).
- Surface flow at skeleton bays (SFSB).
- SFSP combined with tailrace improvements.
- SFSB combined with tailrace improvements.
- SFSP combined with a forebay behavioral guidance structure (BGS) and/or tailrace improvements.
- SFSB combined with a forebay BGS and/or tailrace improvements.

Alternative implementation has been divided into two phases to imbed critical decision points within the implementation process. In Phase I, data gaps will be addressed during alternative implementation. For example, the potential to reduce turbine entrainment through surface flow at the spillway and tailrace modifications to improve egress will be assessed. Prior to Phase II, evaluation of biotic parameters will indicate — if performance goals are not being met — those additional forebay and/or tailrace alternatives needed to meet targeted survival rates. If Phase II is necessary, alternatives being considered currently include a BGS, additional tailrace modifications (e.g., JBS outfall relocations), and/or other improvements. This strategy was developed so that alternative implementation will be performed in a manner that confirms the decision model assumptions, provides for critical decision points in the process, and allows maximum flexibility at minimal risk to target species.

6.3. Strategic Approach

From the specifics of the alternatives determined by the decision model, the implementation of a logical decision making process was developed. Developing a working system becomes more difficult in implementation due to the interrelated aspects of each alternative, the potential for new information driving decisions, and the dynamic nature of criteria and funding. With those factors in mind, the following logical progression is formulated.

Given the relatively high survival estimates for the JDA spillway, it is natural to conclude that leading more fish to the spillway and using a combination of spillway weirs; potentially in concert with a forebay BGS would be a straightforward solution for increasing overall fish passage survival. However, the dynamic and interdependent hydraulic conditions in the tailrace, forebay, and spillway require a comprehensive investigation of the system as it affects safe fish passage and survival. Also, the stagnant flow area downstream of the skeleton bays provides hydraulic cover for predators residing in the tailrace. Therefore, surface flow bypass, tailrace improvements, and subsequently (Phase II) a forebay BGS, and project operation improvements will be investigated. The project will start late in the third quarter of Fiscal Year 2006 and is tentatively scheduled to be completed some time in 2013. The actual duration of the project will be dependent on the alternatives selected, which could shorten or extend the time from concept to implementation.

The Strategic Plan developed from the Decision Analysis Framework within the JDA COP consists of the following implementation stages: (1) a feasibility study to recommended alternative(s) for implementation; (2) a detailed design report for the selected alternative(s); (3) plans and specifications for the construction of a prototype(s) and/or final alternative(s); and (4) multiple years of biological testing to confirm improved dam passage survival rates for the fish species and life history phases passing JDA. Critical decision points and evaluation loops are imbedded within the strategy to allow input and direction from Portland District and regional fish managers.

Due to the size and potential cost of many of these alternatives, they will likely have to be separated to be pursued separately and then evaluated as part of the system to see how the pieces work together to meet the project passage goals. The applied logic for evaluating and testing the various fish passage alternatives is represented graphically in Figure 6-1. The logic presented is generalized in that it evaluates the system goal and the general decisions that should be made based on post-construction biological evaluations. The normal process as defined in this figure is to perform feasibility, design, construction, and then evaluation. If the goal is met, then the system is optimized. If the goal is not met, the decision model loops back to determine which additional alternative or correction provides the best probability of reaching the targeted survival rate.

Draft 12/08/05
JDA COP Strategic Plan
Chart Rev. 2a

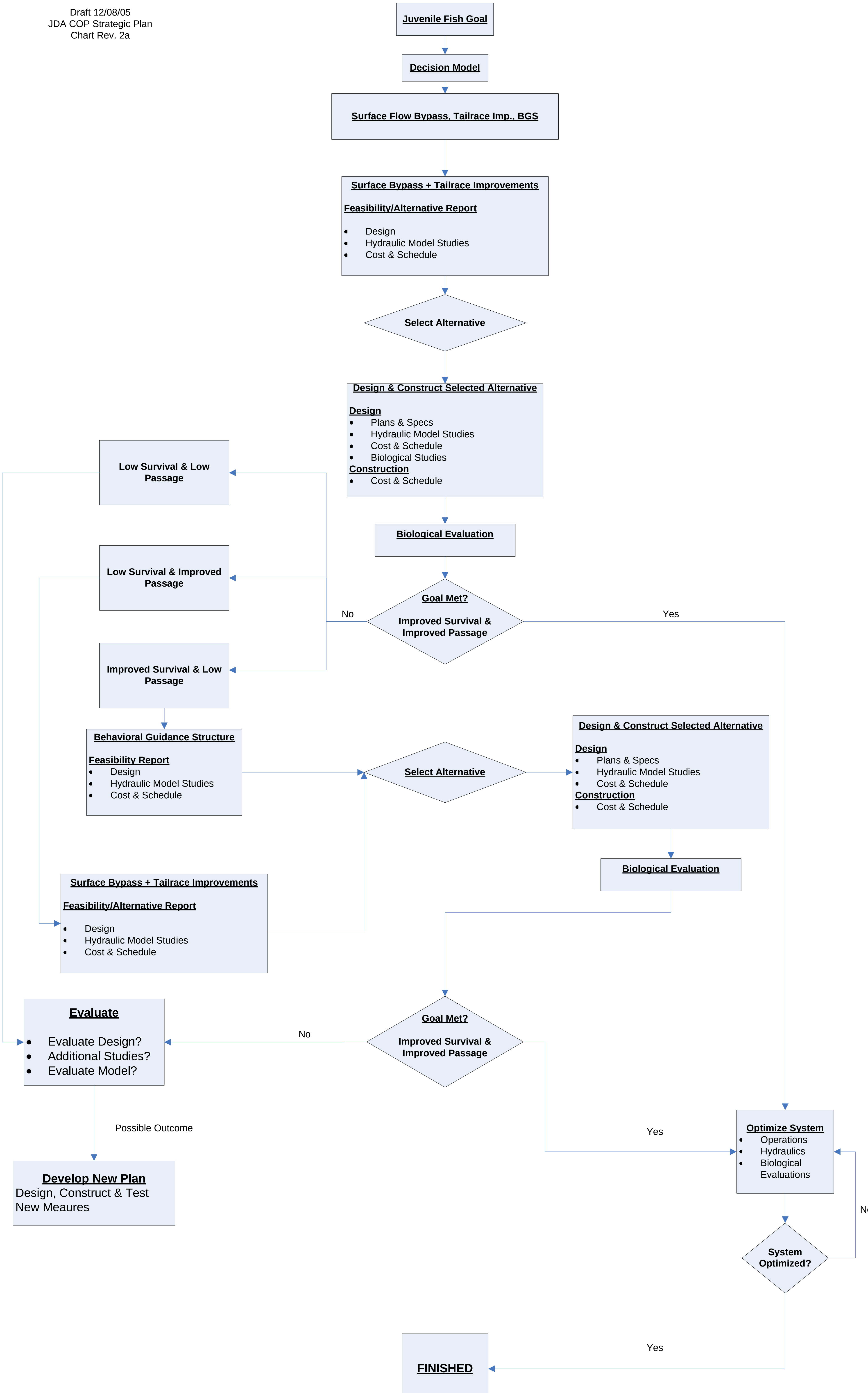
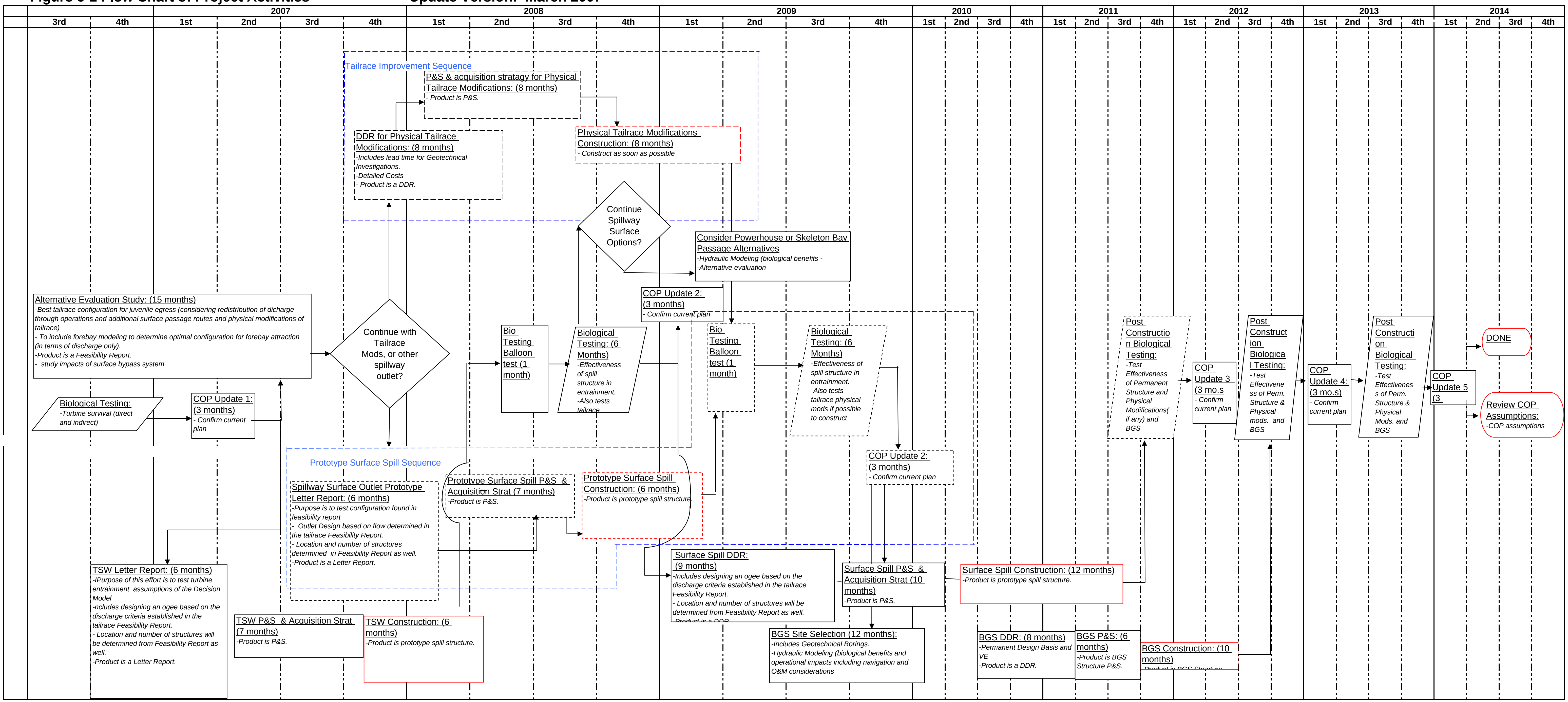


Figure 6-1 Logic and Strategic Approach

John Day Configuration and Operation Plan

Figure 6-2 Flow Chart of Project Activities

Update Version: March 2007



Notes:
1. The schedule shown assumes Regional Fishery Agency agreement for funding of the proposed actions
2. The Flow Chart is subject to changes based upon information gained throughout the alternative development process

An overall JDA systems improvement feasibility study will be conducted. The study will look at the dynamic relationship between the three fish passage routes (spillway, powerhouse, and JBS) and the trouble spots identified in the tailrace (i.e., the stagnant zone in front of the skeleton bay and the large eddy downstream of the powerhouse). The objective of this study will be to derive an alternative that addresses safe fish passage from the forebay through the tailrace.

In development of the Strategic Plan, alternatives that used surface flow through the spillway (e.g., RSW or skeleton bay surface bypass) proved cost-effective solutions to increasing fish survival at JDA. From work at Walla Walla District, a less expensive structure for testing the RSW or surface flow concept was formulated. This surface outlet structure was named a top spillway weir (TSW) and is being be adapted for use to address a large data gap at the John Day Dam. This data gap is to determine if a surface bypass at JDA measurably reduces powerhouse and turbine passage rates. The use of TSW(s) to emulate an RSW will allow for a cost effective method of biological evaluation of a potential multiple bay spillway surface bypass without the large capital investment of multiple RSWs. The TSW(s) can be used to evaluate forebay passage times, has a lifetime expectancy of roughly 50 years, as well as provides a method to better define design factors such as geometry, location, and discharge rates for a surface bypass at the skeleton or spillbays.

Recommendations from the feasibility study will be briefed to Corps' management and regional fish managers in late Fiscal Year 2007. Results from TSW biological evaluations should provide insight into data gaps, and better define the path forward towards reaching performance goals at JDA. Based on these and other results (i.e., McNary TSW studies) a critical decision point will be reached. Specifically, whether to seek management approval and regional buy-in for a Detailed Design Report followed by plans and specifications for tailrace improvements should be executed. Depending on the complexity and cost of the recommended alternatives, resulting from the feasibility study, construction could start in late 2009.

Construction of a permanent surface flow bypass structures (assuming this is warranted and approved) will be initiated in 2010. The TSW(s) may provide a permanent and cost-effective solution to providing surface flow bypass at JDA. Due to their limited cost, in relation to an RSW, multiple TSW(s) placed strategically in the spillway could provide operational flexibility to meet the demands of both spring and summertime migrants. Construction duration will be dependent on the selected alternative but could extend into 2011. In 2009, if goals are not met through surface bypass, tailrace improvements and other improvements at the powerhouse will likely occur. Concurrently, site selection for a BGS, if warranted, will begin. Assuming that the installation of the BGS is necessary and prudent to meet project goals, construction will start late in 2011 with completion projected in mid-2012. Final proof of concept studies (at least two consecutive years) will start in late 2011 and continue through 2013 (see the suggested timeline in Figure 6-2). Potential forebay, powerhouse, spillway, tailrace, and operational factors will be evaluated and reevaluated with each improvement as a part of the strategic plan.

6.3.1. Tailrace Improvement Feasibility Study

As discussed above, a primary concern at JDA, relative to survival of migrating juvenile salmonids, is the hydraulic flow necessary to rapidly and safely move fish through dam tailrace areas. The scope of the study will encompass bathymetry assessment and evaluation and will incorporate modeling studies, testing all phases of prototype design, development, and ultimately, construction. While considering all components affecting fish passage, this feasibility study will initially focus on improving these tailrace conditions. First, alternatives will be evaluated in the context of tailrace egress capability and potential. Of particular concern is the need to eliminate the stagnant flow area below the skeleton bays. Second, alternatives will be evaluated based on their potential to integrate the benefits of surface flow bypass system as well as optimized powerhouse flows.

The following tailrace improvement alternatives were provided by regional input and will be incorporated into the feasibility study in combination with the alternatives in Section 6.2.

- Removal of tailrace dredge spoils islands.
- Create flow through and/or over the skeleton bays (vary amount of flow).
- Fill the area downstream of the skeleton bays.
- Manipulate existing flow to force current through the stagnant area downstream of the skeleton bays by using a floating barrier or turning vanes downstream of North powerhouse turbine units.
- Construct a concrete spillwall between the spillway and powerhouse.
- Operational modifications.
- Relocation of the JBS outfall.

Specific biological and hydraulic criteria that will be used to evaluate alternatives include, but are not limited to:

- Minimize the area of stagnant flow downstream of the skeleton bays.
- Increase transport velocities in the tailrace to provide good downstream egress conditions for migrating fish.
- Minimize eddies in the tailrace.
- Minimize predator habitat within the tailrace (structural and hydraulic).
- Impact the ability of adult fish to find the fish-ladder entrances.

The tailrace systems improvement feasibility study will provide recommendations with pros and cons to aid in the decision making process leading to the implementation of an alternative or set of alternatives. The activities that support this study include baseline data and evaluation criteria for impacted passage routes, selection, and prioritization of identified alternatives; computational and physical modeling; and biological evaluation. It is expected that the final report will be completed in summer 2008. Figure 6-2 graphically delineates the schedule.

6.3.2. Powerhouse Operations

Although efforts have been made to reduce turbine passage for juvenile salmonids, due to the large attractions flows fish continue to utilize this route. Hydraulic turbine model investigations conducted under the Turbine Survival Program (TSP) suggest that the best hydraulic conditions occur when they operate with an open geometry and smooth streamlined flow resulting in little to no turbulence. Operating under these conditions will likely increase passage survival probabilities for fish passing through turbines. The TSP team will partner with the JDA Configuration team to investigate powerhouse operations.

The JDA turbines can operate at the lower 1% of peak performance. Using the 1:25 scale model of the JDA turbines located at the Engineer Research and Development Center, the TSP has been able to create quality flow through the turbines by adjusting operating parameters (i.e., blade angle, wicket gates, and stay vanes). Modeling and testing conducted by the TSP suggests that operating the powerhouse at the upper 1% of efficiency is not only desirable from the perspective of efficient power generation but also provides better fish passage conditions. However, additional field study is necessary to index operating parameters in the context of fish passage and survival. Furthermore, powerhouse operations directly impact draft tube volumes and flows, which in turn impacts hydraulic conditions in the tailrace. Balanced distribution of flow through the draft-tubes should positively change flow characteristics, both in the draft tubes and in the tailrace.

Biological index testing will determine if a change in turbine operation results in a significant change in turbine-passage survival, and will further identify which operational changes or conditions result in the best survival. This will be accomplished by defining the various physical conditions within the turbine through model investigations and field testing. The plan begins with model investigations and a biological index test of the John Day turbines. The resulting biological data will be combined with the model data to support further development of operational guidelines.

The product for this activity will be a report that articulates the study design, summarizes and interprets the data in the context of the stated goals and objectives and provides powerhouse operation recommendations. The activities that support this study include additional physical and computational modeling of turbine geometry in order to achieve the desired, streamlined flow conditions through the unit. The estimated cost for these studies is $4 million. Figure 6-2 graphically delineates the schedule.

6.3.3. Behavioral Guidance System

The BGS is included in the strategy for the improvements at John Day following success of several other alternatives. It would not make sense to install a BGS that concentrates fish to a location where they can't be passed quickly and safely both through the spillway and tailrace. The BGS must be installed following the other alternatives because it is used to guide fish to a safe and effective passage route. Completion of alternatives that define acceptable tailrace egress and successful surface bypass will be completed first, and then if project goals are not met, further improvement and efficiency of passage will be performed with BGS.

6.3.4. Surface Bypass Systems (Top Spillway Weir)

There has been an emphasis on placing a RSW at various projects to increase passage efficiency and survival over the spillway for migrating juvenile salmonids. While the expected benefits derived from the use of this technology are not conclusive, they are promising. Studies of fish passage behavior at JDA have shown that operating the spillway does not reduce the number of fish passing through turbines, which indicates that fish passing through the spillway would likely pass through the JBS in the absence of spill. Fish passage efficiency estimates were nearly equal for spring migrants between tests of 12-hour and 24-hour spillway operation (see Section 3). Due to the high costs of installing a permanent surface-flow structure, the potential benefits to fish passage need to be evaluated. Moreover, while physical and numerical modeling can provide insight into hydraulic conditions, the behavioral responses of fish to a surface flow bypass system are difficult to predict.

The Walla Walla District has developed a TSW that may effectively simulate the hydraulic behavior of an RSW. It is also conceivable that a TSW may serve as a stand-alone alternative in lieu of an RSW. Two primary benefits of the TSW are the relatively low cost ($2 million compared to $15 for a single RSW) and portability. This portability can help identify the correct location and effectiveness of a more permanent surface flow structure. In spring 2007, the Walla Walla District is testing a TSW at McNary Dam. This test is evaluating direct mortality and injury associated with passage over the TSW in relation to a normal spillbay. If the TSW is successful, testing of fish behavior relative to a TSW will be conducted during the 2007 juvenile salmonid out-migration.

Data from preliminary direct injury and survival balloon tag testing at the McNary TSW will provide a general viability assessment of fish passage and survival over the TSW. If it is determined to be safe for fish, the TSW will be tested using run-of-the-river fish in spring 2007. Portland District will coordinate with Walla Walla District to track and monitor success and lessons learned. These direct injury and survival data will also serve as an imbedded decision point on the path forward toward evaluating TSW(s) at JDA. Portland District also will evaluate the available design criteria to assess modifications needed in order to adapt a TSW to the differing structural configuration at JDA. The estimated cost for the study, design, and construction of a TSW is $6 million. A graphical delineation of the schedule of this activity is shown in Figure 6-2.

6.4. MONITORING PROGRESS

Dam passage survival for yearling and subyearling Chinook salmon and steelhead trout migrating past JDA will be evaluated at multiple junctures during the overall process. Based on the results of the biological studies, progress toward the targeted 96% total dam passage survival will be determined. The process and decision points laid out in this strategy will be adjusted as necessary with information from prototypes and biological studies in an effort to meet this goal. The project will be considered complete when a consistent survival rate of 96% is achieved for each life history and species (typically similar estimates in at least two consecutive years of study), or regional fish managers agree that survival has been maximized at JDA.

6.5. SCHEDULE

The overall schedule initiates with TSW forebay evaluations and proceeding towards the tailrace. The systems feasibility study includes, if necessary, the construction of a BGS and the corresponding necessary biological testing through 2013. The schedule is driven by in-water work period constraints for construction, methodology, and internal business practices and processes. For example, an alternative is conceptualized, studied, and modeled. The resulting data is analyzed and a report and recommendations are generated. The recommendations are then briefed to senior management and regional fish managers. Once recommendations are approved, detailed design reports and plans and specifications are generated prior to construction. Post-construction monitoring is conducted to evaluate biological results from the constructed alternative. With each additional change or alternative added, the process is reiterated and the strategic plan is updated to insure that survival is optimally progressing toward the desired goal. A summary of this process and schedule is available in Figure 6-2. The schedule shown could be shortened if alternatives are implemented in parallel as opposed to sequentially. Parallel implementation can be a high risk endeavor. Such an implementation strategy requires both confidence and available funding for the selected alternatives. The schedule provided follows a sequential format which allows confirmation of success prior to implementation of the next alternative. The schedule shown is also optimistic in that some decisions are to be made with minimum or anecdotal biological data and will be subject to regional coordination.

6.6. BUDGET

The overarching goal at JDA is to achieve a 96% total dam passage survival rate for yearling and subyearling Chinook salmon and steelhead trout. While the overall recommended approach is comprehensive and holistic, the project will stop when the goal is met. In other words, if the 96% total dam passage survival rate is met as a result of reducing powerhouse entrainment and enhancing egress via TSW(s), and this is substantiated through biological evaluation, then the project will be considered complete and all activities associated with additional alternative investigations and/or construction will be terminated.

While the total estimated costs for the various alternatives are provided in Section 4 and in Appendix A, it is difficult to predict with any certainty what the overall costs will be for taking this project to completion. For example, TSW(s) are estimated to cost approximately $2 million each. However, it is not known if the TSW technology will work at JDA or if a stand-alone or multiple TSWs will be needed to reduce powerhouse entrainment of passing. Physical and computational fluid dynamics modeling both suggest that such a surface bypass system may require complementary tailrace improvements, which are estimated to cost from $17 to $20 million. Concomitantly, it is unclear whether a behavioral guidance system (approximately $55 million) will be necessary to complement the TSW(s) through enhancing passage efficiencies. Based upon all data presented herein, the most appropriate approach is to conduct the systems feasibility study to assess the alternatives and combination of alternatives (estimated cost is $500,000), culminating in a final report with a recommended alternative(s) for implementation. Such a strategy ensures that the development of one alternative complements and builds upon existing works.

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APPENDIX A

FACT SHEETS

Alternative 1: Extended-length Submersible Bar Screens (ESBS)

Description

A screened juvenile bypass system (JBS) diverts a proportion of fish passing through turbine intakes into a collection channel, which then routes and releases the fish downstream of the dam. The objective of this alternative is to increase fish guidance efficiency (FGE) over the existing JBS by incrementally reducing the proportion of turbine entrained fish and releasing collected fish in a tailrace location that provides the lowest opportunity for smolts to encounter predators. New screens may not improve passage survival over the current JBS due to increased gatewell turbulence. The main features of the system are extended-length submersible bar screens (ESBS) and new vertical barrier screens (VBS). Final design studies would resolve issues such as VBS final design for gatewell flow distribution, gatewell debris studies, VBS cleaning device, and the decision on bar screens versus polyester mesh screens. Existing components of the current JBS, such as the orifices, collection channel, transportation flume, and outfall, would not change.

Status

The current JBS was constructed and put into operation with submerged traveling screens (STS) in about 1986. The existing system has undergone extensive testing and modification for optimization. A juvenile monitoring facility was completed in 1998. Testing of an ESBS system was initiated in 1996 with testing continuing until 2002. More recently, regional acceptance of screened juvenile bypass systems is eroding. The Fish Facility Design Review Work Group members from the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the states and tribes have hypothesized that there is a latent mortality associated with JBS passage that is not found for fish passing via spill. This hypothesis has not been tested or substantiated for fish passing through the JBS.

Cost

The cost for implementation of an ESBS system was estimated in 2000 and is updated to current costs for this study. The cost included the ESBS and VBS, as well as all other program-related costs including design, model testing, prototype testing, and implementation. The cost for this alternative included debris measures installed for all units including VBS deck slot modifications; bar screen VBS as necessary; new poly VBS frames where necessary; a debris cleaner; and a debris boom to limit debris from going to the powerhouse and plugging the screens. The debris boom is expected to be approximately 3,500-feet long with a design similar to a limited depth log or floating barrier boom used at other project intakes to limit debris. Additional model and biological testing to confirm design parameters is included as a placeholder cost to perform minor testing to refine all components and minimize injury. The total cost for implementation of this alternative is estimated at $76.2 million (Table A-1). The O&M costs are estimated at $810,000 annually. Post-construction monitoring costs are estimated at $8 million.

Table A-1. Alternative 1 – ESBS Cost Estimate

Item	Unit Cost	Units	Total Costs
Design Development			
Design documentation/model testing/biological testing	8,000,000	1	8,000,000
Construction			
16 unit ESBS implementation	2,025,887	16	32,414,187
15 unit VBS deck modifications	933,000	15	13,995,000
5 unit bar screen VBS installation	400,000	5	2,000,000
10 unit poly VBS screens	200,000	10	2,000,000
VBS bar screen cleaner (testing/implementation)	1,000,000	1	1,000,000
Debris boom to spillway bay 20 (3,500 feet)	8,400,000	1	8,400,000
16 unit ESBS implementation	2,025,887	16	32,414,187
P&S, S&A, EDC costs (14 % of construction costs)			8,373,286
Construction subtotal (rounded)			68,200,000
Total Cost for Implementation			**76,200,000**
Annual O&M Costs			**810,000**
Post-construction Monitoring			**8,000,000**

Water Quality Impacts

It is expected that minimal to no water quality impacts would occur with this alternative (all total dissolved gas impacts are accounted for in the spill operations).

Timing/Schedule

The design of the ESBS system is nearly complete. The engineering required to implement plans and specifications (P&S) is minimal; the implementation strategy would be to take the Unit 7 plans and specifications for the ESBS and deck modifications and begin construction of ESBS units and deck modifications. Deck modifications would be required for all units to allow for VBS cleaning. This is considered necessary due to the potential for debris issues in the future. At the same time of the ESBS/Deck slot contract, a debris study would be initiated to determine which bays would require stainless steel VBSs and automatic screen cleaners. It is expected that the program implementation would take approximately 5 years for full installation of all 16 units at JDA and would include completing and accounting for all debris issues.

Biological Considerations

All regional groups do not support bypass systems. Opponents suggest that there is a latent mortality effect of bypass systems on juvenile salmonids; however, this has not been tested at JDA. Also, there have been several incidents where numerous juvenile Pacific lampreys were found impinged on bar screens when the trash sweep failed. The effect of these bar screen systems on Pacific lamprey is not known; however, this continues to be evaluated. Extended-length submersible bar screen evaluations, conducted at JDA 1996, reported FGE for juvenile Chinook salmon in the spring and summer at 84% and 60%, respectively. Descaling was less than 1% and orifice passage efficiency exceeded 97.5% for the Chinook outmigrants. The prototype screens were evaluated again in 1999 and FGE was estimated to be 80% for yearling Chinook salmon. However, unacceptably high mortality rates were found and the 1999 study was stopped. The VBS was modeled and the porosity optimized and retested in spring 2001. For debris testing, the prototype VBS was tested with stainless steel bar screen panels. A bar screen gap of 1.75 millimeters (mm) and bar screen panels in a horizontal configuration were tested. As a result of spring testing, the mortality issue was relieved with the change in the VBS porosity, but the horizontal bar screen panels experienced vibration and fatigue damage as a result of water flowing past it. As a result of that testing, the panels were modified and tested again in 2003. The ESBS was modified in 2002 and 2003 to change the bar screen material to 1.75 mm spacing and to reinforce the porosity panels. Orifice testing was to be performed if the VBS testing did not improve FGE or delay in the gatewell. At this time, orifice modifications are not expected to be necessary.

Results of 1999, 2001 and 2003 testing has shown the potential for FGE improvements in Unit 7. Prior to implementation, further testing in the south powerhouse will be performed. This will be done to determine the need for using bar screen panels on the VBS. The concern on the south powerhouse units is that if large amounts of debris are collected on the face of the VBS, cleaning or damage to the polyethylene VBS mesh would affect the continued use of the system. If debris on the VBS is a problem, a bar screen VBS and a cleaning system would be designed for full implementation. The determination of how many gatewells would require bar screen panels would be determined through testing. For this study, it was assumed that the first 6 units would receive bar screen panels and the remaining units would use a polyethylene mesh VBS.

Operational Constraints

Special project operations are not planned for this alternative. This alternative will be evaluated for a full range of spill percentages.

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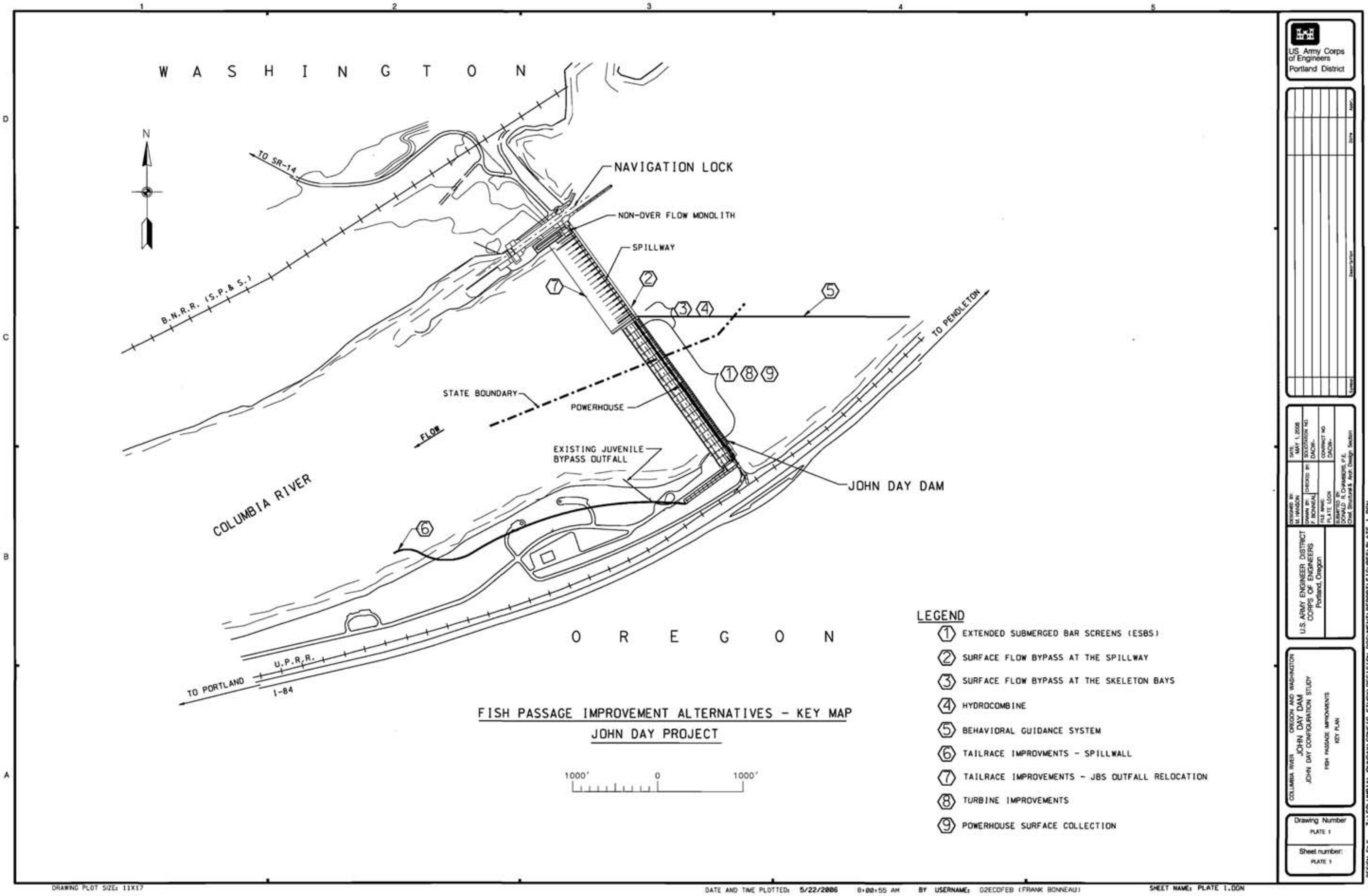
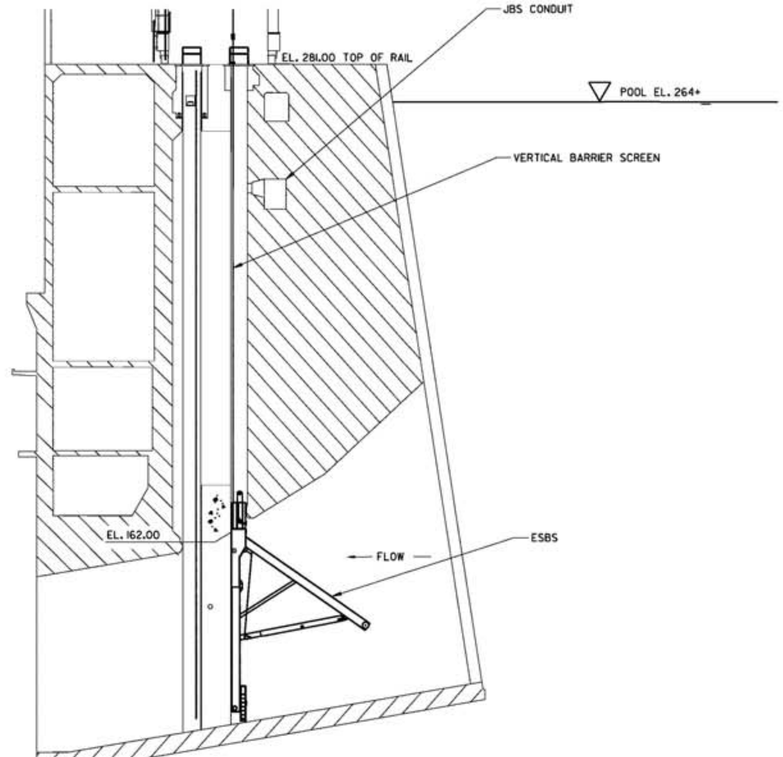

WASHINGTON
N
TO SR-14
NAVIGATION LOCK
NON-OVER FLOW MONOLITH
SPILLWAY
B.N.R.R. (S.P.& S.)
TO PENDLETON
STATE BOUNDARY
POWERHOUSE
FLOW
EXISTING JUVENILE BYPASS OUTFALL
JOHN DAY DAM
COLUMBIA RIVER
OREGON
U.P.R.R.
TO PORTLAND
I-84
FISH PASSAGE IMPROVEMENT ALTERNATIVES - KEY MAP
JOHN DAY PROJECT
1000' 0 1000'
LEGEND
1 EXTENDED SUBMERGED BAR SCREENS (ESBS)
2 SURFACE FLOW BYPASS AT THE SPILLWAY
3 SURFACE FLOW BYPASS AT THE SKELETON BAYS
4 HYDROCOMBINE
5 BEHAVIORAL GUIDANCE SYSTEM
6 TAILRACE IMPROVMENTS - SPILLWALL
7 TAILRACE IMPROVEMENTS - JBS OUTFALL RELOCATION
8 TURBINE IMPROVEMENTS
9 POWERHOUSE SURFACE COLLECTION
US Army Corps of Engineers
Portland District
DESIGNED BY: M. HANSON
DRAWN BY: F. BONNEAU
CHECKED BY:
DATE: MAY 1, 2006
SOLICITATION NO. DACW-
CONTRACT NO. DACW-
FILE NAME: PLATE 1.DGN
SUBMITTED BY: DONALD R. CHAMBERS, P.E. Chief, Structural & Arch. Design Section
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS Portland, Oregon
COLUMBIA RIVER OREGON AND WASHINGTON
JOHN DAY DAM
JOHN DAY CONFIGURATION STUDY
FISH PASSAGE IMPROVEMENTS
KEY PLAN
Drawing Number PLATE 1
Sheet number: PLATE 1
DESIGN FILE: Z:\COLUMBIA\JOHNDAY\CONFIG_STUDY\DECISION_DOCUMENT\REPORT\FIGURES\PLATE 1.DGN
DRAWING PLOT SIZE: 11X17
DATE AND TIME PLOTTED: 5/22/2006 8:00:55 AM BY USERNAME: G2ECOFEB (FRANK BONNEAU)
SHEET NAME: PLATE 1.DGN

ALTERNATIVE NO. 1, EXTENDED SUBMERGED BAR SCREENS



ESBS IN OPERATING POSITION

12" 0 5' 10' 15' 20'

US Army Corps of Engineers
Portland District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
Portland, Oregon

DATE: MAY 1, 2006

COLUMBIA RIVER OREGON AND WASHINGTON
JOHN DAY DAM
JOHN DAY CONFIGURATION STUDY
ESBS ARRANGEMENT
ALTERNATIVE1

Drawing Number
ALTERNATIVE1
Sheet number:
FIGURE 1

DESIGN FILE: Z:\COLUMBIA\JOHNDAY\CONFIG_STUDY\DECISION_DOCUMENT\REPORT\FIGURES\ALT1.DGN

DRAWING PLOT SIZE: 11X17
DATE AND TIME PLOTTED: 5/22/2006 10:12:50 AM BY USERNAME: G2ECOFEB (FRANK BONNEAU)
SHEET NAME: ESBS FIG 1.DGN

Alternative 2: Surface Flow at Spillway (SFSP)

Description

This alternative was taken directly from the work for a removable spillway weir (RSW) at JDA. A RSW was designed as an option in the Surface Bypass Collection System Combinations Report, Lower Snake River (completed in 1998). The design completed for JDA in Detailed Design Report (DDR) No. 53 (2001) was based on a design required to prototype test surface flow at the skeleton bays (see Alternative 3). The RSW was designed to pass a unit flow volume (cfs per foot) comparable to the skeleton unit surface bypass spillway bays. The RSW entrance depth was designed to elevation 245.5 feet MSL. An RSW of lower flow volume, or the use of multiple RSWs, was not considered for implementation; however, the cost for a different crest elevation RSW is not significantly different than the RSW cost used in this analysis. Also, RSW costs constructed for the Walla Walla District are similar to what was used in this analysis.

Because final design of a SFSP has not occurred, two RSWs were used as a surrogate to estimate costs, passage discharge, benefits, etc. The primary function of a surface-oriented outlet at the spillway is to improve fish passage efficiency (FPE) by shifting fish passage distribution from the powerhouse to the spillway to improve the non-turbine passage. The second benefit is to reduce forebay residence time. A surface flow outlet at the spillway would be similar in concept to an RSW and would likely be a benign overflow-type weir with no spillway regulation to provide an unobstructed surface passage route at the spillway. The alternative evaluated considers the construction of several surface flow outlets. Due to the large forebay at JDA, it was assumed that one outlet would not be sufficient and that two RSWs reflect the type of design, modeling, and biological effort that would be required in design and construct a surface flow outlet at the spillway.

Model studies to determine proper SFSP configuration and project operations that provide optimum forebay or tailwater conditions have not been conducted. It is likely that multiple SFSPs would be required to optimize fish passage at JDA. Also, the design of the SFSP will likely change depending upon the target flow, entrance depth, etc.

Status

An RSW has been designed and operated at both Lower Granite and Ice Harbor Dams (Ice Harbor was installed for testing in 2005). Other installations will likely be constructed at the Lower Monumental and Little Goose projects on the Snake River.

Cost

The RSW designed for DDR No. 53 (2001) had a fully funded cost estimate of $11.8 million. The total cost for implementation of this alternative is estimated at $45.9 million (Table A-2). The O&M costs for two SFSPs are estimated at $400,000 annually. Post-construction monitoring costs are estimated at $6 million.

Water Quality Impacts

Water quality impacts are not anticipated as this alternative is assumed to be similar to a spillway bay.

Table A-2. Alternative 2 – SFSP Cost Estimate

Item	Unit Cost	Units	Total Costs
Design Development			
Design documentation/model testing			2,000,000
Biological testing to develop design			6,000,000
Construction			
Plans and specifications			2,000,000
SFSP installation	14,950,000	2	29,900,000
P&S, S&A, EDC costs (6%, 6%, and 8% of construction costs, respectively)			5,980,000
Construction subtotal (rounded)			37,900,000
Total Cost for Implementation			**45,900,000**
Annual O&M Costs			**400,000**
Post-construction Monitoring			**6,000,000**

Timing/Schedule

It is expected that the program implementation would take approximately 4 years from start of design to completion of construction. Hydraulic modeling and biological testing will be important for developing a surface flow structure at the JDA spillway. It is expected that construction will take approximately 1 year per spillway bay from start to finish.

Biological Considerations

Surface flow at the spillway is expected to provide improved passage conditions for migrating juvenile salmonids by reducing forebay passage delays and by guiding more fish away from turbine passage, thereby increasing overall dam passage survival. It also may provide the same benefits for steelhead kelts. For this analysis, 40,000 cfs flow (2 spillbays at 20,000 cfs each) was used to draw flow away from the powerhouse. Location, entrance depth, and discharge will need to be reevaluated and optimized based upon spill levels and spill patterns at the forebay and tailrace. The estimated survival increases over current conditions are 1.2% and 1.0% for spring and summer migrants, respectively.

Operational Constraints

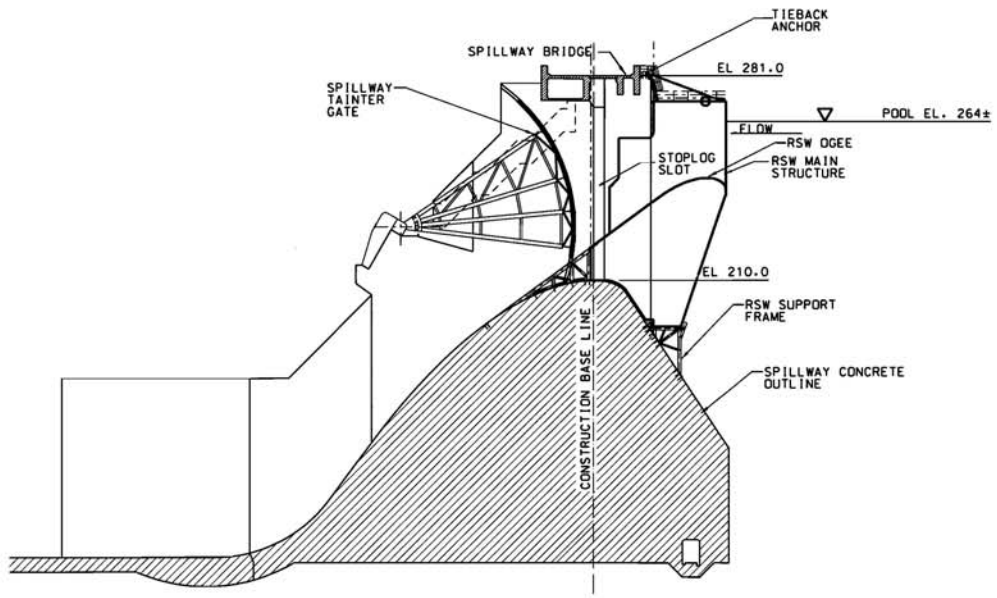
Operational constraints will be based upon regionally accepted spill levels and river flows.

References

John Day Lock and Dam, Removable Spillway Weir, Detailed Design Report No. 53, October 2001.

Lower Granite Lock and Dam, Removable Spillway Weir Design Report

ALTERNATIVE NO.2, SURFACE FLOW BYPASS AT THE SPILLWAY



JOHN DAY SPILLWAY CROSS SECTION

SCALE: 1/16" = 1'-0"

US Army Corps of Engineers Portland District

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS Portland, Oregon

COLUMBIA RIVER OREGON AND WASHINGTON JOHN DAY DAM JOHN DAY CONFIGURATION STUDY

SURFACE FLOW BYPASS AT THE SPILLWAY ALTERNATIVE 2

Drawing Number ALTERNATIVE 2

Sheet number: FIGURE 2

DRAWING PLOT SIZE: 11X17 DATE AND TIME PLOTTED: 5/22/2006 8:44:36 AM BY USERNAME: G2ECOFEB (FRANK BONNEAU) SHEET NAME: FIGURE-2

Alternative 3: Surface Flow at Skeleton Bays (SFSB)

Description

Surface collection success at other hydroelectric projects on the Columbia and Snake River systems generated interest in surface collection studies at Corps' projects. The Portland District evaluated surface collection for JDA and completed a Feature Design Memorandum (FDM No. 52) on a recommended alternative in 1998. The recommended alternative converts two skeleton bays on the north end of the powerhouse into six 21-foot-wide overflow spillway chutes. The crest elevation of the spillway is at elevation 242.5 MSL. The chutes discharge into the tailrace at different elevations to optimize tailrace conditions for dissolved gas. Overflow discharge from each chute is approximately 6,000 cfs for a total potential discharge of 36,000 cfs. The design of the system enables a much higher flow to dissolved gas ratio than the existing spillway bays. Additional spill capacity of approximately 36,000 cfs during the spring outmigration may enable project operations to stay within water quality parameters during a 10-year flood event. Preliminary general model investigations identified that in order to channel surface bypass flow downstream and avoid large tailwater eddies, a maximum spill level of about 40% is needed when total river discharge is 300,000 cfs. At 200,000 cfs, the maximum recommended spill level is about 28%. It is assumed that spill will occur 24 hours per day.

This alternative provides several biological benefits similar to Alternative 2. These benefits include shifting fish passage distribution from the powerhouse to the spillway to improve non-turbine passage and reducing forebay residence time by providing a normative passage route with a benign over flow type weir with no spillway regulation to provide an unobstructed surface passage route at the spillway. This alternative also would benefit the tailrace residence time in that it would be operated with additional spillway flow to provide good tailrace egress, as well as diminishing the dead area that currently exists downstream of the skeleton bays between the powerhouse and the spillway.

Status

The potential of converting one or two of the skeleton units at the JDA powerhouse into a surface bypass spillway (SBS) was investigated in FDM No. 52. After review of the FDM, the regional Systems Configuration Team recommended not to proceed with construction. Primary concerns were the costs associated with the SBS and uncertainty of the benefits. The Systems Configuration Team requested the Corps to evaluate testing the SBS concept at a spillbay and to evaluate a four-unit skeleton bay SBS.

Testing the concept of a SBS was attempted with the design of the removable spillway weir. Prior to modifying the JDA powerhouse and expending a large cost for that design, it was foreseen that the concept would have to be proven. This work was designed as DDR No. 53, John Day Lock and Dam, Removable Spillway Weir, but never implemented due to the unsure benefits.

Cost

The total cost for implementation of this alternative is estimated at $129.2 million (Table A-3). The O&M costs are estimated at $170,000 annually. Post-construction monitoring costs are estimated at $6 million.

Water Quality Impacts

The SFSB would be operated in a manner so as to not increase total dissolved gas (TDG) production from current levels. All impacts will be accounted for in the percent spill used.

Table A-3. Alternative 3 – SFSB Cost Estimate

Item	Unit Cost	Units	Total Costs
Design Development			
Design documentation/model testing			2,000,000
Biological testing to develop design			6,000,000
Construction			
FDM No. 52 construction costs			101,000,000
P&S, S&A, EDC costs (20% of construction costs)			20,200,000
Construction subtotal			121,200,000
Total Cost for Implementation			**129,200,000**
Annual O&M Costs	85,000	2	**170,000**
Post-construction Monitoring			**6,000,000**

Timing/Schedule

From the schedule produced in FDM No. 52, the implementation time from start of plans and specifications to a completed SFSB is 5 years (assuming a P&S start at the beginning of a calendar year). The duration of construction is approximately 3 years.

Biological Considerations

Similar to the previous alternative, providing surface flow through or over the powerhouse skeleton bays would likely result in an overall improvement to juvenile salmonids dam-passage survival by reducing forebay passage delays and turbine passage. Radio-telemetry and hydroacoustic studies at JDA have demonstrated that juvenile salmonids swim across the face of the powerhouse and spillway near the surface; thus, they may be available for surface collection. Based on an analysis in FDM No. 52, from 23% to 71% of the yearling outmigrants and from 23% to 74% of the subyearling outmigrants should utilize the proposed two-unit SFSB. It would also provide improved tailrace egress conditions by eliminating the stagnant-flow area downstream of the powerhouse.

Operational Constraints

The SFSB will be operated in a specific manner to optimize the passage of juveniles and to be under the limit of the TDG requirements. Also, specific tailrace operations will be required to optimize downstream flow and balance powerhouse, SFSB, and spillway flow.

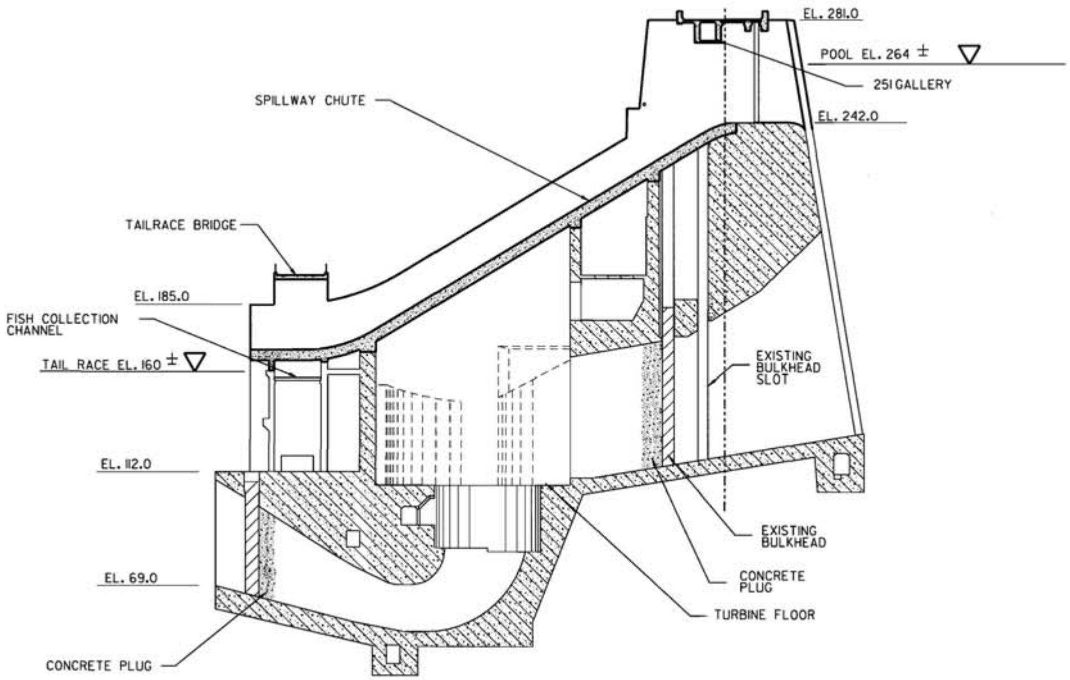
References

John Day Lock and Dam Surface Bypass Spillway, Feature Design Memorandum No. 52, September 1998.

John Day Lock and Dam Removable Spillway Weir, Detailed Design Report No. 53, October 2001.

US Army Corps of Engineers
Portland District

ALTERNATIVE NO. 3, SURFACE FLOW BYPASS AT THE SKELETON BAYS



SPILLWAY SECTION LOOKING NORTH

60' 0 60'

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
Portland, Oregon

COLUMBIA RIVER OREGON AND WASHINGTON
JOHN DAY DAM
JOHN DAY CONFIGURATION STUDY
SURFACE FLOW BYPASS AT THE SKELETON BAYS
ALTERNATIVE 3

Drawing Number: ALTERNATIVE 3

Sheet number: FIGURE 3

DRAWING PLOT SIZE: 11X17 DATE AND TIME PLOTTED: 5/22/2006 8:53:24 AM BY USERNAME: G2ECOFEB (FRANK BONNEAU) SHEET NAME: FIG3.DGN

Alternative 4: Powerhouse Hydrocombine

Description

A hydrocombine option was considered because it is similar to the "Wells intake" which was the initial impetus for the Surface Collection Program. The benefit of a hydrocombine is that the spillway bay is located over the powerhouse unit such that as flow moves toward the powerhouse, it would be drawn down into the intake. Generally, juvenile fish tend to move upward in the water column as the flow dives. A horizontal spillway ogee would be placed above the hydrocombine intake which would split the flow horizontally and provide an outlet for fish being drawn into the intake. This outlet would be open to the surface so it would intercept both diving juvenile fish and those seeking a surface outlet at the powerhouse. This alternative has the benefit that the powerhouse unit must be operating to draw the most fish to the unit. It is anticipated that the direct passage of surface water would provide greater juvenile attraction and higher survival by keeping juvenile fish from diving 40 feet to go under the tainter gate during downstream passage. This alternative has a benefit similar to the other spillway alternatives in that it is expected to reduce forebay residence time; with appropriate spillway flow, it also would reduce tailrace residence time.

A blank skeleton bay lends itself to an unrestricted design of the turbine. It is not unreasonable to expect that new turbines could be designed and operated with fish survival rates as high as or higher than 96%, the goal for juvenile fish survival at JDA. Also, if the high volume of flow currently discharged over the spillway could be passed through "high survival" turbines installed in the skeleton bays, then egress conditions would improve. Although this alternative currently does not have an acceptable cost-benefit ratio, it could become more attractive in the future as the demand for regional power increases.

Status

A hydrocombine was never designed for JDA; conceptually a skeleton bay unit could be reconstructed to be a hydrocombine.

Cost

The cost of a single unit hydrocombine has not been calculated but is estimated at $100 million per unit. The total cost for implementation of two hydrocombine units is estimated at $256 million (Table A-4). The O&M costs are estimated at $304,000 annually. Post-construction monitoring costs are estimated at $8 million.

Table A-4. Alternative 4 – Hydrocombine Cost Estimate

Item	Unit Cost	Units	Total Cost
Design Development			
Design documentation/model testing			8,000,000
Biological testing to develop design			12,000,000
Construction			
Hydrocombine unit	100,000,000	2	200,000,000
P&S, S&A, EDC costs (18% of construction costs)	18,000,000	2	36,000,000
Construction subtotal			236,000,000
Total Cost for Implementation			**256,000,000**
Annual O&M Costs	152,000	2	**304,000**
Post-construction Monitoring			**8,000,000**

Water Quality Impacts

Water quality impacts will need to be assessed with respect to surface bypass spill, powerhouse flow, and spillway flow. Water quality will be optimized.

Timing/Schedule

The estimated duration for design and construction of this alternative is 6.5 years.

Biological Considerations

The expected effects of a hydrocombine would be similar to that of a spillway.

Operational Constraints

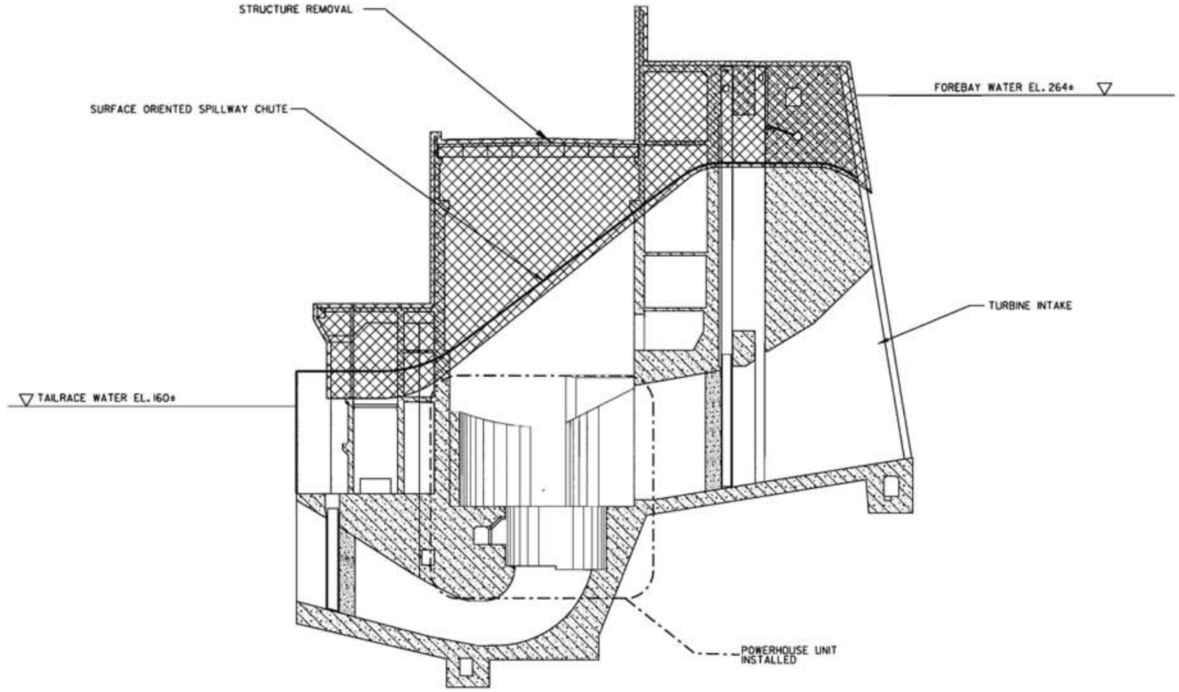
No specific operational constraints have been identified.

References

John Day Lock and Dam Removable Spillway Weir, Detailed Design Report No. 53, October 2001.

Lower Granite Lock and Dam Removable Spillway Weir, Design Report

ALTERNATIVE NO.4, HYDRO COMBINE



POWERHOUSE SECTION LOOKING NORTH

SCALE: 1" = 500'
500' 0 500'

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Portland District

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CORPS OF ENGINEERS
Portland, Oregon

COLUMBIA RIVER OREGON AND WASHINGTON
JOHN DAY DAM
JOHN DAY CONFIGURATION STUDY
HYDRO COMBINE ARRANGEMENT
ALTERNATIVE 4

Drawing Number
ALTERNATIVE 4
Sheet number:
FIGURE 4

DRAWING PLOT SIZE: 11X17 DATE AND TIME PLOTTED: 5/22/2006 9:00:29 AM BY USERNAME: D2ECOFEB (FRANK BONNEAU) SHEET NAME: FIGURE 4.DGN

Alternative 5: Behavioral Guidance System (BGS)

Description

For this alternative, a behavioral guidance system (BGS) would be placed in the forebay to maximize juvenile guidance to the spillway for the amount of spillway discharge. There are two primary objectives: (1) increase dam passage survival for juvenile salmonids, and (2) increase the cost-effectiveness of operating the spillway as a bypass system. Since most fish are in the top portion of the water column, current design concepts all revolve around a floating structure with a curtain hanging down into the water that alters the hydraulic characteristics and guides fish away from the powerhouse to the spillway. This alternative also has the potential to reduce forebay residence time and enhance FPE, as well as having the potential to reduce spillway flow (the alternative was evaluated in this study with the current spillway flow volumes).

Status

There is currently no design for this option. This alternative will need a feasibility study (including model studies), a detailed design report (DDR), and plans and specifications (P&S). The goal of the feasibility study is to investigate prototype and permanent options of how a BGS could be implemented at JDA. The DDR and P&S will follow the feasibility study if the system is found to be feasible and is a regional priority.

Cost

The BGS estimate for JDA is based on a preliminary estimate for at BGS at The Dalles (approximately $30 million). By comparing the different sites, anchorage considerations, depth of anchors, and length of the structure, the total cost for implementation of this alternative at JDA are estimated at $61.1 million (Table A-5). The O&M costs are estimated at $115,000 annually. Post-construction monitoring costs are estimated at $6 million.

Table A-5. Alternative 5 – BGS Cost Estimate

Item	Unit Cost	Units	Total Cost
Design Development			
Design documentation/model testing			2,000,000
Biological testing to develop design			6,000,000
Construction			
BGS (3,500 feet long)	45,000,000	1	45,000,000
P&S, S&A, EDC costs (18% of construction costs)	8,100,000	1	8,100,000
Construction subtotal			53,100,000
Total Cost for Implementation			**61,100,000**
Annual O&M Costs			**115,000**
Post-construction Monitoring			**6,000,000**

Water Quality Impacts

It is expected that minimal to no water quality impacts would occur with this alternative (all total dissolved gas impacts are accounted for in the spill operations).

Timing/Schedule

A detailed schedule of the BGS construction was developed to be similar to The Dalles BGS schedule. It is estimated that the after 2 years of design, the construction would take approximately 2 years. The feasibility and detailed design would include biological studies, hydraulic model studies, fishery agency coordination, exploration, and design work. The estimate includes completion of a DDR and P&S.

Biological Considerations

From a behavioral perspective, juvenile salmonids tend to follow flow during their downstream migration to the ocean. Given this behavioral tendency and because JDA is limited to the amount of water it can spill, most flow and therefore fish first approach the powerhouse. A BGS strategically placed in the forebay can guide fish from one area of the forebay to another giving them more opportunity to detect a safer route of passage. For example, the BGS designed for The Dalles Dam forebay was intended to guide fish away from the powerhouse toward the spillway. Essentially, a BGS in the JDA forebay can make spillway flow more efficient in passing juvenile salmonids at lower spill levels. Other benefits could include reducing forebay delay. The use of a BGS would be especially beneficial if it is determined that limiting spill is necessary to provide adequate tailrace egress.

Operational Constraints

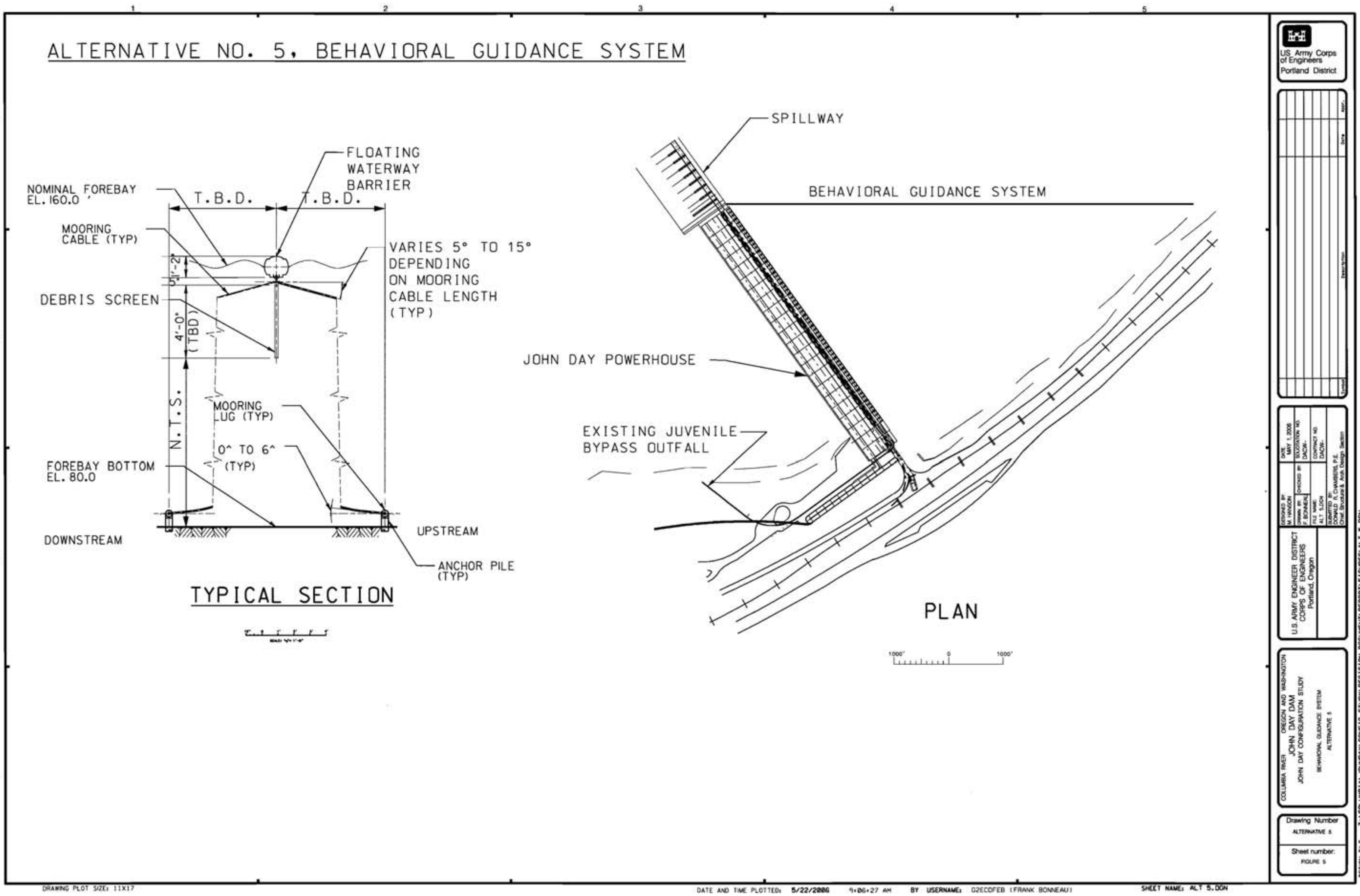
Special project operations are not planned for this alternative. The alternative will be evaluated for a full range of spill percentages.

References

Lower Granite Dam Behavioral Guidance Structure, Preliminary Design Report, March 1997.

Bonneville Dam Second Powerhouse, Physical Guidance Device Letter Report, August 1998.

The Dalles Juvenile Behavioral Guidance System Feasibility Report (under development).



ALTERNATIVE NO. 5, BEHAVIORAL GUIDANCE SYSTEM
NOMINAL FOREBAY EL. 160.0'
T.B.D.
T.B.D.
FLOATING WATERWAY BARRIER
MOORING CABLE (TYP)
VARIES 5° TO 15° DEPENDING ON MOORING CABLE LENGTH (TYP)
DEBRIS SCREEN
1'-2"
4'-0" (TBD)
N.T.S.
MOORING LUG (TYP)
0^ TO 6^ (TYP)
FOREBAY BOTTOM EL. 80.0
DOWNSTREAM
UPSTREAM
ANCHOR PILE (TYP)
TYPICAL SECTION
SPILLWAY
BEHAVIORAL GUIDANCE SYSTEM
JOHN DAY POWERHOUSE
EXISTING JUVENILE BYPASS OUTFALL
PLAN
1000'
0
1000'
US Army Corps of Engineers Portland District
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS Portland, Oregon
COLUMBIA RIVER OREGON AND WASHINGTON
JOHN DAY DAM
JOHN DAY CONFIGURATION STUDY
BEHAVIORAL GUIDANCE SYSTEM
ALTERNATIVE 5
Drawing Number ALTERNATIVE 5
Sheet number: FIGURE 5
DRAWING PLOT SIZE: 11X17
DATE AND TIME PLOTTED: 5/22/2006 9:06:27 AM BY USERNAME: G2ECDFEB (FRANK BONNEAU)
SHEET NAME: ALT 5.DGN

Alternative 6: Tailrace Improvements – Tailrace Spillwall

Description

To divide the flow in the stilling basin to a smaller area to control and to allow better guidance of outmigrants in the JDA tailrace, a spillwall could be constructed similar to the training wall constructed at The Dalles in 2004. Although it is not known where the location of a spillwall would be most effective, the wall would extend from approximately 2 feet above normal high tailwater to the stilling basin floor. The length of a wall from the vertical face of the existing spillway piers to the end sill would be approximately 232 feet. The thickness of the spillwall would be 12 feet to match the existing pier thickness. With normal tailwater elevation of approximately 160 MSL, the wall would be approximately 48 feet high (the stilling basin elevation is elevation 114 MSL with the end sill at elevation 127 MSL). Most importantly, the depth from normal tailwater (elevation 160 MSL) to the bottom of the stilling basin is 46 feet. The estimated volume of concrete for this type of wall would be about 5,000 cubic yards. Installation of this wall also would include the removal of one or two baffle blocks in the stilling basin and the use of high-capacity, post-tensioned anchors.

An advantage of a spillwall separating the powerhouse from the spillway is that it eliminates the entrainment of powerhouse flow into the stilling basin and prevents the circulation of flow below the powerhouse. This confines the spill flow as mentioned but also improves egress conditions for turbine and bypassed fish. In addition, it has the potential to reduce total dissolved gas (TDG) saturation by preventing entrained powerhouse flows from becoming saturated within the stilling basin. This alternative would greatly improve tailrace egress. The estimated total cost for design and construction of this alternative is approximately $17.8 million over a 3-year period.

Status

There are no designs currently available for use at JDA. This alternative is in the concept stage.

Cost

Costs for this alternative are based on actual construction costs for The Dalles spillwall, which was completed in 2004. The costs were increased to capture the increased width, height, and length of a spillwall at JDA. The total cost for implementation of this alternative is estimated at $20 million (Table A-6). The O&M costs are estimated at $16,500 annually. Post-construction monitoring costs are estimated at $6 million.

Table A-6. Alternative 6 – Tailrace Spillwall Cost Estimate

Item	Unit Cost	Units	Total Cost
Design Development			
Design documentation/model testing			2,000,000
Biological testing to develop design			6,000,000
Construction			
Spillwall	10,000,000	1	10,000,000
P&S, S&A, EDC costs (20% of construction costs)	2,000,000	1	2,000,000
Construction subtotal			12,000,000
Total Cost for Implementation			**20,000,000**
Annual O&M Costs			**16,500**
Post-construction Monitoring			**6,000,000**

Water Quality Impacts

It is expected that minimal to no water quality impacts would occur with this alternative (all TDG impacts are accounted for in the spill operations).

Timing/Schedule

An approximate schedule for construction of this alternative was taken from the time to construct The Dalles spillwall. Total implementation time is estimated at 4 years.

Biological Considerations

The primary objective of this alternative is to minimize or eliminate poor hydraulic conditions in the tailrace of JDA. Under the current project configuration hydraulic conditions have been identified as causing increased tailrace egress times and lower passage survival for fish passing through both turbines and the JBS. The primary benefits to implementation of a spill wall alone will be streamlined flow for fish passing through the spillway. Combined with other alternatives (e.g., surface flow at the spillway and a BGS), a spillwall may help increase dam-passage survival.

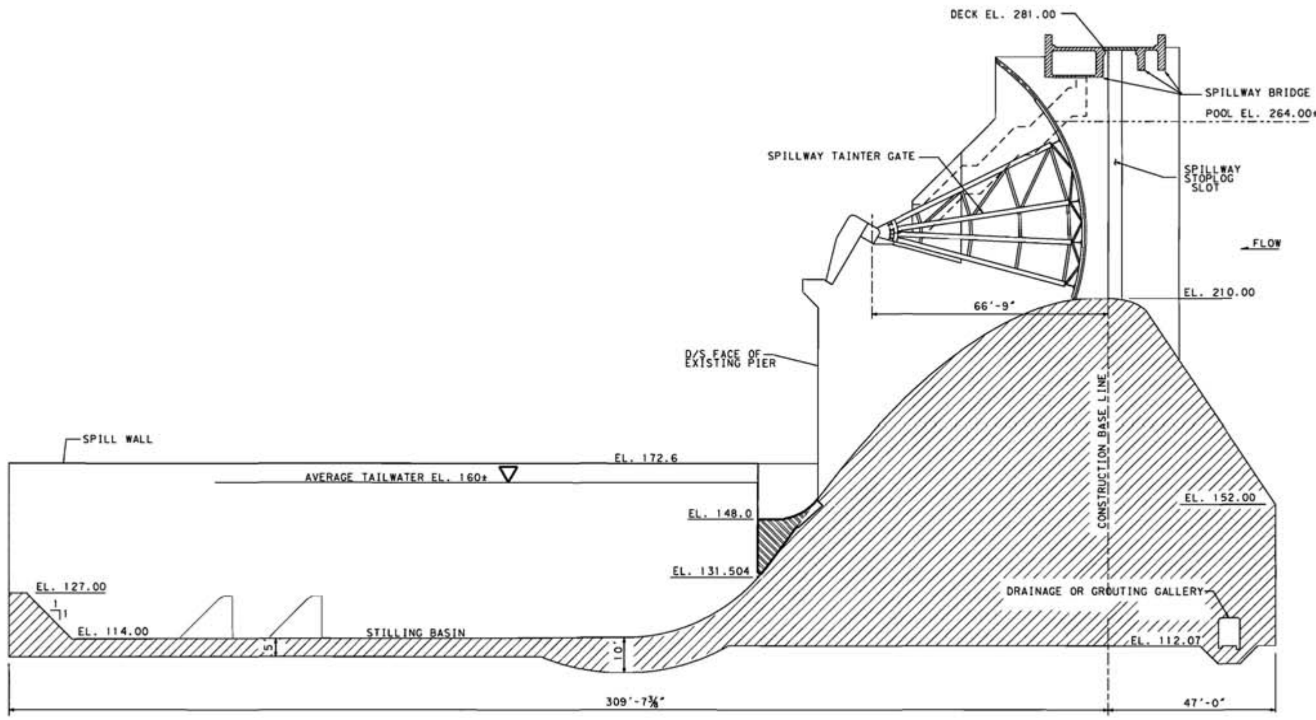
Operational Constraints

Any change of the stilling basin requires changing powerhouse and spillway operation. The alternative will be evaluated for a full range of spill percentage.

References

The Dalles Spillwall Letter Report, Plans and Specifications, and associated cost and coordination information.

ALTERNATIVE NO.6, TAILRACE IMPROVEMENTS-TAILRACE SPILLWALL



TYPICAL SPILLWAY CROSS SECTION WITH SPILLWALL

SCALE: 1"= 20'

US Army Corps of Engineers Portland District

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COLUMBIA RIVER OREGON AND WASHINGTON JOHN DAY DAM JOHN DAY CONFIGURATION STUDY

SPILLWALL ALTERNATIVE 6

Drawing Number ALTERNATIVE 6

Sheet number: FIGURE 6

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Alternative 7: JBS Outfall Relocation

Description

Improvements to the JBS outfall may produce additional juvenile fish survival benefits. This alternative would optimize the location of the outfall further downstream and further out in the river. The current JBS outfall could be located in an area such that river velocities and flow conditions at the outfall minimize predation and maximize downstream fish movement.

Status

This alternative is currently in the concept stage.

Cost

The estimated costs for this alternative are based on similar construction activities at other projects. The total cost for implementation is estimated at $16.8 million (Table A-7). The O&M costs are estimated at $16,500 annually. Post-construction monitoring is estimated at $4 million.

Table A-7. Alternative 7 – Tailrace JBS Outfall Relocation Cost Estimate

Item	Unit Cost	Units	Total Cost
Design Development			
Design documentation/model testing			1,000,000
Biological testing to develop design			4,000,000
Construction			
JBS outfall relocation	10,000,000	1	10,000,000
P&S, S&A, EDC costs (18% of construction costs)	1,800,000	1	1,800,000
Total Cost for Implementation			**16,800,000**
Annual O&M Costs			**16,500**
Post-construction Monitoring			**4,000,000**

Water Quality Impacts

It is expected that minimal to no water quality impacts would occur with this alternative (all total dissolved gas impacts are accounted for in the spill operations).

Timing/Schedule

Total implementation time is estimated at 3 years.

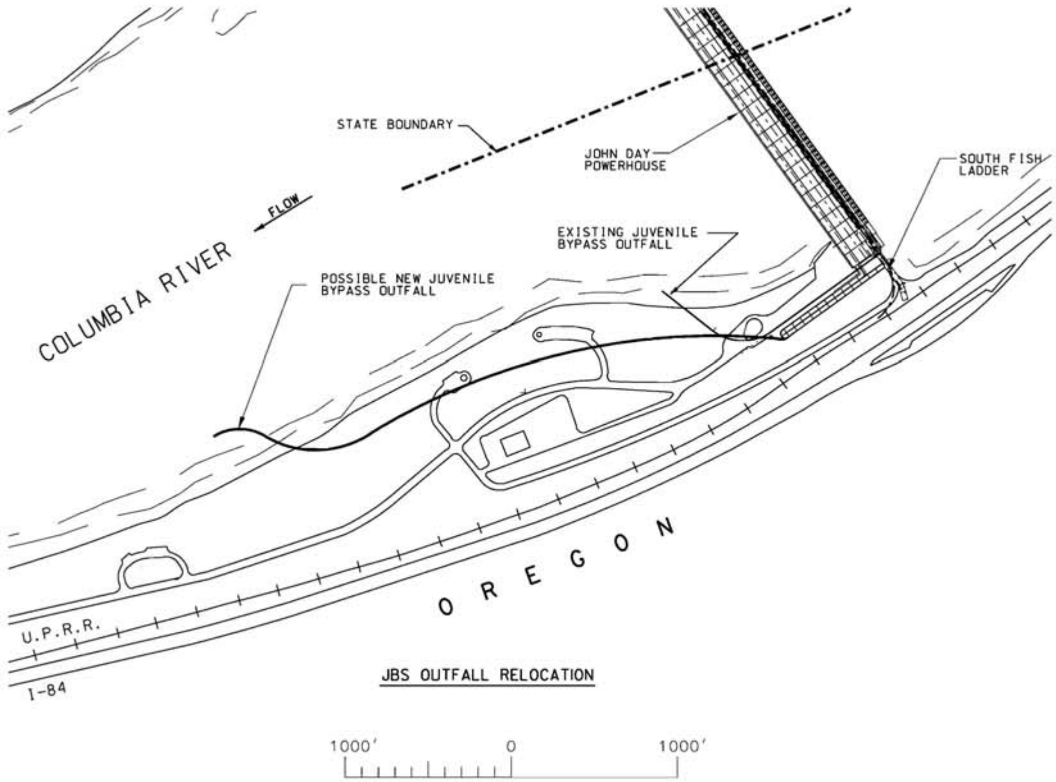
Biological Considerations

During periods of high spill, fish that exit the current JBS outfall follow the flow upstream toward the powerhouse. Relocation of the JBS outfall would provide an overall improvement to passage survival through that route, especially during high spill.

Operational Constraints

Relocating the JBS outfall may require powerhouse or spillway operational changes that require flow out of particular bays to achieve optimum conditions near the outfall. This tailrace operation cannot be determined at this time, but is not expected to change any input criteria with respect to the configuration analysis. The alternative will be evaluated for a full range of spill percentage.

ALTERNATIVE NO. 7, TAILRACE IMPROVEMENTS-JBS OUTFALL RELOCATION



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COLUMBIA RIVER OREGON AND WASHINGTON
JOHN DAY DAM
JOHN DAY CONFIGURATION STUDY
JBS OUTFALL RELOCATION
ALTERNATIVE 7

Drawing Number
ALT 7.DGN

Sheet number:
FIGURE 7

DRAWING PLOT SIZE: 11X17

DATE AND TIME PLOTTED: 5/22/2006 9:17:23 AM BY USERNAME: G2ECOFEB (FRANK BONNEAU)

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Alternative 8: Turbine Improvements

Description

The purpose of this alternative is to determine and upgrade the generating units at JDA to increase juvenile fish survival and decrease mortality in powerhouse flow. The features that most likely would be made for improving fish passage include new runners, modified stay-vane and wicket gates, and draft-tube modifications. Costs associated with other improvements, such as new windings, were not included in the analysis of this alternative. No specific improvements have yet been identified, but the modifications are expected to increase survival and efficiency over the existing powerhouse units. Previous model investigations of stay-vane, wicket gate, and draft-tube modifications have shown a 1% to 2% increase in turbine efficiency.

Status

Turbine improvements have not been quantified for JDA. It is expected that it will take approximately 4 years to start the unit modification process and progress at a rate of one unit every 6 months. If two units can be taken out of service at one time, it may only take 4 years to complete the process.

Cost

Design development costs were increased for this alternative since it is likely that a turbine model will have to be constructed to model different configurations. The cost estimate is based on work at Bonneville where minimum gap runners are being installed during the Bonneville rehabilitation program. The total cost for implementation is estimated at $203.6 million (Table A-8). The O&M costs for this alternative would be no different than for the existing units because the same number of units would be operating. Post-construction monitoring costs are estimated at $8 million.

Table A-8. Alternative 8 – Turbine Improvements Cost Estimate

Item	Unit Cost	Units	Total Cost
Design Development			
Design documentation/model testing			6,000,000
Biological testing to develop design			4,000,000
Construction			
New runner and other efficiency measures	11,000,000	16	176,000,000
P&S, S&A, EDC costs (10% of construction costs)	17,600,000	1	17,600,000
Construction subtotal			193,600,000
Total Cost for Implementation			**203,600,000**
Annual O&M Costs			**0**
Post-construction Monitoring			**8,000,000**

Water Quality Impacts

It is expected that minimal to no water quality impacts would occur with this alternative (all total dissolved gas impacts are accounted for in the spill operations).

Timing/Schedule

The schedule for this type of work would likely be 4 years to start on implementation of the first unit. The unit modification will take approximately 6 months per unit. For this estimate it is assumed that all units will be installed 9 years after the start of design. Efficiencies are assumed so that the project could be completed sooner than the sequential time of 6 months per unit. Full benefits of this option would likely not be realized for 9 to 12 years.

Biological Considerations

Research is indicating that changing current turbine geometry and operation could reduce direct fish mortality that is caused by turbulence, strike, and pinching-related injuries occurring within turbine units. Turbine operational improvements (i.e., unit priorities and operating points) could also reduce indirect effects such as susceptibility to predators following turbine passage.

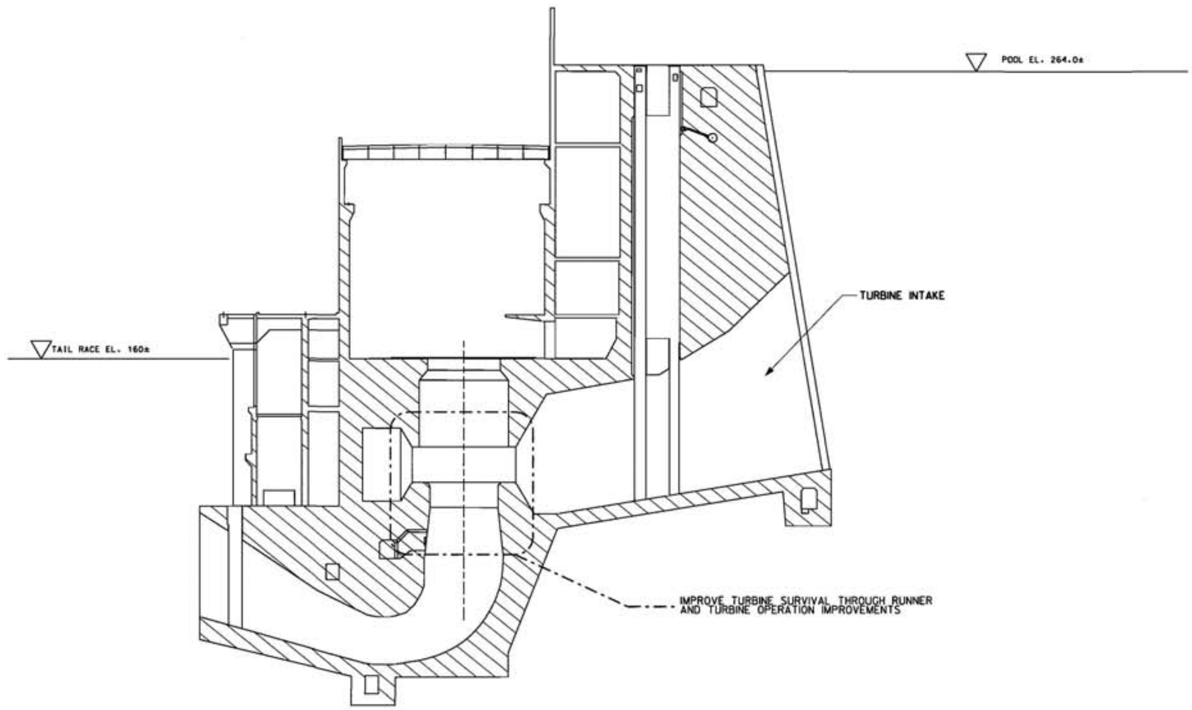
Operational Constraints

No specific operational constraints have been identified.

References

Bonneville First Powerhouse Major Rehabilitation and minimum gap runner installation.

ALTERNATIVE NO.8 TURBINE IMPROVEMENTS



JOHN DAY POWERHOUSE SECTION

SCALE: 1" = 20'
20' 0 20'

US Army Corps of Engineers
Portland District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
Portland, Oregon

COLUMBIA RIVER OREGON AND WASHINGTON
JOHN DAY DAM
JOHN DAY CONFIGURATION STUDY
TURBINE IMPROVEMENTS
ALTERNATIVE 8

Drawing Number
ALTERNATIVE 8

Sheet number:
FIGURE 8

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Alternative 9: Powerhouse Surface Collection

Description

Powerhouse surface collection alternatives were investigated by Harza Engineering (1994). The final selected alternative was a steel structure attached to the face of the powerhouse with an open channel, flow outlet channel that crossed the face of powerhouse units 1-16 and was extended to the tailrace. This alternative has the benefit of only spilling water in excess of powerhouse capacity or in excess of powerhouse demand. The premise of this alternative would be that fish would be attracted to the powerhouse with flow to the turbines. Surface outlets would be provided above each generating unit to allow fish to pass downstream through an open channel. Benefits from this alternative include reduced forebay residence time and reduced spillway flow.

Status

The design is at the feasibility stage at this time.

Cost

The cost estimate is taken from the Harza Engineering (1994) report for the Venturi powerhouse surface collector alternative. The total cost for implementation is estimated at $288.2 million (Table A-9). The O&M costs are estimated at $2.1 million annually. Post-construction monitoring costs are estimated at $12 million.

Table A-9. Alternative 9 – Powerhouse Surface Collection

Item	Unit Cost	Units	Total Costs
Design Development			
Design documentation/model testing			5,000,000
Biological testing of options			12,000,000
Construction			
Full powerhouse surface collection	226,000,000	1	226,000,000
P&S, S&A, EDC costs (20% of construction costs)	45,200,000	1	45,200,000
Construction subtotal			271,200,000
Total Cost for Implementation			**288,200,000**
Annual O&M Costs			**2,100,000**
Post-construction Monitoring			**12,000,000**

Water Quality Impacts

The primary benefit of this alternative is to decrease spill to involuntary only and operate the powerhouse and surface collector as necessary to obtain maximum benefit. The alternative that Harza evaluated resulted in the use of approximately 24,000 cfs, dewatered it to 1,600 cfs, and discharged it downstream near the existing JBS outfall. Therefore, replacing all voluntary spill would require 24,000 surface bypass flow.

Timing/Schedule

Powerhouse surface collection would likely be similar to the ESBS schedule with 2-3 years of work prior to the first year of construction, and 3 years of construction would likely be needed.

Biological Considerations

This alternative would provide similar benefits to migrant juvenile salmonids as the other surface flow routes discussed previously. The magnitude of the benefit would be dependent on several factors including the amount of attraction and entrainment flow, the ability of the structure to guide fish away from turbines, and the location of the outfall (JBS or spillway).

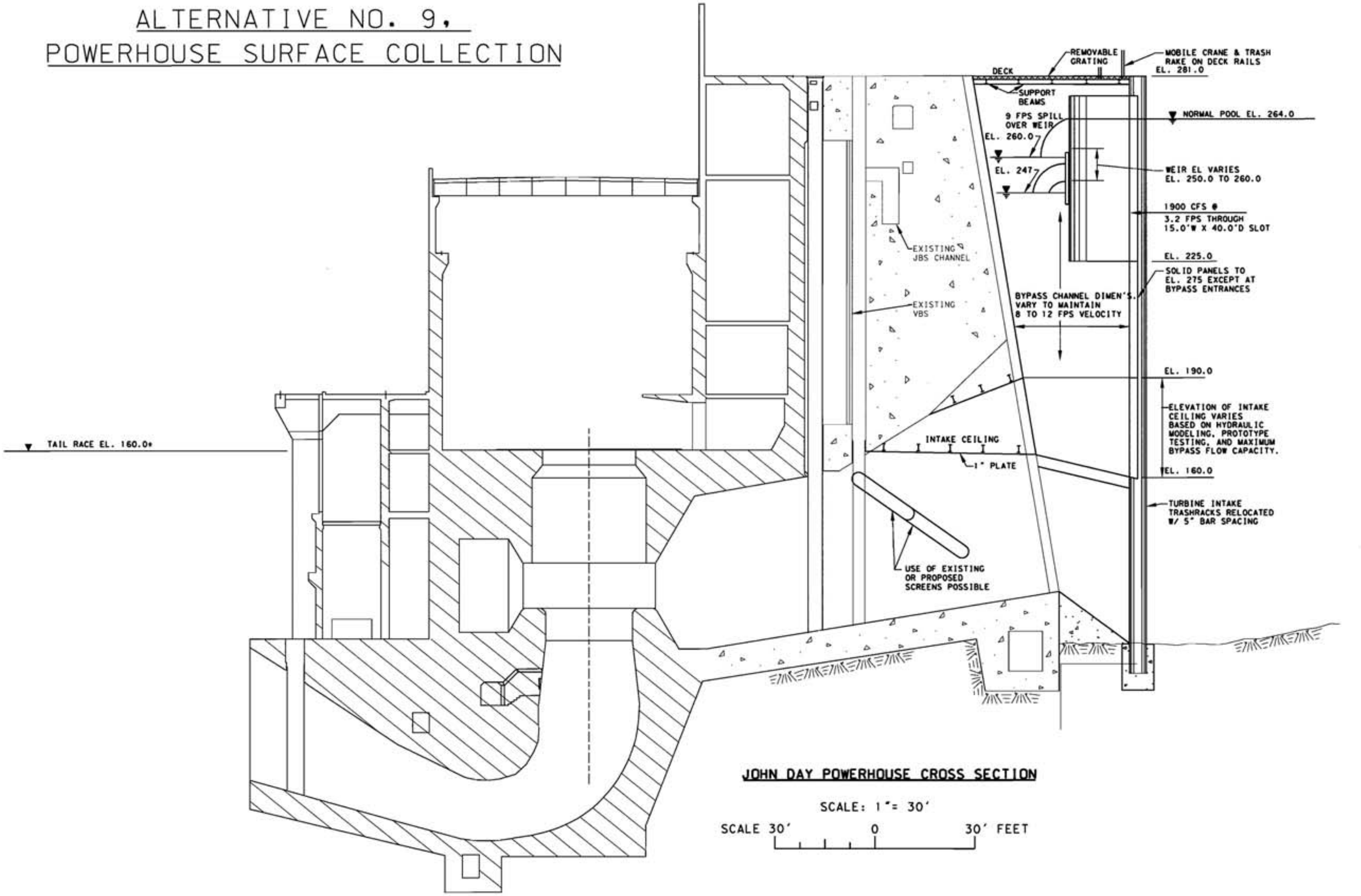
Operational Constraints

An operational constraint would likely be to operate the powerhouse units such that flow into the surface collectors is optimized. This operation would be determined through testing and study. Unit limitation was not considered as a factor in this alternative because it is assumed that the surface collector structure would operate under current powerhouse guidelines and requirements.

References

Harza Engineering. Surface Bypass Alternative Study at John ay Powerhouse – Final Report, December 1994.

ALTERNATIVE NO. 9,
POWERHOUSE SURFACE COLLECTION



US Army Corps of Engineers
Portland District

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CORPS OF ENGINEERS
Portland, Oregon

COLUMBIA RIVER OREGON AND WASHINGTON
JOHN DAY DAM
JOHN DAY CONFIGURATION STUDY
POWER HOUSE SURFACE COLLECTION
ALTERNATIVE 9

Drawing Number: ALTERNATIVE 9
Sheet number: FIGURE 9

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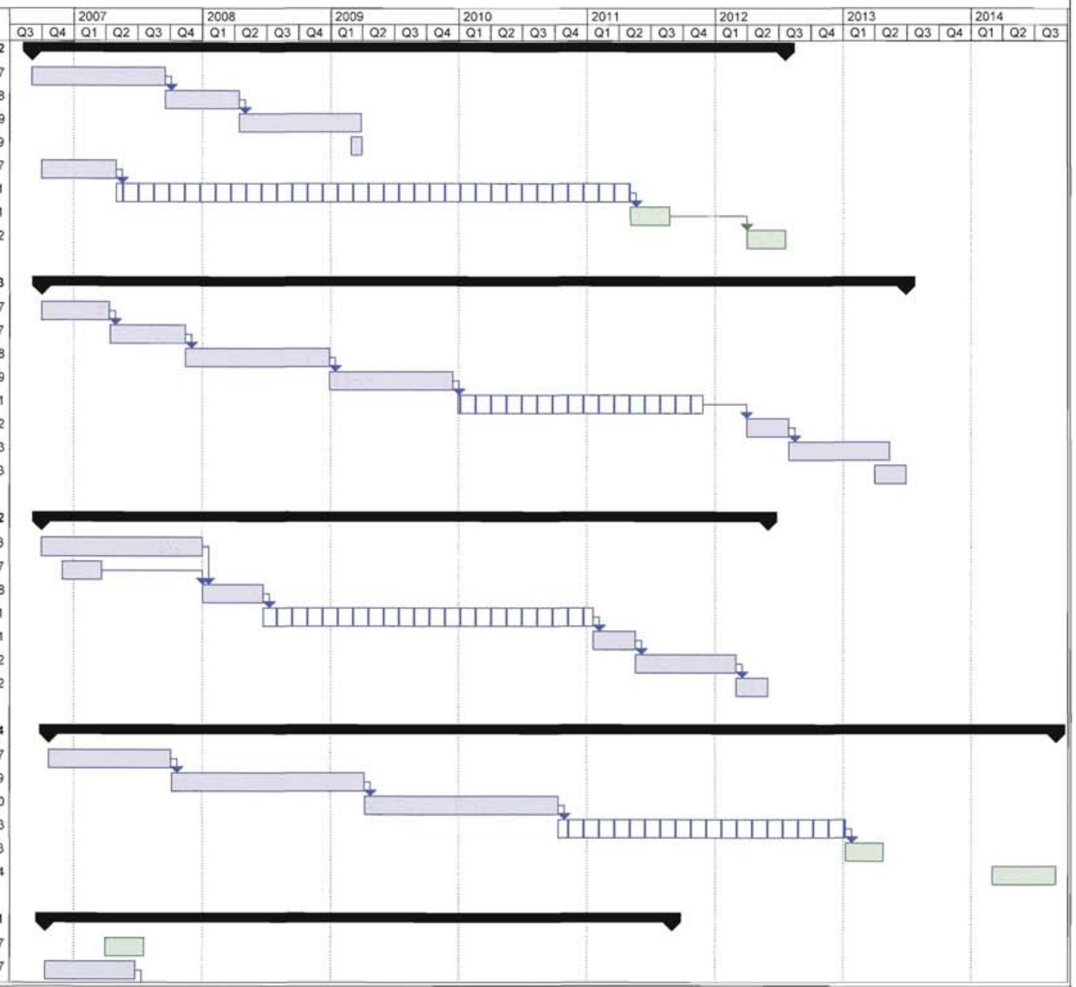
John Day Configuration Study - Alternative Construction Schedules

ID	Task Name	Start	Finish
1	**Alt 1 ESBS Implementation**	**Tue 9/5/06**	**Fri 7/20/12**
2	Trash and Debris Concerns DDR	Tue 9/5/06	Tue 9/18/07
3	Plans & Specifications	Wed 9/19/07	Tue 4/15/08
4	Trash and Debris Measures Construction	Wed 4/16/08	Mon 3/30/09
5	Debris Measures Construction Complete	Mon 3/2/09	Wed 4/1/09
6	ESBSand VBS P&S	Tue 10/3/06	Thu 5/3/07
7	ESBS Construction	Fri 5/4/07	Wed 5/4/11
8	1st Year Biological Testing	Thu 5/5/11	Wed 8/24/11
9	2nd Year Biological Testing	Mon 4/2/12	Fri 7/20/12
10			
11	**Alt 2 Surface Flow Bypass at the Spillway**	**Tue 10/3/06**	**Fri 6/28/13**
12	Feasibility Report	Tue 10/3/06	Fri 4/13/07
13	DDR	Mon 4/16/07	Wed 11/14/07
14	Plans and Specifications	Thu 11/15/07	Mon 12/29/08
15	Bid and Award Process	Tue 12/30/08	Thu 12/17/09
16	Construction	Fri 1/1/10	Mon 11/28/11
17	First Year Bio Testing	Mon 4/2/12	Mon 7/30/12
18	Follow on Improvements	Tue 7/31/12	Mon 5/13/13
19	Second Year Bio Testing	Mon 4/1/13	Fri 6/28/13
20			
21	**Alt 3 Surface Flow Bypass at Skeleton Bays**	**Tue 10/3/06**	**Thu 5/31/12**
22	Plans and Specifications	Tue 10/3/06	Wed 1/2/08
23	Baseline Biological Testing 1st Year	Fri 12/1/06	Thu 3/22/07
24	Bid and Award Process	Thu 1/3/08	Mon 6/23/08
25	Construction	Tue 6/24/08	Wed 1/19/11
26	First Year Bio Testing	Thu 1/20/11	Thu 5/19/11
27	Follow on Improvements	Fri 5/20/11	Thu 3/1/12
28	Second Year Bio Testing	Fri 3/2/12	Thu 5/31/12
29			
30	**Alt 4 Hydrocombine in PH Units**	**Mon 10/23/06**	**Fri 8/29/14**
31	Feasibility Report	Mon 10/23/06	Fri 10/5/07
32	DDR	Mon 10/8/07	Wed 4/8/09
33	Plans & Specifications	Thu 4/9/09	Mon 10/11/10
34	Prototype Construction	Tue 10/12/10	Mon 1/7/13
35	Prototype Evaluation	Tue 1/8/13	Wed 4/24/13
36	2nd Year Prototype/1st Year Post Construction Evaluation	Mon 3/3/14	Fri 8/29/14
37			
38	**Alt 5 Behavioral Guidance System**	**Thu 10/12/06**	**Wed 8/31/11**
39	Baseline Biological Behavior Testing	Mon 4/2/07	Fri 7/20/07
40	Feasibility Report	Thu 10/12/06	Mon 6/25/07

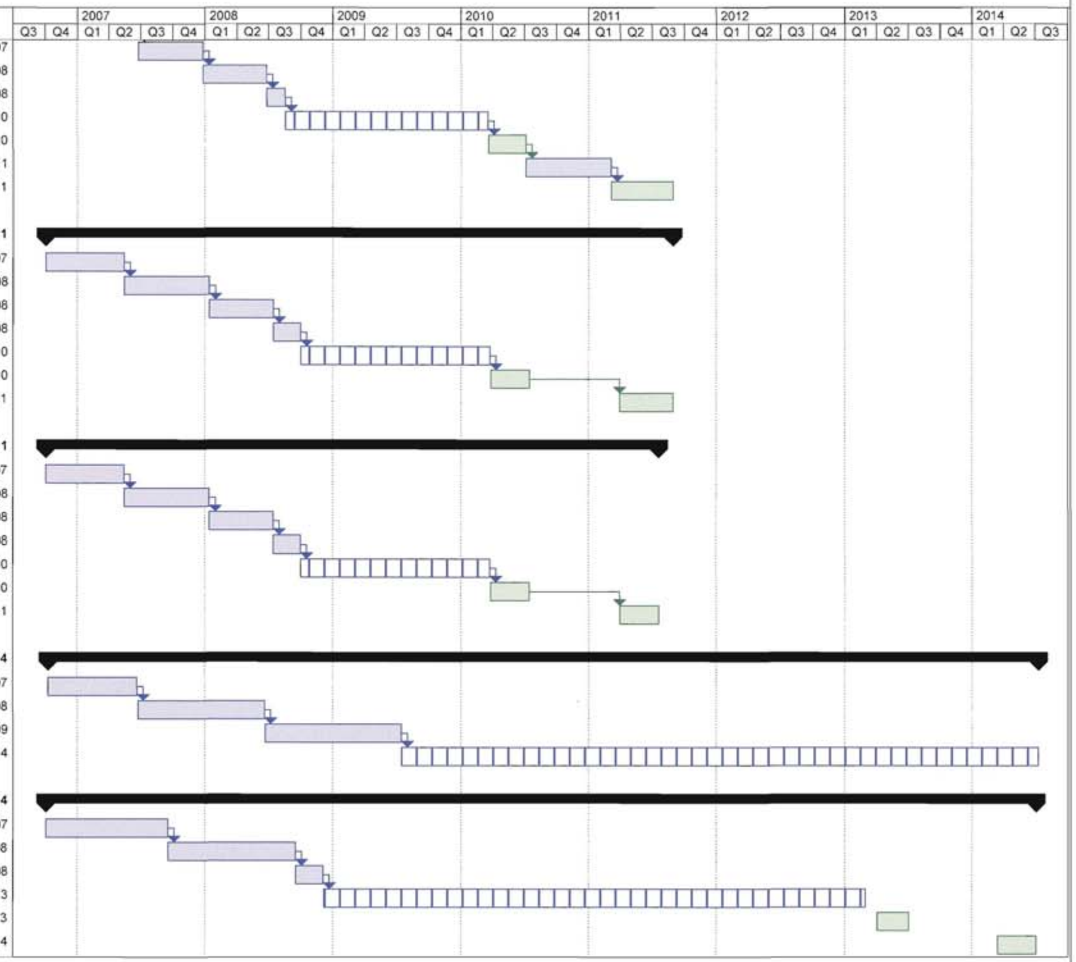


Project: Summary Schedule 06
Date: Thu 5/18/06

Legend: Task; Split; Progress; Milestone; Summary; Rolled Up Task; Rolled Up Split; Rolled Up Milestone; Rolled Up Progress; External Tasks; Project Summary; External Milestone; Deadline

John Day Configuration Study - Alternative Construction Schedules

ID	Task Name	Start	Finish
41	DDR	Tue 6/26/07	Thu 12/27/07
42	Plans & Specifications	Fri 12/28/07	Thu 6/26/08
43	Bid and Award Process	Fri 6/27/08	Mon 8/18/08
44	Prototype Construction	Tue 8/19/08	Fri 3/19/10
45	Prototype Evaluation	Mon 3/22/10	Tue 7/6/10
46	Engineer Follow-on Improvements (Small Contract)	Wed 7/7/10	Mon 3/7/11
47	2nd Year Prototype/1st Year Post Construction Evaluation	Tue 3/8/11	Wed 8/31/11
48			
49	**Alt 6 Tailrace Improvements - Spillwall**	**Thu 10/5/06**	**Wed 8/31/11**
50	Feasibility Report	Thu 10/5/06	Wed 5/16/07
51	DDR	Thu 5/17/07	Mon 1/14/08
52	Plans & Specifications	Tue 1/15/08	Tue 7/15/08
53	Bid and Award Process	Wed 7/16/08	Thu 10/2/08
54	Prototype Construction	Fri 10/3/08	Fri 3/26/10
55	1st Year Biological Testing	Mon 3/29/10	Fri 7/16/10
56	2nd Year Biological Testing	Fri 4/1/11	Wed 8/31/11
57			
58	**Alt 7 Tailrace Improvements - JBS Outfall**	**Thu 10/5/06**	**Thu 7/21/11**
59	Feasibility Report	Thu 10/5/06	Wed 5/16/07
60	DDR	Thu 5/17/07	Mon 1/14/08
61	Plans & Specifications	Tue 1/15/08	Tue 7/15/08
62	Bid and Award Process	Wed 7/16/08	Thu 10/2/08
63	Prototype Construction	Fri 10/3/08	Fri 3/26/10
64	1st Year Biological Testing	Mon 3/29/10	Fri 7/16/10
65	2nd Year Biological Testing	Fri 4/1/11	Thu 7/21/11
66			
67	**Alt 8 Turbine Improvements**	**Thu 10/12/06**	**Fri 7/11/14**
68	Feasibility Report	Thu 10/12/06	Fri 6/22/07
69	DDR	Mon 6/25/07	Fri 6/20/08
70	Plans & Specifications	Mon 6/23/08	Thu 7/16/09
71	Prototype Construction	Fri 7/17/09	Fri 7/11/14
72			
73	**Alt 9 Powerhouse Surface Collection**	**Thu 10/5/06**	**Fri 7/4/14**
74	Design DDR/Testing	Thu 10/5/06	Tue 9/18/07
75	Plans & Specifications	Wed 9/19/07	Wed 9/17/08
76	Bid and Award Process	Thu 9/18/08	Fri 12/5/08
77	Construction	Mon 12/8/08	Fri 3/1/13
78	1st Year Biological Testing	Thu 4/4/13	Wed 7/3/13
79	2nd Year Biological Testing	Mon 3/17/14	Fri 7/4/14



Project: Summary Schedule 06
Date: Thu 5/18/06

Task		Milestone		Rolled Up Split		External Tasks		Deadline	
Split		Summary		Rolled Up Milestone		Project Summary			
Progress		Rolled Up Task		Rolled Up Progress		External Milestone			

APPENDIX B

ECONOMIC INFORMATION

Hydropower and Economic Impacts Analysis for John Day Configuration Study

February 2006

Prepared by

U.S. Army Corps of Engineers
Northwestern Division
Columbia Basin
P.O. Box 2870
Portland, Oregon 97208-2870

Table of Contents

List of Tables

Introduction

This hydropower study has been prepared by the Corps of Engineers, Northwestern Division, Columbia Basin Water Management Division (NWD), Power Branch for input to the John Day Configuration Study under preparation by the Corps of Engineers, Portland District. The John Day Configuration Study is in response to the National Oceanic and Atmospheric Administration (NOAA) Fisheries 2000 BiOp (BiOp) to study alternatives for enhancement of endangered fish. The study is programmed under the Columbia River Fish Mitigation Program. This hydropower study includes the hydroregulation of projects in the Columbia River coordinated hydropower system that consists of federal, private, and public utility projects in the Columbia and Snake River Basins.

Purpose and Scope

The purpose of this study is to assess the monthly hydropower impacts to the Columbia River coordinated hydropower system due to various spill and turbine efficiency scenarios at the John Day Project. The monthly hydropower impact data will be provided to the NWD's Hydropower Analysis Center to determine the economic impacts. The results of these studies will be used to determine the sensitivity of the various scenarios and to aid the Portland District in determining the future direction of the fish program at the John Day Project.

General Hydroregulation Assumptions

The Pacific Northwest reservoir system was modeled using the Corps' HYSSR model. HYSSR is a FORTRAN model with a monthly time step. There are 14 periods, one period for each month except April and August, which are split in half months (AP1 and APR are the first and second halves of April, and AG1, and AUG are the first and second halves of August). Model runs cover a 60-year period from August 1928 through July 1989. All scenarios are "continuous" type studies with reservoirs starting full on July 31st 1928, except for Libby, Grand Coulee, Hungry Horse, and Dworshak, which start at their draft limits for McNary fish flow objectives. The model is run assuming perfect foresight of natural streamflows.

For projects other than John Day, scenarios were modeled using project operational data as submitted by their project owners in accordance with the Pacific Northwest Coordination Agreement (PNCA) for the 2003-04 operating year. The PNCA is an agreement between hydropower project owners with projects on the Columbia River and its tributaries, to plan, coordinate, and operate their systems to optimize power production while meeting other non-power uses, such as flood control, navigation, and operations for fish.

Description of Scenarios

Forty-four scenarios for John Day were developed and are listed in Table 1. Spring and summer spill percentages for fish for each scenario are provided. The percent values are the percent of regulated flow through John Day that is voluntarily spilled for fish. Scenarios 11 through 14 include 20,000 cfs fish spill flow in addition to the spill that is given in percent of the regulated flow. The additional 20,000 cfs may be spilled through a removable spillway weir, skeleton bay surface bypass, or a hydrocombine. Descriptions of the scenarios are provided in Sections 2.1 through 2.4.

Table 1. List of Scenarios

Scenario	Spring Spill		Summer Spill		Additional Spill (cfs)
	Daytime %	Nighttime %	Daytime %	Night %	
Base Case	0	60	30	30	
1	0	0	0	0	
2	0	5	5	5	
3	0	10	10	10	
4	0	20	10	15	
5	0	25	15	25	
6	0	35	15	30	
7	0	40	20	40	
8	0	50	30	45	
9	0	60	35	55	
10	0	0	0	0	20,000
11	10	10	10	10	20,000
12	20	20	20	20	20,000
13	30	30	30	30	20,000
14	40	40	40	40	20,000
15	Same as Base Case but with 5% decrease in JDA turbine efficiency				
16	Same as Scenario 1 but with 5% decrease in JDA turbine efficiency				
17	Same as Scenario 2 but with 5% decrease in JDA turbine efficiency				
18	Same as Scenario 3 but with 5% decrease in JDA turbine efficiency				
19	Same as Scenario 4 but with 5% decrease in JDA turbine efficiency				
20	Same as Scenario 5 but with 5% decrease in JDA turbine efficiency				
21	Same as Scenario 6 but with 5% decrease in JDA turbine efficiency				
22	Same as Scenario 7 but with 5% decrease in JDA turbine efficiency				
23	Same as Scenario 8 but with 5% decrease in JDA turbine efficiency				
24	Same as Scenario 9 but with 5% decrease in JDA turbine efficiency				
25	Same as Scenario 10 but with 5% decrease in JDA turbine efficiency				
26	Same as Scenario 11 but with 5% decrease in JDA turbine efficiency				
27	Same as Scenario 12 but with 5% decrease in JDA turbine efficiency				
28	Same as Scenario 13 but with 5% decrease in JDA turbine efficiency				
29	Same as Scenario 14 but with 5% decrease in JDA turbine efficiency				
30	Same as Base Case but with 2% increase in JDA turbine efficiency				
31	Same as Scenario 1 but with 2% increase in JDA turbine efficiency				
32	Same as Scenario 2 but with 2% increase in JDA turbine efficiency				
33	Same as Scenario 3 but with 2% increase in JDA turbine efficiency				
34	Same as Scenario 4 but with 2% increase in JDA turbine efficiency				
35	Same as Scenario 5 but with 2% increase in JDA turbine efficiency				
36	Same as Scenario 6 but with 2% increase in JDA turbine efficiency				
37	Same as Scenario 7 but with 2% increase in JDA turbine efficiency				
38	Same as Scenario 8 but with 2% increase in JDA turbine efficiency				
39	Same as Scenario 9 but with 2% increase in JDA turbine efficiency				
40	Same as Scenario 10 but with 2% increase in JDA turbine efficiency				
41	Same as Scenario 11 but with 2% increase in JDA turbine efficiency				
42	Same as Scenario 12 but with 2% increase in JDA turbine efficiency				
43	Same as Scenario 13 but with 2% increase in JDA turbine efficiency				
44	Same as Scenario 14 but with 2% increase in JDA turbine efficiency				

Base Case Scenario

John Day. The project is modeled as a run of river project with forebay elevations of El. 262.5 April 16th through September 30th and El. 265.0 ft October 1st through April 15th. The flow loss through the project is 1,280 cfs year around. The flow loss is associated with fish ladders, leakage, and miscellaneous flows. The Base Case includes 60% spill at night during the spring spill season and 30% spill 24-hours per day during the summer spill season, which is the currently planned operation. The percent spill is the percent of regulated flow through the project that is spilled to assist juvenile fish in passing through the project. For this study, the spring spill season for fish occurs from April 10th through June 20th, and the summer spill season is June 21st through August 31st. The spill flow rate is limited by the gas cap. The gas cap is the maximum spill that does not create more than the 120% total dissolved gas (TDG) saturation temporary limit. This TDG limit is as recommended in the BiOp.

Operating Rule Curves. Projects in the system first draft to their operating rule curves. Operating rule curves are made up of a combination of critical rule curves, refill curves, and flood control curves. If the system does not meet the load by operating to the operating rule curves, then projects proportionally draft from their operating rule curves toward empty until the load is met.

Critical Rule Curves. Critical Rule Curves are the projects' ending elevations from the PNCA 2003-2004 critical period Final Regulation. The Final Regulation models the Columbia River hydropower system using operating criteria defined by project owners on the Columbia River and a critical low water year to determine the amount of energy the system should be able to produce in any given year. This amount of energy is called the Firm Energy Load Carrying Capability (FELCC). The project's monthly ending elevations that produce the FELCC are the critical rule curves. The critical rule curves are based on the August 1936 through July 1937 historical streamflows adjusted for the 1990 level irrigation depletions.

Loads. PNCA coordinated system loads were computed for each year of the 60-year model run (July 1928 and July 1989). The loads were based on the FELCC from the PNCA 2003-2004 operating year. The FELCC was adjusted for each year due to the generation capability of the hydro-independent projects, which are projects that serve load in the northwest, but are not in the PNCA coordinated system.

Refill Curves. Variable Refill Curves and Assured Refill Curves are as developed for the PNCA Refill study for 2003-04. The purpose of the refill curves are to help ensure the system is as full as possible so that the maximum amount of water is available for generation in the following year, but still meets the current year's loads.

Flood Control Curves. Flood control curves include VARQ flood control at Libby and Hungry Horse, and 3.6/4.08 Million Acre-ft (Maf), Arrow/Mica flood control split. Flood control curves are maximum elevations that each storage reservoir may operate to. Flood control curves ensure that space is available such that reservoirs may capture runoff and the system can regulate the flow to prevent flooding downstream of The Dalles Dam.

Fish Spill. Fish spill criteria for projects are as shown in Table 1 and are based on 2003-04 spill criteria, except for John Day's, which were updated for this study. Some projects spill a percent of regulated flow without a spill cap, spill a fixed flow amount, or spill a percent of regulated flow up to a cap. The spill caps for Corps projects were determined based on meeting total dissolved gas standards while trying to meet fish passage criteria. To develop spill caps and percentages when a project spills differently at night-time hours vs. daytime hours, monthly spill caps and percentages were computed for use in HYSSR. For example, the spill at John Day is represented as approximately 30% daily/monthly spill when the prescribed spill is 0% during the day and 60% during the night. The spill percentages have also been prorated for the number of night-time vs. daytime hours based on the Corps of Engineers Fish Passage Plan.

Table 2. Project Period Average Spill Cap (cfs) and Percent Spill

Project	Apr 1-15	Apr 15-30	May	June	July	Aug 1-15	Aug 16-31
Wells	0%	6.5%	6.5%	0%	6.5%	2.5%	0%
Rocky Reach	0%	15%	21.8%	15%	15%	15%	0%
Rock Island	0%	20%	20%	20%	20%	20%	0%
Wanapum	0%	43%	43%	46%	49%	49%	49%
Priest Rapids	0%	61%	61%	50%	39%	39%	39%
L. Granite	16,467	19,000	19,000	12,667	*	*	*
Little Goose	13,000 cfs	15,000 cfs	15,000 cfs	10,000 cfs	*	*	*
L. Monumental	34,667 cfs	40,000 cfs	40,000 cfs	26,667 cfs	*	*	*
Ice Harbor	62,833 cfs	72,500 cfs	72,500 cfs	72,500 cfs	72,500 cfs	72,500 cfs	72,500 cfs
McNary	34,000 cfs	85,000 cfs	85,000 cfs	85,000 cfs			
John Day	24,000 cfs	71,000 cfs	71,573 cfs	95,833 cfs	80,000 cfs	80,000 cfs	80,000 cfs
	12%	30%	29%	28%	30%	30%	30%
The Dalles	42,800 cfs	107,000 cfs	107,000 cfs	107,000 cfs	107,000 cfs	107,000 cfs	107,000 cfs
	16%	40%	40%	40%	40%	40%	40%
Bonneville	38,483 cfs	95,292 cfs	95,474 cfs	93,906 cfs	93,750 cfs	95,375 cfs	95,938 cfs

(*) No spill for-fish-passage required.

Canadian Treaty Projects Operation. The Canadian Treaty projects (Mica, Duncan and Arrow), are operated per the 2003-04 Detailed Operating Plan (DOP). The DOP is based on the Assured Operating Plan that was developed six years in advance of the operating year in accordance with the Columbia River Treaty, an agreement between the United States and Canadian governments to coordinate the operation of the Columbia River.

Libby. For January through April, Libby was operated to meet target flood control elevations. For May and June, Libby was modeled to meet target sturgeon flows. For July and August, Libby drafts from the end of June elevation to El. 2439 feet (ft) at the end of August with constant outflows to aid in meeting McNary fish flow objectives, and while meeting bull trout minimum flows. Libby drafts below El. 2439 ft. to meet bull trout minimum flows in July and August if needed. For September through November, Libby operates for power to the operating rule curves or as needed to meet load. In December, Libby operates to target the flood control El. 2411 ft.

Hungry Horse. Hungry Horse was modeled to meet Columbia Falls and local minimum flows year-round. In January through March, the project drafts for power as needed to draft limits equal to the higher of the Variable Draft Limits (VDLs) and the Integrated Rule Curves. VDLs are designed to limit the drafting of the reservoir for power purposes such that there is a 75% chance of reaching the April 10th flood control elevation. For the first half of April through July, the project targets flood control elevations. In the first and second half of August, Hungry Horse drafts as needed for McNary fish flow objectives to draft limits of El. 3550 and El. 3540 ft, respectively. For September, October, November, and December, Hungry Horse drafts for power to draft limits of El. 3545, 3545, 3542, and

3533 ft, respectively; however, the project is allowed to draft below all draft limits in order to meet the minimum flows.

Albeni Falls. Albeni Falls fills in April through June to El. 2062.5 and drafts in September through November to the winter elevation El. 2055.

Grand Coulee. In January through March, the project operates for power to the draft limits of the higher of the VDLs, and the resident fish limits of El. 1260, 1250, and 1240 ft in January, February, and March, respectively. The VDLs for Grand Coulee are designed such that there is an 85% confidence of reaching the flood control elevation by April 10th. In December through May, Grand Coulee drafts as needed to meet the Vernita Bar flow requirement. Grand Coulee augments for McNary and Priest Rapids flow objectives April through August. End of period draft limits for these flow objectives for the first and second half of April, May, June, July, and the first and second half of August are El. 1280, 1280, 1280, 1288, 1285, 1280, and 1280/1278 feet, respectively. The project drafts for power in September, October, November and December, with draft limits of El.1283, 1283, 1275, and 1270 ft, respectively. Chum flow objectives of 125 kcfs at Bonneville were met by drafting Grand Coulee, but were subject to draft limits of El. 1275, 1270 ft, in November and December, and VDLs in January through March. Pumping from Lake Roosevelt to Banks Lake was modeled based on the Bureau of Reclamation's PNCA 2003-04 data.

McNary. McNary flow objectives for salmon are those recommended in the BiOp. The flow objectives for April 10th through June 30th vary between 220,000 cfs and 260,000 cfs. If the April runoff volume forecast at The Dalles Project for April through August is less than 80 million-acre-feet (Maf), the flow objective is 220,000 cfs. If the volume forecast is greater than 92 Maf, the flow objective is 260,000 cfs. If the forecasted volume is between 80 and 92 Maf, the flow objective is linearly interpolated between 220,000 cfs and 260,000 cfs. The flow objective for July and August is 200,000 cfs.

Priest Rapids. Priest Rapids flow objectives for steelhead are for the period April 10 through June 30. The flow objective is 135,000 cfs. The prorated period average flow objective for the first half of April is 90,000 cfs. The Vernita Bar requirement is dependent on the October and November flows at Wanapum Dam and is between 50,000 cfs and 70,000 cfs in December through May.

Brownlee. Brownlee operates to the fixed elevation operation used in the PNCA studies.

Dworshak. In January through June the project operates to target flood control elevations. Dworshak drafts to meet Lower Granite flow objectives in July through August. In September through December, the project operates on minimum flow of 1,300 cfs or flood control. Although the BiOp discusses flow objectives at Lower Granite in the spring that would be met by drafting of Dworshak, the BiOp places priority on June refill rather than meeting spring flow objectives, therefore Dworshak was modeled to refill in June.

Lower Granite. Lower Granite flow objectives in July and August range from 50,000 cfs to 55,000 cfs and are based on the April through July volume forecast (determined in June) at Lower Granite. Flow objectives are based on recommendations contained in the BiOp.

Lower Snake Projects Minimum Operating Pool (MOP). The Lower Snake River projects are operated as run-of-river projects, and run to MOP in April-August, except for Lower Granite that runs to MOP in April-October. The projects run to full pool in all other periods.

Scenarios 1 through 14

All project operational data for Scenarios 1 through 14 are the same as for the Base Case except for John Day's spill criteria, which are provided in Table 3. Spill criteria for the Base Case are shown for comparison purposes. Monthly spill caps were determined based on John Day project monthly median regulated flows from the continuous study from the PNCA 2003-04 operating year, and biological testing. For scenarios 11 through 14, the spill cap limits the percent of regulated flow plus the additional 20,000 cfs spill.

Table 3. John Day Month Average Spill Caps (cfs) and Spill Percentages

Scenario	AP1	APR	MAY	JUN	JUL	AG1	AUG
Base Case-60% night in summer	24000	71000	71573	95833	80000	80000	80000
and 30% 24-hour in spring	12%	30%	29%	28%	30%	30%	30%
1. 0/0 0/0 [(1)]	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
2. 0/0 5/5	16000	40000	71573	68750	80000	80000	80000
	1%	3%	2%	2%	5%	5%	5%
3. 0/10 10/10	16000	40000	71573	68750	80000	80000	80000
	2%	5%	5%	5%	10%	10%	10%
4. 0/20 10/15	16000	40000	71573	68750	80000	80000	80000
	4%	10%	10%	9%	12%	13%	13%
5. 0/25 15/25	16000	40000	71573	68750	80000	80000	80000
	5%	13%	12%	11%	20%	20%	20%
6. 0/35 15/30	16000	41500	52487	50417	80000	80000	80000
	7%	18%	17%	16%	22%	23%	23%
7. 0/40 20/40	16000	47500	71573	68750	85000	80000	80000
	8%	20%	19%	18%	29%	30%	30%
8. 0/50 30/45	20000	70000	71573	68750	95000	85000	80000
	10%	25%	24%	23%	37%	38%	38%
9. 0/60 35/55	24000	71000	71573	68750	115000	105000	80000
	12%	30%	29%	28%	44%	45%	45%
10. 0% 24-hr + 20 kcfs	8000	20000	20000	20000	20000	20000	20000
	-	-	-	-	-	-	-
11. 10% 24-hr + 20 kcfs	32000	80000	150000	150000	80000	80000	80000
	7%	10%	10%	10%	10%	10%	10%
12. 20% 24-hr + 20 kcfs	32000	80000	150000	150000	80000	80000	80000
	14%	20%	20%	20%	20%	20%	20%
13. 30% 24-hr + 20 kcfs	32000	80000	150000	150000	80000	80000	80000
	21%	30%	30%	30%	30%	30%	30%
14. 40% 24-hr +20 kcfs	32000	80000	150000	150000	83000	80000	80000
	28%	40%	40%	40%	40%	40%	40%

(1) The notation "0/0 0/0" means 0% daytime spill in spring/0% night-time spill in spring and 0% daytime spill in summer/0% night-time spill in summer.

Scenarios 15 through 29

An assumption was made that John Day Project's turbine efficiency would be reduced by 5% if fish bypass screens were placed in the turbine intakes or a fish bypass structure was placed in front of the intakes. Scenarios 15 through 29 are the same as the Base Case and Scenarios 1 through 14, respectively, except that the generation for John Day was reduced by 5% year-round. Scenarios 15 through 29 did not require HYSSR model runs because the assumption was made that reducing John Day generation by 5% would have little effect on system operation and flows.

Scenarios 30 through 44

An assumption was made that John Day Project's turbine efficiency would be increased by 2% if new turbines were installed. This assumption is based on the increase in efficiency of the new minimum gap runner units installed at Bonneville Dam. Scenarios 30 through 44 are the same as the Base Case and Scenarios 1 through 14, respectively, except that the generation for John Day was increased by 2% year-round. Scenarios 30 through 44 did not require a HYSSR model runs because the assumption was made that increasing John Day generation by 2% would have little effect on system operation and flows.

Summary and Comparison of John Day Spill and System Generation

Summary of John Day Spill.

The 60-Year period average spill at John Day for each scenario that a model run was made is shown in Table 4. Spill shown in January and March is involuntary spill, or spill that occurred because inflow to the project exceeded the hydraulic capacity of the powerhouse. This occurred in 2 years for January, and 1 year for March.

Table 4. John Day 60-Year Month Average Spill (cfs)

SCENARIO	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL
Base Case 0/60 30/30	52656	44352	0	0	0	0	671	0	145	21034	62909	65985	79546	61432
1. 0/0 0/0	0	0	0	0	0	0	671	0	145	0	1947	4371	15801	0
2. 0/0 5/5	8777	7392	0	0	0	0	671	0	145	1998	8477	8645	19659	10424
3. 0/10 10/10	17568	14793	0	0	0	0	671	0	145	3996	12940	15388	25775	20827
4. 0/20 10/15	22834	19231	0	0	0	0	671	0	145	7993	24249	27736	34413	24995
5. 0/25 15/25	35127	29588	0	0	0	0	671	0	145	9984	30519	32876	38935	41662
6. 0/35 15/30	40392	34022	0	0	0	0	671	0	145	13122	37320	43622	48798	45840
7. 0/40 20/40	52689	44353	0	0	0	0	671	0	145	14023	42089	50802	55429	60234
8. 0/50 30/45	66627	56108	0	0	0	0	671	0	145	17528	56910	60108	63974	75150
9. 0/60 35/55	78983	65177	0	0	0	0	671	0	145	21034	62999	65936	68815	89786
10. No spill + 20 kcfs	20000	20000	0	0	0	0	671	0	145	8000	20854	21909	31411	20000
11. 10% 24-hr + 20 kcfs	37563	34784	0	0	0	0	671	0	145	21994	44129	47149	54015	40840
12. 20% 24-hr + 20 kcfs	55106	49575	0	0	0	0	671	0	145	30286	66493	73918	80758	61623
13. 30% 24-hr + 20 kcfs	72176	64253	0	0	0	0	671	0	145	31948	76245	100880	107888	75069
14. 40% 24-hr +20 kcfs	79065	75149	0	0	0	0	671	0	145	32000	78715	123413	128020	82291

Table 5 shows the number of years that spill at John Day was less than, equal to, and greater than the spill cap. For Scenarios 2 through 9, if the spill flow was less than the cap, then the project spilled the percent of regulated flow as shown on Table 3. In the years that the John Day spill flow was equal to the cap, the percent of regulated flow would have exceeded the cap, and the model limited spill flow to the cap. In the years that the spill exceeded the cap, the regulated flow through John Day was greater than the hydraulic capacity of the powerhouse plus the spill cap, resulting in involuntary spill.

For Scenarios 10 through 14, if the spill was less than the cap, then John Day spilled the percent of regulated flow from Table 3 plus 20,000 cfs. If the spill was equal to the cap, then the percent of regulated flow plus the 20,000 cfs exceeded the cap, and the cap limited the spill. In the years that the spill exceeded the cap, the regulated flow through John Day was greater than the hydraulic capacity of the powerhouse plus the spill cap, resulting in involuntary spill.

Table 5. Number of Years Spill is Less than, Equal to, and Greater than the Spill Cap

SCENARIO		AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL
Base Case 0/60 30/30	**Years < Cap**	60	60	-	-	-	-	-	-	-	31	31	24	43	51
	Years = Cap	0	0	-	-	-	-	-	-	-	29	29	35	14	9
	Years > Cap	0	0	-	-	-	-	-	-	-	0	0	1	3	0
1. 0/0 0/0	**Years < Cap**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Years = Cap	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Years > Cap	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. 0/0 5/5	**Years < Cap**	60	60	-	-	-	-	-	-	-	60	59	60	56	60
	Years = Cap	0	0	-	-	-	-	-	-	-	0	0	0	0	0
	Years > Cap	0	0	-	-	-	-	-	-	-	0	1	0	4	0
3. 0/10 10/10	**Years < Cap**	60	60	-	-	-	-	-	-	-	60	59	60	56	60
	Years = Cap	0	0	-	-	-	-	-	-	-	0	0	0	0	0
	Years > Cap	0	0	-	-	-	-	-	-	-	0	1	0	4	0
4. 0/20 10/15	**Years < Cap**	60	60	-	-	-	-	-	-	-	60	58	60	56	60
	Years = Cap	0	0	-	-	-	-	-	-	-	0	0	0	0	0
	Years > Cap	0	0	-	-	-	-	-	-	-	0	2	0	4	0
5. 0/25 15/25	**Years < Cap**	60	60	-	-	-	-	-	-	-	59	50	60	56	60
	Years = Cap	0	0	-	-	-	-	-	-	-	1	8	0	0	0
	Years > Cap	0	0	-	-	-	-	-	-	-	0	2	0	4	0
6. 0/35 15/30	**Years < Cap**	60	60	-	-	-	-	-	-	-	41	29	41	39	60
	Years = Cap	0	0	-	-	-	-	-	-	-	19	30	17	13	0
	Years > Cap	0	0	-	-	-	-	-	-	-	0	1	2	8	0
7. 0/40 20/40	**Years < Cap**	60	60	-	-	-	-	-	-	-	31	30	54	48	57
	Years = Cap	0	0	-	-	-	-	-	-	-	29	30	5	7	3
	Years > Cap	0	0	-	-	-	-	-	-	-	0	0	1	5	0
8. 0/50 30/45	**Years < Cap**	58	59	-	-	-	-	-	-	-	31	42	41	37	49
	Years = Cap	0	1	-	-	-	-	-	-	-	29	18	18	18	11
	Years > Cap	2	0	-	-	-	-	-	-	-	0	0	1	5	0
9. 0/60 35/55	**Years < Cap**	59	49	-	-	-	-	-	-	-	31	30	24	18	51
	Years = Cap	1	11	-	-	-	-	-	-	-	29	30	35	37	9
	Years > Cap	0	0	-	-	-	-	-	-	-	0	0	1	5	0
10. 0% spill + 20 kcfs	**Years < Cap**	0	0	-	-	-	-	-	-	-	0	0	0	0	0
	Years = Cap	60	60	-	-	-	-	-	-	-	60	57	54	47	60
	Years > Cap	0	0	-	-	-	-	-	-	-	0	3	6	13	0
11. 10% 24-hr + 20 kcfs	**Years < Cap**	60	60	-	-	-	-	-	-	-	60	60	60	58	60
	Years = Cap	0	0	-	-	-	-	-	-	-	0	0	0	0	0
	Years > Cap	0	0	-	-	-	-	-	-	-	0	0	0	2	0
12. 20% 24-hr + 20 kcfs	**Years < Cap**	60	60	-	-	-	-	-	-	-	22	48	60	58	59
	Years = Cap	0	0	-	-	-	-	-	-	-	38	12	0	0	1
	Years > Cap	0	0	-	-	-	-	-	-	-	0	0	0	2	0
13. 30% 24-hr + 20 kcfs	**Years < Cap**	45	57	-	-	-	-	-	-	-	2	19	60	56	27
	Years = Cap	15	3	-	-	-	-	-	-	-	58	41	0	2	33
	Years > Cap	0	0	-	-	-	-	-	-	-	0	0	0	2	0
14. 40% 24-hr +20 kcfs	**Years < Cap**	13	40	-	-	-	-	-	-	-	0	8	45	41	4
	Years = Cap	47	20	-	-	-	-	-	-	-	60	52	15	17	0
	Years > Cap	0	0	-	-	-	-	-	-	-	0	0	0	2	56

Summary of System Generation

Table 6 shows the 60-year average monthly system generation in average megawatts (aMW) for the Base Case. It should be noted that the generation values are approximations of system generation based on PNCA coordinated projects, the stated operating criteria, and limitations of the HYSSR model. This data is appropriate for use as a basis for comparison of scenarios in this report and should not be used for any other purpose.

Table 6. 60-Year Average System Generation (aMW)

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
Base Case 0/60 30/30	13348	11701	7544	9382	11819	12998	16626	12657	12237	14262	14740	16458	18294	15170	13357

Table 7 shows the differences in system generation between each scenario and the Base Case. A positive number means the comparison scenario produced more generation than the Base Case.

For Scenarios 1 through 7, the average annual generation is 159 to 31 aMW, respectively, greater than the Base Case. As spill increases from Scenario 2 to Scenario 7, generation decreases.

For Scenario 8, the spill regime, on average, is similar to the Base Case, therefore the average annual generation difference is just 1 aMW less than the Base Case. However, the spill in Scenario 8 provides less spill in the spring (more generation) and more spill in the summer (less generation).

For Scenario 9, the spring spill criteria are the same as for the Base Case, but include more summer spill. Although the spring spill criteria are the same, the additional spill in the summer causes the system to draft deeper in some years to meet the load. This leaves less water in the system for generation in September through April. Scenario 9 produces 26 aMW annual average generation less than the Base Case.

Scenario 10 and 11, produce 109 and 50 aMW, respectively, more average annual generation than in the Base Case because there is less spill. Scenarios 12, 13, and 14, produce 12, 65, and 101 aMW, respectively, less generation than in the Base Case because there is more spill.

For Scenarios 15 through 29, the system generation was computed to be the generation from the Base Case through Scenario 14 minus 5% of John Day project's generation from the respective scenarios. This procedure to estimate the system generation would be more accurate if the system operated to the operating rule curve 100% of the time (met the load and produced additional secondary energy). The system operates to the operating rule curve over 90% of the time for all scenarios. If a more detailed study were to be done, for the other 10% of the periods when the system load was just met, the system generation would not be reduced by 5% of John Day's generation because the rest of the system would draft additionally to produce enough energy to meet the load. However, in subsequent periods, when the system returns to the operating rule curve, there would be less water available in the more detailed study, and therefore less generation. This effect in a hydroregulation is a matter of shifting water from one period to another and some generation differences due to head differences. However, the differences would be small, and the method used is acceptable for this level of study.

For Scenarios 30 through 44, the system generation was computed to be generation from the Base Case through Scenario 14 plus 2% of John Day project's generation from those scenarios. This method provides an estimate of the system generation if John Day project installed turbines with 2% greater efficiency. The method used is sufficient for the level of the report.

Overall, the greatest increase in generation from the Base Case occurs with Scenario 31 (no spill scenario + 2% increase in turbine efficiency), with an increase of average annual generation of 185 aMW, a 1.4% system difference. The greatest decrease in generation from the Base Case occurs with Scenario 29 (40% spill 24-hours per day, plus 20 kcfs additional spill, minus 5% of John Day generation) with a decrease in average annual generation of 152 aMW, or 1.1% system difference.

Table 7. 60-Year Average Difference in System Generation (aMW) from Base Case

SCENARIO	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
1. 0/0 0/0	399	336	11	7	16	2	3	4	-3	158	398	395	406	409	159
2. 0/0 5/5	334	285	10	5	14	2	3	3	0	138	356	368	382	340	142
3. 0/10 10/10	270	230	9	5	12	2	3	3	0	123	326	326	345	273	122
4. 0/20 10/15	233	198	8	4	9	2	2	3	0	95	251	250	291	243	101
5. 0/25 15/25	142	119	6	3	6	1	2	2	0	80	209	216	263	136	76
6. 0/35 15/30	103	79	5	3	5	0	2	2	0	57	165	146	197	108	56
7. 0/40 20/40	13	3	3	1	2	0	1	1	0	50	132	99	156	14	31
8. 0/50 30/45	-94	-86	-1	-1	-4	0	-1	-1	0	25	31	38	98	-81	-1
9. 0/60 35/55	-192	-146	-3	-7	-10	-1	-2	-3	0	-1	-10	1	67	-177	-26
10. 20 kcfs spill	253	194	7	3	8	2	2	2	-3	100	279	286	305	275	109
11. 10% 24-hr + 20 kcfs	120	74	3	2	4	0	1	1	-3	-1	124	127	163	140	50
12. 20% 24-hr + 20 kcfs	-20	-36	-2	-3	-3	0	0	-1	-3	-62	-28	-48	-8	2	-12
13. 30% 24-hr + 20 kcfs	-149	-144	-9	-13	-13	-2	-2	-3	-4	-75	-94	-229	-192	-77	-65
14. 40% 24-hr +20 kcfs	-196	-212	-11	-22	-25	-6	-4	-6	-4	-75	-109	-386	-336	-112	-101
15. Basecase - 5%	-46	-39	-31	-39	-49	-55	-74	-55	-57	-67	-66	-74	-78	-54	-56
16. Scenario 1 - 5%	335	281	-20	-32	-33	-53	-71	-51	-60	83	311	301	308	333	95
17. Scenario 2 - 5%	273	233	-21	-34	-35	-53	-71	-52	-57	64	271	275	285	268	79
18. Scenario 3 - 5%	212	181	-22	-34	-37	-53	-71	-52	-57	50	243	235	250	205	60
19. Scenario 4 - 5%	177	150	-23	-35	-40	-53	-72	-52	-57	23	171	163	198	176	40
20. Scenario 5 - 5%	90	75	-25	-36	-43	-54	-72	-53	-57	9	132	131	172	75	16
21. Scenario 6 - 5%	53	37	-26	-36	-44	-55	-72	-53	-57	-13	90	65	109	48	-3
22. Scenario 7 -5%	-33	-36	-28	-38	-47	-55	-73	-54	-57	-20	59	20	70	-41	-27
23. Scenario 8 - 5%	-135	-120	-32	-40	-53	-55	-75	-56	-57	-44	-37	-38	15	-130	-57
24. Scenario 9 - 5%	-228	-177	-34	-46	-59	-56	-76	-58	-57	-68	-76	-73	-14	-221	-81
25. Scenario 10 - 5%	196	147	-24	-36	-41	-53	-72	-53	-60	28	198	197	212	206	47
26. Scenario 11 - 5%	69	32	-28	-37	-45	-55	-73	-54	-60	-68	51	47	77	79	-9
27. Scenario 12 - 5%	-65	-73	-33	-42	-52	-55	-74	-56	-60	-126	-93	-119	-85	-52	-68
28. Scenario 13 - 5%	-187	-175	-40	-52	-62	-57	-76	-58	-61	-138	-155	-291	-260	-126	-118
29. Scenario 14 - 5%	-232	-239	-42	-61	-74	-61	-78	-61	-61	-138	-169	-440	-397	-159	**-152**
30. Basecase + 2%	18	15	12	16	19	22	30	22	23	27	26	30	31	22	22
31. Scenario 1 + 2%	425	358	23	23	35	24	33	26	20	188	433	433	445	439	**185**
32. Scenario 2 + 2%	359	306	22	21	33	24	33	25	23	168	390	405	421	369	167
33. Scenario 3 + 2%	293	250	21	21	31	24	33	25	23	152	359	362	383	300	147
34. Scenario 4 + 2%	256	217	20	20	28	24	32	25	23	124	283	285	328	270	125
35. Scenario 5 + 2%	163	137	18	19	25	23	32	24	23	109	240	250	299	160	100
36. Scenario 6 + 2%	123	96	17	19	24	22	32	24	23	85	195	179	232	132	80
37. Scenario 7 + 2%	31	18	15	17	21	22	31	23	23	78	161	131	190	36	54
38. Scenario 8 + 2%	-78	-72	11	15	15	22	29	21	23	52	58	68	131	-61	21
39. Scenario 9 + 2%	-178	-134	9	9	9	21	28	19	23	26	16	31	99	-159	-4
40. Scenario 10 + 2%	276	213	19	19	27	24	32	24	20	129	311	321	342	302	134
41. Scenario 11 + 2%	140	91	15	18	23	22	31	23	20	26	153	159	197	165	73
42. Scenario 12 + 2%	-2	-21	10	13	16	22	30	21	20	-36	-2	-20	23	24	10
43. Scenario 13 + 2%	-134	-132	3	2	6	20	28	19	19	-50	-70	-204	-165	-57	-44
44. Scenario 14+ 2%	-182	-201	1	-7	-6	16	26	16	19	-50	-85	-365	-312	-93	-81

Energy Benefits Impact of Various Spill and Turbine Efficiency Scenarios

The impact on energy benefits of the various John Day Project spill and turbine efficiency scenarios was determined by first converting the differences in system generation between each scenario and the Base Case, summarized in Table 7, from aMW to MWh, then applying monthly energy values (in $/MWh) to the converted system generation differences. Each monthly system generation difference in MWh was obtained by multiplying the number of hours in the month by the corresponding monthly system generation difference in aMW. Table 8 summarizes the results of the conversion process. Due to the magnitude of the system generation differences, the values shown in Table 8 are expressed in GWh (equivalent to 1,000 MWh).

Table 8. 60-Year Average Difference in System Generation (GWh) from Base Case

SCENARIO	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	YEAR
1. 0/0 0/0	144	129	8	5	12	1	2	3	-2	57	143	294	292	304	1393
2. 0/5 5/5	120	109	7	4	10	1	2	2	0	50	128	274	275	253	1244
3. 0/10 10/10	97	88	6	4	9	1	2	2	0	44	117	243	248	203	1069
4. 0/20 10/15	84	76	6	3	6	1	1	2	0	34	90	186	210	181	885
5. 0/25 15/25	51	46	4	2	4	1	1	1	0	29	75	161	189	101	666
6. 0/35 15/30	37	30	4	2	4	0	1	1	0	21	59	109	142	80	491
7. 0/40 20/40	5	1	2	1	1	0	1	1	0	18	48	74	112	10	272
8. 0/50 30/45	-34	-33	-1	-1	-3	0	-1	-1	0	9	11	28	71	-60	-9
9. 0/60 35/55	-69	-56	-2	-5	-7	-1	-1	-2	0	0	-4	1	48	-132	-228
10. 20 kcfs spill	91	74	5	2	6	1	1	1	-2	36	100	213	220	205	955
11. 10% 24-hr + 20 kcfs	43	28	2	1	3	0	1	1	-2	0	45	94	117	104	438
12. 20% 24-hr + 20 kcfs	-7	-14	-1	-2	-2	0	0	-1	-2	-22	-10	-36	-6	1	-105
13. 30% 24-hr + 20 kcfs	-54	-55	-6	-10	-9	-1	-1	-2	-3	-27	-34	-170	-138	-57	-569
14. 40% 24-hr +20 kcfs	-71	-81	-8	-16	-18	-4	-3	-4	-3	-27	-39	-287	-242	-83	-885
15. Basecase - 5%	-16	-15	-22	-29	-35	-41	-55	-37	-42	-24	-24	-55	-56	-40	-492
16. Scenario 1 - 5%	120	108	-14	-24	-23	-39	-53	-34	-44	30	112	224	221	248	831
17. Scenario 2 - 5%	98	89	-15	-25	-25	-39	-53	-35	-42	23	98	205	205	199	690
18. Scenario 3 - 5%	76	69	-16	-25	-26	-39	-53	-35	-42	18	87	175	180	152	523
19. Scenario 4 - 5%	64	58	-17	-26	-29	-39	-54	-35	-42	8	62	121	143	131	349
20. Scenario 5 - 5%	32	29	-18	-27	-31	-40	-54	-36	-42	3	47	97	124	56	141
21. Scenario 6 - 5%	19	14	-19	-27	-31	-41	-54	-36	-42	-5	32	48	79	36	-26
22. Scenario 7 -5%	-12	-14	-20	-28	-34	-41	-55	-36	-42	-7	21	15	51	-30	-234
23. Scenario 8 - 5%	-48	-46	-23	-30	-38	-41	-56	-38	-42	-16	-13	-28	11	-97	-500
24. Scenario 9 - 5%	-82	-68	-25	-34	-42	-41	-57	-39	-42	-25	-27	-54	-10	-164	-708
25. Scenario 10 - 5%	70	56	-17	-27	-29	-39	-54	-36	-44	10	71	147	152	154	415
26. Scenario 11 - 5%	25	12	-20	-27	-32	-41	-55	-36	-44	-24	18	35	55	58	-76
27. Scenario 12 - 5%	-23	-28	-24	-31	-37	-41	-55	-38	-44	-45	-33	-89	-61	-39	-592
28. Scenario 13 - 5%	-67	-67	-29	-38	-44	-42	-57	-39	-45	-50	-56	-216	-187	-94	-1033
29. Scenario 14 - 5%	-83	-92	-30	-45	-53	-45	-58	-41	-45	-50	-61	-327	-286	-118	-1333
30. Basecase + 2%	7	6	9	12	14	16	22	15	17	10	10	22	22	16	197
31. Scenario 1 + 2%	153	137	17	17	26	18	24	17	15	68	156	322	321	327	1617
32. Scenario 2 + 2%	129	117	16	15	24	18	24	17	17	60	140	301	303	274	1465
33. Scenario 3 + 2%	106	96	15	15	23	18	24	17	17	55	129	270	276	223	1287
34. Scenario 4 + 2%	92	83	15	15	20	18	24	17	17	45	102	212	236	201	1099
35. Scenario 5 + 2%	59	52	13	14	18	17	24	16	17	39	86	186	216	119	876
36. Scenario 6 + 2%	44	37	13	14	18	16	24	16	17	31	70	133	167	98	697
37. Scenario 7 + 2%	11	7	11	12	15	16	23	15	17	28	58	97	137	27	474
38. Scenario 8 + 2%	-28	-28	8	11	11	16	21	14	17	19	21	51	94	-46	188
39. Scenario 9 + 2%	-64	-51	7	6	7	15	21	13	17	9	6	23	72	-119	-36
40. Scenario 10 + 2%	99	82	14	14	20	18	24	16	15	46	112	239	246	225	1171
41. Scenario 11 + 2%	51	35	11	13	17	16	23	15	15	9	55	118	142	122	644
42. Scenario 12 + 2%	-1	-8	8	9	12	16	22	14	15	-13	-1	-15	16	18	90
43. Scenario 13 + 2%	-48	-51	2	2	5	15	21	13	14	-18	-25	-152	-119	-43	-384
44. Scenario 14+ 2%	-65	-77	1	-5	-4	12	19	11	14	-18	-31	-271	-224	-69	-706

The basis and procedure for the development of the monthly energy values utilized in this study are summarized in the following sections, followed by a summary of the monthly energy value results and the energy benefits impact of each spill and turbine efficiency scenario.

Basis for Development of Monthly Energy Values

The monthly energy values utilized in this study to determine the energy benefits impact of each scenario are based on information developed by Platts Power Outlook Research Service, a wholesale North American power market forecast service. Platts is a Division of the McGraw-Hill Companies, Inc. Platts data sets are proprietary and are used under subscription by the Corps of Engineers' Hydropower Analysis Center.

Platts uses AuroraXMP, an electric energy market model owned and licensed by EPIS, Incorporated to forecast market clearing prices for electric power. Platts estimates both on-peak and off-peak energy values on an annual and monthly basis for a 20-year forecast period from 2005 through 2024.

The hourly market-clearing price is based upon a fixed set of resources dispatched in least-cost order to meet demand while subject to emissions limits. The hourly price is set equal to the variable cost of the marginal resource needed to meet the last unit of demand. A long-term resource optimization feature within the AURORA model allows generating resources to be added or retired based on economic profitability. Market-clearing price and the resource portfolio are interdependent. Market-clearing price affects the revenues any particular resource
can earn and consequently will affect which resources are added or retired. AURORA sets the market-clearing price using assumptions on demand levels (load) and supply costs. The demand forecast implicitly includes the effect of price elasticity over time. The supply side is defined by the cost and operating characteristics of individual electric generating plants, including resource capacity, heat rate and fuel price. AURORA recognizes the effect that transmission capacity and prices have on the system's ability to move generation output between areas.

In providing input data to AURORA, Platts utilizes numerous other models and data sources including the following:

- Electricity Demand model
- Coal Market model
- Gas Market model
- NEWGen database of new generating capacity
- SO2 and NOx emissions allowance price forecasting model

Platts develops power price forecasts for all North American Electric Reliability Council (NERC) regions, including the U.S. portion of the Northwest Power Area (NWPAUS), the NERC subregion that covers the northwestern corner of the continental U.S., including the states of Idaho, Oregon, Utah and Washington, most of Montana and Nevada, and small portions of California and Wyoming. Platts develops separate forecasts for five market zones within NWPAUS, including the market zone that includes the states of Oregon, Washington, and northern Idaho. The Platts power price forecast for this market zone served as the basis for the energy values utilized in this study.

The energy values utilized in this study are based on the Baseline Price forecast in the June 2005 release by the Platts Power Outlook Research Service and represent conditions as of the second quarter of 2005 (April through June). The Baseline forecast assumes that average hydrologic conditions occur during each year of the simulation.

Monthly Energy Values Procedure

As discussed earlier, Platts provides a 20-year forecast of projected market energy values on both an annual and monthly basis for the period 2005 through 2024. In order to account for the monthly impact on energy benefits of the various John Day Project spill and turbine efficiency scenarios, the Platts "all hours energy plus capacity" monthly energy value forecast was utilized in the study. This forecast takes into account both the on-peak and off-peak value of energy, which is appropriate for this study since the impacts of each John Day scenario are experienced during both on-peak and off-peak periods. This forecast also includes a value of capacity component in the monthly energy values, which recognizes that in the future as demand levels increase and older power plants are retired, there will be a need for power plant capacity additions to the power system. Thus, the monthly energy benefits impact of each John Day scenario that was estimated using the Platts "all hours energy plus capacity" forecast also included a component representing the monthly capacity benefits impact of the scenario.

In order to determine the impact on energy benefits of each John Day Project spill and turbine efficiency scenario, a levelized energy value was developed for each month using as input the Platts 20-year monthly energy value forecast described previously. The development of each levelized energy value assumed a 35-year economic period of analysis (starting in 2005 and ending in 2039) and a FY 06 Federal interest rate of 5.125%. Monthly energy values for the years after 2024 (the last year of the Platts forecast) were assumed to be equal to the Platts monthly energy value for the year 2024. Since the Platts monthly energy values are provided only in Nominal Dollars (inflation included), each monthly value was converted to Constant 2005 Dollars (inflation removed) based on the annual inflation rates used by Platts. Each levelized monthly energy value was computed by first determining the present worth (to the year 2005) of the monthly energy value for each year in the 35-year period of analysis, then totaling the present worth monthly energy values, and finally applying an amortization factor.

Monthly Energy Values Results

Table 9 shows the computations that were required to develop the levelized energy value for the month of January. The energy values shown in the third column for the years 2005 through 2024 were obtained from the Platts forecast, while the shaded energy values shown in the column for the years 2025 through 2039 are assumed constant since these represent years beyond Platts 20-year forecast period.

The computational procedure that was utilized to develop the levelized energy value for January was also utilized to develop the levelized energy values for the months February through December. Table 10 summarizes (in bold) the levelized energy value results for each month of the year. Also included in the table are the value of energy (VE) and value of capacity (VC) components that correspond to each levelized energy value. The table results show that there are three months (July, August, and September) where the levelized monthly energy value includes a value of capacity component. The reason for this is that while NWPAUS is a winter-peaking region, it typically exports large amounts of energy to California and the Desert Southwest during the summer to meet the summertime peak loads of these regions.

Summary of Impacts to Energy Benefits of the Various Scenarios

The impact on energy benefits of each John Day Project spill and turbine efficiency scenario was determined by multiplying the scenario monthly differences in system generation from the Base Case, which are summarized in Table 8, by the levelized monthly energy values from Table 10.

Table 11 summarizes the monthly and annual impact on energy benefits for all the scenarios. For each scenario the energy benefits impact for the summer months of July, August and September also includes a component representing the capacity benefits impact of the scenario.

Table 9. Levelized Energy Value Computation for January

FY06 FEDERAL INTEREST RATE			5.125%
PERIOD OF ANALYSIS START YEAR			2005
PERIOD OF ANALYSIS END YEAR			2039
YEAR	PRESENT WORTH FACTOR	ENERGY VALUE $/MWh	PW ENERGY VALUE $/MWh
2004	1.0000	-----	-----
2005	0.9512	47.99	45.65
2006	0.9049	52.12	47.16
2007	0.8608	54.53	46.94
2008	0.8188	53.55	43.84
2009	0.7789	52.14	40.61
2010	0.7409	49.10	36.38
2011	0.7048	44.91	31.65
2012	0.6704	44.43	29.79
2013	0.6377	43.15	27.52
2014	0.6067	40.75	24.72
2015	0.5771	36.60	21.12
2016	0.5489	34.28	18.82
2017	0.5222	33.44	17.46
2018	0.4967	31.93	15.86
2019	0.4725	31.70	14.98
2020	0.4495	31.16	14.00
2021	0.4276	32.31	13.82
2022	0.4067	33.33	13.56
2023	0.3869	35.11	13.58
2024	0.3680	34.31	12.63
2025	0.3501	34.31	12.01
2026	0.3330	34.31	11.43
To	-----	-----	-----
2039	0.1739	34.31	106.53
PW ENERGY VALUE TOTAL			660.05
PERIOD OF ANALYSIS (YRS)			35
LEVELIZED ENERGY VALUE ($/MWh)			**40.95**

Table 10. Levelized Monthly Energy Values

Month	Levelized EV $/MWh	VE Component $/MWh	VC Component $/MWh
JAN	**40.95**	40.95	0.00
FEB	**43.18**	43.18	0.00
MAR	**42.32**	42.32	0.00
APR	**37.51**	37.51	0.00
MAY	**33.15**	33.15	0.00
JUN	**31.40**	31.40	0.00
JUL	**56.02**	39.99	16.03
AUG	**73.55**	41.48	32.07
SEP	**46.81**	41.29	5.52
OCT	**40.04**	40.04	0.00
NOV	**44.10**	44.10	0.00
DEC	**44.44**	44.44	0.00

Table 11 shows that the scenario with the greatest **positive** impact on annual energy benefits ($74.5 million per year increase) is Scenario 31, a scenario that does not include any spill for juvenile fish at John Day. This scenario does include turbine runner replacement at John Day, which is assumed to increase generation at the project by 2% year-round.

Table 11 also shows that the scenario with the greatest **negative** impact on annual energy benefits ($57.1 million per year decrease) is Scenario 29. This scenario includes a John Day juvenile fish spill percentage of 40% 24-hours per day plus an additional 20 kcfs spill for juvenile fish. The additional 20 kcfs may be spilled through a removable spillway weir, skeleton bay surface bypass, or a hydrocombine. This scenario also includes the addition of fish bypass screens in the John Day turbine intakes or a fish bypass structure in front of the intakes, which is assumed to decrease generation at the project by 5% year-round.

Table 11. 60-Year Average Difference in Energy Benefits ($1,000) from Base Case

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	YEAR
Energy Value ($/MWh)	73.55	73.55	46.81	40.04	44.10	44.44	40.95	43.18	42.32	37.51	37.51	33.15	31.40	56.02	
SCENARIO															
1. 0/0 0/0	10565	9490	371	209	508	66	91	116	-94	2134	5375	9743	9178	17047	64799
2. 0/5 5/5	8844	8050	337	149	445	66	91	87	0	1864	4808	9077	8636	14171	56625
3. 0/10 10/10	7149	6496	303	149	381	66	91	87	0	1661	4402	8041	7799	11379	48006
4. 0/20 10/15	6170	5592	270	119	286	66	61	87	0	1283	3390	6166	6579	10128	40197
5. 0/25 15/25	3760	3361	202	89	191	33	61	58	0	1080	2822	5328	5946	5669	28600
6. 0/35 15/30	2727	2231	169	89	159	0	61	58	0	770	2228	3601	4454	4502	21049
7. 0/40 20/40	344	85	101	30	64	0	30	29	0	675	1783	2442	3527	584	9693
8. 0/50 30/45	-2489	-2429	-34	-30	-127	0	-30	-29	0	338	419	937	2215	-3376	-4635
9. 0/60 35/55	-5084	-4124	-101	-209	-318	-33	-61	-87	0	-14	-135	25	1515	-7378	-16003
10. 20 kcfs spill	6699	5479	236	89	254	66	61	58	-94	1350	3768	7054	6895	11462	43379
11. 10% 24-hr + 20 kcfs	3178	2090	101	60	127	0	30	29	-94	-14	1675	3133	3685	5835	19834
12. 20% 24-hr + 20 kcfs	-530	-1017	-67	-89	-95	0	0	-29	-94	-837	-378	-1184	-181	83	-4419
13. 30% 24-hr + 20 kcfs	-3945	-4067	-303	-387	-413	-66	-61	-87	-126	-1013	-1269	-5649	-4341	-3209	-24937
14. 40% 24-hr +20 kcfs	-5190	-5988	-371	-655	-794	-198	-122	-174	-126	-1013	-1472	-9521	-7596	-4668	-37888
15. Basecase - 5%	-1207	-1087	-1048	-1154	-1543	-1803	-2268	-1599	-1790	-908	-892	-1819	-1755	-2259	-21135
16. Scenario 1 - 5%	8857	7948	-677	-946	-1035	-1737	-2177	-1483	-1883	1123	4196	7416	6954	13896	40453
17. Scenario 2 - 5%	7220	6582	-711	-1005	-1099	-1737	-2177	-1512	-1790	863	3659	6784	6438	11170	32686
18. Scenario 3 - 5%	5607	5104	-745	-1005	-1162	-1737	-2177	-1512	-1790	670	3275	5801	5645	8526	24500
19. Scenario 4 - 5%	4678	4245	-779	-1035	-1257	-1737	-2207	-1512	-1790	311	2314	4025	4486	7336	17078
20. Scenario 5 - 5%	2384	2120	-846	-1065	-1353	-1770	-2207	-1541	-1790	118	1777	3229	3885	3118	6059
21. Scenario 6 - 5%	1401	1037	-880	-1065	-1384	-1803	-2207	-1541	-1790	-177	1215	1592	2469	2011	-1123
22. Scenario 7 -5%	-863	-1003	-947	-1125	-1480	-1803	-2238	-1570	-1790	-267	791	492	1588	-1694	-11908
23. Scenario 8 - 5%	-3561	-3395	-1082	-1184	-1669	-1803	-2299	-1628	-1790	-587	-503	-934	345	-5433	-25523
24. Scenario 9 - 5%	-6036	-4995	-1149	-1363	-1859	-1836	-2328	-1686	-1790	-922	-1026	-1796	-318	-9216	-36319
25. Scenario 10 - 5%	5181	4141	-812	-1065	-1289	-1737	-2207	-1541	-1883	379	2678	4870	4786	8601	20101
26. Scenario 11 - 5%	1824	904	-947	-1095	-1416	-1803	-2238	-1570	-1883	-918	693	1153	1738	3274	-2283
27. Scenario 12 - 5%	-1713	-2051	-1116	-1244	-1638	-1805	-2267	-1628	-1883	-1700	-1253	-2939	-1927	-2174	-25337
28. Scenario 13 - 5%	-4964	-4948	-1352	-1540	-1954	-1871	-2328	-1686	-1914	-1867	-2096	-7173	-5876	-5266	-44834
29. Scenario 14 - 5%	-6139	-6755	-1421	-1808	-2335	-2002	-2389	-1773	-1914	-1867	-2286	-10847	-8969	-6615	**-57119**
30. Basecase + 2%	483	435	419	462	617	721	907	640	716	363	357	728	702	904	8454
31. Scenario 1 + 2%	11248	10107	790	670	1125	787	999	756	621	2538	5846	10674	10068	18308	**74538**
32. Scenario 2 + 2%	9494	8637	756	611	1062	787	999	727	716	2264	5267	9994	9515	15372	66200
33. Scenario 3 + 2%	7766	7053	723	611	998	787	999	727	716	2058	4853	8937	8661	12520	57409
34. Scenario 4 + 2%	6767	6131	689	581	903	787	968	727	716	1672	3820	7023	7416	11245	49444
35. Scenario 5 + 2%	4310	3858	622	551	808	754	968	698	716	1465	3241	6167	6770	6689	37617
36. Scenario 6 + 2%	3258	2709	588	551	776	721	968	698	716	1148	2634	4405	5248	5498	29917
37. Scenario 7 + 2%	827	520	520	492	681	721	938	669	716	1052	2179	3222	4302	1495	18333
38. Scenario 8 + 2%	-2060	-2043	386	432	490	721	877	610	716	708	787	1686	2964	-2553	3720
39. Scenario 9 + 2%	-4703	-3775	318	253	299	688	846	552	716	350	221	753	2248	-6642	-7876
40. Scenario 10 + 2%	7307	6015	655	551	871	787	968	698	621	1739	4204	7928	7739	12607	52690
41. Scenario 11 + 2%	3719	2565	520	521	744	721	938	669	621	348	2067	3924	4464	6860	28681
42. Scenario 12 + 2%	-56	-603	352	372	522	722	907	610	621	-492	-28	-482	518	986	3949
43. Scenario 13 + 2%	-3538	-3715	116	74	204	656	846	552	589	-671	-939	-5039	-3727	-2387	-16978
44. Scenario 14+ 2%	-4810	-5681	49	-194	-177	523	785	465	589	-671	-1147	-8991	-7047	-3890	-30196

APPENDIX C

DECISION MODEL INFORMATION

John Day Configuration Study - Total Dissolved Gas

Total dissolved gas (TDG) was a criterion in the multi-criteria decision model. To include the effects of TDG in the model, SYSTDG was used in the computations to determine the number of hours TDG levels will exceed the gas cap in the JDA tailrace to the Bonneville tailrace. The model, developed by Michael Schnieder and Kathryn Balka of the U.S. Army Corps of Engineers Engineer Research Development Center, investigates the interaction of processes responsible in generating TDG pressures. For the multi-criteria decision model, the following 15 spill scenarios were used:

	Spring		Summer		RSW
	am (kcfs)	pm (kcfs)	am (kcfs)	pm (kcfs)	(kcfs)
1	0	0	0	0	
2	0	5	0	5	
3	0	10	10	10	
4	0	20	10	15	
5	0	25	15	25	
6	0	35	15	30	
7	0	40	20	40	
8	0	50	30	45	
9	0	60	30	30	
10	0	60	35	55	
11	0	0	0	0	20
12	10	10	10	10	20
13	20	20	20	20	20
14	30	30	30	30	20
15	40	40	40	40	20

kcfs = thousand cfs

The following table shows the number of hours each individual project exceeded the TDG cap and the cumulative total of hours the TDG cap is exceeded from JDA tailwater to Bonneville tailwater for each operation scenario. A total of 4,418 spill hours per project resulted for the spring and summer spill period.

The table also shows the order the scenarios from least number of total hours the TDG cap is exceeded to most number of hours the TDG cap is exceeded. The data was then normalized and input into the multi-criteria decision model. To normalize the data the following relationship was used:

$$\text{Normalized Value} = [(V - V_{least}) / (V_{largest} - V_{least})] \times 100$$

where

V= the value to be normalized
V_{least}= the smallest value in the data set
$V_{largest}$= the largest value in the data set

Scenario (percent spill*)	Bon TW	Bon FB	TDA TW	TDA FB	JDA TW	Total Hours Exceeding Gas Cap JDA TW to BON TW	% Hrs Exceeded JDA TW to BON TW	Rank
0/0 0/0	64	11	0	0	5	80	0.4%	0.000
0/5 0/5	72	15	0	0	5	92	0.4%	0.020
0/10 10/10	75	17	0	0	5	97	0.4%	0.029
0/20 10/15	78	31	0	2	5	116	0.5%	0.061
0/25 15/25	83	38	0	10	5	136	0.6%	0.094
0/0 0/0 +20,000 cfs	83	50	0	0	5	138	0.6%	0.098
10/10 10/10 +20,000 cfs	95	76	0	3	5	179	0.8%	0.167
0/35 15/30	90	64	3	18	5	180	0.8%	0.169
0/40 20/40	94	95	3	24	5	221	1.0%	0.238
20/20 20/20 +20,000 cfs	101	114	0	17	5	237	1.1%	0.265
0/50 30/45	102	122	13	82	5	324	1.5%	0.411
30/30 30/30 +20,000 cfs	115	199	3	62	5	384	1.7%	0.513
0/60 30/30 (Base Case)	113	146	71	245	5	580	2.6%	0.843
0/60 35/55	114	146	71	245	5	581	2.6%	0.845
40/40 40/40 +20,000 cfs	127	276	33	232	5	673	3.0%	1.000

* Percent spill as spring-day/spring-night, summer-day/summer-night
BON TW = Bonneville tailwater
TDA TW = The Dalles tailwater
JDA TW = John Day tailwater

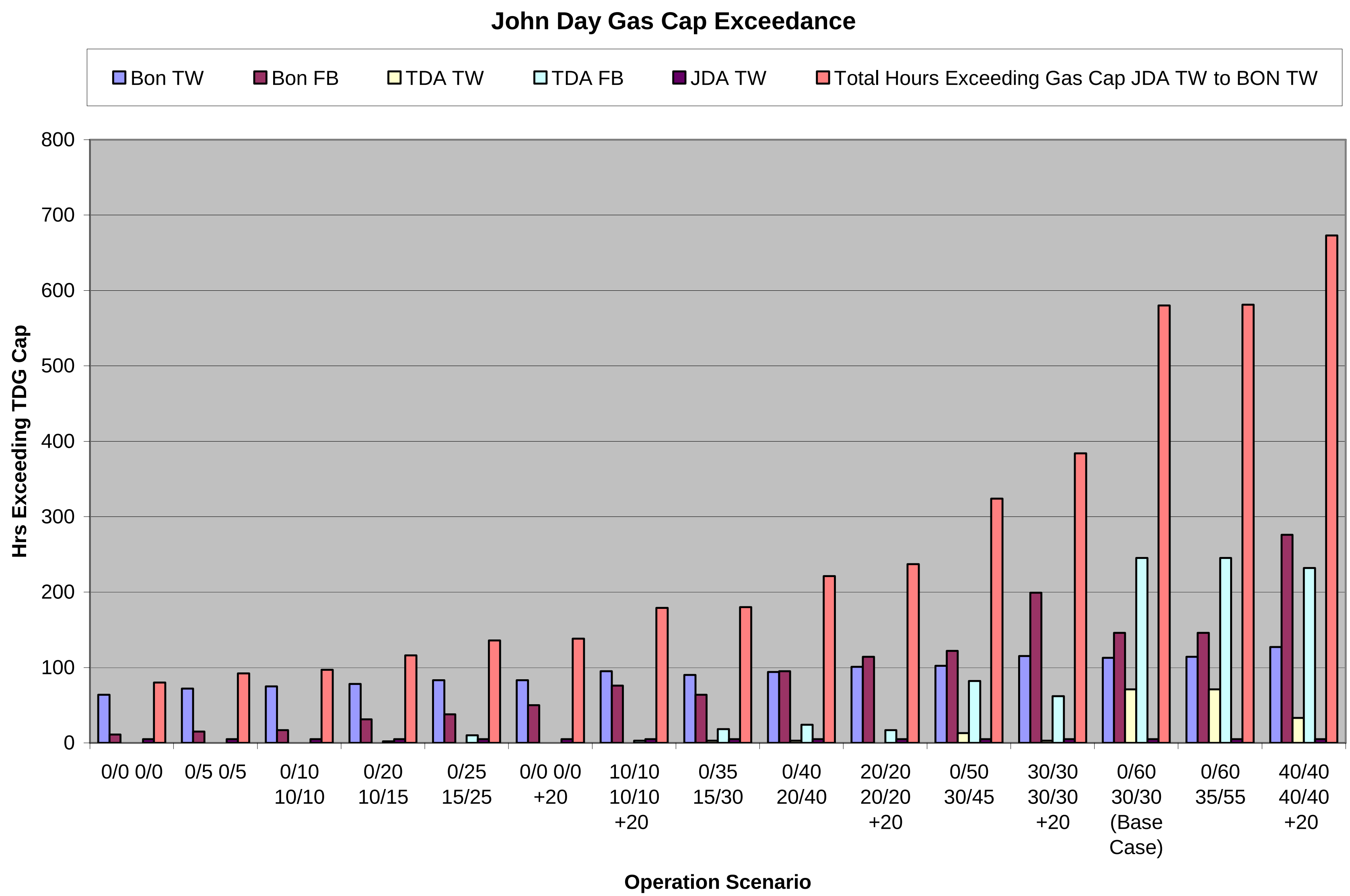

John Day Gas Cap Exceedance
Bon TW
Bon FB
TDA TW
TDA FB
JDA TW
Total Hours Exceeding Gas Cap JDA TW to BON TW
Hrs Exceeding TDG Cap
0
100
200
300
400
500
600
700
800
0/0 0/0
0/5 0/5
0/10 10/10
0/20 10/15
0/25 15/25
0/0 0/0 +20
10/10 10/10 +20
0/35 15/30
0/40 20/40
20/20 20/20 +20
0/50 30/45
30/30 30/30 +20
0/60 30/30 (Base Case)
0/60 35/55
40/40 40/40 +20
Operation Scenario

Table --- Model Sensitivities to Weights

Model Criteria Weights (Preliminary)

Level 1 wts		Level 2 wts		Level 3 wts	Ranking	Preliminary Model	1 - wts	2- wts	3-wts	#	Steelhead Rules	1 - wts	2- wts	3-wts	#	Yearling Ch. Rules	1 - wts	2- wts	3-wts	#	Sub Yrl Rules	1 - wts	2- wts	3-wts	#	Juv Fish Rules	1 - wts	2- wts	3-wts	#
100	Yearling Chinook	100	Dam Survival	n/a	1	SFS 20+20	0	0		1	SFS+BGS+TR IM 40+20	100	100		1	SFS+BGS+TR IM 40+20	0	0		1	SFS+BGS+TR IM 40+20	100	100		1	SFS+BGS+TR IM 40+20	0	0		1
		50	Forebay Retention	n/a	2	SFSB 20+20		0		2	SFSB+BGS+TR IM 40+20		50		2	SFSB+BGS+TR IM 40+20		0		2	HYDROC+BGS+TR IM 40+20		50		2	SBAY SBYPAS+BGS+TR IM 40+20		0		2
		75	Tailrace Egress	n/a	3	SFS+TR IM 20+20		0		3	HYDROC+BGS+TR IM 40+20		75		3	HYDROC+BGS+TR IM 40+20		0		3	SFSB+BGS+TR IM 40+20		75		3	HYDROC+BGS+TR IM 40+20		0		3
		25	SAR	n/a	4	SFS+BGS+TR IM 20+20		0		4	SFS+BGS+TR IM 30+20		25		4	SFS+BGS+TR IM 30+20		0		4	SFS+BGS+TR IM 30+20		25		4	SFS+BGS+TR IM 30+20		0		4
100	Steelhead	100	Dam Survival	n/a	5	HYDROC+BGS+TR IM 20+20	100	100		5	SFSB+BGS+TR IM 30+20	0	0		5	SFSB+BGS+TR IM 30+20	0	0		5	SFSB+BGS+TR IM 30+20	100	100		5	SFSB+BGS+TR IM 30+20	0	0		5
		50	Forebay Retention	n/a	6	SFS+BGS+TR IM 0+20		50		6	HYDROC+BGS+TR IM 30+20		0		6	HYDROC+BGS+TR IM 30+20		0		6	HYDROC+BGS+TR IM 30+20		50		6	HYDROC+BGS+TR IM 30+20		0		6
		75	Tailrace Egress	n/a	7	HYDROC+BGS+TR IM 0+20		75		7	SFS+BGS+TR IM 20+20		0		7	SFSB+BGS+TR IM 20+20		0		7	SFSB 40+20		75		7	SFSB+BGS+TR IM 20+20		0		7
		25	SAR	n/a	8	SFS 10+10		25		8	SFSB+BGS+TR IM 20+20		0		8	SFS+BGS+TR IM 20+20		0		8	SFSB +TRB 40+20		25		8	HYDROC+BGS+TR M 20+20		0		8
100	Subyearling Chinook	100	Dam Survival	n/a	9	SFSB 10+20	0	0		9	HYDROC+BGS+TR IM 20+20	0	0		9	HYDROC+BGS+TR IM 20+20	100	100		9	SFSB+TR IM 40+20	100	100		9	SFS+BGS+TR IM 20+20	0	0		9
		50	Forebay Retention	n/a	10	SFSB+TR IM 20+20		0		10	HYDROC+TR IM 40+20		0		10	SFS+TR IM 40+20		50		10	HYDROC+TR IM 40+20		50		10	HYDROC+TR IM 40+20		0		10
		75	Tailrace Egress	n/a				0					0					75					75					0		
		25	SAR	n/a				0					0					25					25					0		
75	Adults	100	Downstream Migrants	n/a			0	0				0	0				0	0				0	0				0	0		
		50	Upstream Migrants	n/a				0					0					0					0					0		
30	Timing	n/a					0					0					0					0					0			
50	Effects on Other Species and Life Stages	100	Lamprey				0	0				0	0				0	0				0	0				0	0		
			Adult	100					0					0					0					0					0	
			Juvenile	100					0					0					0					0					0	
50	Economics	100	Life Cycle Cost	n/a			0	0				0	0				0	0				0	0				100	100		
		100	Foregone Power	n/a				0					0					0					0					100		
25	TDG	n/a					0					0					0					0					0			

Table --- Model Sensitivities to Weights

Model Criteria Weights (Preliminary)

Level 1 wts		Level 2 wts		Level 3 wts	Ranking	Preliminary Model	Econ Rules	1 - wts	2- wts	3-wts	#	Timing Rules	1 - wts	2- wts	3-wts	#	Econ and Timing Rules	1 - wts	2- wts	3-wts	#	Other Species Rule	1 - wts	2- wts	3-wts	#	Adult Passage Rules	1 - wts
100	Yearling Chinook	100	Dam Survival	n/a	1	SFS 20+20	TR IM 0/10 10/10	0	0		1	CURRENT PROJECT 0/60 30/30	0	0		1	CURRENT PROJECT 0/60 30/30	0	0		1	SFS+BGS+TR IM 20 +20	0	0		1	SFS+BGS+TR IM 0+20	0
		50	Forebay Retention	n/a	2	SFSB 20+20	JBS OR+TR IM 0/10 10/10		0		2	ESBS 0/60 35/35		0		2	TR IM 0/10 10/10		0		2	SFSB+BGS+TR IM 20+20		0		2	SFS+BGS+TR IM 10+20	
		75	Tailrace Egress	n/a	3	SFS+TR IM 20+20	TR IM 0/20 10/15		0		3	TR IM 0/10 10/10		0		3	TR IM 0/20 10/15		0		3	HYDROC+BGS+TR IM 20+20		0		3	SFS+BGS+TR IM 20+20	
		25	SAR	n/a	4	SFS+BGS+TR IM 20+20	JBS OR+TR IM 0/20 10/15		0		4	TR IM 0/20 10/15		0		4	SFS 10+20		0		4	BGS+TR IM 0/10 10/10		0		4	SFS+BGS+TR IM 30+20	
100	Steelhead	100	Dam Survival	n/a	5	HYDROC+BGS+TR IM 20+20	BGS+TR IM 0/10 10/10	0	0		5	TR IM 0/25 15/25	0	0		5	TR IM 0/25 15/25	0	0		5	BGS+TR IM 0/20 10/15	0	0		5	SFS+BGS+TR IM 40+20	0
		50	Forebay Retention	n/a	6	SFS+BGS+TR IM 0+20	TR IM 0/25 15/25		0		6	TR IM 0/35 15/30		0		6	TR IM 0/35 15/30		0		6	BGS+TR IM 0/25 15/25		0		6	SFSB+BGS+TR IM 0+20	
		75	Tailrace Egress	n/a	7	HYDROC+BGS+TR IM 0+20	JBS OR+TR IM 0/25 15/25		0		7	TR IM 0/40 20/40		0		7	TR IM 0/40 20/40		0		7	BGS+TR IM 0/35 15/30		0		7	SFSB+BGS+TR IM 10+20	
		25	SAR	n/a	8	SFS 10+10	BGS+TR IM 0/20 10/15		0		8	TR IM 0/50 30/45		0		8	JBS OR 0/40 20/40		0		8	SFS+BGS+TR IM 30+20		0		8	SFSB+BGS+TR IM 20+20	
100	Subyearling Chinook	100	Dam Survival	n/a	9	SFSB 10+20	ESBS+TR IM 0/0 0/0	0	0		9	TR IM 0/60 35/55	0	0		9	SFSB 10+20	0	0		9	SFSB+BGS+TR IM 30+20	0	0		9	SFSB+BGS+TR IM 30+20	0
		50	Forebay Retention	n/a	10	SFSB+TR IM 20+20	TR IM 0/35 15/30		0		10	JBS OR 0/40 20/40		0		10	SFS 20+20		0		10	HYDROC+BGS+TR IM 30+20		0		10	SFSB+BGS+TR IM 40+20	
		75	Tailrace Egress	n/a					0					0					0					0				
		25	SAR	n/a					0					0					0					0				
75	Adults	100	Downstream Migrants	n/a				0	0				0	0				0	0				100	100				0
		50	Upstream Migrants	n/a					0					0					0					100				
30	Timing	n/a						100					100					0					0					0
50	Effects on Other Species and Life Stages	100	Lamprey					0	0				0	0				100	100				0	0				0
			Adult	100						0					0					100					0			
			Juvenile	100						0					0					100					0			
50	Economics	100	Life Cycle Cost	n/a				0	0				100	100				0	0				0	0				0
		100	Foregone Power	n/a					0					100					0					0				
25	TDG	n/a						0					0					0					0					100

Table --- Model Sensitivities to Weights

Model Criteria Weights (Preliminary)

Level 1 wts		Level 2 wts		Level 3 wts	Ranking	Preliminary Model	2- wts	3-wts	#	TDG Rules	1 - wts	2- wts	3-wts	#	Adult Pass & Other Species Rule	1 - wts	2- wts	3-wts	#	Prelim. and Econ Breakpoint (37)	1 - wts	2- wts	3-wts	#	Prelim. and Timing Breakpoint (25)	1 - wts	2- wts	3-wts	#
100	Yearling Chinook	100	Dam Survival	n/a	1	SFS 20+20	0		1	TR IM 0/10 10/10	0	0		1	SFS+BGS+TR IM 20+20	100	100		1	HYDROC+BGS+TR IM 20+20	100	100		1	SFS +BGS+TR IM 0+20	100	100		1
		50	Forebay Retention	n/a	2	SFSB 20+20	0		2	TR IM +TRB 0/10 10/10		0		2	SFSB+BGS+TR IM 20+20		50		2	SFS 20+20		50		2	SFS 20+20		50		2
		75	Tailrace Egress	n/a	3	SFS+TR IM 20+20	0		3	ESBS+TR IM 0		0		3	HYDROC+BGS+TR IM 20+20		75		3	SFSB 20+20		75		3	SFS+BGS+TR IM 20+20		75		3
		25	SAR	n/a	4	SFS+BGS+TR IM 20+20	0		4	ESBS+TR IM 0/5 5/5		0		4	SFS+BGS+TR IM 30+20		25		4	SFS+BGS+TR IM 20+20		25		4	SFSB 20+20		25		4
100	Steelhead	100	Dam Survival	n/a	5	HYDROC+BGS+TR IM 20+20	0		5	ESBS+TR IM 0/10 10/10	0	0		5	SFS+BGS+TR IM 40+20	100	100		5	HYDROC+BGS+TR IM 0+20	100	100		5	HYDROC+BGS+TR IM 0+20	100	100		5
		50	Forebay Retention	n/a	6	SFS+BGS+TR IM 0+20	0		6	BGS+TR IM 0/10 10/10		0		6	SFSB+BGS+TR IM 30+20		50		6	SFS+TR IM 20+20		50		6	HYDROC+BGS+TR IM 20+20		50		6
		75	Tailrace Egress	n/a	7	HYDROC+BGS+TR IM 0+20	0		7	JBS OR+TR IM 0/10 10/10		0		7	SFSB+BGS+TR IM 40+20		75		7	SFS+BGS+TR IM 0+20		75		7	SFS+TR IM 20+20		75		7
		25	SAR	n/a	8	SFS 10+10	0		8	ESBS+JBS OR+TRB 0/10 10/10		0		8	HYDROC+BGS+TR IM 30+20		25		8	SFSB+BGS+TR IM 20+20		25		8	SFSB+BGS+TR IM 0+20		25		8
100	Subyearling Chinook	100	Dam Survival	n/a	9	SFSB 10+20	0		9	ESBS+JBS OR+TR IM 0/5 5/5	0	0		9	HYDROC+BGS+TR IM 40+20	100	100		9	HYDROC+BGS+TR IM 10+10	100	100		9	SFS 10+10	100	100		9
		50	Forebay Retention	n/a	10	SFSB+TR IM 20+20	0		10	ESBS+JBS OR+TR IM 0/5 5/5		0		10	SFS 20+20		50		10	SBAY SPBYASS 10+10		50		10	SFS+BGS+TR IM 10+10		50		10
		75	Tailrace Egress	n/a			0					0					75					75					75		
		25	SAR	n/a			0					0					25					25					25		
75	Adults	100	Downstream Migrants	n/a			0				100	100				75	100				75	100				75	100		
		50	Upstream Migrants	n/a			0					100					50					50					50		
30	Timing	n/a														30	n/a				**25**	n/a				30	n/a		
50	Effects on Other Species and Life Stages	100	Lamprey				0				100	100				50	100				50	100				50	100		
			Adult	100				0					100					100					100					100	
			Juvenile	100				0					100					100					100					100	
50	Economics	100	Life Cycle Cost	n/a			0				0	0				**37**	100				50	100				50	100		
		100	Foregone Power	n/a			0					0					100					100					100		
25	TDG	n/a									0					25					25					**40**			

Table --- Model Sensitivities to Weights

Model Criteria Weights (Preliminary)

Level 1 wts		Level 2 wts		Level 3 wts	Ranking	Preliminary Model	Prelim. and TDG Breakpoint (40)	1 - wts	2- wts	3-wts	#	Prelim. and Other Species Breakpoint (30)	1 - wts	2- wts	3-wts
100	Yearling Chinook	100	Dam Survival	n/a	1	SFS 20+20	SFS+BGS+TR IM 0+20	100	100		1	SFS+BGS+TR IM 0+20	100	100	
		50	Forebay Retention	n/a	2	SFSB 20+20	SFS 20+20		50		2	SFS 20+20		50	
		75	Tailrace Egress	n/a	3	SFS+TR IM 20+20	HYDROC+BGS+TR IM 0+20		75		3	HYDROC+BGS+TR IM 0+20		75	
		25	SAR	n/a	4	SFS+BGS+TR IM 20+20	SFSB 20+20		25		4	SFS 10+20		25	
100	Steelhead	100	Dam Survival	n/a	5	HYDROC+BGS+TR IM 20+20	SFS 10+10	100	100		5	SFSB 20+20	100	100	
		50	Forebay Retention	n/a	6	SFS+BGS+TR IM 0+20	HYDROC+BGS+TR IM 20+20		50		6	SFSB 10+20		50	
		75	Tailrace Egress	n/a	7	HYDROC+BGS+TR IM 0+20	SFS+TR IM 20+20		75		7	SFS+TR IM 20+20		75	
		25	SAR	n/a	8	SFS 10+10	SFS+BGS+TR IM 20+20		25		8	SFS+TR IM 10+20		25	
100	Subyearling Chinook	100	Dam Survival	n/a	9	SFSB 10+20	SFSB 10+20	100	100		9	SFSB+BG+TR IM 0+20	100	100	
		50	Forebay Retention	n/a	10	SFSB+TR IM 20+20	SFSB+BGS+TR IM 0+20		50		10	HYDROC+BGS+TR IM 10+20		50	
		75	Tailrace Egress	n/a					75					75	
		25	SAR	n/a					25					25	
75	Adults	100	Downstream Migrants	n/a				75	100				75	100	
		50	Upstream Migrants	n/a					50					50	
30	Timing	n/a						30	n/a	.			30	n/a	
50	Effects on Other Species and Life Stages	100	Lamprey					**30**	100				50	100	
			Adult	100						100					100
			Juvenile	100						100					100
50	Economics	100	Life Cycle Cost	n/a				50	100				50	100	
		100	Foregone Power	n/a					100					100	
25	TDG	n/a						25					25		

[redacted]

Current Project (0/60 30/30)	95.7	3.6	0.5	0.5	75.2	96.2	3.8	0.5	0.5	75.1	89.1	2.3	0.5	0.5	60.2	0.5	0.5	0.5	0.5	64799000.0	[redacted]	0.0	0.0	0.8	83.4	85.3	64.9
ESBS (0/60 35/55)	96.0	3.6	0.5	0.5	76.1	96.6	3.9	0.5	0.5	76.4	95.1	2.5	0.6	0.4	83.7	0.5	0.6	0.5	0.5	101118000.0	[redacted]	3413536.0	45.0	0.8	85.1	87.8	88.0
SFS (10/10 10/10) +20 kcfs	94.6	3.7	0.7	0.7	54.6	95.0	4.2	0.7	0.7	52.7	89.5	2.2	0.7	0.7	58.1	0.7	0.6	0.5	0.5	44965000.0	[redacted]	2966447.0	78.0	0.2	73.1	74.7	66.1
SFS (20/20 20/20) +20 kcfs	95.3	3.5	0.7	0.7	64.8	95.6	3.9	0.7	0.7	62.3	91.5	2.2	0.7	0.7	67.7	0.7	0.6	0.9	0.5	69218000.0	[redacted]	2966447.0	78.0	0.3	79.1	79.9	73.9
SFS (30/30 30/30) +20 kcfs	96.0	3.6	0.7	0.7	73.4	96.1	3.8	0.7	0.7	70.6	93.1	2.4	0.7	0.7	75.7	0.7	0.6	0.8	0.5	89736000.0	[redacted]	2966447.0	78.0	0.5	84.2	84.3	80.4
SFS (40/40 40/40) +20 kcfs	96.5	3.8	0.7	0.7	80.5	96.6	3.9	0.7	0.7	77.7	94.4	2.5	0.7	0.7	82.2	0.7	0.6	0.7	0.6	102687000.0	[redacted]	2966447.0	78.0	1.0	88.5	88.1	85.6
SFSB (10/10 10/10) +20 kcfs	97.2	3.6	0.7	0.7	54.6	97.5	4.1	0.7	0.7	52.6	93.5	1.8	0.7	0.7	58.1	0.7	0.6	0.5	0.5	44965000.0	[redacted]	8480304.0	78.0	0.2	73.1	74.6	66.1
SFSB (20/20 20/20) +20 kcfs	97.3	3.4	0.7	0.7	64.8	97.6	3.7	0.7	0.7	62.3	94.5	1.9	0.7	0.7	67.6	0.7	0.6	0.9	0.5	69218000.0	[redacted]	8480304.0	78.0	0.3	79.2	79.8	73.9
SFSB (30/30 30/30) +20 kcfs	97.5	3.5	0.7	0.7	73.4	97.7	3.6	0.7	0.7	70.6	95.4	2.0	0.7	0.7	75.7	0.7	0.6	0.8	0.5	89736000.0	[redacted]	8480304.0	78.0	0.5	84.3	84.3	80.4
SFSB (40/40 40/40) +20 kcfs	97.6	3.7	0.7	0.7	80.5	97.7	3.8	0.7	0.7	77.6	96.1	2.1	0.7	0.7	82.3	0.7	0.6	0.7	0.6	102687000.0	[redacted]	8480304.0	78.0	1.0	88.4	88.0	85.7
Hydrocombine (30/30 30/30) +20 kcfs	96.5	3.5	0.7	0.7	73.4	96.4	3.6	0.7	0.7	70.6	94.8	2.0	0.7	0.7	75.6	0.7	0.6	0.8	0.5	81777000.0	[redacted]	12803773.0	94.0	0.5	84.2	84.2	80.3
Hydrocombine (40/40 40/40) +20 kcfs	96.9	3.7	0.7	0.7	80.5	96.8	3.7	0.7	0.7	77.6	95.7	2.1	0.7	0.7	82.3	0.7	0.6	0.7	0.6	94995000.0	[redacted]	12803773.0	94.0	1.0	88.5	88.0	85.7
JBS Outfall Relocation (0/40 20/40)	95.8	3.3	0.4	0.6	63.7	96.7	3.8	0.4	0.6	64.5	90.9	2.3	0.5	0.5	66.1	0.5	0.5	0.7	0.4	55106000.0	[redacted]	782061.0	46.0	0.2	75.7	79.1	70.1
JBS Outfall Relocation (0/50 30/45)	96.2	3.4	0.5	0.5	69.9	96.9	3.7	0.5	0.5	70.2	92.3	2.4	0.5	0.4	73.1	0.5	0.5	0.6	0.4	69434000.0	[redacted]	782061.0	46.0	0.4	79.8	82.5	76.2
JBS Outfall Relocation (0/60 35/55)	96.4	3.6	0.5	0.5	75.1	97.1	3.9	0.5	0.5	75.1	94.0	2.5	0.6	0.4	81.1	0.5	0.5	0.6	0.6	80802000.0	[redacted]	782061.0	46.0	0.8	83.3	85.3	83.3
Tailrace Improvements (0/10 10/10)	96.1	3.6	0.3	0.7	39.3	97.0	4.2	0.3	0.7	42.8	89.5	2.0	0.3	0.6	31.2	0.5	0.5	0.9	0.4	16793000.0	[redacted]	1696490.0	45.0	0.0	59.4	66.4	39.3
Tailrace Improvements (0/20 10/15)	96.4	3.3	0.4	0.6	48.4	97.1	3.9	0.4	0.6	50.9	90.2	1.9	0.3	0.6	37.2	0.5	0.5	0.9	0.4	24602000.0	[redacted]	1696490.0	45.0	0.1	65.5	71.2	44.6
Tailrace Improvements (0/25 15/25)	96.5	3.2	0.4	0.6	52.6	97.2	3.7	0.4	0.6	54.5	91.8	1.9	0.4	0.5	50.3	0.5	0.5	0.8	0.4	36199000.0	[redacted]	1696490.0	45.0	0.1	68.2	73.2	56.2
Tailrace Improvements (0/35 15/30)	96.8	3.2	0.4	0.6	60.2	97.3	3.5	0.4	0.6	61.3	92.4	1.9	0.4	0.5	55.3	0.5	0.5	0.8	0.5	43750000.0	[redacted]	1696490.0	45.0	0.2	73.3	77.3	60.5
Tailrace Improvements (0/40 20/40)	96.9	3.2	0.4	0.6	63.7	97.4	3.5	0.4	0.6	64.6	93.8	1.9	0.5	0.5	66.1	0.5	0.5	0.7	0.5	55106000.0	[redacted]	1696490.0	45.0	0.2	75.6	79.2	70.1
Tailrace Improvements (0/50 30/45)	97.1	3.3	0.5	0.5	69.9	97.5	3.6	0.5	0.5	70.2	94.7	2.0	0.5	0.4	73.0	0.5	0.5	0.6	0.4	69434000.0	[redacted]	1696490.0	45.0	0.4	79.9	82.6	76.2
Tailrace Improvements (0/60 35/55)	97.2	3.5	0.5	0.5	75.1	97.6	3.7	0.5	0.5	75.1	95.6	2.2	0.6	0.4	81.1	0.5	0.5	0.5	0.6	80802000.0	[redacted]	1696490.0	45.0	0.8	83.3	85.4	83.3
Turbine Improvements (0/60 35/55)	96.0	3.5	0.5	0.5	75.1	96.3	3.7	0.5	0.5	75.1	95.4	2.2	0.6	0.4	81.1	0.5	0.5	0.5	0.6	72675000.0	[redacted]	9689545.0	108.0	0.8	83.3	85.3	83.3
ESBS + JBS Outfall Relocation (0/25 15/25)	95.8	3.5	0.4	0.6	54.5	97.3	4.2	0.4	0.6	57.0	91.7	2.2	0.4	0.5	57.2	0.5	0.6	0.8	0.3	58740000.0	[redacted]	4195597.0	45-91	0.1	71.6	77.7	68.5
ESBS + JBS Outfall Relocation (0/35 15/30)	96.2	3.4	0.4	0.6	61.8	97.4	3.9	0.4	0.6	63.4	92.3	2.2	0.4	0.5	61.4	0.5	0.6	0.8	0.4	65922000.0	[redacted]	4195597.0	45-91	0.2	76.2	81.0	71.6
ESBS + JBS Outfall Relocation (0/40 20/40)	96.4	3.4	0.4	0.6	65.2	97.5	3.9	0.4	0.6	66.4	93.7	2.3	0.5	0.5	70.7	0.5	0.6	0.7	0.4	76707000.0	[redacted]	4195597.0	45-91	0.2	78.3	82.6	78.5
ESBS + JBS Outfall Relocation (0/50 30/45)	96.7	3.5	0.5	0.5	71.1	97.5	3.9	0.5	0.5	71.8	94.6	2.4	0.5	0.4	76.7	0.5	0.6	0.6	0.4	90322000.0	[redacted]	4195597.0	45-91	0.4	81.9	85.4	82.9
ESBS + JBS Outfall Relocation (0/60 35/55)	96.9	3.6	0.5	0.5	76.1	97.6	3.9	0.5	0.5	76.4	95.6	2.5	0.6	0.4	83.7	0.5	0.6	0.5	0.5	101118000.0	[redacted]	4195597.0	45-91	0.8	85.1	87.7	88.0
ESBS + Turbine Improvements (0/50 30/45)	95.9	3.4	0.5	0.5	71.1	96.4	3.7	0.5	0.5	71.8	95.1	2.0	0.5	0.4	76.8	0.5	0.6	0.6	0.4	61079000.0	[redacted]	13103081.0	108-153	0.4	82.0	85.3	83.0
ESBS + Turbine Improvements (0/60 35/55)	96.2	3.6	0.5	0.5	76.2	96.6	3.8	0.5	0.5	76.5	96.0	2.1	0.6	0.4	83.6	0.5	0.6	0.5	0.5	72675000.0	[redacted]	13103081.0	108-153	0.8	85.2	87.9	87.9
SFS + Turbine Improvements (30/30 30/30) +20 kcfs	96.2	3.5	0.6	0.7	73.4	96.2	3.7	0.6	0.7	70.6	94.8	2.0	0.6	0.7	75.7	0.7	0.6	0.8	0.5	81777000.0	[redacted]	12655992.0	108-156	0.5	84.2	84.3	80.4
SFS + Turbine Improvements (40/40 40/40) +20 kcfs	96.6	3.8	0.6	0.7	80.5	96.6	3.8	0.6	0.7	77.6	95.7	2.1	0.6	0.7	82.3	0.7	0.6	0.7	0.6	94995000.0	[redacted]	12655992.0	108-156	1.0	88.5	88.0	85.7
SFSB + Turbine Improvements (10/10 10/10) +20 kcfs	97.1	3.4	0.7	0.7	54.7	97.5	4.1	0.7	0.7	52.7	93.4	1.8	0.7	0.7	58.0	0.7	0.6	0.5	0.5	36118000.0	[redacted]	18169849.0	108-186	0.2	73.2	74.7	66.1
SFSB + Turbine Improvements (20/20 20/20) +20 kcfs	97.3	3.4	0.7	0.7	64.8	97.6	3.7	0.7	0.7	62.2	94.5	1.9	0.7	0.7	67.6	0.7	0.6	0.9	0.5	60850000.0	[redacted]	18169849.0	108-186	0.3	79.2	79.8	73.9
SFSB + Turbine Improvements (30/30 30/30) +20 kcfs	97.5	3.5	0.7	0.7	73.4	97.7	3.7	0.7	0.7	70.6	95.4	2.0	0.7	0.7	75.7	0.7	0.6	0.8	0.5	81777000.0	[redacted]	18169849.0	108-186	0.5	84.3	84.3	80.3
SFSB + Turbine Improvements (40/40 40/40) +20 kcfs	97.6	3.8	0.7	0.7	80.5	97.8	3.8	0.7	0.7	77.5	96.1	2.1	0.7	0.7	82.3	0.7	0.6	0.7	0.6	94995000.0	[redacted]	18169849.0	108-186	1.0	88.5	87.9	85.7
Hydrocombine + Turbine Improvements (30/30 30/30) +20 kcfs	96.5	3.5	0.7	0.7	73.4	96.4	3.6	0.7	0.7	70.7	94.8	2.0	0.7	0.7	75.6	0.7	0.6	0.8	0.5	81777000.0	[redacted]	22493318.0	108-202	0.5	84.3	84.3	80.3
Hydrocombine + Turbine Improvements (40/40 40/40) +20 kcfs	96.9	3.7	0.7	0.7	80.5	96.8	3.7	0.7	0.7	77.6	95.7	2.1	0.7	0.7	82.3	0.7	0.6	0.7	0.6	94995000.0	[redacted]	22493318.0	108-202	1.0	88.4	88.1	85.7
BGS + Turbine Improvements (0/60 35/55)	96.0	3.6	0.6	0.5	75.1	96.5	3.7	0.6	0.5	75.1	95.4	2.1	0.7	0.4	81.0	0.8	0.4	0.5	0.7	72675000.0	[redacted]	12987179.0	110-218	0.8	83.3	85.4	83.2
JBS Outfall Relocation + Turbine Improvements (0/35 15/30)	96.0	3.3	0.4	0.6	60.3	96.8	3.7	0.4	0.6	61.4	92.4	1.9	0.4	0.5	55.2	0.5	0.5	0.8	0.5	34882000.0	[redacted]	10471606.0	108-154	0.2	73.4	77.4	60.5
JBS Outfall Relocation + Turbine Improvements (0/40 20/40)	96.2	3.3	0.4	0.6	63.7	96.9	3.6	0.4	0.6	64.4	93.8	2.0	0.5	0.5	66.2	0.5	0.5	0.7	0.5	46466000.0	[redacted]	10471606.0	108-154	0.2	75.6	79.1	70.2
JBS Outfall Relocation + Turbine Improvements (0/50 30/45)	96.5	3.4	0.5	0.5	69.9	97.1	3.6	0.5	0.5	70.2	94.6	2.0	0.5	0.4	73.0	0.5	0.5	0.6	0.4	61079000.0	[redacted]	10471606.0	108-154	0.4	79.8	82.5	76.2
JBS Outfall Relocation + Turbine Improvements (0/60 35/55)	96.8	3.5	0.5	0.5	75.1	97.3	3.7	0.5	0.5	75.2	95.6	2.2	0.6	0.4	81.1	0.5	0.5	0.5	0.6	72675000.0	[redacted]	10471606.0	108-154	0.8	83.3	85.4	83.3
Tailrace Improvements + Turbine Improvements (0/10 10/10)	96.1	3.6	0.3	0.7	39.2	97.0	4.2	0.3	0.7	42.8	89.4	2.0	0.3	0.6	31.3	0.5	0.5	0.9	0.4	7390000.0	[redacted]	11386035.0	108-153	0.0	59.3	66.3	39.3
Tailrace Improvements + Turbine Improvements (0/20 10/15)	96.4	3.4	0.4	0.6	48.4	97.1	3.8	0.4	0.6	50.8	90.2	2.0	0.3	0.6	37.2	0.5	0.5	0.9	0.4	15355000.0	[redacted]	11386035.0	108-153	0.1	65.5	71.1	44.6
Tailrace Improvements + Turbine Improvements (0/25 15/25)	96.6	3.3	0.4	0.6	52.6	97.2	3.7	0.4	0.6	54.5	91.8	1.9	0.4	0.5	50.4	0.5	0.5	0.8	0.4	27182000.0	[redacted]	11386035.0	108-153	0.1	68.2	73.3	56.2
Tailrace Improvements + Turbine Improvements (0/35 15/30)	96.8	3.1	0.4	0.6	60.2	97.3	3.5	0.4	0.6	61.4	92.4	1.9	0.4	0.5	55.3	0.5	0.5	0.8	0.5	34882000.0	[redacted]	11386035.0	108-153	0.2	73.3	77.3	60.6
Tailrace Improvements + Turbine Improvements (0/40 20/40)	96.9	3.2	0.4	0.6	63.7	97.3	3.5	0.4	0.6	64.5	93.8	2.0	0.5	0.5	66.1	0.5	0.5	0.7	0.5	46466000.0	[redacted]	11386035.0	108-153	0.2	75.7	79.2	70.1
Tailrace Improvements + Turbine Improvements (0/50 30/45)	97.0	3.3	0.5	0.5	69.9	97.5	3.5	0.5	0.5	70.2	94.6	2.1	0.5	0.4	73.1	0.5	0.5	0.6	0.5	61079000.0	[redacted]	11386035.0	108-153	0.4	79.8	82.5	76.2
Tailrace Improvements + Turbine Improvements (0/60 35/55)	97.2	3.5	0.5	0.5	75.1	97.6	3.6	0.5	0.5	75.1	95.6	2.2	0.6	0.4	81.0	0.5	0.5	0.5	0.6	72675000.0	[redacted]	11386035.0	108-153	0.8	83.3	85.4	83.3
ESBS + Tailrace Improvements (0/0 0/0)	96.4	4.4	0.3	0.7	32.0	97.5	5.2	0.3	0.7	37.6	91.1	1.9	0.3	0.6	24.8	0.5	0.6	1.0	0.5	24346000.0	[redacted]	5110026.0	45-90	0.0	57.6	67.7	44.7
ESBS + Tailrace Improvements (0/5 5/5)	96.6	4.2	0.3	0.7	36.9	97.5	4.9	0.3	0.7	41.8	91.8	1.9	0.3	0.6	33.1	0.5	0.6	0.5	0.3	32113000.0	[redacted]	5110026.0	45-90	0.0	60.7	69.9	50.7
ESBS + Tailrace Improvements (0/10 10/10)	96.6	3.9	0.3	0.7	41.7	97.6	4.6	0.3	0.7	45.8	92.5	1.8	0.3	0.6	40.7	0.5	0.6	0.9	0.3	40299000.0	[redacted]	5110026.0	45-90	0.0	63.7	71.9	56.3
ESBS + Tailrace Improvements (0/20 10/15)	96.8	3.5	0.4	0.6	50.4	97.6	4.1	0.4	0.6	53.5	93.0	1.8	0.3	0.6	45.8	0.5	0.6	0.9	0.3	47721000.0	[redacted]	5110026.0	45-90	0.1	69.1	76.0	60.1
ESBS + Tailrace Improvements (0/25 15/25)	96.9	3.4	0.4	0.6	54.5	97.6	3.9	0.4	0.6	57.0	94.0	1.8	0.4	0.5	57.1	0.5	0.6	0.8	0.3	58740000.0	[redacted]	5110026.0	45-90	0.1	71.6	77.7	68.4
ESBS + Tailrace Improvements (0/35 15/30)	97.1	3.3	0.4	0.6	61.8	97.7	3.8	0.4	0.6	63.4	94.4	1.8	0.4	0.5	61.4	0.5	0.6	0.8	0.4	65922000.0	[redacted]	5110026.0	45-90	0.2	76.2	81.0	71.6
ESBS + Tailrace Improvements (0/40 20/40)	97.2	3.4	0.4	0.6	65.1	97.7	3.7	0.4	0.6	66.4	95.3	1.9	0.5	0.5	70.7	0.5	0.6	0.7	0.4	76707000.0	[redacted]	5110026.0	45-90	0.2	78.2	82.5	78.4
ESBS + Tailrace Improvements (0/50 30/45)	97.3	3.4	0.5	0.5	71.1	97.8	3.7	0.5	0.5	71.9	95.8	2.0	0.5	0.4	76.7	0.5	0.6	0.6	0.4	90322000.0	[redacted]	5110026.0	45-90	0.4	82.0	85.5	82.9
ESBS + Tailrace Improvements (0/60 35/55)	97.4	3.6	0.5	0.5	76.1	97.8	3.7	0.5	0.5	76.5	96.5	2.2	0.6	0.4	83.7	0.5	0.6	0.5	0.5	101118000.0	[redacted]	5110026.0	45-90	0.8	85.1	87.8	88.1
SFS + Tailrace Improvements (10/10 10/10) +20 kcfs	97.2	3.6	0.7	0.7	54.6	97.5	4.1	0.7	0.7	52.7	93.5	1.8	0.7	0.7	58.0	0.7	0.6	0.5	0.5	44965000.0	[redacted]	4662937.0	78-123	0.2	73.2	74.7	66.1
SFS + Tailrace Improvements (20/20 20/20) +20 kcfs	97.4	3.4	0.7	0.7	64.8	97.6	3.7	0.7	0.7	62.3	94.5	1.9	0.7	0.7	67.7	0.7	0.6	0.9	0.5	69218000.0	[redacted]	4662937.0	78-123	0.3	79.2	79.8	73.9
SFS + Tailrace Improvements (30/30 30/30) +20 kcfs	97.5	3.5	0.7	0.7	73.4	97.7	3.6	0.7	0.7	70.6	95.4	2.0	0.7	0.7	75.7	0.7	0.6	0.8	0.5	89736000.0	[redacted]	4662937.0	78-123	0.5	84.3	84.3	80.3
SFS + Tailrace Improvements (40/40 40/40) +20 kcfs	97.7	3.7	0.7	0.7	80.5	97.7	3.7	0.7	0.7	77.6	96.1	2.1	0.7	0.7	82.2	0.7	0.6	0.7	0.6	102687000.0	[redacted]	4662937.0	78-123	1.0	88.4	88.0	85.7
SFSB + Tailrace Improvements (10/10 10/10) +20 kcfs	97.2	3.6	0.7	0.7	54.6	97.5	4.1	0.7	0.7	52.7	93.5	1.8	0.7	0.7	58.1	0.7	0.6	0.5	0.5	44965000.0	[redacted]	10176794.0	78-123	0.2	73.1	74.7	66.1
SFSB + Tailrace Improvements (20/20 20/20) +20 kcfs	97.4	3.4	0.7	0.7	64.8	97.6	3.7	0.7	0.7	62.3	94.5	1.9	0.7	0.7	67.6	0.7	0.6	0.9	0.5	69218000.0	[redacted]	10176794.0	78-123	0.3	79.2	79.9	73.8
SFSB + Tailrace Improvements (30/30 30/30) +20 kcfs	97.4	3.5	0.7	0.7	73.4	97.7	3.6	0.7	0.7	70.6	95.4	2.0	0.7	0.7	75.7	0.7	0.6	0.8	0.5	89736000.0	[redacted]	10176794.0	78-123	0.5	84.3	84.2	80.4
SFSB + Tailrace Improvements (40/40 40/40) +20 kcfs	97.6	3.7	0.7	0.7	80.5	97.8	3.7	0.7	0.7	77.6	96.1	2.2	0.7	0.7	82.3	0.7	0.6	0.7	0.6	102687000.0	[redacted]	10176794.0	78-123	1.0	88.4	88.0	85.7
Hydrocombine + Tailrace Improvements (10/10 10/10) +20 kcfs	97.2	3.6	0.7	0.7	54.6	97.5	4.1	0.7	0.7	52.6	93.5	1.8	0.7	0.7	58.0	0.7	0.6	0.5	0.5	36118000.0	[redacted]	14500263.0	94-139	0.2	73.1	74.6	66.1
Hydrocombine + Tailrace Improvements (20/20 20/20) +20 kcfs	97.3	3.4	0.7	0.7	64.8	97.6	3.7	0.7	0.7	62.3	94.5	1.9	0.7	0.7	67.7	0.7	0.6	0.9	0.5	60850000.0	[redacted]	14500263.0	94-139	0.3	79.1	79.8	73.9
Hydrocombine + Tailrace Improvements (30/30 30/30) +20 kcfs	97.5	3.5	0.7	0.7	73.4	97.7	3.6	0.7	0.7	70.5	95.4	2.0	0.7	0.7	75.6	0.7	0.6	0.8	0.5	81777000.0	[redacted]	14500263.0	94-139	0.5	84.2	84.2	80.3
Hydrocombine + Tailrace Improvements (40/40 40/40) +20 kcfs	97.7	3.7	0.7	0.7	80.5	97.8	3.8	0.7	0.7	77.7	96.1	2.2	0.7	0.7	82.3	0.7	0.6	0.7	0.6	94995000.0	[redacted]	14500263.0	94-139	1.0	88.5	88.1	85.7
BGS + Tailrace Improvements (0/10 10/10)	96.2	3.6	0.4	0.7	39.3	97.0	4.2	0.4	0.7	42.8	89.4	2.0	0.4	0.6	31.3	0.5	0.4	0.9	0.5	16793000.0	[redacted]	4994124.0	110-135	0.0	59.3	66.3	39.4
BGS + Tailrace Improvements (0/20 10/15)	96.4	3.3	0.5	0.6	48.5	97.1	3.8	0.5	0.6	50.8	90.2	2.0	0.4	0.6	37.2	0.5	0.4	0.9	0.5	24602000.0	[redacted]	4994124.0	110-135	0.1	65.5	71.1	44.5
BGS + Tailrace Improvements (0/25 15/25)	96.6	3.3	0.5	0.6	52.6	97.2	3.7	0.5	0.6	54.6	91.8	1.9	0.5	0.5	50.3	0.6	0.4	0.8	0.5	36199000.0	[redacted]	4994124.0	110-135	0.1	68.2	73.4	56.2
BGS + Tailrace Improvements (0/35 15/30)	96.8	3.2	0.5	0.6	60.2	97.3	3.6	0.5	0.6	61.3	92.5	1.9	0.5	0.5	55.3	0.6	0.4	0.8	0.6	43750000.0	[redacted]	4994124.0	110-135	0.2	73.4	77.3	60.5
BGS + Tailrace Improvements (0/40 20/40)	96.9	3.2	0.5	0.6	63.7	97.3	3.5	0.5	0.6	64.5	93.8	1.9	0.6	0.5	66.1	0.7	0.4	0.7	0.6	55106000.0	[redacted]	4994124.0	110-135	0.2	75.7	79.2	70.1
BGS + Tailrace Improvements (0/50 30/45)	97.1	3.3	0.6	0.5	69.9	97.5	3.5	0.6	0.5	70.1	94.6	2.0	0.6	0.4	73.1	0.7	0.4	0.6	0.6	69434000.0	[redacted]	4994124.0	110-135	0.4	79.9	82.4	76.2
BGS + Tailrace Improvements (0/60 35/55)	97.2	3.5	0.6	0.5	75.1	97.5	3.6	0.6	0.5	75.1	95.6	2.2	0.7	0.4	81.1	0.8	0.4	0.5	0.7	80802000.0	[redacted]	4994124.0	110-135	0.8	83.3	85.4	83.3

[redacted]

JBS Outfall Relocation + Tailrace Improvements (0/10 10/10)	96.1	3.6	0.3	0.7	39.3	97.0	4.2	0.3	0.7	42.7	89.4	2.0	0.3	0.6	31.2	0.5	0.5	0.9	0.4	16793000.0	[redacted]	2478551.0	46-91	0.0	59.3	66.3	39.3
JBS Outfall Relocation + Tailrace Improvements (0/20 10/15)	96.5	3.3	0.4	0.6	48.4	97.1	3.8	0.4	0.6	50.8	90.2	2.0	0.3	0.6	37.3	0.5	0.5	0.9	0.4	24602000.0	[redacted]	2478551.0	46-91	0.1	65.4	71.1	44.6
JBS Outfall Relocation + Tailrace Improvements (0/25 15/25)	96.6	3.2	0.4	0.6	52.6	97.2	3.7	0.4	0.6	54.5	91.9	1.9	0.4	0.5	50.4	0.5	0.5	0.8	0.4	36199000.0	[redacted]	2478551.0	46-91	0.1	68.2	73.2	56.2
JBS Outfall Relocation + Tailrace Improvements (0/35 15/30)	96.8	3.2	0.4	0.6	60.2	97.3	3.5	0.4	0.6	61.3	92.4	1.9	0.4	0.5	55.3	0.5	0.5	0.8	0.5	43750000.0	[redacted]	2478551.0	46-91	0.2	73.3	77.2	60.5
JBS Outfall Relocation + Tailrace Improvements (0/40 20/40)	96.9	3.2	0.4	0.6	63.7	97.4	3.5	0.4	0.6	64.5	93.8	1.9	0.5	0.5	66.2	0.5	0.5	0.7	0.5	55106000.0	[redacted]	2478551.0	46-91	0.2	75.7	79.1	70.1
JBS Outfall Relocation + Tailrace Improvements (0/50 30/45)	97.0	3.3	0.5	0.5	69.9	97.4	3.5	0.5	0.5	70.1	94.7	2.0	0.5	0.4	73.0	0.5	0.5	0.6	0.5	69434000.0	[redacted]	2478551.0	46-91	0.4	79.8	82.4	76.2
JBS Outfall Relocation + Tailrace Improvements (0/60 35/55)	97.2	3.5	0.5	0.5	75.1	97.6	3.6	0.5	0.5	75.2	95.6	2.2	0.6	0.4	81.1	0.5	0.5	0.5	0.6	80802000.0	[redacted]	2478551.0	46-91	0.8	83.3	85.4	83.3
ESBS + JBS Outfall Relocation + Turbine Improvements (0/10 10/10)	95.8	4.0	0.3	0.7	41.7	97.3	4.7	0.3	0.7	45.9	92.5	1.8	0.3	0.6	40.7	0.5	0.6	0.9	0.3	7390000.0	[redacted]	13885142.0	108-199	0.0	63.7	72.0	56.4
ESBS + JBS Outfall Relocation + Turbine Improvements (0/20 10/15)	96.1	3.6	0.4	0.6	50.4	97.4	4.3	0.4	0.6	53.5	93.0	1.8	0.3	0.6	45.9	0.5	0.6	0.9	0.3	15355000.0	[redacted]	13885142.0	108-199	0.1	69.1	76.0	60.2
ESBS + JBS Outfall Relocation + Turbine Improvements (0/25 15/25)	96.2	3.5	0.4	0.6	54.5	97.5	4.1	0.4	0.6	56.9	94.1	1.8	0.4	0.5	57.1	0.5	0.6	0.8	0.3	27182000.0	[redacted]	13885142.0	108-199	0.1	71.6	77.7	68.4
ESBS + JBS Outfall Relocation + Turbine Improvements (0/35 15/30)	96.5	3.4	0.4	0.6	61.8	97.5	3.9	0.4	0.6	63.4	94.4	1.8	0.4	0.5	61.4	0.5	0.6	0.8	0.4	34882000.0	[redacted]	13885142.0	108-199	0.2	76.2	81.0	71.6
ESBS + JBS Outfall Relocation + Turbine Improvements (0/40 20/40)	96.7	3.4	0.4	0.6	65.2	97.6	3.8	0.4	0.6	66.4	95.3	1.9	0.5	0.5	70.8	0.5	0.6	0.7	0.4	46466000.0	[redacted]	13885142.0	108-199	0.2	78.3	82.5	78.5
ESBS + JBS Outfall Relocation + Turbine Improvements (0/50 30/45)	96.9	3.5	0.5	0.5	71.1	97.7	3.8	0.5	0.5	71.9	95.8	2.0	0.5	0.4	76.7	0.5	0.6	0.6	0.4	61079000.0	[redacted]	13885142.0	108-199	0.4	82.0	85.5	82.9
ESBS + JBS Outfall Relocation + Turbine Improvements (0/60 35/55)	97.1	3.6	0.5	0.5	76.1	97.7	3.8	0.5	0.5	76.5	96.5	2.2	0.6	0.4	83.7	0.5	0.6	0.5	0.5	72675000.0	[redacted]	13885142.0	108-199	0.8	85.1	87.8	88.0
ESBS + JBS Outfall Relocation + Tailrace Improvements (0/0 0/0)	96.4	4.4	0.3	0.7	32.0	97.5	5.2	0.3	0.7	37.6	91.1	1.9	0.3	0.6	24.8	0.5	0.6	1.0	0.5	24346000.0	[redacted]	5892087.0	46-136	0.0	57.6	67.7	44.6
ESBS + JBS Outfall Relocation + Tailrace Improvements (0/5 5/5)	96.5	4.2	0.3	0.7	37.0	97.5	4.9	0.3	0.7	41.8	91.8	1.9	0.3	0.6	33.1	0.5	0.6	0.5	0.3	32113000.0	[redacted]	5892087.0	46-136	0.0	60.7	69.8	50.8
ESBS + JBS Outfall Relocation + Tailrace Improvements (0/10 10/10)	96.6	3.9	0.3	0.7	41.7	97.6	4.6	0.3	0.7	45.9	92.5	1.8	0.3	0.6	40.7	0.5	0.6	0.9	0.3	40299000.0	[redacted]	5892087.0	46-136	0.0	63.6	72.0	56.4
ESBS + JBS Outfall Relocation + Tailrace Improvements (0/20 10/15)	96.8	3.5	0.4	0.6	50.5	97.6	4.1	0.4	0.6	53.5	93.0	1.8	0.3	0.6	45.9	0.5	0.6	0.9	0.3	47721000.0	[redacted]	5892087.0	46-136	0.1	69.1	75.9	60.1
ESBS + JBS Outfall Relocation + Tailrace Improvements (0/25 15/25)	96.9	3.4	0.4	0.6	54.4	97.7	4.0	0.4	0.6	57.0	94.0	1.8	0.4	0.5	57.1	0.5	0.6	0.8	0.3	58740000.0	[redacted]	5892087.0	46-136	0.1	71.6	77.7	68.4
ESBS + JBS Outfall Relocation + Tailrace Improvements (0/35 15/30)	97.1	3.3	0.4	0.6	61.8	97.7	3.7	0.4	0.6	63.5	94.4	1.8	0.4	0.5	61.4	0.5	0.6	0.8	0.4	65922000.0	[redacted]	5892087.0	46-136	0.2	76.2	81.1	71.6
ESBS + JBS Outfall Relocation + Tailrace Improvements (0/40 20/40)	97.2	3.3	0.4	0.6	65.1	97.8	3.7	0.4	0.6	66.4	95.3	1.9	0.5	0.5	70.8	0.5	0.6	0.7	0.4	76707000.0	[redacted]	5892087.0	46-136	0.2	78.3	82.6	78.5
ESBS + JBS Outfall Relocation + Tailrace Improvements (0/50 30/45)	97.3	3.4	0.5	0.5	71.1	97.8	3.7	0.5	0.5	71.8	95.9	2.0	0.5	0.4	76.7	0.5	0.6	0.6	0.4	90322000.0	[redacted]	5892087.0	46-136	0.4	82.0	85.4	82.9
ESBS + JBS Outfall Relocation + Tailrace Improvements (0/60 35/55)	97.5	3.6	0.5	0.5	76.1	97.8	3.7	0.5	0.5	76.5	96.5	2.2	0.6	0.4	83.6	0.5	0.6	0.5	0.5	101118000.0	[redacted]	5892087.0	46-136	0.8	85.1	87.9	87.9
SFS + BGS + Tailrace Improvements (0/0 0/0) +20 kcfs	97.0	4.1	0.8	0.7	42.7	97.4	4.8	0.8	0.7	41.5	92.3	1.8	0.8	0.7	46.8	0.9	0.5	1.0	0.8	21420000.0	[redacted]	7960571.0	110-233	0.1	66.0	68.7	57.0
SFS + BGS + Tailrace Improvements (10/10 10/10) +20 kcfs	97.2	3.6	0.8	0.7	54.6	97.5	4.1	0.8	0.7	52.7	93.5	1.8	0.8	0.7	58.1	0.9	0.5	0.5	0.6	44965000.0	[redacted]	7960571.0	110-233	0.2	73.1	74.7	66.1
SFS + BGS + Tailrace Improvements (20/20 20/20) +20 kcfs	97.3	3.4	0.8	0.7	64.8	97.6	3.7	0.8	0.7	62.3	94.5	1.9	0.8	0.7	67.6	0.9	0.5	0.9	0.6	69218000.0	[redacted]	7960571.0	110-233	0.3	79.1	79.8	73.8
SFS + BGS + Tailrace Improvements (30/30 30/30) +20 kcfs	97.5	3.5	0.8	0.7	73.4	97.7	3.6	0.8	0.7	70.6	95.4	2.0	0.8	0.7	75.7	0.9	0.5	0.8	0.6	89736000.0	[redacted]	7960571.0	110-233	0.5	84.3	84.3	80.4
SFS + BGS + Tailrace Improvements (40/40 40/40) +20 kcfs	97.7	3.7	0.8	0.7	80.5	97.8	3.7	0.8	0.7	77.6	96.1	2.2	0.8	0.7	82.3	0.9	0.5	0.7	0.7	102687000.0	[redacted]	7960571.0	110-233	1.0	88.5	88.0	85.7
SFSB + BGS + Tailrace Improvements (0/0 0/0) +20 kcfs	96.9	4.1	0.8	0.7	42.7	97.5	4.8	0.8	0.7	41.5	92.2	1.8	0.8	0.7	46.8	0.9	0.5	1.0	0.8	21420000.0	[redacted]	13474428.0	110-233	0.1	66.1	68.7	57.0
SFSB + BGS + Tailrace Improvements (10/10 10/10) +20 kcfs	97.1	3.6	0.8	0.7	54.6	97.5	4.1	0.8	0.7	52.6	93.5	1.8	0.8	0.7	58.1	0.9	0.5	0.5	0.6	44965000.0	[redacted]	13474428.0	110-233	0.2	73.1	74.6	66.1
SFSB + BGS + Tailrace Improvements (20/20 20/20) +20 kcfs	97.4	3.4	0.8	0.7	64.8	97.6	3.7	0.8	0.7	62.3	94.5	1.9	0.8	0.7	67.6	0.9	0.5	0.9	0.6	69218000.0	[redacted]	13474428.0	110-233	0.3	79.2	79.8	73.8
SFSB + BGS + Tailrace Improvements (30/30 30/30) +20 kcfs	97.5	3.5	0.8	0.7	73.4	97.7	3.6	0.8	0.7	70.6	95.4	2.0	0.8	0.7	75.7	0.9	0.5	0.8	0.6	89736000.0	[redacted]	13474428.0	110-233	0.5	84.3	84.3	80.4
SFSB + BGS + Tailrace Improvements (40/40 40/40) +20 kcfs	97.6	3.7	0.8	0.7	80.5	97.8	3.7	0.8	0.7	77.6	96.1	2.1	0.8	0.7	82.2	0.9	0.5	0.7	0.7	102687000.0	[redacted]	13474428.0	110-233	1.0	88.4	88.0	85.7
Hydrocombine + BGS + Tailrace Improvements (0/0 0/0) +20 kcfs	96.9	4.1	0.8	0.7	42.7	97.4	4.8	0.8	0.7	41.5	92.3	1.8	0.8	0.7	46.8	0.9	0.5	1.0	0.8	12109000.0	[redacted]	17797897.0	110-155	0.1	66.0	68.8	57.0
Hydrocombine + BGS + Tailrace Improvements (10/10 10/10) +20 kcfs	97.1	3.6	0.8	0.7	54.6	97.5	4.1	0.8	0.7	52.6	93.5	1.8	0.8	0.7	58.1	0.9	0.5	0.5	0.6	36118000.0	[redacted]	17797897.0	110-155	0.2	73.1	74.6	66.2
Hydrocombine + BGS + Tailrace Improvements (20/20 20/20) +20 kcfs	97.3	3.4	0.8	0.7	64.8	97.6	3.7	0.8	0.7	62.3	94.5	1.9	0.8	0.7	67.7	0.9	0.5	0.9	0.6	60850000.0	[redacted]	17797897.0	110-155	0.3	79.2	79.8	73.9
Hydrocombine + BGS + Tailrace Improvements (30/30 30/30) +20 kcfs	97.5	3.5	0.8	0.7	73.4	97.7	3.6	0.8	0.7	70.6	95.4	2.0	0.8	0.7	75.7	0.9	0.5	0.8	0.6	81777000.0	[redacted]	17797897.0	110-155	0.5	84.2	84.3	80.4
Hydrocombine + BGS + Tailrace Improvements (40/40 40/40) +20 kcfs	97.6	3.7	0.8	0.7	80.5	97.8	3.7	0.8	0.7	77.5	96.1	2.1	0.8	0.7	82.3	0.9	0.5	0.7	0.7	94995000.0	[redacted]	17797897.0	110-155	1.0	88.4	87.9	85.7
ESBS + Turbine Improvements + Tailrace Improvements (0/0 0/0)	96.5	4.5	0.3	0.7	32.0	97.5	5.2	0.3	0.7	37.6	91.1	1.9	0.3	0.6	24.8	0.5	0.6	1.0	0.5	-9739000.0	[redacted]	14799571.0	108-198	0.0	57.6	67.7	44.6
ESBS + Turbine Improvements + Tailrace Improvements (0/5 5/5)	96.5	4.2	0.3	0.7	37.0	97.5	4.9	0.3	0.7	41.8	91.8	1.9	0.3	0.6	33.1	0.5	0.6	0.5	0.3	-1401000.0	[redacted]	14799571.0	108-198	0.0	60.7	69.8	50.8
ESBS + Turbine Improvements + Tailrace Improvements (0/10 10/10)	96.6	3.9	0.3	0.7	41.7	97.6	4.6	0.3	0.7	45.9	92.5	1.8	0.3	0.6	40.8	0.5	0.6	0.9	0.3	7390000.0	[redacted]	14799571.0	108-198	0.0	63.7	72.0	56.4
ESBS + Turbine Improvements + Tailrace Improvements (0/20 10/15)	96.8	3.5	0.4	0.6	50.5	97.7	4.1	0.4	0.6	53.5	93.0	1.8	0.3	0.6	45.8	0.5	0.6	0.9	0.3	15355000.0	[redacted]	14799571.0	108-198	0.1	69.1	75.9	60.1
ESBS + Turbine Improvements + Tailrace Improvements (0/25 15/25)	96.9	3.4	0.4	0.6	54.5	97.6	4.0	0.4	0.6	57.0	94.0	1.8	0.4	0.5	57.1	0.5	0.6	0.8	0.3	27182000.0	[redacted]	14799571.0	108-198	0.1	71.6	77.7	68.4
ESBS + Turbine Improvements + Tailrace Improvements (0/35 15/30)	97.1	3.3	0.4	0.6	61.8	97.7	3.8	0.4	0.6	63.4	94.5	1.8	0.4	0.5	61.4	0.5	0.6	0.8	0.4	34882000.0	[redacted]	14799571.0	108-198	0.2	76.2	81.0	71.6
ESBS + Turbine Improvements + Tailrace Improvements (0/40 20/40)	97.2	3.3	0.4	0.6	65.1	97.7	3.7	0.4	0.6	66.4	95.3	1.9	0.5	0.5	70.8	0.5	0.6	0.7	0.4	46466000.0	[redacted]	14799571.0	108-198	0.2	78.3	82.6	78.5
ESBS + Turbine Improvements + Tailrace Improvements (0/50 30/45)	97.3	3.4	0.5	0.5	71.1	97.7	3.7	0.5	0.5	71.8	95.9	2.0	0.5	0.4	76.8	0.5	0.6	0.6	0.4	61079000.0	[redacted]	14799571.0	108-198	0.4	82.0	85.4	82.9
ESBS + Turbine Improvements + Tailrace Improvements (0/60 35/55)	97.4	3.6	0.5	0.5	76.2	97.8	3.7	0.5	0.5	76.5	96.5	2.2	0.6	0.4	83.7	0.5	0.6	0.5	0.5	72675000.0	[redacted]	14799571.0	108-198	0.8	85.2	87.8	88.0
SFS + Turbine Improvements + Tailrace Improvements (0/0 0/0) +20 kcfs	96.9	4.1	0.7	0.7	42.7	97.4	4.8	0.7	0.7	41.4	92.3	1.8	0.7	0.7	46.8	0.7	0.6	1.0	0.7	12109000.0	[redacted]	14352482.0	108-233	0.1	66.0	68.6	57.0
SFS + Turbine Improvements + Tailrace Improvements (10/10 10/10) +20 kcfs	97.2	3.6	0.7	0.7	54.6	97.5	4.1	0.7	0.7	52.6	93.5	1.8	0.7	0.7	58.1	0.7	0.6	0.5	0.5	36118000.0	[redacted]	14352482.0	108-233	0.2	73.1	74.6	66.1
SFS + Turbine Improvements + Tailrace Improvements (20/20 20/20) +20 kcfs	97.3	3.4	0.7	0.7	64.8	97.6	3.7	0.7	0.7	62.2	94.5	1.9	0.7	0.7	67.6	0.7	0.6	0.9	0.5	60850000.0	[redacted]	14352482.0	108-233	0.3	79.1	79.8	73.9
SFS + Turbine Improvements + Tailrace Improvements (30/30 30/30) +20 kcfs	97.5	3.5	0.7	0.7	73.4	97.7	3.6	0.7	0.7	70.6	95.4	2.0	0.7	0.7	75.6	0.7	0.6	0.8	0.5	81777000.0	[redacted]	14352482.0	108-233	0.5	84.2	84.2	80.3
SFS + Turbine Improvements + Tailrace Improvements (40/40 40/40) +20 kcfs	97.6	3.8	0.7	0.7	80.5	97.8	3.8	0.7	0.7	77.6	96.1	2.1	0.7	0.7	82.3	0.7	0.6	0.7	0.6	94995000.0	[redacted]	14352482.0	108-233	1.0	88.5	88.1	85.7
SFSB + Turbine Improvements + Tailrace Improvements (0/0 0/0) +20 kcfs	96.9	4.1	0.7	0.7	42.7	97.4	4.7	0.7	0.7	41.5	92.3	1.8	0.7	0.7	46.8	0.7	0.6	1.0	0.7	12109000.0	[redacted]	19866339.0	108-233	0.1	66.0	68.7	57.0
SFSB + Turbine Improvements + Tailrace Improvements (10/10 10/10) +20 kcfs	97.1	3.6	0.7	0.7	54.6	97.5	4.1	0.7	0.7	52.7	93.5	1.8	0.7	0.7	58.0	0.7	0.6	0.5	0.5	36118000.0	[redacted]	19866339.0	108-233	0.2	73.1	74.7	66.1
SFSB + Turbine Improvements + Tailrace Improvements (20/20 20/20) +20 kcfs	97.3	3.4	0.7	0.7	64.9	97.6	3.7	0.7	0.7	62.3	94.5	1.9	0.7	0.7	67.6	0.7	0.6	0.9	0.5	60850000.0	[redacted]	19866339.0	108-233	0.3	79.2	79.8	73.9
SFSB + Turbine Improvements + Tailrace Improvements (30/30 30/30) +20 kcfs	97.5	3.5	0.7	0.7	73.5	97.7	3.6	0.7	0.7	70.6	95.4	2.0	0.7	0.7	75.7	0.7	0.6	0.8	0.5	81777000.0	[redacted]	19866339.0	108-233	0.5	84.3	84.2	80.4
SFSB + Turbine Improvements + Tailrace Improvements (40/40 40/40) +20 kcfs	97.7	3.7	0.7	0.7	80.5	97.8	3.7	0.7	0.7	77.7	96.1	2.1	0.7	0.7	82.3	0.7	0.6	0.7	0.6	94995000.0	[redacted]	19866339.0	108-233	1.0	88.4	88.1	85.7
Hydrocombine + Turbine Improvements + Tailrace Improvements (0/0 0/0) +20 kcfs	96.9	4.1	0.7	0.7	42.7	97.4	4.8	0.7	0.7	41.4	92.3	1.8	0.7	0.7	46.8	0.7	0.6	1.0	0.7	12109000.0	[redacted]	24189808.0	108-247	0.1	66.0	68.6	57.0
Hydrocombine + Turbine Improvements + Tailrace Improvements (10/10 10/10) +20 kcfs	97.2	3.6	0.7	0.7	54.7	97.5	4.1	0.7	0.7	52.7	93.5	1.8	0.7	0.7	58.1	0.7	0.6	0.5	0.5	36118000.0	[redacted]	24189808.0	108-247	0.2	73.2	74.7	66.1
Hydrocombine + Turbine Improvements + Tailrace Improvements (20/20 20/20) +20 kcfs	97.3	3.4	0.7	0.7	64.8	97.6	3.7	0.7	0.7	62.2	94.5	1.9	0.7	0.7	67.7	0.7	0.6	0.9	0.5	60850000.0	[redacted]	24189808.0	108-247	0.3	79.1	79.7	73.9
Hydrocombine + Turbine Improvements + Tailrace Improvements (30/30 30/30) +20 kcfs	97.5	3.5	0.7	0.7	73.4	97.7	3.7	0.7	0.7	70.6	95.4	2.0	0.7	0.7	75.6	0.7	0.6	0.8	0.5	81777000.0	[redacted]	24189808.0	108-247	0.5	84.2	84.3	80.3
Hydrocombine + Turbine Improvements + Tailrace Improvements (40/40 40/40) +20 kcfs	97.6	3.8	0.7	0.7	80.5	97.7	3.7	0.7	0.7	77.5	96.1	2.1	0.7	0.7	82.3	0.7	0.6	0.7	0.6	94995000.0	[redacted]	24189808.0	108-247	1.0	88.5	87.9	85.8
BGS + Turbine Improvements + Tailrace Improvements (0/10 10/10)	96.1	3.6	0.4	0.7	39.3	97.0	4.2	0.4	0.7	42.8	89.5	2.0	0.4	0.6	31.2	0.5	0.4	0.9	0.5	7390000.0	[redacted]	14683669.0	110-263	0.0	59.3	66.4	39.3
BGS + Turbine Improvements + Tailrace Improvements (0/20 10/15)	96.4	3.3	0.5	0.6	48.4	97.1	3.8	0.5	0.6	50.8	90.2	2.0	0.4	0.6	37.2	0.5	0.4	0.9	0.5	15355000.0	[redacted]	14683669.0	110-263	0.1	65.4	71.1	44.6
BGS + Turbine Improvements + Tailrace Improvements (0/25 15/25)	96.6	3.3	0.5	0.6	52.6	97.2	3.7	0.5	0.6	54.5	91.8	1.9	0.5	0.5	50.4	0.6	0.4	0.8	0.5	27182000.0	[redacted]	14683669.0	110-263	0.1	68.2	73.3	56.2
BGS + Turbine Improvements + Tailrace Improvements (0/35 15/30)	96.8	3.2	0.5	0.6	60.3	97.3	3.5	0.5	0.6	61.3	92.4	1.9	0.5	0.5	55.3	0.6	0.4	0.8	0.6	34882000.0	[redacted]	14683669.0	110-263	0.2	73.4	77.2	60.5
BGS + Turbine Improvements + Tailrace Improvements (0/40 20/40)	96.9	3.2	0.5	0.6	63.7	97.4	3.5	0.5	0.6	64.5	93.8	2.0	0.6	0.5	66.1	0.7	0.4	0.7	0.6	46466000.0	[redacted]	14683669.0	110-263	0.2	75.7	79.1	70.1
BGS + Turbine Improvements + Tailrace Improvements (0/50 30/45)	97.1	3.4	0.6	0.5	69.9	97.5	3.5	0.6	0.5	70.2	94.7	2.0	0.6	0.4	73.1	0.7	0.4	0.6	0.6	61079000.0	[redacted]	14683669.0	110-263	0.4	79.9	82.5	76.2
BGS + Turbine Improvements + Tailrace Improvements (0/60 35/55)	97.2	3.5	0.6	0.5	75.1	97.6	3.7	0.6	0.5	75.0	95.7	2.2	0.7	0.4	81.1	0.8	0.4	0.5	0.7	72675000.0	[redacted]	14683669.0	110-263	0.8	83.3	85.3	83.3
JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/10 10/10)	96.2	3.7	0.3	0.7	39.3	96.9	4.2	0.3	0.7	42.7	89.5	2.0	0.3	0.6	31.4	0.5	0.5	0.9	0.4	7390000.0	[redacted]	12168096.0	108-199	0.0	59.3	66.3	39.4
JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/20 10/15)	96.4	3.3	0.4	0.6	48.4	97.1	3.8	0.4	0.6	50.8	90.2	2.0	0.3	0.6	37.2	0.5	0.5	0.9	0.4	15355000.0	[redacted]	12168096.0	108-199	0.1	65.4	71.1	44.5
JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/25 15/25)	96.5	3.2	0.4	0.6	52.6	97.1	3.7	0.4	0.6	54.5	91.8	1.9	0.4	0.5	50.4	0.5	0.5	0.8	0.4	27182000.0	[redacted]	12168096.0	108-199	0.1	68.2	73.2	56.2
JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/35 15/30)	96.8	3.2	0.4	0.6	60.2	97.3	3.6	0.4	0.6	61.4	92.4	1.9	0.4	0.5	55.3	0.5	0.5	0.8	0.5	34882000.0	[redacted]	12168096.0	108-199	0.2	73.4	77.3	60.5
JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/40 20/40)	96.9	3.2	0.4	0.6	63.7	97.4	3.5	0.4	0.6	64.5	93.8	1.9	0.5	0.5	66.1	0.5	0.5	0.7	0.5	46466000.0	[redacted]	12168096.0	108-199	0.2	75.7	79.1	70.1
JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/50 30/45)	97.1	3.4	0.5	0.5	69.9	97.5	3.5	0.5	0.5	70.2	94.7	2.0	0.5	0.4	73.1	0.5	0.5	0.6	0.5	61079000.0	[redacted]	12168096.0	108-199	0.4	79.8	82.5	76.2
JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/60 35/55)	97.2	3.5	0.5	0.5	75.1	97.6	3.6	0.5	0.5	75.1	95.6	2.2	0.6	0.4	81.1	0.5	0.5	0.5	0.6	72675000.0	[redacted]	12168096.0	108-199	0.8	83.3	85.4	83.3
ESBS + JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/0 0/0)	96.4	4.5	0.3	0.7	32.0	97.5	5.2	0.3	0.7	37.6	91.1	1.9	0.3	0.6	24.8	0.5	0.6	1.0	0.5	-9739000.0	[redacted]	15581632.0	108-244	0.0	57.6	67.7	44.6
ESBS + JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/5 5/5)	96.5	4.2	0.3	0.7	37.0	97.5	4.9	0.3	0.7	41.9	91.8	1.9	0.3	0.6	33.1	0.5	0.6	0.5	0.3	-1401000.0	[redacted]	15581632.0	108-244	0.0	60.7	69.9	50.8
ESBS + JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/10 10/10)	96.6	3.9	0.3	0.7	41.7	97.6	4.6	0.3	0.7	45.9	92.5	1.8	0.3	0.6	40.7	0.5	0.6	0.9	0.3	7390000.0	[redacted]	15581632.0	108-244	0.0	63.7	71.9	56.4
ESBS + JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/20 10/15)	96.8	3.5	0.4	0.6	50.5	97.6	4.1	0.4	0.6	53.5	93.0	1.8	0.3	0.6	45.8	0.5	0.6	0.9	0.3	15355000.0	[redacted]	15581632.0	108-244	0.1	69.1	76.0	60.1
ESBS + JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/25 15/25)	96.9	3.4	0.4	0.6	54.5	97.7	4.0	0.4	0.6	56.9	94.0	1.8	0.4	0.5	57.1	0.5	0.6	0.8	0.3	27182000.0	[redacted]	15581632.0	108-244	0.1	71.7	77.7	68.4
ESBS + JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/35 15/30)	97.1	3.3	0.4	0.6	61.8	97.7	3.8	0.4	0.6	63.5	94.4	1.8	0.4	0.5	61.4	0.5	0.6	0.8	0.4	34882000.0	[redacted]	15581632.0	108-244	0.2	76.2	81.1	71.6
ESBS + JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/40 20/40)	97.2	3.4	0.4	0.6	65.1	97.7	3.7	0.4	0.6	66.3	95.3	1.9	0.5	0.5	70.8	0.5	0.6	0.7	0.4	46466000.0	[redacted]	15581632.0	108-244	0.2	78.3	82.5	78.5
ESBS + JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/50 30/45)	97.3	3.4	0.5	0.5	71.1	97.8	3.7	0.5	0.5	71.8	95.9	2.0	0.5	0.4	76.8	0.5	0.6	0.6	0.4	61079000.0	[redacted]	15581632.0	108-244	0.4	82.0	85.3	82.9
ESBS + JBS Outfall Relocation + Turbine Improvements + Tailrace Improvements (0/60 35/55)	97.5	3.6	0.5	0.5	76.1	97.8	3.7	0.5	0.5	76.5	96.5	2.2	0.6	0.4	83.7	0.5	0.6	0.5	0.5	72675000.0	[redacted]	15581632.0	108-244	0.8	85.1	87.8	88.0