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Columbia River Salmon Mitigation Analysis
System Configuration Study
Phase I

Appendix F
System Improvements Technical Report
Lower Columbia River

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Columbia Fish and Wildlife Program

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Section 1 - Introduction

1.1 Purpose.

This appendix presents preliminary information on possible improvements to existing lock and dam projects on the lower Columbia River operated by the U.S. Army Corps of Engineers, Portland District. The report is prepared in response to the Northwest Power Planning Council's (NPPC) Columbia Fish and Wildlife Program. The purpose of the improvements would be to enhance the survival of migrating adult and juvenile salmonids in passing through the lower Columbia projects. Some of the improvements addressed in the study relate to specific measures addressed in the NPPC Phase Two Amendments. Others were identified through coordination with regional fishery agencies and Tribes.

The purpose of the study is to identify alternative implementation methods for each of the improvements, perform preliminary engineering and design evaluations, estimate the potential biological benefits, provide preliminary cost estimates for implementation and operation, estimate implementation schedules, and develop the requirements for further evaluations, including engineering and biological hydraulic model and field studies, for the next phase of work.

1.2 Improvements Evaluated.

All of the measures considered would be intended to improve survival for migrating juvenile salmonids. One would also be intended to benefit adult migrants as well, as indicated below. The following potential improvement measures were studied:

a. Extended-Length Screens at John Day.

Evaluate the benefits of installing extended-length turbine intake guidance screens to intercept a greater depth of water entering the turbine intakes. This will presumably intercept a larger percentage of downstream migrant salmonids, increase fish guidance efficiency (FGE), and increase project survival.

b. Juvenile Transportation at John Day.

Evaluate the possible transportation of downstream migrants to shorten in-river travel time, and avoid bypass predation and reservoir mortality at the two downstream projects (The Dalles and Bonneville).

c. Bonneville Outfalls.

Evaluate existing juvenile bypass system (JBS) outfalls; and research possible improvements to relocation of the outfalls. Documentation of existing baseline data is provided to assess problems with passage survival through these systems (Bonneville First and Second Powerhouses). This study includes a definition of various strategies and fisheries criteria developed since the completion of these facilities.

d. Bonneville First Powerhouse Fish Guidance Efficiency.

Evaluate the potential to improve Bonneville First Powerhouse fish guidance efficiency (FGE). Increased FGE will guide a larger percentage of downstream migrant juvenile salmonids away from turbine passage and increase project passage survival. Alternatives to increase guidance are reviewed and preliminarily evaluated.

e. Turbine Passage Survival.

Evaluated improvements to turbines that could be made to increase passage survival. The study examines potential areas of study with regard to the causal agents of mortality to juvenile fish passing through the turbine environment. Definitions and outlines of research programs needed to evaluate turbine components and operations are presented.

f. Spill Patterns/Flip-Lips at John Day.

Evaluate the potential to modify spill patterns at John Day to optimize operations and schedule for adult and juvenile passage and survival. Included in this analysis is the evaluation of adding flip-lips to the John Day spillway to decrease potential gas supersaturation resulting from high levels of spill.

g. Bonneville First and Second Powerhouse Downstream Migrant Facilities.

This study investigates the potential to improve the downstream migrant (DSM) facilities at both powerhouses. Baseline passage survival data is reviewed and possible options, and ranges of benefits, are presented. Changes since the construction of these facilities in juvenile bypass system fisheries criteria are addressed, and improvements are evaluated for possible benefits in passage survival.

h. Short-Haul Barging.

Evaluate an alternative strategy (short-haul barging) to fixed, single site juvenile bypass outfall release locations. This study is conceived as a potential outfall/release strategy to decrease indirect mortality at and near outfall release sites. The measure is evaluated for the Bonneville project in this report, but could have application at other projects.

i. Bonneville Package Analyses.

Combinations of Bonneville improvements were also evaluated. The analysis provides a preliminary estimate of the potential survival benefits of implementing these measures as a package. Two package analyses were conducted. Package A includes improvements to both powerhouse DSM's, Bonneville FGE, and relocation of outfall sites. Package B includes improvements to both powerhouse DSM's, Bonneville First Powerhouse FGE, and short-haul barging.

1.3. Scope.

This document is a reconnaissance-level study. As such, the evaluations rely substantially on existing available information in assessing engineering and design requirements, biological effects, and costs. No new biological and/or engineering research studies have been conducted to assess the possible benefits to increased survival for these improvements.

To evaluate biological effects, originally all eight system improvement studies were analyzed for biological benefits using the Columbia River Salmon Passage (CRiSP) model developed by the University of Washington, Center for Quantitative Science. CRiSP is a system-wide (Columbia River Basin) model that simulates the effects of Pacific Northwest hydroelectric operations and fishery programs on passage of juvenile salmonids in the Columbia River systems. Since CRiSP measures system-wide survival, statistically significant benefits from individual system improvements were not generally realized from the model. CRiSP is not sensitive to relatively small changes in project passage conditions at specific projects. Two measures, John Day transportation and turbine passage improvements, were analyzed using CRiSP because these measures involve passage through more than one project.

To estimate the potential benefits to migrant salmonids for the specific project passage improvements, Portland District developed spreadsheet models to analyze project-specific benefits. Assumptions and parameters for the spreadsheet model were derived from information developed from previous studies and/or regionally accepted values. The overall change in project-specific survival was calculated based on the estimated changes in direct and indirect mortality for the particular passage route or facility in question. These assumptions are detailed in each section.

1.4. Acronyms.

Acronyms are defined the first time they are referenced throughout this study. These acronyms are referenced in this paragraph as follows:

Acronym	Definition
CRiSP	Columbia River Salmon Passage
DSM	Downstream Migrant System
ESBS	Extended-Length Submergible Barrier Screen
ESTS	Extended-Length Submergible Traveling Screen
FPDEP	Fish Passage Development and Evaluation Program
FTE	Fish Passage Efficiency
FGE	Fish Guidance Efficiency
JBS	Juvenile Bypass System
MOA	Memorandum of Agreement
m.s.l.	Mean sea level
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
PIT	Passive Integrated Transponder
SOR	System Operational Review
SSTS	Standard Submergible Traveling Screen
STIE	Shortened Turbine Intake Extension
STS	Submergible Traveling Screen
VBS	Vertical Barrier Screen
WES	Waterways Experiment Station, Vicksburg, Mississippi

Section 2 - Extended Screens at John Day

2.1. Proposed Improvements to Existing Systems.

Forty-foot extended-length screens are proposed at John Day. The screens could either be extended-length submergible bar screens (ESBS) or extended-length submergible traveling screens (ESTS). Research to date at McNary and The Dalles projects suggest ESBS's provide higher guidance and are expected to have lower operation and maintenance costs, therefore, are the more likely choice. Existing vertical barrier screens (VBS) will also need to be replaced to accommodate for the increased flows up the gate slots; orifice and turbine efficiencies will be evaluated for the changed flow conditions; and the maintenance facility will be updated to accommodate the extended screens.

2.2. Existing System Description and Operation.

a. General.

Currently 20-foot submersible traveling screens guide juveniles at John Day Lock and Dam. The screens become operational in 1986. Features directly related to the guidance screen operation are the VBS's, orifices, a collection channel, and maintenance facility. Forty-nine submergible traveling screens (STS) are operated in the 16 existing units. The 49 STS's include three screens for each operating unit and one spare. If turbine units are placed in the remaining four skeleton bays, 12 additional screens would be required. Each of the existing units use three screens. Vertical barrier screens, orifices, and a mined collection channel are located immediately downstream of the 20-foot traveling screens. These features will be effected by double-length screens because of the increased flows in the gate slot. Outside of the flow area, the maintenance facility handles repair and maintenance of existing screens. This operation must be revisited to handle longer submerged screens.

b. Project Description.

John Day Dam is a multipurpose project located on the Columbia River approximately 25 miles upstream (east) of the city of The Dalles, Oregon. The project spans the Columbia River between Washington and Oregon on a north-south alignment at river mile (RM 215.6). The project includes a 113-foot lift navigation lock, a 20-bay spillway, a 20-unit powerhouse (only 16 operating units), both concrete and earthfill non-overflow sections, and two adult fish passage ladders. There is also currently a screened downstream juvenile salmonid bypass system and a juvenile monitoring facility.

c. Original Bypass.

The original juvenile bypass system (JBS) consisted of fish entrances (one orifice in each bulkhead slot), a collection conduit, and a transportation pipe from the powerhouse to the tailrace. No guidance screens were included in the original bypass. Juvenile salmonids entered the turbine intake from the forebay, and an estimated 5 to 10 percent then voluntarily rose up in the bulkhead slot where they must then find the 14-inch bellmouthed intake to a 6-inch pipe leading to the collection conduit (COE, 1979). The orifice entrances consisted of a 14-inch bell opening in the center of the upstream wall of the intake bulkhead slot and a 6-inch pipe connecting to a tapered collection conduit. Flow into each entrance was controlled by a 14-inch sluice gate. The centerline elevation of the entrance pipes were at elevation (El.) 256.5 feet mean sea level (msl) in the bulkhead slot. The collection conduit, which essentially operated as a manifold into which the 60 entrance pipes carried water and fish, varied from a 6-inch-diameter pipe at the extreme south end to a 48-inch-diameter pipe halfway along the powerhouse (south half). The north half of the collection conduit varied from a 4-foot-square conduit (midpoint) to a 5-foot-4-inch square conduit at the extreme north end. The collection conduit ran parallel to the axis of the powerhouse at a centerline elevation of 253.0 feet msl. The collection conduit extended into the central non-overflow dam section between the powerhouse and the spillway section. The conduit entered the non-overflow section as a 5-foot-4-inch-square conduit, went through a 90-degree turn downstream and a series of reductions before entering the 24-inch-diameter transportation pipe, which extended to the powerhouse tailrace deck (El. 185.0 msl). A 2- by 5-foot sluice gate was located in the non-overflow section between the collection conduit and the transportation pipe. The transportation pipe carried the water and collected downstream migrants from the downstream side of the sluice gate (centerline El. 252.8 msl), through a short, rectangular channel and transition to enter the transportation pipe a centerline elevation of approximately 245.0 msl. The 24-inch-diameter transportation pipe dropped from El. 245.0 and into an open flume supported on the powerhouse deck (El. 185.0 msl). This open flume was added in 1972 to monitor and evaluate fish using the bypass system.

d. 1973 Research.

Research was initiated in 1973 to evaluate the JBS at John Day. Objectives were to 1) determine the relative efficiency of the bypass system as designed; 2) determine the condition of fish that have passed through the system; and 3) develop ways of improving fish passage in the event it was found to be deficient (Sims and Johnson, 1976, 1977, 1978). The relative efficiency of the original bypass system was indeed found to be inefficient in guiding juvenile salmonids, and research and modifications continued to enhance project survival.

e. Existing Bypass.

Research and modifications continued on needed improvements to the juvenile salmonid collection and bypass system at John Day, and were completed in 1986 (Swan *et al.*, 1982; Krcma *et al.*, 1983, 1986; Brege *et al.*, 1987). The present juvenile fish collection portion of the system consists of STS's installed in the gatewell slot to intercept juvenile fish passing into the power generating turbines and guide the fish up into the gatewell slot and VBS's to prevent the fish from reentering the turbine intakes. The bypass system consists of 14-inch-diameter orifices leading from the gatewell slot and VBS's to prevent the fish from reentering the turbine intakes. The bypass system consists of 14-inch-diameter orifices leading from the gatewell slot into the collection gallery (14-inch-diameter orifices replaced the 12-inch-diameter orifices in 1993), and a transportation channel which leads to an outfall site located approximately 0.25 miles downstream from the dam. A juvenile fish sampling and handling facility was constructed on the lower portion of the transportation channel for evaluation of fish after they passed through the bypass system. The existing juvenile (smolt) monitoring system was only designed for short-term, periodic monitoring of fish condition passing through the bypass system. These facilities are presently not used as part of the Smolt Monitoring Program for several reasons, including probable adverse impacts to fish monitored by the facilities (Bob Dach, Project biologist, personal communication, 1993). Currently, the Smolt Monitoring Program utilizes an air-lift gatewell dipping system that only samples one or two gatewells from one turbine.

f. Existing Fish Guidance Efficiency.

(1) 1985 and 1986 Values.

FGE at John Day was last studied in 1985 and 1986 to evaluate improvements made to the facilities. Since the rehabilitation of the collection and bypass facilities, FGE was found to be acceptable (>70 percent) for spring migrating yearling chinook salmon (*Oncorhynchus tschawytscha*) and steelhead (*Oncorhynchus gairdneri*), but well below criteria (21 percent in 1985, 35 percent in 1986) for summer migrating fall chinook salmon (Krcma *et al.*, 1986, Brege *et al.*, 1987). Existing FGE values used in this analysis were taken from a National Marine Fisheries Service (NMFS) memorandum dated January 25, 1993, subject input parameters for computer modeling of the Columbia River Basin (NMFS, 1993), for spring/summer chinook salmon, fall chinook salmon, and sockeye salmon. Existing FGE values used in this analysis for steelhead are from Krcma *et al.*, 1986 (table 2-1).

Table 2-1 Fish Guidance Efficiency Values Used for Biological Benefits Analysis			
Species/Stock	Fish Guidance Efficiency		
	Present	High	Low
Yearling Chinook	0.72	0.94	0.91
Subyearling Chinook	0.26	0.49	0.46
Steelhead	0.82	1.00	1.00
Sockeye	0.41	0.59	0.55

(2) Current Estimated FGE.

Estimated high and low FGE values utilized in this analysis for extended-length screens ESTS's and ESBS's) were calculated from existing FGE values, plus the differences realized from testing of STS's, ESTS's, and ESBS's at McNary Dam (Brege *et al.*, 1992, 1993). These estimates must be viewed with the caveat that this information is from another facility, and prototype ESBS/ESTS testing will be necessary to better define the actual FGE that will be realized at John Day with extended-length screens (table 2-1). The high FGE values calculated used existing John Day FGE data, and the actual increase realized at McNary between standard submergible traveling screens (SSTS) and ESTS's. The low FGE values calculated used existing John Day FGE values, and the relative increase realized at McNary between SSTS and ESTS. The actual increase was the difference between SSTS and ESTS, added to existing John Day FGE. The relative increase was the percent difference between SSTS and ESTS, multiplied to existing John Day FGE.

(3) The Dalles FGE Comparisons.

FGE estimates calculated for The Dalles Dam prior to 1993 prototype testing using existing FGE data from The Dalles, and the difference realized from STS, ESBS, and ESTS testing at McNary provided interesting results. FGE estimates calculated were within the range of (or close to) the actual FGE realized during the first year prototype testing for all species/stocks, with the exception of summer migrants (subyearling chinook salmon). FGE values from prototype testing at The Dalles were significantly higher than those calculated using baseline FGE data from The Dalles, and the difference realized from testing at McNary. Part of the difference between FGE estimates calculated and the FGE testing at The Dalles may have been due to 1993 having higher and cooler flows, and an earlier than normal outmigration of subyearling chinook salmon than recent years. Once again, prototype testing of extended-length screens at John Day will be necessary to 1) determine which extended-length screen type works best (traveling or bar screens); 2) determine the proper porosity plate for vertical barrier screens for use with extended-length screens at John Day; and 3) determine the project-specific FGE (and survival estimates) gained from the installation of extended-length screens.

g. Previous Model Studies.

No model studies have been performed to date specifically for the John Day Project. Model studies for other projects that have similar configurations have been performed. An assessment of whether or not these data can be extracted from these studies and applied to John Day needs to be made.

2.3. Fish Guidance Efficiency and Survival Improvements.

a. General.

Starting in the 1960's, the U.S. Army Corps of Engineers (the Corps), in conjunction with NMFS, began developing submersible traveling screens for placement within turbine intakes. The purpose of these screens was to deflect downstream migrant salmonids away from turbine intakes, up into gate slots which the fish exit through orifices into specially-designed bypass systems. Downstream migrant salmonids are then collected for transportation or bypassed around the hydroelectric facilities to the tailrace. The effectiveness of the intake guidance screens is the efficiency that the fish be guided away from turbine passage and into the bypass systems or FGE.

b. Variables.

The ability of turbine intake guidance screens to divert juvenile salmonids away from turbine intakes may be influenced by many variables including time of year, water temperatures, behavioral aspects of different species/stocks, and the physiological status of the fish (Brege *et al.*, 1992). FGE studies conducted by NMFS at Columbia and Snake River projects have consistently shown that spring migrant salmonids have higher guidance than summer migrant salmonids. Data acquired at Lower Granite and Little Goose Dams from 1985 to 1989 suggested that fully smolted yearling chinook salmon were more susceptible to guidance by traveling guidance screens (Swan *Et al.*, 1987; Giorgi *et al.*, 1988; Muir *et al.*, 1988, 1990). While guidance at John Day for spring migrant chinook salmon and steelhead has been deemed acceptable, guidance for sockeye salmon and fall chinook salmon has remained below regional standards (at least 70 percent spring and 50 percent summer).

c. Increased Survival.

Extended screens will intercept a greater depth of water entering the turbine intake. The greater amount of water intercepted by the screen will presumably guide a greater percentage of downstream migrants up into the gatewell slot, improving FGE, and presumably increase project survival.

2.4. Engineering Evaluation of Proposed Improvements.

a. General.

This section looks at screening alternatives at John Day, evaluates them, and develops a recommendation to carry into the cost estimate.

b. Alternatives.

Extended screens could be either submersible traveling screens or submersible bar screens. The new length of the screen would either be 40 foot or some other length. New screens could be placed in either some or all of the slots and provisions could be made for the skeleton bays.

c. Assessment of Alternatives.

(1) Traveling Versus Bar Screens.

Existing screens on the Columbia and Snake River Projects are now all currently 20-foot traveling screens. Prototype testing at The Dalles and McNary initially indicate that the bar screens may guide fish better than the travelling screens. The tests are not totally conclusive, and tend to be site-specific. A prototype testing program would be beneficial in determining the most biologically efficient method of diverting juvenile fish out of the turbine intakes. Initially, selecting extended submersible traveling screens would tend to produce conservative costs.

(2) Length.

Forty-foot screens, also known as double length screens, have been selected as the second generation of screen length. This length was selected at The Dalles as the longest screen possible that could be handled and deployed in a practical manner. Shorter screams are feasible, but are not expected to guide as many fish.

(3) Slot Placement.

The same size of screen is normally used in all slots and all slots have always been screened during the fish passage season once a screened bypass is added to a powerhouse. Provisions for the skeleton bays could be made by adding screens in the future when turbines are added. Adding the screens in the future would help keep the initial contract costs lower.

(4) Vertical Barrier Screens.

Adding longer screens will increase and change the patterns of flow in the gate slot and to the orifices. Based on the prototype testing that has been done at McNary and The Dalles, the vertical barrier screens at John Day will have to be remodeled or replaced.

(5) Additional Considerations.

The longer screens will also change the efficiency of the units. Turbine models are required to assess the changes the extended screens will make to the system.

d. Recommendation.

Benefits and costs for the extended screens at John Day will be based on 40-foot extended submerged traveling screens placed in all slots with existing STS's. Since there is no prototype data to base a traveling versus bar screen selection, a prototype testing program is also recommended to aid in the selection process.

e. Design.

Design is based on the extended screens proposed for The Dalles JBS currently under design. The existing STS crane is designed with the capacity and clearances to handle the extended screens. The existing maintenance pits are assumed to have the capability for maintaining the extended screens. The skeleton bays will continue to be used for gate storage.

2.5. Environmental Effects.

a. Basis of Extended-Length Screens.

The concept of installing extended-length screens to existing juvenile bypass systems stems from low FGE of standard-length screens for certain species/stocks. Standard length STS-s are 20 feet in length. Guidance (FGE) at some hydroelectric facilities with standard-length screens has not been as efficient as expected. The idea has been put forth from juvenile salmon vertical distribution analyses that longer screens may guide fish traveling deeper in the water column, and increase FGE at projects where it is below criteria (70 percent at spring, 50 percent at summer) set forth in the Northwest Power Planning Council's *Columbia River Basin Fish and Wildlife Program*, 1987.

b. Testing and Verification of Fish Guidance Efficiency.

Although the hypothesis that longer screens will provide biological benefits to downstream migrant salmonids seems reasonable, it would be imprudent to proceed without hydraulic modeling and/or prototype testing of extended screens. FGE data for John Day was last collected in 1986 under normal pool operations, and also may need to be restudied and verified. FGE has not been assessed for present operation of the John Day pool at minimum irrigation pool. Another component of the Columbia River Salmon Mitigation Analysis (CRSMA), System Configuration Study (SCS), is drawdown of the John Day reservoir to elevation 257, or minimum operating pool. It may also prove to be reasonable and prudent to evaluate intake flow patterns and velocities with a lowered pool through hydraulic model tests. If warranted, field testing of FGE with a lowered pool may be advisable. Also, if drawdown affects hydraulic conditions and/or FGE for standard-length screens, an evaluation of these effects on extended-length screens would be needed.

c. Fish Number Estimates.

(1) Mortality.

Mortality estimates for different downstream passage routes used in this analysis are presented in table 2-2. It must be stressed that these are not project-specific mortality estimates, but generic estimates utilized for all hydroelectric facilities within the Columbia River Basin. Project-specific estimates of survival at John Day based on empirical data would enable the region and the Corps to properly analyze mortalities associated with extended screens. This process would ensure all reasonable and prudent measures were taken to increase project survival, in a cost-effective manner. The mere act of guiding fish away from turbine passage may not necessarily equate to higher survival for downstream migrants, as addressed in the survival studies at Bonneville Second Powerhouse (Ledgerwood *et al.*, 1992).

Table 2-2
Mortality Estimate Used For Biological Benefits Analysis

Passage Route	Mortality
Turbine	0.11
Bypass	0.02
Spill	0.02

(2) Arrivals.

Fish numbers estimated arriving at the John Day Project used in this analysis are presented in table 2-3. Spring/summer chinook salmon are listed as "yearling chinook" and fall chinook salmon are listed as "subyearling chinook."

Table 2-3 Estimated Fish Numbers Arriving at John Day Used for Biological Benefits Analysis	
Species/Stock	**Fish Numbers**
Yearling Chinook	603,000
Subyearling Chinook	2,190,000
Steelhead	242,000
Sockeye	129,000

(3) System Improvement (CRiSP Modeling).

Benefits to downstream migrant juvenile salmonids arising from extended-length screens at John Day were calculated using CRiSP modeling. CRiSP is a fish passage model developed by the University of Washington to simulate and estimate juvenile fish survival through the Columbia River Basin. A complete description of this model is found in *CRiSP.1 Manual*, release date, March 1993.

Reliability of this model is based largely on input parameters used in this analysis. Input parameters are based on current data, research, and coordination within the region. Parameters relating to dam passage established by NMFS (Model Coordination Memo, January 1992) for use by the Model Coordination Team were used when applicable. Other model parameters (such as transportation survival) used were coordinated with SOR A-Fish work group. Due to limited data regarding sockeye salmon input parameters and transportation survival, CRiSP analysis was limited to yearling chinook salmon, subyearling chinook salmon, and steelhead.

Using this information, the CRiSP model was run using 50-year (1928 to 1978) water record to give an estimated "average" survival of juvenile salmonids with and without project improvements. The model was run using a monte carlo analysis to account for variability in many of the input variables. Differences in these conditions were considered the "benefit" of improvements to the system.

(4) Project-Specific Improvement (Spreadsheet Model).

Fish passage models used in the region to estimate survival of juvenile salmonids through the Snake and Columbia River systems are designed to estimate system survival. These models are designed to simulate changes in system operations, and are not sensitive enough to detect small changes in survival due to small improvements at individual projects. These models are also not sensitive to differences in project survivals between tailrace areas (specifically different outfall locations). Therefore, estimation of juvenile fish survival through the John Day project was accomplished using a spreadsheet model developed by Corps of Engineers, Portland District. This model was developed to simulate current project operations and constraints, as well as potential operations. This model also allows partitioning mortality into more areas (such as indirect versus direct causes of mortality) than the larger, more complex fish passage models.

This model assumes dam passage to be by three potential routes: juvenile bypass system, turbine, or spillway. Proportion of fish passing each route is based on project operations, flow levels, FGE, and spill levels. The model calculates number of fish passing each route and, based on input parameters, associates each route with a survival. Total project survival for each stock/species is then calculated.

2.6. Biological Benefits.

a. System-Wide Results.

System-wide survival for downstream migrant juvenile salmonids with extended screens at John Day, as analyzed with the CRiSP model, indicate no statistically significant difference between the base case and improved condition. No differences in system survival were realized for any species/stock utilized in the analysis from their respective point of origin to below Bonneville. This does not, however, mean the proposed improvements have no effect. The CRiSP model was developed to track the downstream migration of salmon and steelhead through the entire Columbia and Snake systems, to below Bonneville Dam, and is not sensitive to relatively small changes in project-specific passage conditions.

b. Project-Specific Benefits.

Project-specific estimates of biological benefits accrued to downstream migrating salmonids from installation of extended-length screens are presented in tables 2-4 and 2-5. Table 2-4 presents the number of fish estimated to survive the John Day Project with the use of extended-length screens in the JBS, providing high and low estimates. Table 2-5 presents the estimated survival (current, low FGE with ESBS/ESTS, high FGE with ESBS/ESTS), and the estimated increase in survival from standard to extended-length screens. Survival estimates for summer migrants (fall chinook salmon) with standard-length screens were calculated using the existing spill level of 20 percent shaped, or 8.3 percent daily average flow. Survival estimates for summer migrants with extended-length screens were calculated without voluntary spill for fish.

Table 2-4 Estimated Fish Numbers Surviving John Day Project With Standard-Length and Extended-Length Screens			
Species/Stock	**Present**	**High FGE**	**Low FGE**
Yearling Chinook	573,000	585,000	585,000
Subyearling Chinook	2,015,000	2,037,000	2,037,000
Steelhead	235,000	237,000	237,000
Sockeye	120,000	121,000	121,000

Table 2-5 Estimated Biological Benefits and Percent Increase (Improved Survival) From Extended Screens at John Day					
Species/Stock	**Estimated Survival (Percent)**			**Estimated Increase (Percent)**	
Yearling Chinook	95	97	97	2	2
Subyearling Chinook	92	93	93	1	1
Steelhead	97	98	98	1	1
Sockeye	93	94	94	1	1

c. Survival Increases.

The estimated project-specific percent increase in survival with extended-length screens ranged from 1.0 to 2.0 percent; however, these estimates do not account for other possible mortality factors that cannot be evaluated without hydraulic modeling, prototype testing, and survival studies. It should be noted that even through this analysis FGE estimates increased 20 percent for fall chinook salmon (from 26 to 46 percent), survival estimates only increased 1 percent for these fish (from 92 to 93 percent). This trend has also been observed in other project-specific FGE/survival evaluations. A biological benefit analysis prepared as an appendix to The Dalles Juvenile Bypass System Environmental Assessment exhibited similar results (COE, 1993). This document reported that decreased indirect mortality at the JBS outfall location accounted for the vast majority of project-specific survival improvements, rather than increased guidance from extended-length screens.

d. Summary - John Day Extended Screens.

Table 2-5 is presented to provide the region and decision makers the means to evaluate the maximum possible benefit estimated from these analyses. It must be stressed that these have been reconnaissance-level studies, and all increases in downstream migrant salmonid survival are estimates. Further studies are necessary to 1) determine the feasibility of extended-length screens at John Day; and 2) to analyze the actual benefits accrued through prototype testing, and post-construction testing.

2.7. Additional Research.

a. Fish Passage Development and Evaluation Program.

The Corps funds the Fish Passage Development and Evaluation Program (FPDEP). This program is the vehicle by which the Corps funds Columbia and Snake River passage and survival research at Corps-operated hydroelectric projects. All aspects of Corps-funded research including needs, priorities, and design are developed and coordinated through the regional fisheries agencies and Indian tribes.

b. Prototype and Model Testing.

Extended-length screens prototype testing at John Day would incorporate the use of ESBS's, ESTS's, and analysis relative to the present STS's. This research should be conducted for 2 to 3 years due to variability in FGE within and between years. In addition to the guidance screens, VBS's, and orifice passage will also need to be tested in conjunction with the extended-length screen tests. It is planned to assess turbine intake and gatewell flows through sectional hydraulic model studies prior to prototype testing of extended-length screens.

c. Turbine Mortality.

One factor that should be addressed in the hydraulic model testing is to look at the possibility that turbine mortality may be increased for unguided fish with the use of extended-length screens. Intake guidance screens redistribute, deflect, and accelerate intake flows toward the bottom of the intake. As theses higher velocity flows pass over the turbine runners, pressure drops across the runner are increased possibly increasing fish mortality. Intake screens may also deflect unguided fish deeper into the turbine intake, distributing fish towards the blade tips where mortality is considered to be higher than at the hub. Fish guidance screens also disrupt the smooth intake flows, reducing turbine efficiency. These screens also may reduce survival of fish passing through the turbines since survival and turbine efficiency are positively correlated. Operating at peak efficiency maximizes turbine survival by producing streamlined flow conditions with a minimum of turbulence (Oligher and Donaldson, 1966; Bell, 1981; Ruggles, 1985; Eicher, 1987).

d. Descaling Rates.

Another factor that needs to be evaluated is what the net percent survival is with the use of extended-length screens. Descaling rates from tests conducted at McNary are higher with extended-length screens than with standard-length screens (Brege *et al.*, 1992). Descaling rates at The Dalles were not significantly different between different screens for spring migrants, but were significantly higher with ESBS's and ESTS's than STS's for summer migrants (B. Sandford, NMFS, Seattle, Memorandum, 1993). What effect this descaling has on the net or actual survival is unknown, however, bypass collection and transportation stress/fatigue studies have shown that descaled fish have the highest delayed mortality (Park *et al.*, 1982). The descaling problems associated with the use of extended-length screens have not been fully evaluated, or corrected, to date.

e. Post-Construction Testing.

With the completion and installation of new extended-length guidance screens, project survival tests are also proposed. Survival studies are needed to alleviate the uncertainties associated with FGE, bypass passage, and passage through different routes, to ascertain actual project survival with extended-length screens. This would consist of a 3-year study of survival rates for both spring and summer migrants, through all passage routes (bypass, spillway, and turbine). It may be possible to conduct survival studies in conjunction with extended-length screen prototype testing. This research would ensure that all aspects of downstream migrant salmonid passage at John Day are better understood, and that the best survival possible is achieved.

f. Passive Integrated Transponder Tags.

The post-construction (or in conjunction with extended-length screen prototype testing) survival study would consist of 3 years of released Passive Integrated Transponder (PIT) tagged hatchery fish released through all passage routes. The Corps, in conjunction with Bonneville Power Administration, is in the process of design Pit-tag smolt monitoring facilities for Bonneville first and second powerhouses, and for John Day. The Dalles JBS will also incorporate the use of PIT tag monitors. The use of PIT tags and detectors at The Dalles could alleviate the need for extensive handling of test fish (mark recapture methodology). Test fish would be PIT tagged, and then released through the different passage routes. Detection of Pit-tagged fish at The Dalles project would possibly decrease the number of test fish needed. This scenario depends on the JBS and PIT facilities being completed at The Dalles.

2.8. Economic Impacts.

a. General.

Replacing the 20-foot STS's with ESTS's or ESBS's has been proposed to improve the project's FGE. This proposed project improvement has been analyzed to provide information regarding its direct and indirect economic impacts. Direct impacts are changes in project outputs, described in market values, while indirect economic impacts are changes in regional or local economic activity resulting from direct impacts. No indirect impacts are anticipated from this proposed project improvement.

b. Spill.

Currently, with 20-foot screens, the John Day project meets FGE criteria for steelhead and spring migrant chinook salmon, but the FGE for sockeye and fall chinook salmon is below fishery criteria (FGE is the percent of juvenile fish guided out of the turbine flow into the bypass system). To achieve criteria, a percentage of river flow equal to the percentage FGE deficit is spilled over the dam's spillway. It is estimated that replacing the 20-foot screens with 40-foot screens will increase project FGE by guiding juvenile fish traveling deeper in the water column into the bypass system which, under the current 70/50 FGE criteria, could decrease or eliminate the need to spill at this project; or, the fishery agencies may increase the project's FGE criteria requiring continued levels of spill for fish. Because of the uncertainty regarding future FGE criteria, the change in the project's hydropower output will be evaluated under current spill levels and with spill eliminated to provide a range of hydropower outputs.

c. Hydropower.

(1) Computer Modeling.

Computer modeling (HYSSR and PCSAM) of the hydropower system's output was performed to determine the extent of hydropower impact from installing 40-foot screens at John Day. The existing (20-foot STS) and future (40-foot) conditions hydropower output was determined based on 50-year average river flows during the juvenile migration period. To estimate hydropower output related to the 40-foot screens, two additional computer simulations of the hydropower system's output were run. One, to estimate system hydropower losses with continued spill for fish and the second, to estimate system losses, if any, without spill for fish (assumes 40-foot screens increases FGE to meet criteria).

(2) Hydropower Production Costs.

Changes in hydropower production capability translate into changes in system hydropower production costs. Reductions in project output result in the need to acquire replacement energy from more costly sources, assumed to be combustion turbines. Increases in hydropower production capability reduce the need for more expensive energy sources. Installation of 40-foot screens at this project while continuing to spill for fish resulted in annual system production costs increases of approximately $1,118,000. If the spilling for fish were eliminated in conjunction with the 40-foot screens, annual system production costs could be reduced by approximately $2,774,000.

d. Other Uses.

No direct impacts to navigation, recreation, irrigation, or flood control are expected from installation and operation of this proposed project improvement.

2.9. Schedule and Cost.

a. Design and Construction Schedule.

The design and construction schedule is shown on figure 2-1. Screens are shown to be in-lace and fully operational by 1 March 2002. Three major stages are proposed. The first stage is a design memorandum that includes prototype testing and results. The second and third stages are the design and construction of the screens. A supply contract is planned for the extended screens. A project facilities construction contract will include orifice, VBS, and all other related work.

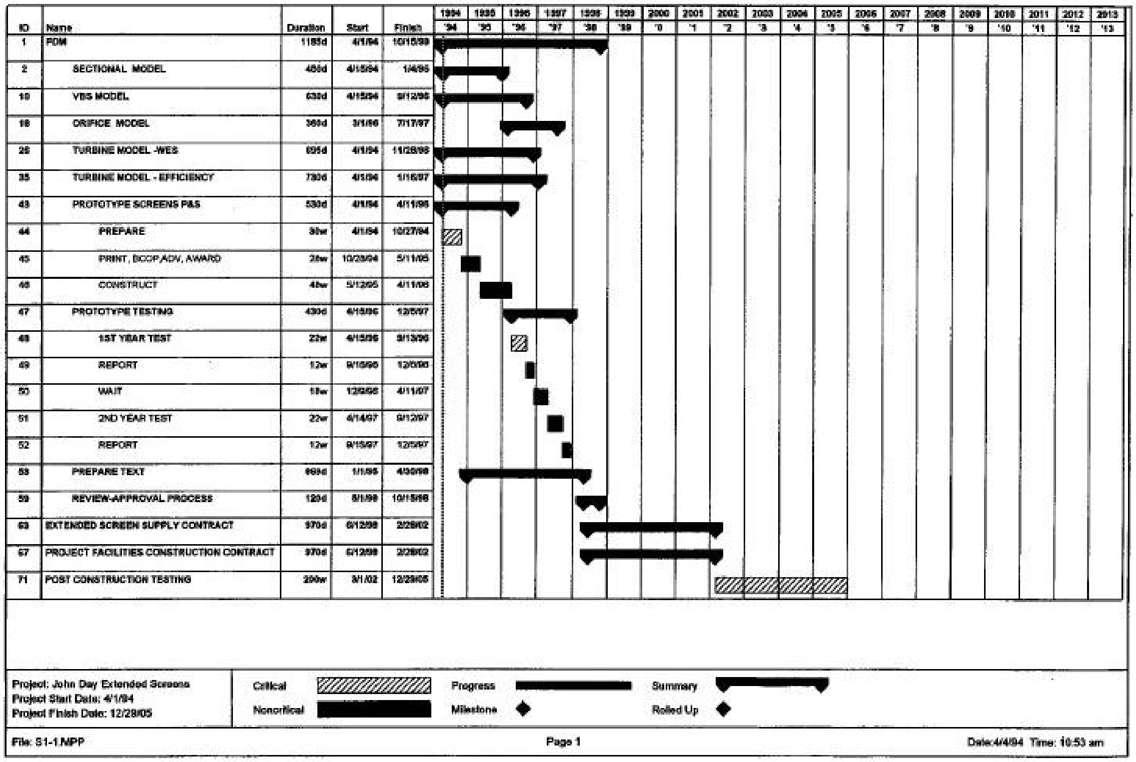

Figure 2-1. John Day Extended Screens Design and Construction Schedule

b. Total Contract Costs.

Total contract costs are shown in table 2-6. Table 2-7 adds planning, engineering, and design costs and presents a fully-funded cost estimate based on the current schedule.

Table 2-6
John Day Dam
Screen Extensions
Construction Cost Estimate

Feature	Quantity	Unit	Unit Price	Total Cost
Contract "A" Prototype Equipment				
Mobilization-Demobilization	1	EA	30,528.88	30,529
Lifting, Actuating and Swivel Beam	1	LS	80,485.23	80,485
Spare Parts for Prototypes	1	EA	206,670.00	206,670
Prototype Vertical Barrier Screens	6	EA	207,020.96	1,242,126
Sum, Contract "A"				**$1,559,810**
Contract "B"				
Mobilization-Demobilization	1	LS	757,901.68	757,902
Vertical Barrier Screens	1	EA	5,855,205.00	5,855,205
O & M Manuals	1	EA	62,236.45	62,236
As-Builts	1	EA	62,236.45	62,236
Existing Screens Salvage Value	1	EA	-6,638.55	(6,639)
Electrical Service Station	1	EA	2,578,954.00	2,578,954
40-Foot STS's	48	EA	612,596.85	29,404,649
Sum, Contract "B"				**$38,714,544**
OPE Testing	1	LS	150,000.00	150,000
Post-Construction Costs	1	LS	1,500,000.00	1,500,000
Testing Prototype--2 Years	2	YRS	225,337.82	450,676
Fyke Net Frames and Dip Basket	1	EA	120,000.00	120,000
Contingency	1	EA	28,681,000.00	28,681,000
Total Fish and Wildlife Facility				**$71,176,029**
Construction Management	1	LS	1,100,000	1,100,000
Contingency	1	LS	434,000	434,000
Total Construction Management				**$1,534,000**
Total Project Cost				**$83,107,029**

Table 2-7
Total Contract Cost Estimate
Columbia River Salmon Mitigation Analysis System Configuration Study--Phase I
Extended Screens at John Day Dam, Columbia River, Oregon

Current MCACES Estimate Prepared: Effective Pricing Level:				Jan 94 Oct 93		Authoriz./Budget Year: 1995 Effect. Pricing Level: Oct 95				Fully-Funded Estimate				
Acct No.	**Feature Description**	**Cost ($K)**	**CNTG ($K)**	**CNTG (%)**	**Total ($K)**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Total ($K)**	**Feature Mid-Pt**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Full ($K)**
Fish and Wildlife Facilities at John Day Dam														
06---	Contract A, Prototype Equipment	1,560	344	22%	1,904	6.8%	1.666	367	2,034	May 97	8.9%	1,814	400	2,214
06---	Contract B, Extended Screens	38,715	8,563	22%	47,248	6.8%	41,359	9,116	50,475	May 03	30.3%	53,890	11,878	65,768
06---	Fyke Net Frames and Dip Baskets (NMFS)	120	26	22%	146	68%	128	28	156	May 03	30.3%	167	37	204
06---	OPE Testing	150	30	20%	180	6.8%	160	32	192	Jul 01	25.4%	201	40	241
06---	Prototype Testing (1st Year)	225	50	22%	275	6/8%	241	53	294	May 98	9.6%	264	58	322
06---	Prototype Testing (2nd Year)	225	50	22%	275	6.8%	241	53	294	May 98	9.6%	264	58	322
06---	Subtotal	40,995	9,033	22%	51,028		43,795	9,650	53,445		29.2%	56,598	12,471	69,069
06---	Post-Construction Costs	1,500	300	20%	1,800	6.8%	1,602	320	1,923	May 98	9.6%	1,756	351	2,108
06---	Total 06 Account	42,495	9,333	22%	51,828		45,397	9,970	55,368		28.6%	58,354	12.822	71,176
Functional Costs														
30---	Planning, Engineering, and Design	6,495	1,182	18%	7,677	8.9%	7,070	1,287	8,356	Jul 01	0.0%	8,797	1.600	10,397
31---	Construction Management	1,100	110	10%	1,210	8.9%	1,197	120	1,317	Jun 03	16.5%	1,394	139	1,534
	Total 30 - 31 Accounts	7,595	1,292	17%	8,887	8.8%	8,267	1,406	9,673		23.3%	10,192	1,739	11,931
	Total All Accounts	50,090	10,625	21%	60,715	7.1%	53,665	11,376	65,041		27.%	68,546	14,561	83,107
Total Project Costs:														**$83,107**

Functional costs were provided by the design section.
Contingency's on 30 and 31 accounts were estimated at 25 % by CENPP-PE-C.
Authorization: Year assumed to be FY 1995.

c. Operation and Maintenance Costs.

Screen maintenance costs are shown on table 2-8. Operation costs will remain the same as current operations.

Table 2-8
Screen Maintenance Costs

Cost Components	20-Foot STS	40-Foot STS	Difference
Annual Screen Maintenance			
Change oil	$300	$500	$200
Tighten chain	100	150	50
Inspect	100	175	75
Repair mesh	100	400	300
Miscellaneous	200	150	50
Handling[1]	800	1,150	350
Totals	**$1,600**	**$2,525**	**$925**
Annual Screen Emergency Repair			
Drive system	$4,000	$8,000	$4,000
Belt Assembly	4,000	8,000	4,000
Miscellaneous	2,000	4,000	2,000
Totals	**$10,000**	**$20,000**	**$10,000**
Rebuilding Costs			
At 12.5 and 37.5 per year	$120,000	$238,000	$118,000
Major Rebuilding Costs			
At 25 and 50-year	$154,000	$436,000	$282,000

[1]25 hours per screen - 40-foot: 18 hours per screen - 20-foot
Source: The Dalles Lock and Dam Prototype Extended Submerged Traveling Screens and Prototype Extended Submerged Bar Screens by CENPD-HD, dated May 1990.

Summary[1]							
Item	Costs	No. of Screens	Total Cost Per Occurrence Interval ($)				
			Annual	12.5 Year	25.0 Year	37.5 Year	50 Year
				(Million)			
Annual maintenance	$925	48					
Annual repair	10,000	3	49,300				
Rebuilding costs	118,000	48	30,000	6.3		6.3	
Major rebuilding costs	282,000	48			15.0		5.0

[1]Inflation factor for all costs: 1.1 during May 1990 to November 1993
Source: The Dalles Lock and Dam Prototype Extended Submerged Traveling Screens and Prototype Extended Submerged Bar Screens by CENPD-HD, dated May 1990.

2.10. Phase II Study Requirements.

a. General.

Design studies leading to a feature design memorandum, and design for plans and specifications are planned for installing the extended screens.

b. Design Memorandum.

One memorandum is planned that will cover prototype testing, model testing, and proposed design; review operation and maintenance procedures for the extended screens; and present a baseline cost estimate. Prototype testing requires the construction of three ESBS's and three ESTS's. The new screens will be tested for two seasons and FGE will be compared against each other and the existing standard length (20-foot) STS's. The VBS and orifice models will be used to refine the design of the VBS's and orifices. The turbine models will be used to increase the operating efficiencies of the new screens.

Proposed designs will outline how the test data will be utilized and provide a basis for plans and specifications.

c. Plans and Specifications.

Designs for plans and specifications will take place concurrently with the second season of prototype testing. If the first year prototype testing results are inconclusive, the schedule for this phase will have to be reevaluated.

d. Model Studies.

Physical model studies are planned for determining the screen types, orifice types, the effect on turbine efficiency, and the effect on fish passing through the turbine.

(1) Sectional Model.

A Sectional Model of a turbine intake is used to help determine the extended screen configuration to be used in the prototype. The model would be a 1:25 scale and would represent 600 feet of the topography upstream of the turbine intake, the roof and floor intake configurations ESTS's, ESBS's, standard STS's, scroll case (no turbine), bulkhead and gateslots, and VBS's. The model study would be performed at Waterways Experiment Station (WES), Vicksburg, Mississippi. Testing of the model would provide the intake and screen velocities that would be expected as if the prototype screens were in operation. The model data would be used in conjunction with prototype data to evaluate the screens.

(2) Vertical Barrier Screen Model.

A VBS model would consist of a 1:12 scale model of the VBS, one bay of the powerhouse unit to the entrance to the turbine, and would include the trashracks, guidance screens, an emergency closure gate, and approximately 240 feet of approach topography. The purpose of the model is to refine the VBS design to accommodate the increased water being diverted up the bulkhead slot as compared with the existing 20-foot-long standard travelling screen.

(3) Orifice Model.

An orifice model is scheduled for determining the best location and configuration for the orifice. An existing orifice as model tested in the Wanapum Dam, Washington Model study shows that a more streamlined orifice would be more desirable to fish, as fish tended to get caught in the expansion downstream of the orifice entrance when going through the orifice and when approaching the orifice when traveling down the collection channel. The orifice would be a 1:4 scale model and would model the bulkhead slot circulation pattern in the upper part of the slot, the orifice configuration, and a portion of the collection channel to simulate flow past the downstream side of the orifice.

(4) Turbine Models.

Two turbine models are scheduled for assessing the hydraulic flow conditions of the flow that is diverted under the screens and that passes through the turbine (WES turbine model). They will also assess the effects of the extended screens on turbine efficiency (turbine efficiency model).

(a) WES Turbine Model.

The WES Turbine Model would analyze the flow directions and velocities that the juveniles would be subjected to when diverted under the screens. The turbine hub and blade would be supplied by a turbine manufacturer and provided to WES. The turbine would be installed in the sectional model.

(b) Turbine Efficiency Model.

The Turbine Efficiency Model would be index-tested at a turbine manufacturer's laboratory. The model study would test the change in turbine efficiencies with the extended screens in place and change in pressures as water passes through the hub and turbine blades. The model would be capable of testing under prototype heads.

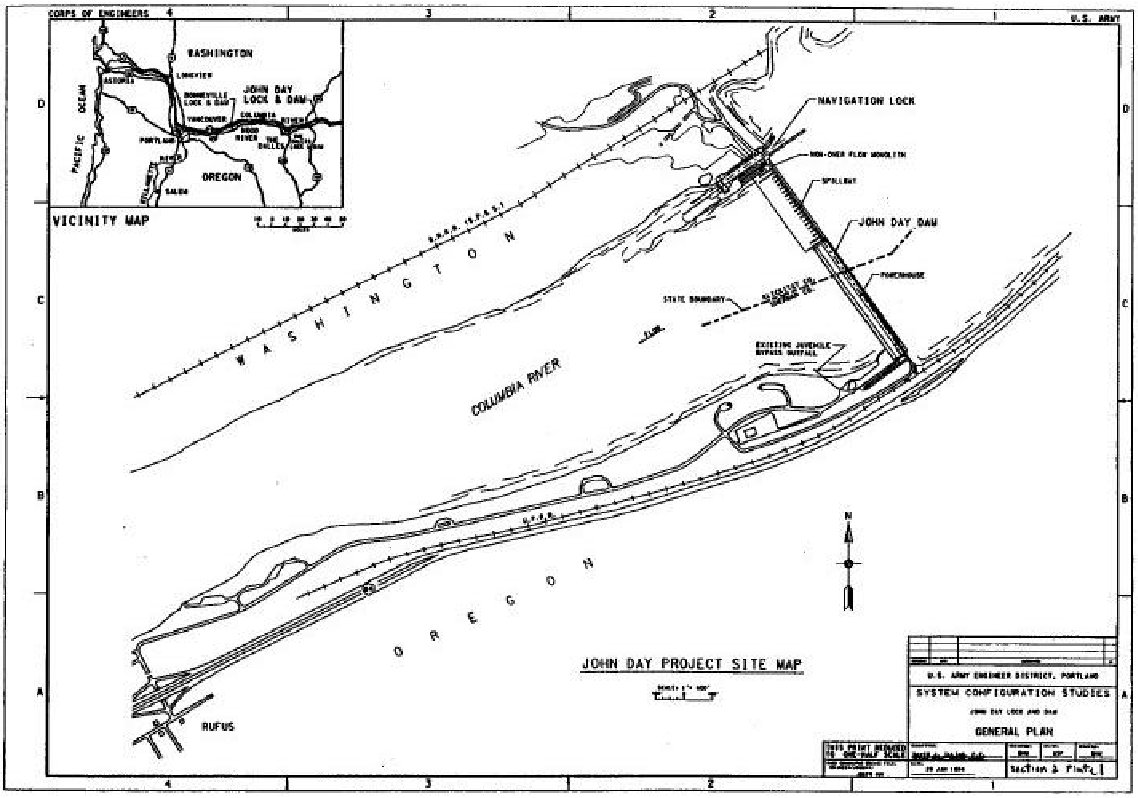

Plate 1. John Day Lock and Dam General Plan

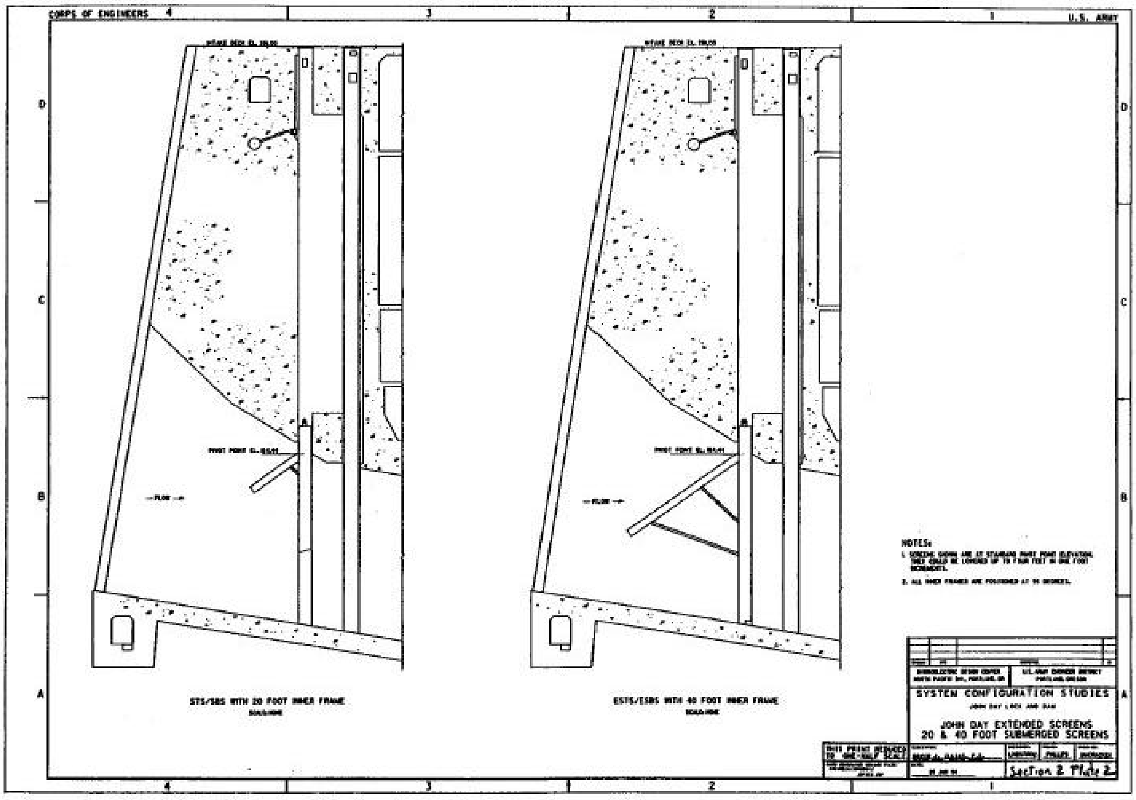

Plate 2. John Day Extended Screens

Section 3 - Juvenile Transportation at John Day

3.1. Proposed Improvements to Existing Systems.

a. General.

A juvenile transportation system capable of full time, part time, and short-haul barging is proposed. Transportation of downstream migrants is expected to shorten in-river time and avoid bypass predation and reservoir mortality. The juvenile transportation system will include new equipment and facilities, replace existing components of the bypass system, and replace all or part of the upgrades in the design of a proposed juvenile fish monitoring and sampling facility. The new equipment and facilities include barges, fish tanker trucks, a three-cell sheet pile barge loading facility and dock, a truck-loading area, covered concrete raceways, and employee parking. It will require replacement of the existing ogee and full flow transportation channel with a reduced flow transportation channel and a new outfall. The dewatering equipment in the proposed monitoring and sampling facility will be replaced, but the monitoring and sampling sections may not require replacement. They will, however, be scheduled for replacement in the new transportation plan.

b. Potential Survival Benefits.

Available literature and data suggest that transportation is beneficial to migrating juvenile salmonids (Park *et al.*, 1982; Park *et al.*, 1983; Matthews *et al.*, 1992), and although it is not a substitute for natural river conditions, it increases survival of downstream migrants with existing river conditions and operation; therefore, it is logical to assume that additional transportation sites may be beneficial to populations of migrating juvenile salmonids in the Columbia and Snake River systems.

John Day Dam is the project below the last collection/transportation site (McNary Dam) in the Columbia River; therefore, it is logical to assume that if transportation is beneficial to juvenile salmonids in the lower river, benefits will be greatest from John Day Dam. Transportation from John Dam has potential to improve survival of migrating juvenile salmonids by bypassing two projects and reservoirs (The Dalles and Bonneville Projects). If mortality due to transportation is less than mortality associated with these reservoirs and projects, transportation from John Day will increase survival of juvenile salmonids.

3.2. Existing System Description and Operation.

a. General.

John Day currently does not have a transportation system. This section discusses the transportation system that will be affected, and a proposed juvenile fish monitoring and sampling facility.

b. Original System.

John Day Dam was designed and built with a juvenile fish bypass system. The original bypass system consisted of an orifice in each gatewell leading to a transportation conduit from the powerhouse to the tailrace. Entry of juvenile fish into the system was considered voluntary since there was no structure to divert juveniles away from the turbines and up into gatewells. Fish guidance was estimated at 5 to 10 percent.

c. 1973 Research.

Research began in 1973 to evaluate the fish bypass systems at John Day Dam. Objectives of study were to determine efficiency of the system, determine condition of bypassed fish, and develop better methods to improve fish passage. Efficiency of the bypass was found to be relatively low and research and modifications continued. Notable modifications to the system include improved orifices, transportation flume, and installation of traveling screens to divert juveniles away from turbine intakes.

d. General Letter Report, Juvenile Fish Passage, The Dalles Dam, February 1987.

This report presented transportation at John Day as an alternative to bypassing fish at The Dalles Lock and Dam. This report did not present any technical information with significant details, and should not be used as a technical reference for construction-related issues.

e. Existing Bypass System.

The existing fish bypass system is similar to other bypass systems in the region. It consists of partially screening turbine intakes that divert fish into a bypass channel through the dam to an outfall area in the tailrace. It begins with standard 20-foot STS that direct flow and juvenile into the gatewell slot. From the slot the fish flow through an orifice into a pressurized flow collection channel. The channel through an orifice into a pressurized flow collection channel. The channel exits the powerhouse through a tainter gate, drops down an ogee chute, travels underground in an open channel conduit and exits into the tailrace through a concrete, U-shaped channel. A sampling station is located at the outfall, but is not usable under normal operation because of suspected adverse effects to migrating salmonids. The smolt monitoring system presently in use samples one or two gatewells by removing fish with an airlift system. No barges or trucks transport juvenile salmonids from John Day. Lower Granite, Little Goose, Lower Monumental, and McNary Dams currently transport juveniles by trucks and barges. The system does not dewater the normal discharge flow of approximately 500 cubic feet per second.

f. Prior Studies.

As an attempt to reduce mortality of migrating juvenile salmonids in the Columbia River system, transportation of migrating juvenile salmonids from Little Goose Dam began as a study in 1968, and has continued and expanded to be standard operations at several Corps projects. Transportation studies have varied from calculating transport benefit ratios (TBR), homing studies, disease transmission in barges, stress due to transportation, and improvements to the collection and transportation systems.

Most studies have been focused on relative survival of transported and non-transported fish as adult returns from point of release back to hatcheries, fisheries, or uppermost dam. This ratio is termed transportation benefit ration (TBR). For the vast majority of studies, even when overall returns were very low, transported fish returned at a higher rate than non-transported fish. The most recent completed studies (releases in 1986) have shown TBR's of 1.6 (1.0 to 2.5) for yearling chinook, 2.8 (1.4 to 5.6) for subyearling chinook and 2.0 (1.4 to 2.7) for steelhead. Studies are currently being expanded to include use of PIT tags and detectors to give more accurate estimates of in-river survival.

Through these studies, many improvements in transportation methods and techniques have been developed. Recent reports (Park *et al.*, 1991) have shown that transportation does not create increased stress levels over bypassed fish and that stress actually decreases in fish held in barges.

g. Proposed Juvenile Fish Monitoring and Sampling Facilities.

Reference National Marine Fisheries Service Juvenile Fish Monitoring Sampler and Facility at John Day Dam, December 10, 1992, by Summit Technology, Seattle, Washington. This report recommends a new sampling facility near the existing outfall. It places an inclined screen in the existing transportation channel, dewaters with an overflow weir primary dewatering system outside of the existing transportation channel; and diverts the juvenile through PIT-tag detectors and into a fish elevator for sampling or directly to the tailrace.

3.3. Engineering Evaluation of Proposed Improvements.

a. General Requirements.

The transportation facility would be located on the Oregon shore. This requirement is based on the continuing use of the existing collection channel. The capacity of the facility will be based on the assumption that 20 to 500,000 juveniles will be transported on a daily basis from 1 March to 30 November each year. Barge capacities will be based on current criteria of 0.25 pounds of fish per gallon of water carried in the barge. The facility would be required to have short-haul and long-haul capabilities.

b. Alternatives.

Major alternatives involve locating the facilities, the size of the components, and the degree of use of the existing bypass.

(1) Location.

The location of the loading facility could be near the existing outfall closer to the dam, or downstream of the existing outfall.

(2) Component Sizes.

The size of the holding facilities, barging and trucking capacity, sampling facilities, and dewatering facilities could be based on the average number of fish or the maximum number of fish that pass through the project. Those limits would be based on existing numbers of fish, proposed numbers of fish, or historic levels.

(3) Existing Bypass.

Use of the existing bypass could range from trying to save all existing structures to replacing everything downstream of the powerhouse. The ogee could be replaced with a dissipation channel that leads to an elevated dewatering facility. Excess water could go to the Adult Water Supply conduits through an energy dissipater, into the tailrace, into a small hydropower plant, or back to the existing transportation channel. The existing transportation channel would then be replaced or supplemented with a flume that would go to a sampling facility and the holding facilities or outfall. The sampling facility would either be new or a modified version of the system currently proposed at John Day. The modified version will require fish lifts or elevators to deliver sampled fish to the holding areas. The outfall would be left unchanged, modified for lower flows, abandoned, or removed and replaced. Saving the entire existing bypass will require all transported fish to pass through a fish lift or elevator to the holding areas. This will allow gravity loading of the transport vessels or vehicles.

c. Assessment of Alternatives.

(1) Location.

The loading dock and use of existing facilities will make up the main location selection criteria. The site primarily will have to provide safe navigation passage. This navigation use would be determined by model testing. Use of existing facilities has an obvious impact. Immediately downstream of the existing outfall, the shore is part of the Native American In-Lieu fishing sites. Use of this area would require extensive negotiations and possibly legislative work.

(2) Component Sizes.

The components proposed for short-haul barging will be sized to transport all of the fish bypassed.

(3) Use of Existing Bypass.

Use of the existing bypass in a new transportation facility is not very desirable if fish lifts or elevators are required. Such devices cause higher levels of stress for the fish when they pass through them. Pressure flow through the existing tainter valve is undesirable. Open channel flow over a weir would solve this problem. An elevated dewatering facility would be similar to the other facilities on the Columbia and Snake Rivers. Diversion of excess water into the AWS would be of benefit to that system and would be similar to its use at the other projects. Since the use of fish lifts and elevators are not desirable, a new sampling facility would eliminate that problem. Holding the fish in covered raceways for loading into a dedicated barge would be the most conventional method for that process. The outfall was originally designed without the benefit of model testing. In line with the replacement of the rest of the system and probable upgrading to state of the art bypass design, replacing the existing outfall with a new outfall would be required to provide an outfall similar to new outfalls proposed for construction in the river.

3.4 Biological Benefits.

a. CRiSP Modeling.

Benefits to juvenile salmonids due to transportation from John Day were calculated using CRiSP modeling. CRiSP is a fish passage model developed by the University of Washington to simulate and estimate juvenile fish survival through the Columbia River. Complete description of this model is found in *CRiSP.1 Manual,* release date: March 1993.

b. Survival Estimates.

Reliability of this model (as with any model) is largely based on input parameters used in analysis. Input parameters were based on current data, research, and coordination. Parameters relating to dam passage established by NMFS (Model Coordination Memorandum, January 1992) for use by the Model Coordination Team were used when applicable. Other model parameters (such as transportation survival) used were coordinated with System Operational Review (SOR) A-fish work group. Due to limited data regarding sockeye salmon input parameters and transportation survival, CRiSP analysis was limited to yearling chinook, subyearling chinook, and steelhead.

The CRiSP model allows for analysis of transportation by allocating survival rates of transported fish and then "transporting" these fish to any downstream location in the system. For this analysis, all fish were transported to below Bonneville Dam.

Methods of estimating survival of transported fish were based on transportation research and calculated TBR's. The TBR's used were from research at Lower Granite Dam and McNary Dam in 1986 (Matthews *et al.*, 1993). TBR's were 1.6 (range of 1.0 to 2.5) for yearling chinook, 2.0 (range of 1.4to 2.7) for steelhead, and 2.8 (range of 1.4 to 5.6) for subyearling chinook salmon. The CRiSP model was then used to estimate in-river survival of fish from transport dam to below Bonneville Dam in study year 1986. Multiplying TBR's by corresponding in-river survival gave an estimate of transportation survival (in 1986) (table 3-1). It was assumed that transport survival was constant over all years and flow issues. Therefore, the 1986 survival estimate was used for all modeling. TBR's calculated from other projects were used since no data is available for transport research at John Day. Transport research will be required at John Day to more accurately determine potential benefits.

Table 3-1
Summary of Transportation Benefit Ratio and Transport Survivals

Species	TBR[1]	Survival of Control Fish (In-River) to Below Bonneville (Percentage)	Estimated Transport Survival in 1986 (Percentage)
Yearling chinook	1.6 (1.0 to 2.5)	37y	59 (37 to 93)
Steelhead	2.0 (1.4 to 2.7)	35y	70 (49 to 95)
Subyearling chinook	2.8 (1.4 to 5.6)	60[3]	100

[1]Ratio of transported fish to control fish returns to the project.
[2]Control fish were released below Little Goose Dam.
[3]Control fish were released below McNary Dam.

c. System Survival Results.

Transportation survival was assumed to be constant at all projects (independent of distance transported) and over a full range of flow conditions. Therefore, survival of transported fish at John Day was the same as index dam estimates. Numbers of fish to be transported from John Day Dam were based on FGE values reported in the memo to the Model Coordination Team, as described earlier. These values are 72 percent for yearling chinook, 26 percent for subyearling chinook, and 86 percent for steelhead. (These estimates would increase if extended screens were installed at John Day.)

Using this information, the CRiSP model was run using the 50-year (1928 to 1978) water record to give an estimated "average" survival of juvenile salmonids with and without transportation. The model was run using a monte carlo analysis to account for variability in many input variables. Differences in these conditions were considered the "benefit" of transportation from John Day Dam. Values used for survival of transported fish ranged from 59 to 100 percent. This analysis method looks at survival of stocks from the place of release, not from John Day Dam. As a pseudo-sensitivity analysis, a method to estimate "project-specific" benefits using higher transport survivals and releases from John Day forebay was also used.

This method involved using CRiSP survival estimates for "generic" stocks of chinook and steelhead from the forebay of John Day Dam to the tailrace of Bonneville Dam. The "with project" condition assumed that with transportation at John Day Dam, fish will be transported around these lower dams and avoid pool/reservoir mortality. The estimate of survival of fish transported used was 95 percent. The input values used for CRiSP runs were identical to the base case runs used in the "system" analysis.

Estimated system survival of migrating juvenile salmonids is shown in table 3-2. Changes in survival ranged from -5 to +2 percent, depending on stock of fish.

Table 3-2
Estimated System Survival of Juvenile Salmonids
With and Without Transportation at John Day Dam

Stock	Base Case	With John Day Transportation	Difference (Absolute Change) Between Base Case And Transportation
Deschutes (Yearling Chinook)	67	67	0
Rock Creek (Steelhead)	55	50	-5
Dworshak (Steelhead)	48	47	-1
Wenatchee (Steelhead)	30	29	-1
Hanford Ferry (Subyearling Chinook)	62	64	+2
Methow Well Index (Subyearling Chinook)	32	34	+2
Methow (Yearling Chinook)	27	25	-2
Wild Salmon River (Yearling Chinook)	48	48	0
Wild Salmon River Stock (Summer)	41	41	0
Wild Salmon River Stock (Yearling Chinook)	40	40	0

d. Project-Specific Survival (John Day Forebay to Bonneville Tailrace.

Stocks originating in the Snake river show no change in survival. This is most likely due to the high level of transportation of these stocks. A high percentage of these fish are transported in the Snake River and, therefore, only a small percentage will arrive at John Day Dam with the potential to be transported from that location.

Steelhead originating from the mid-Columbia show a slight decrease in survival. This is due to the assumption of using a constant survival for all transportation sites. For these stocks, in-river survival is fairly high and, in many years, is higher than the transportation survival used. This indicates that, given the assumptions used regarding transportation survivals, fish stocks that have a relatively high in-river survival may not benefit from transportation at John Day based on assumptions of transport survival described earlier in this text. However, by the same rationale, if transportation survival is increased over the values used in this analysis, the stocks may benefit from transport at John Day.

Stocks that benefit from transportation, based on this analysis, are mid-Columbia stocks of fall chinook. Model results show a slight increase in survival. This is due to the relatively lower survival of in-river fish than the transportation survival used in this analysis.

Estimated survival of salmonids from John Day forebay to Bonneville tailrace is shown in table 3-3. Base case survival estimates ranged from 77 to 79 percent, and survival with transportation from John Day ranged between 85 to 90 percent, depending on species.

Table 3-3
Estimated Survival of Salmonids
(Project Specific: From John Day Forebay to Bonneville Tailrace)
With and Without Transportation From John Day Dam

Species	Base Case Survival (Percentage)	"With Project" Survival (Percentage)	Estimated "Benefit" (Percentage)
Spring/summer chinook	78	89	11
Fall chinook	78	82	4
Steelhead	78	91	13

e. CRiSP Modeling Summary.

In summary, CRiSP modeling was used to analyze benefits of transporting juvenile salmon from John Day Dam to below Bonneville Dam. Results of estimated system survivals show that there may be some benefit to mid-Columbia stocks of fall chinook, no benefit to Snake River stocks, and a negative benefit to mid-Columbia steelhead and spring chinook. However, this analysis is highly sensitive to assumptions used regarding the survival of transported fish. Transportation studies at John Day are strongly recommended to more accurately determine effects of transportation from John Day Dam.

As a limited sensitivity analysis of transportation survival estimates, the analysis included estimation of "project-specific" survivals, using relatively high transport survivals (95 percent). This helps to give a full range of potential benefits. Project-specific analysis shows a potential benefit of transportation between 5 and 13 percent depending on species. This survival was calculated between John Day forebay and Bonneville tailrace.

This analysis demonstrates potential benefits from transportation of juvenile salmonids from John Day Dam. There is a wide range of benefits shown in this analysis. Reasons for this large range are largely due to the uncertainty regarding survival of transported fish. Although the analysis shows benefits under most conditions, before determining actual benefits from transportation, research designed to better determine effects of transportation are needed.

f. Summary - Transportation from John Day Dam.

Results of this analysis (table 3-4) show that survival of salmonids from John Day Dam to Bonneville tailrace (project-specific) can be improved with transportation from John Day Dam. Improvements in survival were between 4 and 13 percent, depending on species. This percentage of survival is a "maximum" potential benefit, since survival of transported fish was assumed to be high (95 percent).

Table 3-4
Estimated Project Survival
(From John Day Dam to Bonneville Tailrace)
Benefits With Transportation From John Day Dam

Species	Base Case	With Transportation	Percent (Absolute) Change
Yearling chinook	78	89	11
Subyearling chinook	78	82	4
Steelhead	78	91	13

Survival of salmonids through the system (from point of release to below Bonneville Dam) with transportation ranged from -5 to +2 percentage change from the base case, depending on stock and species. Reasons for this estimate being lower than the project-specific survival are: 1) majority of stocks analyzed are released above John Day Dam and, therefore, sustain some mortality prior to reaching John Day Dam (the further upstream the stock is released, the smaller the percentage that arrive at the dam); and 2) survival of transported fish was much lower in this portion of the analysis. If transport survival were increased to levels used in the "project-specific" calculations, it is expected that overall survival would increase slightly.

Results of this analysis show that there is a potential benefit to transportation of juvenile salmonids from John Day Dam. The level of benefit ranges significantly, and studies will be needed to determine the benefits more precisely.

3.5. Economic Impacts.

Transporting bypassed juvenile salmon from John Day project to release sites below Bonneville Dam has been proposed to improve the survival of migrating juvenile salmonids. This proposed project improvement has been analyzed to provide information regarding its direct and indirect economic impacts. Direct economic impacts are changes in project outputs, while indirect economic impacts are changes in regional or local economic activity resulting from direct impacts.

No direct economic impacts are expected from this proposed project improvement. The proposed barge loading would not effect navigation, since the proposed facility would be located on the shore opposite the navigation channel and lock. Recreation is not expected to be impacted, although some bank fishing near the present outfall structure will be displaced. It is assumed that displaced fisherpersons will continue to fish at sites near the proposed facilities. Irrigation, hydropower, and flood control will not be impacted by this proposed project improvement.

No indirect impacts are anticipated from this proposed project improvement.

3.6. Schedules and Cost.

a. Design and Cost Schedule.

The design and construction schedule is shown on figure 3-1. The schedule includes the feasibility study, two design memorandums, and contracts. The feasibility study includes general model construction and testing. One design memorandum will cover the barge loading facilities with its supporting features. It will be the basis of the Transportation Facility Construction Contract. The second memorandum will cover the barge, and will correspond to a Barge Supply Contract.

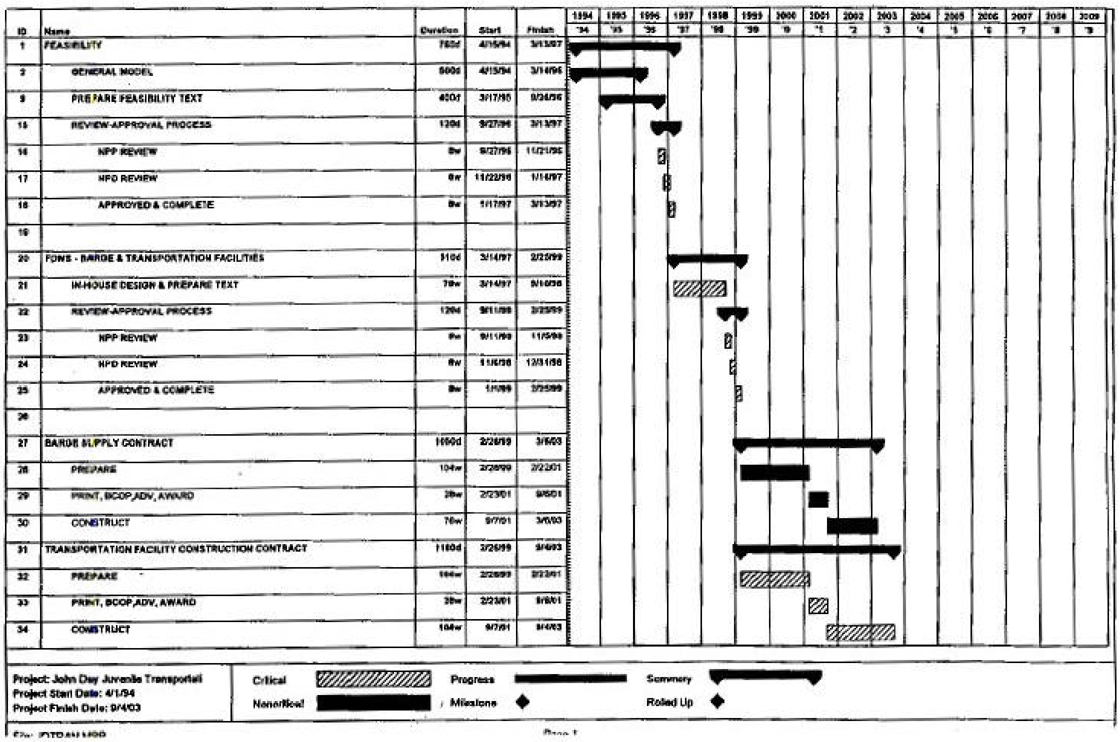

Figure 3-1. John Day Juvenile Transportation Design and Construction Schedule

b. Total Contract Costs.

Total contract costs are presented in table 3-5. Table 3-6 adds planning, engineering, and design costs; and presents a fully-funded cost estimate based on the current schedule.

Table 3-5 John Day Dam Juvenile Transportation Construction Cost Estimate				
Feature	**Quantity**	**Unit**	**Unit Price**	**Total Cost**
Barging Facilities Contract A				
Mobilization-Demobilization	1	LS	328,400.00	328,400
Ogee Removal	1	JOB	30,034.73	30,035
Dewatering Facility	1	EA	3,269,974.38	3,269,974
Excess Water	1	EA	100,115.74	100,116
Elevated Flume--Main	3200	EA	485.65	1,554,080
Elevated Flume--Bypass	1000	EA	500.57	500,570
Towers	80	EA	20,023.15	1,601,852
Sampling Facility	1	EA	1,852,517.68	1,852,518
Barging Facility	1	EA	3,003,324.11	3,003,324
Raceways	1	EA	839,971.08	839,971
Outfall	400	FT	9,010.42	3,604,168
Contingency	1	LS	11,336,000.00	11,336,000.00
Sum, Contract "A"				**$28,021,008**
Barge Contract "B"				
Barges	1	EA	2,756,516.77	2,756,517
Biological Research	1	LS	1,825,000.00	1,825,000
Research S&A	1	LS	60,000.00	60,000
Contingency	1	LS	3,026,000.00	3,026,000
Sum, Contract "B"				**$7,667,517**
Total Fish and Wildlife Facility				**$35,688,524**
Planning, Engineering, and Design	1	LS	7,590,000	7,590,000
Contingency	1	LS	4,322,000	$,322,000
Total Plan, Engr, and Design				**$11,912,000**
Construction Management	1	LS	1,500,000	1,500,000
Contingency	1	LS	974,000	974,000
Total Construction Management				**$2,474,000**
Total Project Cost				**$50,075,524**

Table 3-6 Total Contract Cost Summary Columbia River Salmon Mitigation Analysis System Configuration Study--Phase I Juvenile Transportation at John Day Dam, Columbia River, Oregon														
Current MCACES Estimate Prepared: Effective Pricing Level:				**Jan 94 Oct 93**		**Authoriz./Budget Year: 1995 Effect. Pricing Level: Oct 95**				**Fully-Funded Estimate**				
Acct No.	**Feature Description**	**Cost ($K)**	**CNTG ($K)**	**CNTG (%)**	**Total ($K)**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Total ($K)**	**Feature Mid-Pt**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Full ($K)**
Fish and Wildlife Facilities														
06---	Contract A, Barging Facilities	16,685	4,171	25%	20,856	6.8%	17,820	4,455	22,275	May 02	25.8%	22,417	5,604	28,021
06---	Contract B, Barge	2,757	689	25%	3,446	6.8%	2,944	736	3,680	May 02	25.8%	3,704	926	4,629
06---	Subtotal	19,442	4,860		24,302		20,764	5,191	25,954			26,121	6,530	32,651
06---	Biological Research	1,825	365	20%	2,190	6.8%	1,949	390	2,339	May 02	25.8%	2,452	490	2,942
06---	Research Data	60	12	20%	72	6.8%	64	13	77	May 02	26.8%	81	16	97
	Total 06 Account	21,327	5,237	25%	26,564		22,777	5,594	28,370			28,653	7,037	35,690
Functional Costs-- Planning, Engineering, and Design														
30F--	Feasibility Report	900	180	20%	1,080	8.9%	980	196	1,176	Feb 00	20.1%	1,177	235	1,413
30G--	Feature Design Memoranda													
30G--	Barging Facilities	1,500	300	20%	1,800	8.9%	1,634	327	1,960	Feb 00	20.1%	1,962	392	2,354
30G--	Barge	400	80	20%	480	8.9%	436	87	523	Feb 00	20.1%	523	105	628
30H--	Plans and Specifications													
30H--	Contract A - Barging Facilities	2,600	520	20%	3,120	8.9%	2,831	566	3,398	Feb 00	30.1%	3,401	680	4,081
30H--	Contract B--Barge	400	80	20%	480	8.9%	436	87	523	Feb 00	20.1%	523	105	628

30J--	Design Related Engr. Hyd. Models													
30J--	General Models	150	30	20%	180	8.9%	163	33	196	Feb 00	20.1%	196	39	235
30J--	Dewatering Facilities	140	28	20%	168	8.9%	152	30	183	Feb 00	20.1%	183	37	220
30K--	Engineering During Construction	500	100	20%	600	8.9%	545	109	653	Feb 00	20.1%	654	131	785
30L--	Value Engineering	100	20	20%	120	8.9%	109	22	131	Feb 00	20.1%	131	26	157
30S--	E & D Phase Project Management	900	180	20%	1,080	8.9%	980	196	1,176	Feb 00	20.1%	1,177	235	1,413
	Total 30 Account	7,590	1,518	20%	9,108	8.9%	8,266	1,653	9,919		20.1%	9,927	1,985	11,912
Functional Costs-- Construction Management														
31---	Contract A - Barging Facilities	1,200	240	20%	1,440	8.9%	1,307	261	1,568	Jun 02	26.2%	1,649	330	1,979
31---	Contract B - Barge	300	60	20%	360	8.9%	327	65	392	Jun 02	26.2%	412	82	495
	Total All Accounts	30,417	7,065	23%	37,472	7.4%	32,676	7,573	49,249		24.4%	40,642	9,434	50,076
												Total Project Costs:		**$50,076**

Functional costs were provided by the design section.
Contingency's on 30 and 31 accounts were estimated at 25 % by CENPP-PE-C.
Authorization: Year assumed to be FY 1995.

Operation and maintenance cost for the barge, dock, and raceways are included in table 3-7. Costs for a sampling facility are not included, because they are not expected to increase from the amounts required by the Smolt Monitoring Program.

Table 3-7
Operation and Maintenance Annual Costs

Items	Costs
Barge and Dock Maintenance	
Labor (1,000 hours at $40 per hour)	$40,000
Supplies	10,000
Overhauls	60,000
Subtotal	**$110,000**
Barge Operation	
Labor (3,200 hours at $40 per hour)	$128,000
Supplies	26,000
Fuel	6,000
Subtotal	**$160,000**
Raceway Maintenance	
Labor (1,400 hours at $40 per hour)	$56,000
Supplies	25,000
Subtotal	**$81,000**
Raceway Operations	
Labor (1,600 hours at $40 per hour)	$64,000
Supplies	25,000
Subtotal	**$89,000**
Annual Total	**$440,000**

Note: Sources of data for annual costs from Delivery Order No. 8, *Short-Haul Barging and Sampling Study for The Dalles Juvenile Bypass System Project Final Submittal*, dated December 10, 1992, prepared by Summit Technology, Seattle, Washington.

3.7. Phase II Study Requirements.

a. General.

Phase II includes a feasibility study and biological research.

b. Research.

Although available data indicates that transportation is beneficial to juvenile salmonids, there is much regional discussion regarding the merits of transportation. Therefore, it is necessary to study/monitor transportation from John Day Dam to collect baseline data and ore closely analyze potential benefits. Since there are currently no transportation facilities at John Day, modification of the project would be required to transport studies from this facility.

Fiscal Year (FY)	Research Phase	S&A Costs (K)	Total Costs (K)
1	Juvenile marking and releases	$10	$300
2	Juvenile marking/releases and adult returns	10	500
3	Juvenile marking/releases and adult returns	10	500
4	Adult returns	10	150
5	Adult returns	10	150
6	Adult returns	10	150
7	Final report	--	75
		$60	**$1,825**

c. Feasibility.

(1) Economics.

The feasibility study will include economic analysis.

(2) Engineering.

The engineering appendix will primarily look at locating a barge dock; selecting the barge type and number of barges; and laying out the barging facility, dewatering facility, raceways, and sampling facilities. Extensive effort is planned for incorporating the existing system and proposed Smolt Monitoring Facility into the transportation plan. Siting of the dock, navigation of the barge, and locating the outfall will be the principle purpose of the proposed general model. Alternatives discharging the excess water into the AWS and a small hydropower plant will be evaluated. The barging process will be outlined in detail to provide a basis of costs and the feature design memorandums.

3.8. Design and Construction.

Two design memorandums, continued biological testing, general model testing, construction of a dewatering facility, and plans and specifications for two contracts that: 1) fabricate a barge; and 2) construct a transportation facility, are proposed after Phase II.

a. Design Memorandums.

(1) Transportation Facilities Features Design Memorandum.

This memorandum will cover the features developed in the feasibility study. The dewatering facility, excess water to the AWS or tailrace, sampling facility, Smolt Monitoring Facility modifications, transportation flume, raceway, outfall, docking facility, and barge loading equipment will be presented. Operation and maintenance procedures, costs, and worker requirements will be identified for estimating future project costs and future work force needs.

(2) Barge Feature Design Memorandum.

The barge feature design memorandum will cover the barge design and its operating and maintenance procedures and costs.

b. General Model Testing.

A general model study of the tailrace flow conditions may be necessary to study outfall locations and assess alternative locations for a fish barge docking facility. The model study would be performed at Waterways Experiment Station, Vicksburg, Mississippi. The model would be 1:80 scale, and would model approximately 5 miles of the river, the powerhouse structure, spillway, and navigation lock. Model construction cost of $623,000 will be covered by the John Day Spill Pattern Study.

(1) Transportation Facilities Construction Contract.

The tailrace conditions would be studied to determine the best outfall location within the vicinity of the project. Model flow velocity and direction measurements would be taken for the entire tailrace and the fill range of discharges from minimum powerhouse flow to 700,000 cubic feet per second (ft^3/s). Point velocities will be taken at the selected outfall site during refinement of the outfall location. Tests using dye streaks will provide three-dimensional and subjective information. Spill conditions could also be modeled. The outfall site selection would be based on distance from the eddy areas, flow velocities and directions at the outfall site, and flow conditions downstream of the outfall site.

(2) Barge Supply Contract.

A model fish barge dock will be constructed and placed in the model at alternative locations in the general model tailrace. The purpose of the study is to assess the maneuverability of the fish barge under various powerhouse flow conditions and to determine what is acceptable. A model fish barge would be "driven" to approach, and exit the dock area under various powerhouse flow conditions. The path of the barge as it approaches the dock would be documented with time-lapse photography.

c. Dewatering Facility Model.

A dewatering facility model would be necessary to assess the hydraulic conditions as flow exists the pressurized collection channel and flows into the dewatering facility. The model study effort would be based on the WES 1:12 scale model of The Dalles Dewatering Facility Model.

d. Plans and Specifications.

(1) Transportation Facilities Construction Contract.

The design and preparation of plans and specifications is planned for the features selected in the design memorandum process.

(2) Barge Supply Contract.

The design and preparation of plans and specifications is planned for the barge or barges outlined in the design memorandum process.

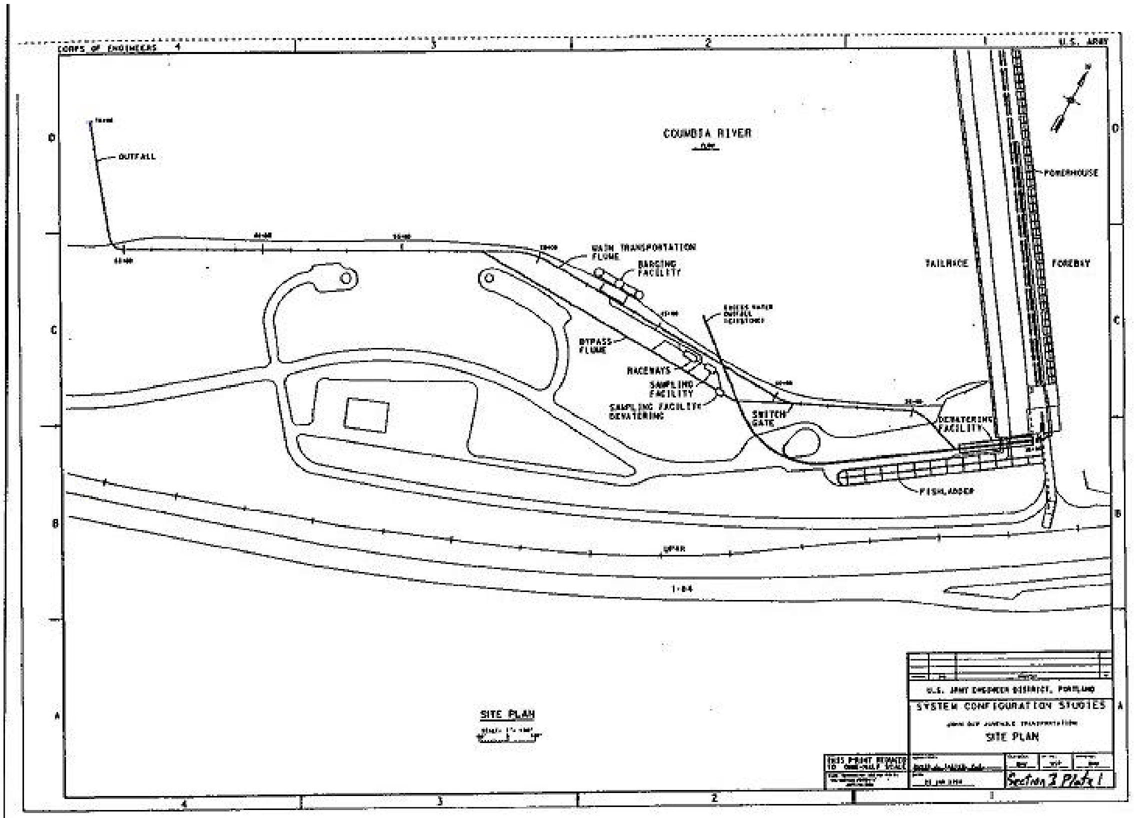

Plate 3. John Day Juvenile Transportation Site Plan

Section 4 - Bypass Outfalls at Bonneville

4.1. Proposed Improvements to Existing Systems.

New outfalls at Bonneville First and Second Powerhouses are expected to minimize predation and potentially reduce mortality. Each powerhouse will replace its existing pressurized underwater outfall with an open channel flume. Both systems will include a new transportation channel, a new outfall, and utilize the proposed Juvenile Fish Monitoring and Sampling Facilities. The Bonneville First Powerhouse flume will be approximately 1,500 feet long. The outfall will extend approximately 100 feet into the tailrace. The Bonneville Second Powerhouse flume will be approximately 9,000 feet long. Its outfall will extend about 120 feet into the tailrace. For a fixed outfall the maximum amount of time the release point would be above tailwater and within entrance criteria is 70 percent. With a floating outfall or two outfall structures at two release elevations, the release could be above water 100 percent of the time.

4.2. Existing System Descriptions and Operation.

a. General.

The juvenile bypass systems were made operational in 1981 (Second Powerhouse) and 1983 (First Powerhouse), and were considered state-of-the-art outfalls at that time. The juvenile release sites (outfalls) portion of the bypass system begins at the down wells downstream of the dewatering facilities. This system is pressurized and terminates below the tailrace water surface downstream of the turbine boils.

b. Bonneville First Powerhouse Existing Bypass.

The existing bypass runs from the turbine intakes to the release point in the tailrace. The juvenile migrant fish are diverted from the turbine intakes into the gatewells by submerged traveling screens. Fish and water pass through 12-inch-diameter orifices at each gatewell into a collection channel running the length of the powerhouse. The channel, running from the south to the north, increases in width as it traverses the powerhouse. The fish are separated from the bulk of the water in the collection channel by a movable inclined dewatering screen at the downstream end of the channel. The water surface level is controlled by a weir located beneath the inclined screen. After passing over the dewatering screen, the fingerlings and remaining water enter the outfall pipeline. This pipeline is 3-feet in diameter until after it passes through a vertical bend. It is 2 feet in diameter thereafter. The juvenile fish are discharged 300 feet downstream of the powerhouse face below water at Elevation 0.0 and directly below pier 10 centerline.

c. Bonneville Second Powerhouse Existing Bypass.

The existing bypass runs from the turbine intakes to the release point in the tailrace. There is a submersible traveling screen at each intake to guide juvenile migrant fish into the intake gatewell. Fish pass through 12-inch-diameter orifices at each gatewell into a long channel running the length, from south to north, of the powerhouse. At the downstream end of the channel, an inclined screen crowds the fish up to the crest of an overflow weir. The fish and water then drop into a downwell. The downwell transitions from 6 by 14 feet to 6 by 6 feet, and then to a 4-foot-diameter pipe. The vertical pipe then turns horizontal and reduces to a 3-foot-diameter, and remains this size to the outlet at the tailrace. The 3-foot-diameter pipe, known as the DSM release pipe, makes several bends and slope changes on the way to the tailrace. The pipe exits to the tailrace underwater at a 20-degree angle up from horizontal near midstream.

d. Proposed Juvenile Fish Monitoring and Sampling Facilities.

These facilities are proposed at each of the Bonneville sites. They will replace the existing samplers above the discharge and porosity control wells and add PIT-tag sampling capability. The sampling facilities are not part of the system improvements. Capability to accommodate new outfalls are presumed to be requirements for design of the new monitoring and sampling facilities.

e. Model Studies.

Locating the critical outfall sites for Bonneville First and Second Powerhouses will be done principally through model studies. This hydraulic evaluation will be performed in conjunction with a biological evaluation of potential sites. Engineering parameters will somewhat limit potential sites, including navigation, topography, access, river profile, existing structures and allowable flume slope. It is assumed that collection channels in either powerhouse can be rerouted to run the opposite direction to allow for potential outfall locations.

These model studies will occur on an existing general hydraulic model at WES. The model is a 1:100 scale hydraulic model of Bonneville First and Second Powerhouses, spillway, and navigation locks. The model includes the river upstream the channel to all three structures, as well as the channel downstream, including the confluence of all three channels and the combined channel for approximately 2 miles downstream. The model was originally constructed to evaluate navigation and portions need to be reconstructed prior to outfall location testing.

4.3. Biological Background.

a. Bonneville Survival Testing.

(1) General.

From 1987 to 1990, an evaluation was initiated to evaluate the survival of subyearling fish passing Bonneville Dam. The primary goal of this study was to determine the relative survival of juveniles passing through the various juvenile passage routes including the bypass, spillway, and turbines. Additional releases were made approximately 1 to 2 miles downstream of the dam and at the downstream edge of a turbine boil. Estimates of short-term survival were made based on recovery of juvenile fish near the upper end of the estuary. Long-term estimates of survival through adult returns are not yet complete.

(2) Results and Evaluation.

The survival study is unique, as this study compared the relative survival of various juvenile passage routes through the project. Although the study design could not detect direct from indirect mortality, id did allow for more comprehensive evaluation of project survival. Preliminary information indicate that juvenile subyearlings passing through the bypass system survived 8 percent less than those going through the turbines and that juveniles placed 1.5 miles downstream survived 10 percent better than the turbine released fish (Ledgerwood *et al.*, 1990). This study also reported a 7-percent difference in mortality from the tailrace released fish to the fish released downstream, indicating increased losses in the tailrace zone not directly attributable to the bypass system. In 1987, the subyearling released 1.5 miles downstream had the lowest survival of all other subyearlings released for that year. The authors suggested this survival rate was due to the downstream control fish being released on the shoreline, and were apparently more severely preyed upon by predators inhabiting the shoreline areas than the other release groups. In subsequent years fish released in the downstream area were located in mid-river with higher water velocities had higher survival rates than other release groups.

(3) Similarities at Tanner Creek.

Similar results were observed when juveniles were released in Tanner Creek versus mid-channel (Ledgerwood, 1980). Juvenile recovery data indicated a 33-percent increased survival rate for those juveniles transported to mid-river for release. Based on these evaluations, it is apparent that juveniles have varying survival rates dependent on where they are released, the hydraulic conditions associated with the release sites, and the condition (fitness) of the fish released.

b. Predation Studies.

In 1992, the U.S. Fish and Wildlife Service conducted a study concurrent with the indirect survival study with NMFS. This study examined the predation rates of squawfish on juveniles based on the various release sites. The authors found significantly higher numbers of juveniles were found in squawfish originating from the bypass than all other release sites (from personal communications with Poe, 1993). The above-mentioned studies suggest that indirect mortality is an important factor influencing juvenile survival past Bonneville dam. For this analysis, indirect survival rates are primarily affected by predation rates on juvenile salmonids.

Predation appears to be a major factor affecting survival of juveniles in tailraces of Lower Columbia River Projects. Predation appears to be most severe in areas immediately below the dams (Peterson *et al.*, 1990; Poe *et al.*, 1991; Rieman *et al.*, 1991), and is probably due to concentrating the juveniles at the bypass outfalls and from reduced ability of juveniles to avoid predators following release from the stressful environment in the bypass system.

c. Release Site Criteria.

To increase survival past the first and second powerhouse at Bonneville Dam, the Portland District proposes to replace the juvenile release sites to an area designed to meet new release site criteria, which include:

- Water velocities of 4 feet per second (ft/s) or greater near and downstream of the outfall.

- Recovery area downstream of the release site. Time necessary for juveniles to recover from stress and disorientation related to passage through the bypass system.

- Distance from in-water structures or backwater areas. This is based on the squawfish strike distance to prey from holding cover.

- Dispersal of flows downstream. This factor attempts to categorize the behavioral movements of juveniles under a range of flows below the release site.

The primary objectives of the proposed release sites is to provide a safe passage route for juvenile salmonids exiting the bypass system and to minimize predation on juveniles downstream of the release site. It is not expected that meeting these criteria will eliminate predation on juvenile salmonids, but will provide an area that minimizes predation while giving the juveniles time to reorient following passage through the bypass system.

4.4. Biological Evaluation.

a. General.

Fish benefits were estimated using a Corps spreadsheet and CRiSP for Bonneville Dam. Two flow rates for spring and summer were evaluated which included 200 (spring)/160 (summer) kcfs (based on the NMFS biological opinion, 1993), and 300 (spring)/250 (summer) kcfs. The number of fish arriving at Bonneville and other input values used are described in section 5.

b. Release Site Assumptions.

Biological benefits are based upon the difference in indirect juvenile survival associated with the new juvenile release sites compared to the existing sites. We assumed that the new proposed release sites would be located in an area that adequately meets the criteria discussed above. The indirect survival estimates are based on the assumption that survival is affected by flow levels, hydraulic conditions near and downstream of the release sites, and condition of the juveniles at release. Information from the squawfish swimming performance evaluation suggested that velocities for release sites range from 100 to 130 cm/sec., 3.3 to 4.3 ft/s (Mesa, personal communication, 1993). The assumption made on predator/prey interaction is that water velocities in excess of their swimming capability will reduce their prey capture rates.

For this analysis, it was assumed that the proposed release site would be located in an area that adequately meets the criteria listed above. Physical modeling of the tailrace under various flow discharge levels will need to be conducted to ensure that this assumption can be met. We also assumed that juveniles released near or in low velocity or backwater areas will have higher predation rates resulting in higher mortality than juveniles released in higher velocity areas. Ranges of indirect mortality were estimated for this analysis due to the high degree of uncertainty of the survival rates.

c. Second Powerhouse Summer Migrants.

Based on the NMFS indirect assessments of bypass survival in 1988, 1989, and 1990, we estimate that bypass mortality is 19-percent relative to the downstream releases. Of this 19 percent, the bypass to tailrace and tailrace to downstream release data indicate approximately 8 percent of the mortality is occurring in the bypass itself, and approximately 8 percent is occurring in the tailrace. The releases for these studies were made in the bypass channel at Unit 17; therefore, most of the bypass collection channel was not tested with this release. To account for impacts associated with the entire channel, an additional 2 percent mortality was arbitrarily added to the level of mortality in the bypass itself. This addition to the mortality level increases the total mortality attributable to the bypass from 8 percent to 10 percent. Adding this mortality (10 percent) to the tailrace mortality (8 percent) allows us to estimate bypass survival for summer fish to be 82 percent.

The new proposed juvenile release site evaluate the affects associated with the outfall site and areas immediately below the juvenile outfall. We assumed that 8 percent of the indirect mortality is associated with predation related to the existing outfall at the second powerhouse. With a new outfall location, but utilizing the existing bypass system, we estimated that indirect mortality would be reduced to 4 percent with a range from 4 to 8 percent. Installation of a new outfall will increase survival through the bypass from 82 to 86 percent, with a range from 82 to 86 percent.

We also estimated the indirect mortality associated with a new outfall associated with improvements to the DSM. With improvements to the DSM, we assumed the juvenile fitness would be much improved upon exiting the system and result in increased survival. We estimated that the indirect mortality rate would be 2 to 4 percent, and overall bypass survival would increase from 82 to 93 percent (87 percent DSM improvements and 91 to 93 percent in combination with the new outfall site). This estimate was not used in this analysis to determine potential survival increases but, logically, improvements to the DSM will reduce outfall mortality. This project estimate was included in the Bonneville Package Analysis.

d. Second Powerhouse Spring Migrants.

Information from the USFWS simulation model estimated tailrace predation rates between spring and summer fish at McNary Dam (Peterson and DeAngelis, 1992). This study indicated that predation rates in July were double those in May, primarily due to very high prey density, warmer river temperatures, and small prey size. For this analysis, we assumed that yearling chinook tailrace mortality is 45 percent of the summer migrants at Bonneville Dam (personal communication, Tom Poe), or 8 percent times .45 equals 4. We estimated that total bypass mortality of spring migrants to be 5 percent attributable to the bypass system itself and 4 percent due to the tailrace, for a total of 9-percent mortality or 91-percent survival. With relocation of the juvenile outfall, we estimate that indirect mortality would be reduced by 2 percent (range 2 to 4 percent). This setup would increase survival from 91 to 93 percent.

Similar to the summer migrants, we estimate that combining the DSM improvements and relocating the outfalls, this will improve the fitness of the fish exiting the outfall, and will further reduce indirect mortality to 1 to 2 percent. This would increase survival from 91 to 97 percent (91 to 94 percent DSM improvements and 94 to 97 percent from relocation of outfall).

e. First Powerhouse Summer Migrants.

Based on the NMFS indirect assessments of bypass survival in 1992, we estimate that bypass mortality is 28 percent relative to the downstream release. Of this 28-percent mortality, we estimate 1/3 or 9 percent to be attributable to the bypass system and 2/3 or 19 percent to the location of the outfall and tailrace. An additional 2-percent mortality was added to the bypass system to account for the effects of the entire collection channel. In the NMFS survival test, fish were released in unit 9, which is near the downstream end of the collection channel. This addition increases the total mortality attributable to the bypass from 9 to 11 percent. Adding this mortality (11 percent) to the tailrace mortality (15 percent) allows us to estimate bypass survival for summer fish to be 70 percent.

Relocation of the outfall at the first powerhouse will require that the pressurized pipe and downwell be converted to an open transportation flume. For this analysis, we assumed that 1/4 of the mortality within the bypass system is associated with each component of the system, or 3 percent for the downwell and 3 percent for the pressurized pipe. This relocation will increase the survival in the bypass from 70 to 76 percent.

A reduction in indirect mortality from relocation of the outfall is estimated to range from 8 to 18 percent (does not account for inclined screen modifications). The relatively high indirect mortality compared to the Bonneville Second Powerhouse release site is due to the site location constraints. After an initial view of the general model, their location may not be ideal for an outfall near Bradford Island for the full range of flows. As the juvenile bypass system at the first powerhouse flows to the north end of the powerhouse, there may be constraints (due to head loss) to how far away the outfall may be located. For this analysis we assumed that the outfall will be located near the tip of Bradford Island and out in the channel. Therefore, we assumed that the location would not be as good as other potential sites further downstream, and estimated that mortality to be about 8 percent, or an increase in indirect survival of 11 percent. This location, in combination with increased survival due to improvements of the downwell (3 percent) and pressurized pipe (3 percent) will increase bypass survival from 70 to 87 percent.

Similar to the second powerhouse, we assumed that bypass improvements will increase the fitness of the fish and account for an increase of 2 percent indirect survival or 6 percent (8 - 2 percent) indirect mortality. In combination with other bypass improvements [3-percent inclined screen, 3-percent downwell, 3-percent pressurized pipe, and 13-percent outfall (19 - 6 percent)], we estimate this will increase total bypass survival from 70 to 92 percent.

f. First Powerhouse Spring Migrants.

Based on information from the USFWS simulation model, we estimated that yearling chinook tailrace mortality is 45 percent of the summer migrants, or 19 percent times .45 equals 9 percent. We estimated that mortality would be reduced by 1/2, with relocation of the outfall or 4-percent mortality (range from 4 to 8 percent).

Data from the NMFS direct assessment of injury and condition through the second powerhouse bypass system, river-run yearling chinook had less than half the descaling level of river-run subyearling chinook (12 percent versus 28 percent), lower levels of blood lactate (115 mg/dl versus 140 mg/dl), and peak cortisol levels that are approximately equal to river-run subyearling chinook. Based on these observations, we assume that yearling chinook mortality attributable to the bypass system is half that of summer migrants, half of 11 percent, or 6 percent. We assume that converting the pressurized pipe and downwell to an open flume will reduce bypass mortality by 1/2 (1/4 for each component), from 6 to 3 percent.

Relocation of the outfall and converting the pressurized pipe and downwell to an open flume will increase survival from 85 to 93 percent (outfall 9 percent - 4 percent - 5 percent plus 3 percent for open flume = 8 percent improvement).

Improvement to the bypass system with a new outfall will increase fitness of the fish. We assume that with the improvements, indirect mortality at the outfall will be reduced a maximum of 1 percent (4 to 3 percent, and range from 3 to 6 percent). In combination with all bypass improvements, maximum survival increased will be from 85 to 95 percent (4 percent bypass improvements plus 6 percent outfall).

4.5. Engineering Evaluation of Proposed Improvements.

a. General.

The existing outfalls at the Bonneville Project are both pressurized underwater outlets. Open channel above water releases are preferred for discharging the juveniles back into the river. Release areas with highest velocities that meet other criteria are the most desirable outfall locations.

b. Alternatives.

Two primary alternatives were considered. One alternative was a single outfall for the project. The other alternative was one outfall per powerhouse, for a total of two outfalls.

(1) Single Outfall.

The single outfall would be constructed on Bradford Island or Cascades Island. For a Bradford Island outfall, the flow in the Second Powerhouse JBS would have to be reversed and the transportation flume would have to cross the river on the downstream side of the spillway. An outfall on Cascades Island requires reversal of flow at the Second Powerhouse and the First Powerhouse flume to travel across the spillway.

(2) Two Outfalls.

The First Powerhouse outfall would be on Bradford Island. The Second Powerhouse outfall would be on the Washington shore or on Cascades Island. The Cascades Island outfall requires flow reversal of the JBS.

c. Assessment of Alternatives.

Flow reversal and transporting fish in a flume across the spillway require additional study to determine if they are technically feasible. A Second Powerhouse Washington shore outfall and First Powerhouse Bradford Island outfall appears to be technically feasible. Cost estimates can be developed for the feasible locations.

d. Selection.

The two-outfall alternative with the Washington Shore outfalls and the Bradford Island outfall was selected for determining costs and benefits in this report.

e. Design.

The transportation flume and outfalls are based on the same criteria that *The Dalles Juvenile Fish Bypass Feature Design Memorandum Number 28* presents. The flume is covered with elevated corrugated metal pipe supported by steel beams and foundation concrete footings. The outfall is cast in-place concrete supported on two shaped elliptical piers. Continuous inspection is planned for the entire system.

4.6. Biological Benefits.

a. Spreadsheet Input Parameter Ranges.

We estimated the mortality rates associated with the new outfalls vary depending on fitness of the fish, hydraulic conditions near and downstream of the outfall, and timing of fish passage (summer versus spring). Many other factors may influence mortality rates of fish through the bypass or at the outfall, such as water temperature and predator densities. There is little information available that evaluates the increase in survival based on providing an outfall utilizing the above-mentioned criteria. As every project has its own physical characteristics and dynamic tailrace environment, there is considerable uncertainty in assigning mortality rates to specific changes in the system. Due to this uncertainty, ranges of values were used to evaluate the potential for increased survival with relocation of the outfalls (table 4-1).

Table 4-1 Mortality Ranges (Percent)		
Conditions	**Second Powerhouse**	**First Powerhouse**
Base Condition		
Spring Summer	4 8	9 19
Base Condition		
Spring Summer	2-4 4-8	4-8 8-18
Base Condition		
Spring Summer	1-2 2-4	3-6 6-12
[1]Information not used in this analysis.		

b. Spreadsheet Model Results.

Total project survival results due to the relocation of the outfalls are shown in tables 4-2 to 4-5.

Table 4-2 Estimated Project Survival of Juvenile Salmonids With and Without Improved Outfall B1 Priority (Flows of 200/160 cfs)		
Species	**Base Case Survival**	**Survival With Improved Outfall**
Yearling Chinook	93	93-94
Subyearling Chinook	92	93-94
Steelhead	92	93-95
Coho	92	93-95
Sockeye	92-93	93-94

Table 4-3
Estimated Project Survival of Juvenile Salmonids
With and Without Improved Outfall
B1 Priority (Flows of 300/250 cfs)

Species	Base Case Survival	Survival With Improved Outfall
Yearling Chinook	92-93	93-94
Subyearling Chinook	92	93
Steelhead	92	93-94
Coho	92	94-95
Sockeye	92	93-94

Table 4-4
Estimated Project Survival of Juvenile Salmonids
With and Without Improved Outfall
B2 Priority (Flows of 200/160 cfs)

Species	Base Case Survival	Survival With Improved Outfall
Yearling Chinook	92	93-94
Subyearling Chinook	91-92	92-93
Steelhead	92	93-94
Coho	92	93-95
Sockeye	92	92-93

Table 4-5
Estimated Project Survival of Juvenile Salmonids
With and Without Improved Outfall
B2 Priority (Flows of 300/250 cfs)

Species	Base Case Survival	Survival With Improved Outfall
Yearling Chinook	92-93	92-93
Subyearling Chinook	91	92
Steelhead	92	92-93
Coho	92	92-95
Sockeye	92	92-93

Based on the spreadsheet model and the model assumptions, the increases in total project survival from relocation of the outfalls range from 0 to 3 percent, depending on the species.

c. CRiSP Modeling.

The CRiSP model was developed by the University of Washington, and tracks the downstream migration and survival of salmon and steelhead through the Columbia and Snake Rivers to below Bonneville Dam. The model recognizes and accounts for various reservoirs and dam passage parameters, integrating a number of subroutine models to arrive at final estimates of hydrosystem survival. For this analysis, arbitrary numbers of fish for the following stocks were input into the CRiSP model to estimate percent change from the base case for each stock:

Deschutes (Yearling Chinook)	Rock Creek (Steelhead)
Dworshak (Steelhead)	Wenatchee (Steelhead)
Hanford (Subyearling Chinook)	Methow Wells Index (Subyearling Chinook)
Methow (Yearling Chinook)	Wild Snake Fall (Subyearling Chinook)
Wild Snake Spring (Yearling Chinook)	Wild Snake Summer (Subyearling Chinook)

Model runs used input data for the SOR and the Model Coordination Team (letter from Tuttle to fisheries agencies and tribes, dated January 25, 1993). For example, bypass mortality at all dams including Bonneville, is assumed to be 2 percent. Based on this value of 98-percent survival, we assumed that improving the bypass systems at both the Bonneville First and Second powerhouse decreases mortality through each bypass by 50 percent, from 2 percent to 1 percent. Under this condition, survival through the bypass is increased from 98 to 99 percent. To run CRiSP and account for scientific uncertainty bypass survival estimates were ranged for each case. Based on bypass estimates used in the System Operational Review study, base case bypass survival had a mean of 98 percent and a range of 92 to 99 percent, while Bonneville outfall improvements had a base case of 99 percent and a range of 96 to 100 percent.

d. CRiSP Results.

Based on the model input described above, where bypass survival is assumed to be high to start with (98 percent), CRiSP results indicate there were no statistically significant differences between the base case and the improved condition, suggesting the improvements have no effect on survival through the system. This is true for all the stocks listed above from point of origin to below Bonneville Dam, and for the condition modeled, transportation on. We estimate that similar results will be produced when CRiSP is run with transportation turned off. However, that does not mean the proposed improvements have no effect. Rather, CRiSP, the analytical tool used to pick up differences between the base case and the treatment, is not sensitive to relatively small changes in project passage conditions at Bonneville Dam since CRiSP is primarily a model of system-wide effects.

e. Model Analysis Summary.

The CRiSP model shows no benefit from improving the juvenile release sites at both Bonneville powerhouses, primarily because the model is a system-wide model that is relatively insensitive to small improvements in bypass survival at one project. The spreadsheet model developed by CENPP is a project-specific model, and is more sensitive than CRiSP to changes in individual passage parameters at Bonneville Dam. The spreadsheet model indicates that survival past Bonneville Dam could be increased as much as 2 percent with the proposed improvements. Based on the significant number of fish arriving at Bonneville Dam, our best professional opinion that the proposed improvements will improve passage conditions in the fish bypass systems, and the benefits suggested by the spreadsheet model, the proposed improvements are warranted.

4.7. Economic Impact.

Replacing Bonneville Dam's existing pressurized transportation conduit and underwater outfalls with two open transportation channels and above-water outfalls has been analyzed to provide information regarding their combined direct and indirect economic impacts. Direct economic impacts are changes in project outputs, described in market values. Indirect economic impacts are changes in regional or local economic activity resulting from direct impacts. No direct impacts to hydropower, navigation, or recreation are expected from construction of this proposed improvement, nor is any change in local or regional economic activity anticipated from this proposed project improvement.

This proposed project improvement will include new transportation channels and outfalls, and will utilize the proposed juvenile fish monitoring and sampling facilities. The new First Powerhouse transportation channel will extend approximately 1,500 feet downstream along Bradford Island with the outfall located approximately 100 feet out into the Columbia River. The Second Powerhouse channel will extend approximately 9,000 feet downstream along the Washington shore and the outfall located approximately 120 feet out into the river. No additional river flow is expected to be diverted into the proposed transportation channels.

4.8. Schedules and Cost.

a. Design and Construction Schedule.

The design and construction schedule is shown on figure 4-1. It includes a feasibility study that directly leads to plans and specifications, followed by construction of the outfall. The proposed smolt monitoring facilities project schedule is included for a comparison of the two projects.

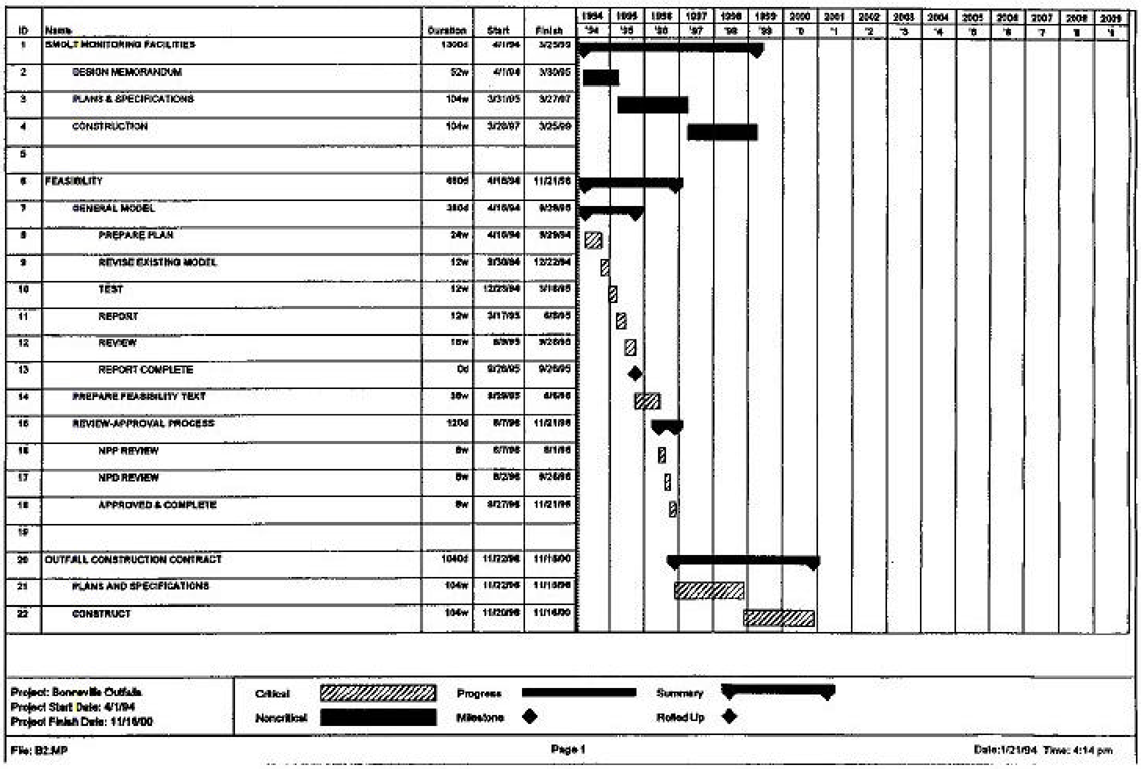

Figure 4-1. Bonneville Outfalls Design and Construction Schedule

b. Total Contract Cost Summaries.

Total construction costs are summarized in table 4-6. Table 4-7 adds biological research and planning, engineering, and design costs and presents a fully-funded cost estimated based on the current schedule.

Table 4-6
Bonneville I and II
Bypass Outfalls, Contracts A and B
Construction Cost Estimate

Feature	Quantity	Unit	Unit Price	Total Cost
Bonneville Bypass Outfalls, Bonneville I				
Mobilization-Demobilization	1	EA	137,414.28	**137,414**
Flume				
Towers	44	EA	28,308.39	1,245,569
Excavation and Backfill	8800	CY	5.43	47,784
Corrugated Flume	1740	LF	1,365.51	2,375,987
Sum, Flume Bonneville I				**$3,669,341**
Outfall				
Riprap	500	CY	39.64	19,820
Rock Anchors	600	FT	24.48	14,690
Abutment Reinforcement	150	CY	355.19	53,279
Concrete Reinforcement	23000	LB	0.88	20,180
Steel Forming	80000	LB	6.85	547,810
Sum, Outfall Bonneville I				**$655,779**
Superstructure				
Concrete	390	CY	355.19	138,530
Concrete Reinforcement	28.6	TON	1,242.38	35,532
Concrete Coating	4333	SF	0.19	840
Handrails	260	FT	20.60	5,360
Monstrand Post Tension Tendons	13520	FT	103.89	1,404,620
Sum, Superstructure at Bonneville I	12480	FT	69.26	864,380
				$2,449,262
Shaped Concrete Piers				
Sum Fish Facilities at Bonneville I	157	CY	599.17	94,070
				$94,070

Bonneville Bypass Outfalls, Bonneville II				
Mobilization-Demobilization	1	EA	429,252.34	**429,252**
Flume				
Towers	190	EA	30,459.09	$5,787,227
Excavation and Backfill	38000	CY	5.57	21,830
Corrugated Flume	7600	FT	1,467.17	11,150,492
Sum, Flume Bonneville II				**$17,149,549**
Outfall				
Riprap	500	CY	42.65	21,325
Rock Anchors	600	FT	26.33	15,798
Abutment Concrete	150	CY	382.18	57,327
Concrete Reinforcement	23000	LB	0.94	21,710
Steel Forming	80000	LB	7.37	589,600
Shaped Concrete Piers	158	CY	644.69	101,216
Sum, Outfall Bonneville II				**$806,976**
Superstructure				
Concrete	450	CY	382.18	171,981
Concrete Reinforcement	33	TON	1,888.01	62,304
Concrete Coating	5000	SF	0.29	1,470
Handrails	300	FT	22.17	6,651
Monstrand Post Tension Tendons	18000	FT	111.78	2,012,120
Bundled Post Tension Tendons	16200	FT	74.52	1,207,270
Sum, Superstructure at Bonneville II				**$3,461,796**
Contingency				16,932,000
Biological Research				2,260,000
Research Contingency				902,000
Total Fish and Wildlife Facility				**$48,947,439**
Planning, Engineering, and Design				5,370,000
Contingency				2,503,000
Total Plan, Engr, and Design				**$7,873,000**
Construction Management				2,000,000
Contingency				1,101,000
Total Construction Management				**$3,101,000**
Total Project Cost				**$59,921,439**

Table 4-7
Total Contract Cost Summary
Columbia River Salmon Mitigation Analysis System Configuration Study--Phase I
Bypass Outfalls at Bonneville (Contracts A and B)
Columbia River, Oregon and Washington

POC: Pat Jones, Chief, Cost Engineering Branch

Current MCACES Estimate Prepared: Effective Pricing Level:				Dec 93 Oct 93		Authoriz./Budget Year: 1995 Effect. Pricing Level: Oct 95				Fully-Funded Estimate				
Acct No.	**Feature Description**	**Cost ($K)**	**CNTG ($K)**	**CNTG (%)**	**Total ($K)**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Total ($K)**	**Feature Mid-Pt**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Full ($K)**
Fish and Wildlife Facilities														
06---	Bonneville I/II	28,853	8,785	30%	37,638	6.8%	30,815	9,382	40,197	Jul 99	13.9%	35,099	10,686	45,785
06---	Biological Research	2,260	339	15%	2,599	6.8%	2,414	362	2,776	Jul 99	13.8%	2,749	412	3,162
	Total Construction Costs	31,113	9,124	29%	40,237		33,229	9,744	42,973			37,848	11,099	48,946
Functional Costs--Planning, Engineering, and Design														
30F--	Feasibility Report	570	143	25%	713	8.9%	621	155	776	Aug 97	7.7%	669	167	836
30G--	Feature Design Memoranda	900	225	25%	1,125	8.9%	980	245	1,225	Aug 97	7.7%	1,056	264	1,319
30H--	Plans and Specifications	2,200	550	25%	2,750	8.9%	2,396	99	2,995	Aug 97	7.7%	2,580	645	3,225

30J--	Design Related Engr. Hyd. Models													
30J--	General Models	100	25	25%	125	8.9%	109	27	136	Aug 97	7.7%	117	29	147
30K--	Engineering During Construction	500	125	25%	625	8.9%	545	136	681	Aug 97	7.7%	586	147	733
30L--	Value Engineering	100	25	25%	125	8.9%	109	27	136	Aug 97	7.7%	117	29	147
30S--	E&D Project Management	1,000	250	25%	1,250	8.9%	1,089	272	1.361	Aug 97	7.7%	1,173	293	1,466
	Total 30 Account	5,370	1,343		6,713	8.9%	5,848	1,462	7,310			6,298	1,575	7,873
Functional Costs--Construction Management														
31---	Bonneville I/II	2,000	500	25%	2,500	8.9%	2,178	545	2,723	Jul 99	13.9%	2,481	620	3,101
	Total 31 Accounts	2,000	500		2,500		2,178	545	2,723			2,481	620	3,101
	Total Costs	38,483	10,966	28%	49,449	7.2%	41,255	11,751	53,006		13.0%	46,627	13,293	59,920
Total Project Costs:														**$59,920-**

Functional costs were provided by the design section.
Contingency's on 30 and 31 accounts were estimated at 25%.
Authorization: Year assumed to be FY 1995.

c. Operation and Maintenance Costs.

Operation and maintenance costs are shown on table 4-8.

Table 4-8
Operation and Maintenance Costs

Items	Notes	Costs	Recurrence Interval Years
Inspection	50 trips (8 hours per trip at $40 per hour)	$16,000	1
Repairs	260 hours at $40 per hour	10,400	1
Supplies		14,000	1
Flume Painting	8.7 feet^2 ($0.50 per foot at 8.340 feet)(not required at 25- and 50-year intervals)	36,000	5
Flume Cleanup	320 hours at $40 per hour	13,000	1
Flume and Lid Replace	420,000 pounds at $2.00 per pound	840,000	25
Debris Removal	(8 hours with two-man crew, 4 times a year at $40 per hour)	2,600	1

Note: Flume maintenance costs from study of transportation flume, *The Dalles Juvenile Bypass System,* Delivery Order No. 7, dated March 1992, by Ebasco Service, Inc., Bellevue, Washington.

4.9 Phase II Study Requirements.

a. General.

This paragraph covers the feasibility study, model studies, and biological research. A design memorandum is not scheduled for the outfalls. All conceptual design, alternative selection, and preliminary design is scheduled for the feasibility study. The design memorandum is not scheduled because technical issues are expected to be resolved during the feasibility study in the Smolt Monitoring Feature Design Memorandum. Final design of the flumes and outfalls will take place during the plans and specifications phase.

b. Feasibility Study.

(1) Economics.

Economics will be included in the feasibility study.

(2) Engineering.

The general model will be calibrated and tested or locating the new outfall sites. Reversing the flow in the Second Powerhouse will be evaluated to determine if it is feasible and if there is any biological benefit for doing it. If reversing the flow was found to be desirable, the entire project scope would change and a design memorandum would be required as well as a budget change and schedule extensions. The study will also evaluate alternative outfall types such as flume construction and flume placement, and creates the baseline cost estimates.

(3) Smolt Monitoring Facilities.

The smolt monitoring facilities are scheduled to be designed and evaluated separately from the outfalls. This study assumes the monitoring facilities will account for the outfalls.

c. Biological Research.

Little information is currently available on the survival of fish associated with relocating outfalls based on the criteria described above. There is concern that predators, like the squawfish, adapt their behavior to meet their biological requirements. Whether or not the squawfish adapt to the juveniles at locations other than tailrace environments or select other prey species is unknown. The biological uncertainties are unclear and further evaluations are needed to determine the affects of our proposed actions.

Considerable information is available on direct and indirect mortalities associated with juvenile passage routes through Bonneville project, which includes the existing outfall and areas downstream. It is unknown, however, whether the new proposed outfall will have similar levels of survival as the downstream control fish released during the survival test. It seems prudent that an evaluation be conducted to determine the relative survival of the new proposed outfall. A survival study based on 3 years of coded-wire tagged and freeze-branded hatchery fish released through the proposed outfall sites, the existing outfall, and spillway are recommended. The 3 years of juvenile release and recovery will be followed by approximately 4 years of adult returns and final reporting. This study can be done concurrently with the feasibility and design phase for this activity. The FPDEP costs associated with the conduct of this study are estimated in table 4-9.

Table 4-9 Biological Study Costs			
Fiscal Year (FY)	**Biological Research**	**S & A ($)**	**Total ($)**
95	Juvenile release - $550,000	15,000	565,000
96	Juvenile release - $550,000	15,000	565,000
97	Juvenile release - $550,000	15,000	565,000
98	Adult returns - $100,000	10,000	110,000
99	Adult returns - $100,000	10,000	110,000
00	Adult returns - $125,000	10,000	135,000
01	Adult Returns - $125,000	10,000	135,000
02	Final Report - $75,000		75,000
Total			**2,260,000**

In addition to these studies, hydraulic model studies of the Bonneville Dam tailrace will be needed in the next phase for this activity. Scopes, schedules and budgets for this work are described elsewhere in this report.

d. Model Studies.

(1) General.

The general hydraulic model will be the principal tool used in evaluating potential outfall locations. It will allow for quick assessment with accurate velocity representation at numerous project operating conditions. The hydraulic information can then be provided to the Corps and other agency fishery biologists for their interpretations.

(2) General Model Construction.

The existing general model will need to be modified to accurately represent the prototype in several areas. It will be necessary to perform hydrosurveys of the project in potential outfall areas if no recent ones are available at the initiation of model construction. No other modifications should be necessary for the model.

(3) Model Testing.

After reconstruction is completed, testing can begin. Testing will be hydraulically limited to regions roughly within 12,000 lineal feet of the powerhouses. Within this range, initial dye testing will provide supporting information for a few sites of higher potential. These remaining sites can then be more thoroughly evaluated for potential. Velocity mapping at various flows will provide velocities average over a given depth (*e.g.*, 25 feet) at hundreds of locations in the channel. A site will be evaluated for several things: 1) average velocity; 2) proximity to structure; 3) stability of flow; 4) depth; and 5) flow conditions downstream of the release point. Upon preliminary identification of outfall locations, the fishery agencies will be invited to provide input to the site selection and process used. If further evaluation is needed, it will be performed prior to final selection. Final selection will then be made and the locations provided for additional engineering work.

(4) Plans and Specifications.

Model testing of the locations will be essentially complete at this point, but if changes to the flume or outfall structure occur because of unforeseen circumstances, such as geotechnical anomalies, additional model testing of slightly varied sights may be necessary. To minimize the disturbance by supporting mechanisms of the outfall, some math modeling may be necessary to refine support shape. Hydraulic calculations will need to be performed on the flume for velocity, slope, and depth. Assurances to eliminate any hydraulic jumps need to be taken. The location and hydraulic characteristics of the smolt monitoring facility will be available at this point, and may further restrict the hydraulically limited sites to closer to the powerhouse. Flow control devices such as weirs, gates, and hydraulic piping must be sized and shapes determined. Support for momentum calculations and flow superelevation will also be performed.

4.10. Plans and Specifications.

The plans and specifications are based on the flumes starting at fixed points in the smolt monitoring facilities. Model studies are scheduled to be completed before this phase begins.

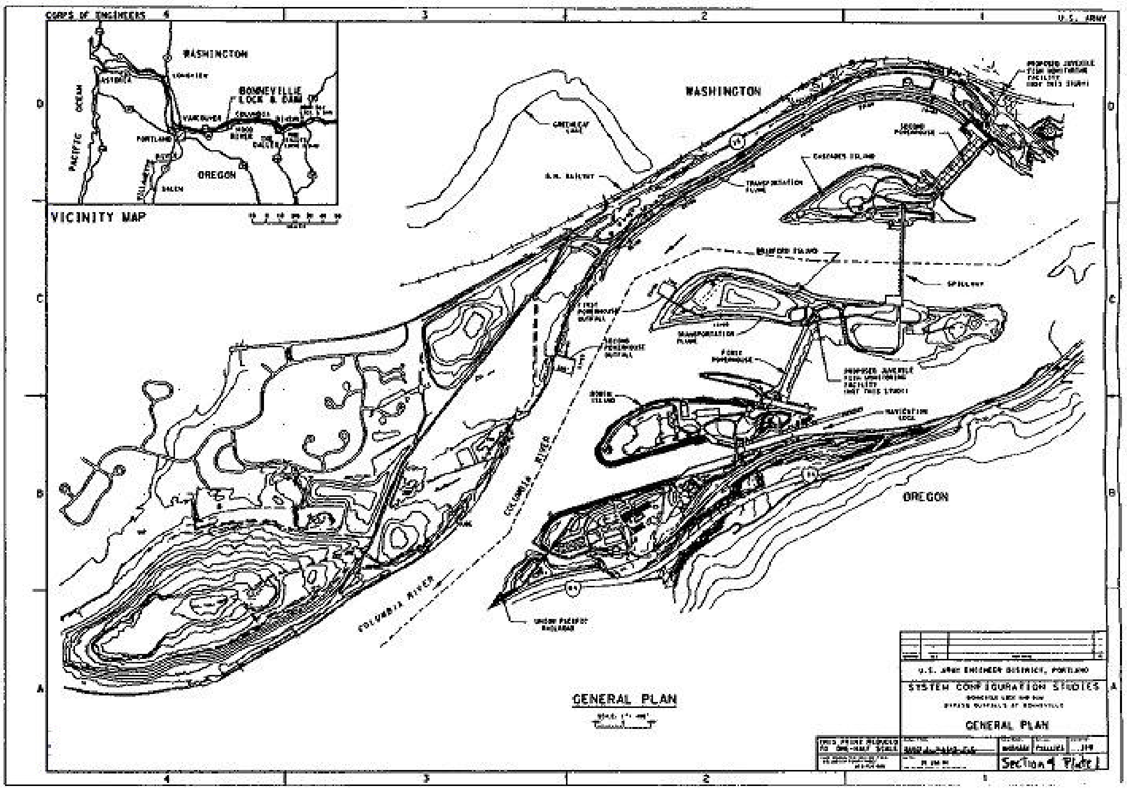

Plate 4. Bypass Outfalls at Bonneville, General Plan

Section 5 - Bonneville Fish Guidance Efficiency

5.1. Existing System Description and Operation.

a. General.

Early actions taken to enhance anadromous fish survival at Bonneville Dam consisted mainly of provision of fish ladders for upstream passage of adult fish past the dam, as well as construction and operation of fish hatcheries to replenish downstream migrating juveniles. With the continued decline of the river's fish runs, juvenile bypass systems were constructed through both powerhouses in 1983 to pass downstream migrating juveniles. Significant efforts have also been made in the study and improvement of conditions for passing of juvenile fish through spillway releases.

b. Juvenile Collection and Bypass Facilities.

(1) Bonneville First Powerhouse FGE Studies.

The Bonneville Dam First Powerhouse was constructed in 1938 without specific regard for protecting juvenile salmon migrating through the ten Kaplan units. Survival studies on fish passing through the turbines and spillway at Bonneville Dam were conducted by the U.S. Fish and Wildlife Service from 1938 through 1944, which estimated turbine passage survival for juvenile fall chinook salmon to be from 85 to 89 percent. Studies of turbine survival conducted at other Columbia River hydroelectric facilities have produced similar estimates.

Starting in the 1960's NMFS, in conjunction with the U.S. Army Corps of Engineers, began developing submersible traveling screens for placement within turbine intakes. These screens deflect downstream migrating juveniles from intakes into gate slots, which they exit through orifices into specially designed bypass systems for subsequent transportation or return to the tailrace. The effectiveness of the intake screens is the efficiency by which they guide fish out of the intake or FGE.

Efforts to study FGE were initiated by NMFS at the Bonneville Dam First Powerhouse starting in 1977, with the investigation of a short stationary barscreen deflector. FGE ranged from 16 to 62 percent with a lowered operating gate and from 43 to 78 percent with the operating gate raised. With the gate in the raised position attraction flow out of the intake and up into the gateslot increased from 90 to 250 ft^3/s.

In 1981, NMFS conducted FGE investigations at the Bonneville First Powerhouse using the standard 20-foot STS. For spring migrants, FGE was greater than the regional goal of 70 percent. Based on these results, STS's were installed and a bypass system constructed inside the existing ice-and-trash sluiceway was completed for the 1983 fish outmigration. The newly constructed bypass system was not evaluated further until the late 1980's.

Starting in approximately 1987, underwater construction activities began to reconfigure the channel in front of the First Powerhouse to reshape flow patterns in the forebay for the new navigation lock. Evaluations of the Corps' physical model of Bonneville Dam were initiated at the Corps' WES. Observations of the reshaped forebay substrate and preliminary designs of the navigation lock's upstream guide wall indicated potential impacts to FGE levels. These designs were particularly a concern for summer migrating subyearling chinook.

Based on the WES observation of potential lock guide wall impacts to First Powerhouse FGE, the lack of any summer FGE data at Bonneville First Powerhouse, and the low FGE levels observed at the Second Powerhouse on summer migrating stocks, NMFS began investigating FGE to gather baseline data prior to installation of the navigation lock upstream guide wall, scheduled for 1993. In 1988, FGE levels for spring migrants were less than those of 1981. FGE averaged 55 percent for coho and 41 percent for yearling chinook, considerably less than the regional goal of 70 percent. FGE of summer migrants, measured for the first time, averaged 11 percent. Due to these low FGE values, the tests were repeated in 1989k with similar results. FGE average 68 percent for coho, 42 percent for yearling chinook, and 5 percent summer migrating subyearling chinook.

Based on these low guidance levels and the substantial decrease in FGE from 1981 to 1988/89, NMFS conducted additional FGE measurements in 1992 to measure differences in FGE between units and the effect of raising the operating gate. While some differences in units were noted, average yearling chinook FGE ranged from 29 to 46 percent, well below the 1981 level of 72 percent. Raising the operating gate in Unit 8 significantly increased yearling chinook FGE from 30 to 50 percent, indicating optimal attraction flow into the gatewell was not being provided by the normal, stored gate conditions.

The 1991 tests were replicated in 1992 along with tests to determine benefits associated with lowering the STS and combining a lowered STS with a raised operating gate. In 1992, yearling chinook FGE was higher but did not significantly improve with the gate raised (43 versus 38 percent). Raising the operating gate increased FGE for stocks other than yearling chinook, although the sample sizes were small. Lowering the screen in combination with raising the operating gate actually reduced FGE, because fish were going over the top of the lowered screen and passing through the gap.

In summary, FGE values for spring migrants decreased in 1988 to 1992 when compared to 1981, for unknown reasons, and current levels are below regional goals. FGE levels were generally increased by raising the operating gate for most species and in most years tested. This increase suggests that currently insufficient flow up the gate slot is available to guide and attract fish away from the intake. While improved under this condition, however, FGE levels were still below regional goals.

Analysis of vertical distribution data suggests spring migrants are distributed just below the STS. Attempts to reach these fish by lowering the STS were confounded by a reduction in FGE associated with fish going over the top of the guidance screen and reentering the intake.

These results indicate that understanding the hydraulic environment of the Bonneville First Powerhouse intake is critical to understanding fish behavior associated with these complex hydraulics. The available information suggests that improvements in spring FGE to regionally accepted levels will only be achieved after thoroughly assessing the hydraulic conditions present and developing optimum hydraulic conditions for fish guidance through intensive physical modeling.

Summer migrant FGE values for Bonneville First Powerhouse are far below the regional goal of 50 percent. Improvements to spring migrant FGE may increase summer migrants substantially. Also, it may be possible to better understand the basis for the low vertical distribution of these summer stocks and formulate additional solutions to their low FGE after thorough evaluations of the hydraulic conditions present.

In addition to the FGE studies described above, research efforts were initiated in 1992 to estimate the survival of fish passing through various passage routes at Bonneville First Powerhouse. Short-term relative survival of subyearling fall chinook salmon was measured during the summer migration period, and long-term survival will be determined through adult returns. Marked fish were released through a First Powerhouse turbine and the bypass system, into the river immediately downstream from where the first and Second Powerhouse tailraces meet, and through a Second Powerhouse turbine. Preliminary results indicate that passage through the First Powerhouse bypass system and tailrace had the lowest relative survival of all the release groups. This information suggests that for summer migrating subyearling chinook, any improvements made to FGE to meet regional goals should be implemented when improvements to bypass survival are made that also meet regional goals for survival.

Based on the available information on FGE and relative survival through various project passage routes, the Bonneville First Powerhouse and bypass system are being operated during the spring. However, starting in 1993, STS's were removed from the powerhouse during the summer to afford subyearling migrants greater protection until solutions to low bypass survival are implemented.

(2) Bonneville Second Powerhouse.

The juvenile bypass system through the Second Powerhouse was designed and constructed at the same time as the powerhouse structure, which was completed in October 1982. Similar to systems at upstream projects, juvenile fish are guided up into the intake gate slots and pass through orifices into a transportation channel. They are carried to the north end of the powerhouse, where the excess flow is separated. After passing through an evaluation facility, they are released downstream of the powerhouse under water.

c. **First Powerhouse Forebay Geometry.**

Approximately 2.5 miles upstream of the powerhouse, the river discharges flow out of the lake area above Cascade Locks and down through 2 miles of swift currents in the single and relatively straight existing natural channel called Cascade Rapids (see figure 5-1). Unlike other upstream projects, upon reaching Bonneville Dam, the flow is split into three geometrically separate channels, depending on project operation. Flow through the First Powerhouse forebay is directly dependent on the discharge being released through the powerhouse turbines, with occasional releases for operation of the navigation lock.

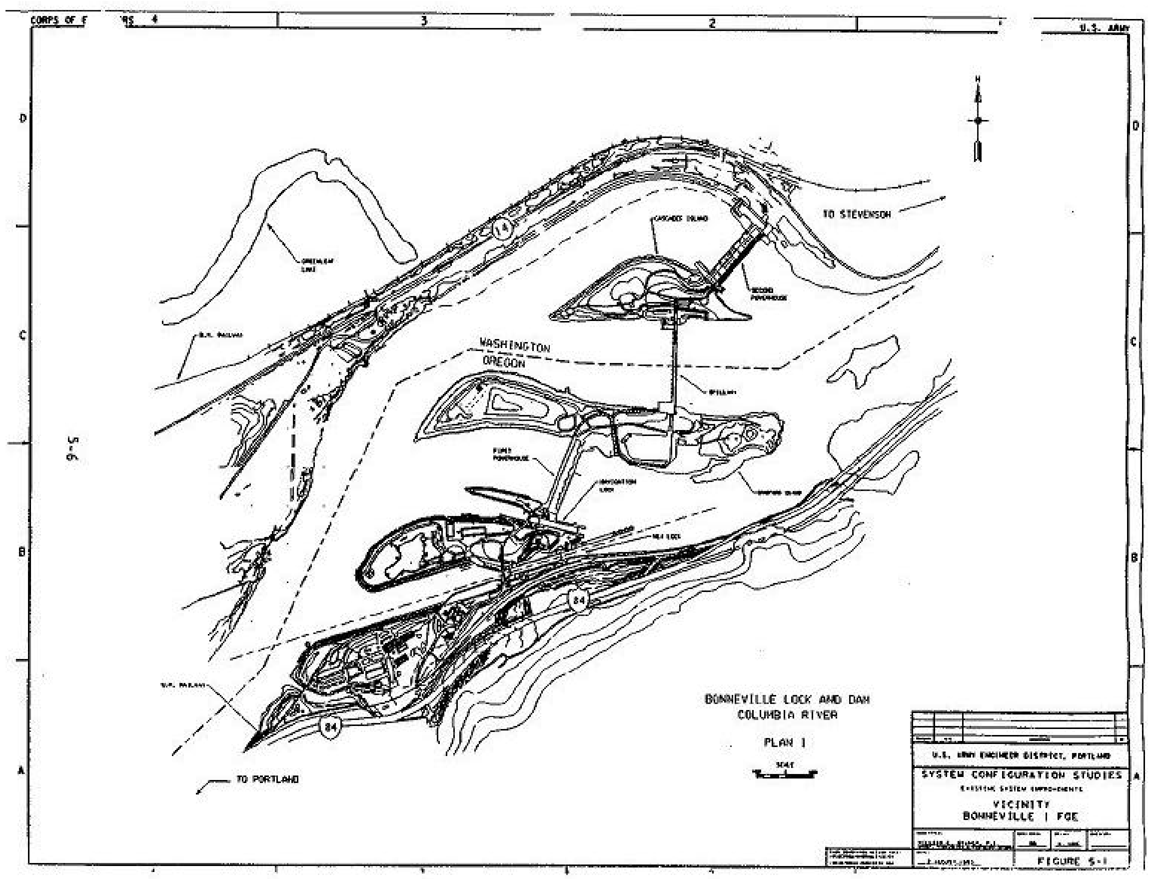

Figure 5-1. Vicinity, Bonneville I FGE

The channel geometry through the First Powerhouse forebay is more complex than other upstream Columbia and Snake River Projects. Flow must enter through the contracted opening from the main river channel and make the turn around the bend at the upstream end of the forebay. It then travels down through a channel that is confined by the Oregon bank on the south side and Bradford Island on the north side. The length through the channel from the upstream end of Bradford Island on the north side. The length through the channel from the upstream end of Bradford Island to the turbine intakes is about 4,300 feet.

Once water has entered the forebay, there are essentially no other outlets except through the powerhouse turbine intakes. Any fingerling fish being carried into the forebay must eventually make passage into the powerhouse intakes and either go up through the intake gate slots and into the JBS transportation channel or through the turbine units.

d. Hydraulic Characteristics of Powerhouse Forebay.

(1) General Project Storage Characteristics.

Bonneville Dam is typically described as a run-of-river project because, at high discharges, flood storage in the reservoir is relatively small. The incoming river discharge must be passed on through the project with minor time of retention. At lower discharges, water is pooled to maintain reservoir elevations for navigation and power production. But project storage still remains relatively small, with normal forebay operating elevations between 71.5 and 76.5 feet National Geodetic Vertical Datum (NGVD). During flooding, the forebay elevations are about 40 feet above tailwater elevations of around 35 feet NGVD. In extreme low-flow periods, forebay elevations are a maximum of about 68 feet above the minimum tailwater elevation of 7 feet NGVD. Because the volume of available storage immediately above the dam is proportionately much less than at John Day, McNary, and other upstream projects, the average velocity through the reservoir is considerably higher than projects upstream.

(2) Extensive Use of First Powerhouse.

Depending on project operation at any certain time, incoming flow is divided into the portion released through the spillway, and the portion passed through the turbines for power production. The use of the Second Powerhouse has generally been held to a minimum due to a poor survival rate of fingerling fish traveling through the juvenile fish passage facilities there.

(3) Characteristics of Currents in Forebay.

Presently, the river discharge flows out of the slower moving lake area above Cascade Locks and descends across the 2 miles of swift rapids in the narrow river channel at average velocities in the range of 1 to 9 ft/s. Upon arriving at the backwater effect created by the spillway and powerhouse structures, the river discharge is decelerated. The average velocities in the forebay of the First Powerhouse drop down into the range of 0.5 to 5 ft/s., but as a result of the velocity attained in the descent down through Cascade Rapids the incoming mass of flow still has energy to be dissipated by small eddying and general hydraulic turbulence.

In 1986 an d1987, as part of the construction of the new lock, underwater groins were built along the channel bottom adjacent to the Oregon bank, and fill was placed between the groins. The desired result of reducing the currents along the bank and forcing more of the incoming flow out into the middle of the powerhouse forebay were achieved, thus resulting in a lessening of the strong currents along the

Oregon bank and a significant improvement of navigation conditions through the First Powerhouse forebay. Because of the changes in the shape and cross-sectional area of the forebay, velocity distributions have changed significantly from distributions existing prior to the channel modifications.

e. Modifications Made for Approach to New Lock.

Starting in approximately 1987, underwater construction activities began to reconfigure the channel in front of the First Powerhouse to reshape flow patterns in the forebay for the new navigation lock. Observations of the reshaped forebay substrate and preliminary designs of the navigation lock's upstream guide wall indicated potential impacts to FGE levels. These impacts were particularly a concern for summer migrating subyearling chinook.

At the upstream entrance to the proposed lock, a guide wall was required for alignment of tows entering the lock. The final guide wall design consisted of both fixed and floating portions totaling 836 feet in length. Refinement of this final design resulted in the addition of 80 skirting panels to the bottom edge of the guide wall for the majority of the length. Based on model studies, conditions for passage of fingerling through the new lock approach channel and under the lock guide wall were found to be satisfactory. Final guide wall model tests measured velocities at various points around the wall and found them to vary from 0.0 to 4.0 ft/s, depending on location of point and river flow.

Because of the nature of the forebay modifications, the velocity patterns through the First Powerhouse forebay and the hydraulic conditions at the powerhouse intakes were changed significantly. The placement of the fill and groins along the Oregon bank up to 40 feet higher than the existing bottom elevation reduced the cross sectional area available for flows along the left side of the forebay considerably (see figure 5-2). The underwater excavation along the south side of Bradford Island increased the cross sectional area available for flow to occur along the right side of the forebay, thus aligning flow more directly into the powerhouse. The placement of the guide wall out into the powerhouse forebay has added a major obstruction to flow along the south side of the powerhouse. The resulting velocities through the middle of the forebay were raised some 1 to 2 ft/sec due to these major changes in cross section area. Flow passing through the powerhouse forebay has now been forced into an alignment that is more central to the forebay geometry and more directly parallel to the axis of the turbine intakes.

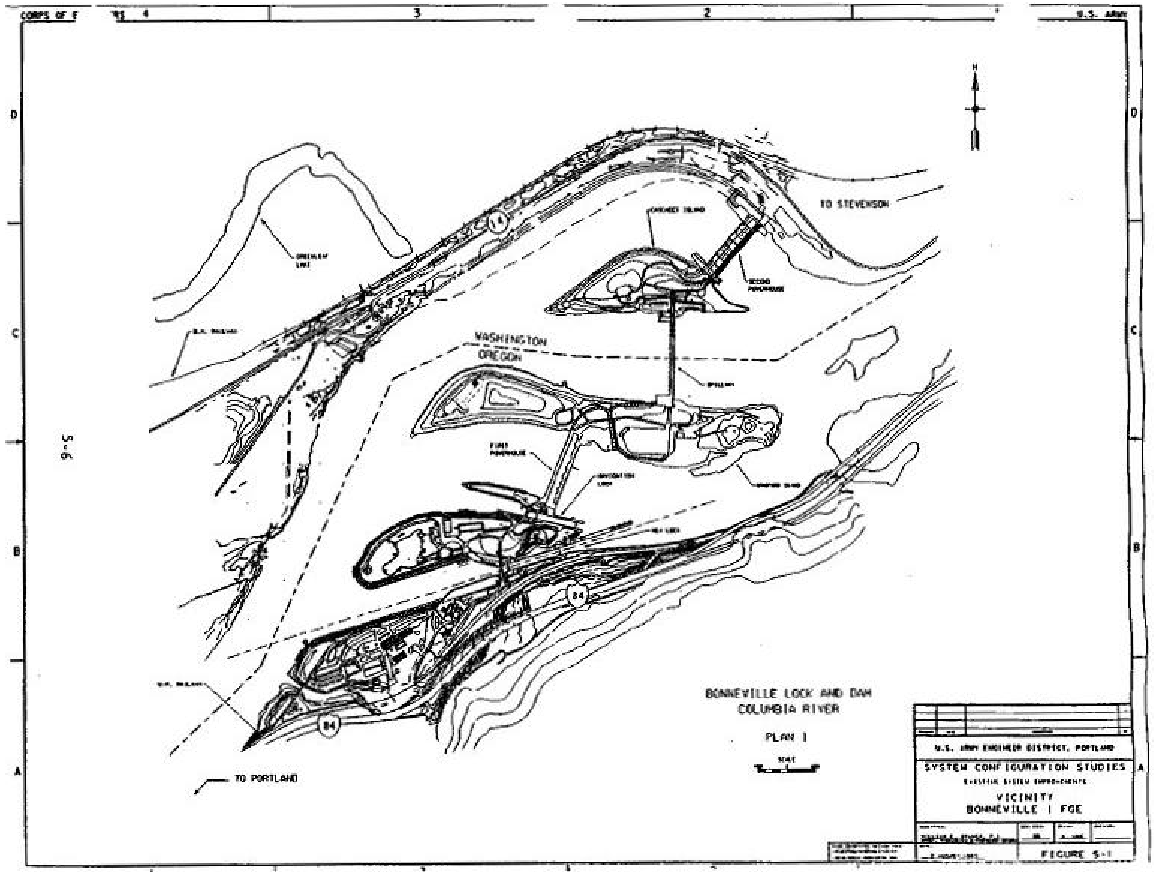

Figure 5-2. Forebay, Bonneville I FGE

f. First Powerhouse Turbine Intakes.

Figure 5-3 shows a comparison of turbine intake geometrics at the various Columbia River Projects. Intake shapes generally fall into two types. The earlier project intakes at Bonneville First Powerhouse, The Dalles, and McNary were constructed with the upstream face of the intake having a curved roof that extended up relatively close to normal operating forebay water surface elevations.

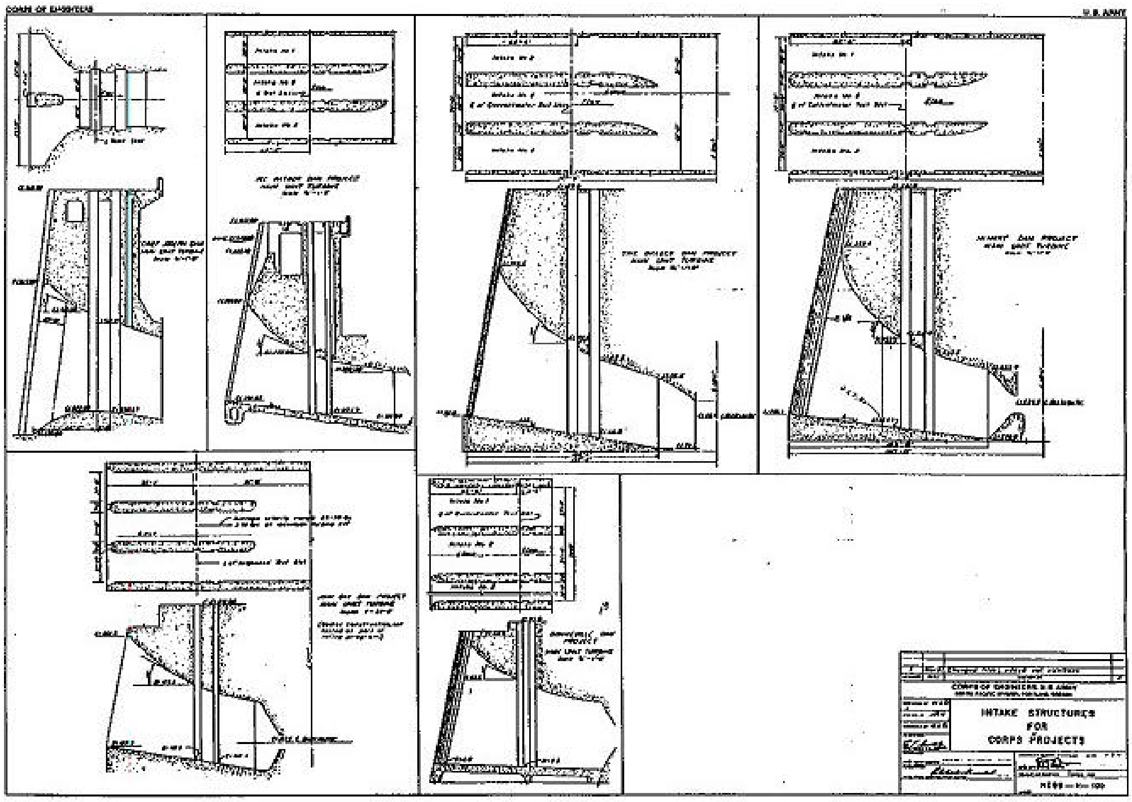

Figure 5-3. Intake Structures for Corps Projects

Flow entering the First Powerhouse intakes (see figure 5-4) encounters a much less abrupt and less clearly defined structural contraction than in the newer type of intake such as at Bonneville Second Powerhouse, John Day, Lower Granite, Ice Harbor, and Chief Joseph Dams. The relatively tall intake geometry plus the fact that the project has a very small variation in forebay operating range gives the turbine intake a much higher ratio of intake height to pool depth. With the smoother and more gradual contraction and hydraulic streamlining of the entering flow, head losses due to contraction will be slightly different for the two different types of intakes. The flow lines past the bulkhead slots, the velocities moving against the screens, the amount of flow up through the gate well slots, and the velocities under the STS's will be characteristically different for the First Powerhouse intakes than in the newer projects.

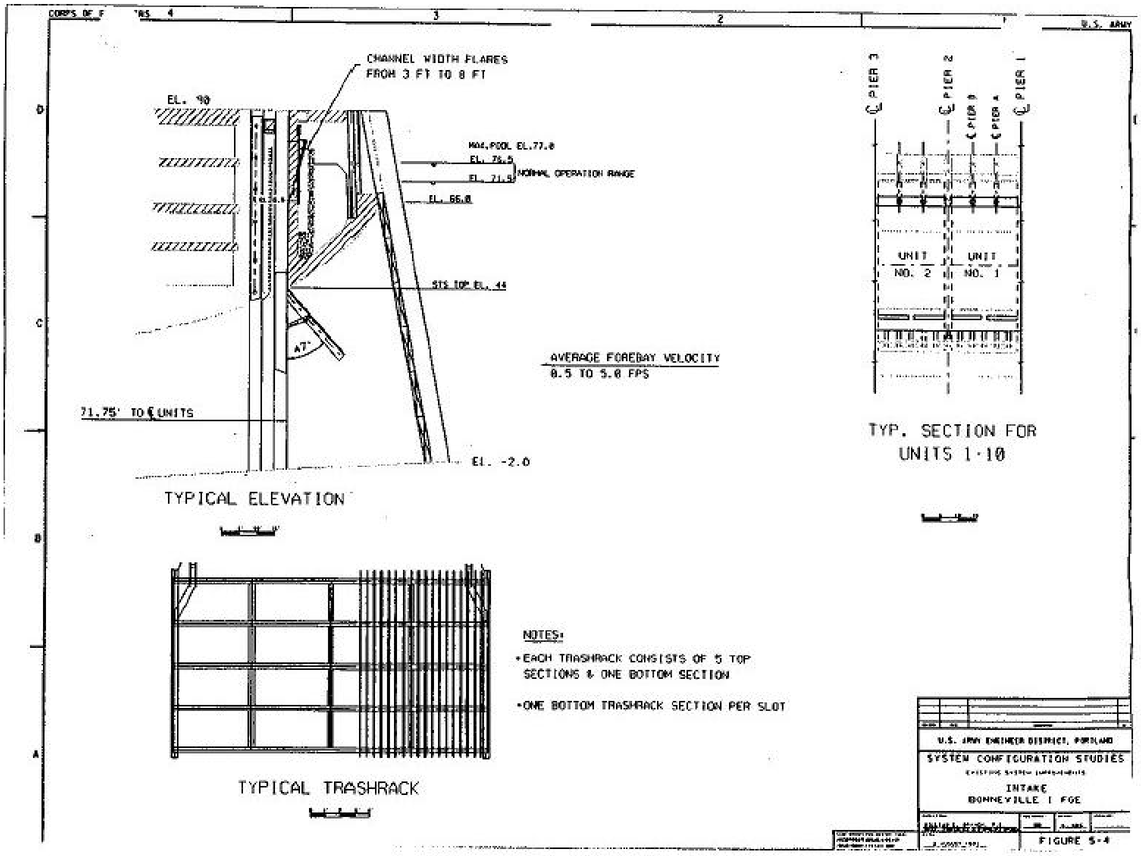

Figure 5-4. Intake, Bonneville I FGE

g. Bypass Components.

(1) Submerged Traveling Screens.

Bar screens 5 feet in length were tested by NMFS at Bonneville First Powerhouse in 1977. The FGE for spring chinook and coho salmon were as high as 70 percent at Bonneville. Problems encountered at that time were mainly debris accumulation and the ability of fish to escape through an opening at the end of the bar screen which was necessary to allow debris to pass back into the turbine intake. It was generally found that 35 to 65 percent screen porosity produced the best guidance conditions and that the angle of the screen positioning relative to the flow lines was the major factor in fish impingement.

In 1981, NMFS tested three STS's, 20 feet in length, at the First Powerhouse. Based on the results of these tests, a complete set of STS's was fabricated and installed in the First Powerhouse forebay turbine intakes in early 1983 as part of the completion of the JBS (see figure 5-5). They are similar to STS's that are presently in use at upstream projects. The screens are 20 feet long, and have the standard mounting position angle of 47 degrees relative to the vertical with the top of screen at El. 44, NGVD.

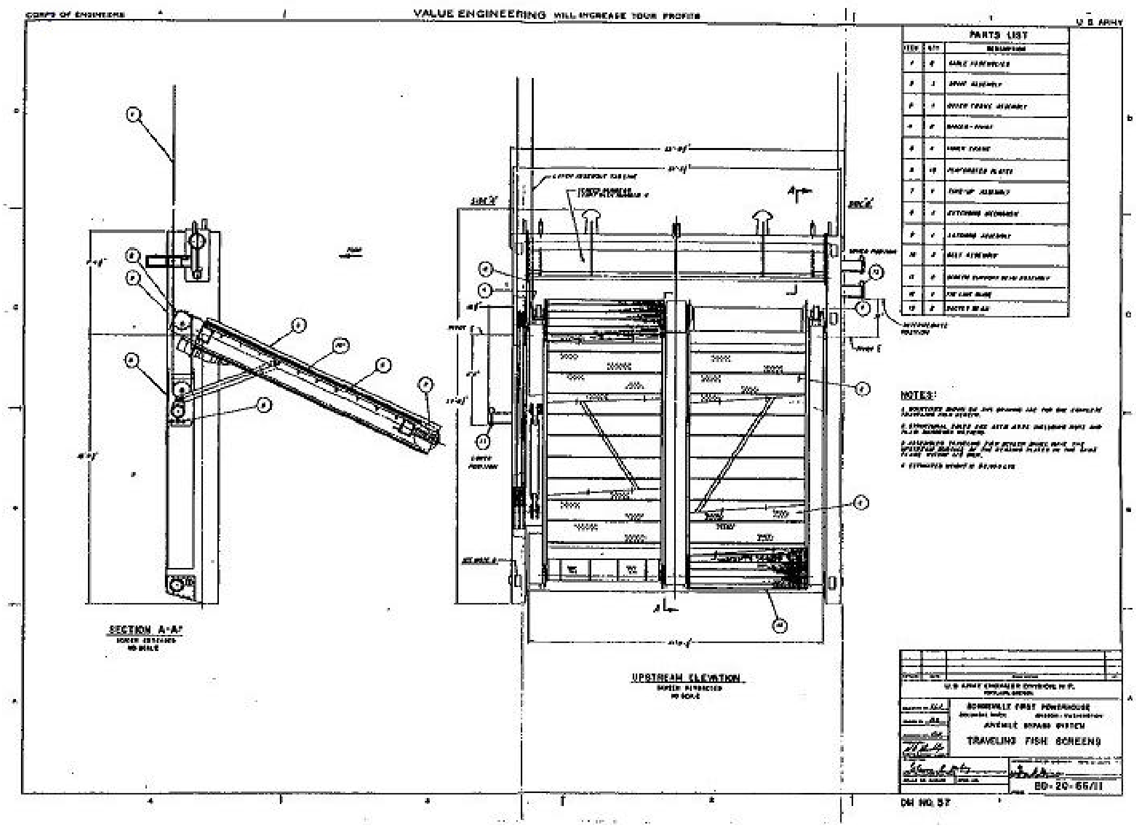

Figure 5-5. Traveling Fish Screens

(2) Vertical Barrier Screens.

As with upstream Columbia and Snake River Projects, VBS's are positioned in the intake gate slots of each turbine intake (see figure 5-6). At the First Powerhouse, the screens are constructed with a polyester screen material that allows flow to move from the upstream side of the gate slot back down into the turbine intakes and on down through the turbines. The screens extend from elevation 42.0 feet to elevation 78.0 feet, constructed in four panels, each 9.0 feet tall.

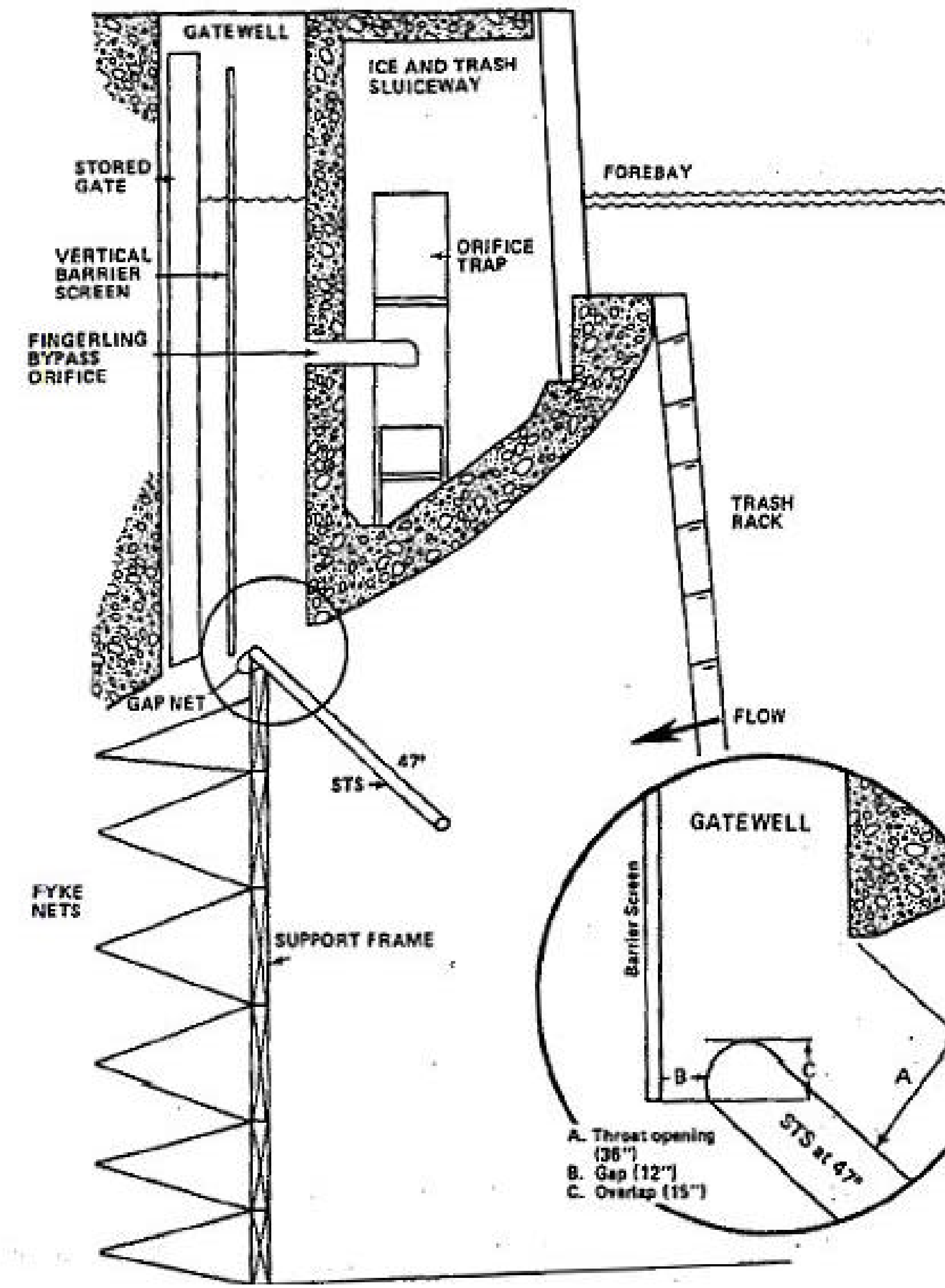

Figure 5-6. A cross section of a turbine intake in the Bonneville First Powerhouse showing location of vertical barrier screen, fingerling bypass orifice (with orifice trap), submersible traveling screen (STS) - with fyke nets, and position and angle (47°) of STS that provided optimum FGE (throat opening, gap, and overlap) during test.

Because of the relative height of the First Powerhouse intakes and the resulting short height of the VBS's, less cross-sectional area for passing flow back down in to the intakes is available than with screens at other comparable projects. This flow leads to potential problems with impingement of fingerlings from too high of velocities passing through the VBS's.

(3) Orifices.

The 12-inch-diameter orifice plates leading out of the intake gate slots are mounted in 18-inch-diameter openings to prevent abrasion to fish in the jet. The orifice plates were designed with knife-edged openings to form a sharp vena contracta and maintain the minimum velocity of 8 ft/s. This velocity had been determined to provide the optimum conditions for attraction of fish out of the intake gate slot, and also for trapping of fish trying to swim back into the gate slot from the transportation channel.

Each orifice discharges in the range of 8.6 to 11 ft^3/s, depending on forebay elevation. Six-inch-diameter light wells shine light into the upstream end of the orifice opening in the intake gate slot for attraction of juveniles toward the orifice jets.

(4) Studies of Effect of Operating Gate Position.

Since 1977, there has been interest in the effect of positioning of the First Powerhouse operating gates in the gatewell slots in what are called the "stored position" or the "raised position." The main influence gate positioning has on FGE is the difference in discharge passing up into the gatewell slots and then through the vertical barrier screens and back down into the turbine intakes. With an increase in discharge up into the bulkhead slot, FGE correspondingly tends to increase.

In 1977, while conducting studies at the First Powerhouse for use of bar screen deflectors for fish guidance, NMFS also studied the effect of raising the operating gate out of the gatewell slot. Discharge increased from 90 to 250 ft^3/s. FGE ranged from 16 to 62 percent with the stored gate and from 43 to 78 percent with the raised gate. Increased FGE's were observed at other upstream projects including McNary and Lower Granite Dams when operating gates were raised.

In 1991, NMFS conducted a study at the First Powerhouse to evaluate the effects of raising the gates along with the determination of the uniformity of FGE across the entire powerhouse. This study concluded that with the operating gate in the stored position, flows were less effective in moving fish up into the gatewell slot.

In 1992, NMFS conducted additional studies to evaluate the effects of raising gates over the entire spring migration of yearling chinook salmon, in conjunction with the angle of position of the STS's. The study consistently showed improved guidance, although the percentage of increase of FGE for yearling chinook was not as high. The study recommended raising of the operating gates at the First Powerhouse during the entire juvenile salmonid outmigration.

(5) Operating Gate Slot Flow Characteristics.

As flow enters the turbine intake from the forebay, with the STS in its operating position, the relatively low porosity of the STS causes a portion of the incoming flow to be deflected up into the gatewell (see figure 5-7). As flow enters the gatewell, it briefly passes through a minimum width opening of 36 inches between the top of the STS and the curved intake roof corner at El. 43.75. Generally, the momentum of the incoming flow carries it vertically upward to some elevation at which it slows and then reverses direction to flow downward along the back of the VBS frame and finally out of the gatewell and back into the turbine intake.

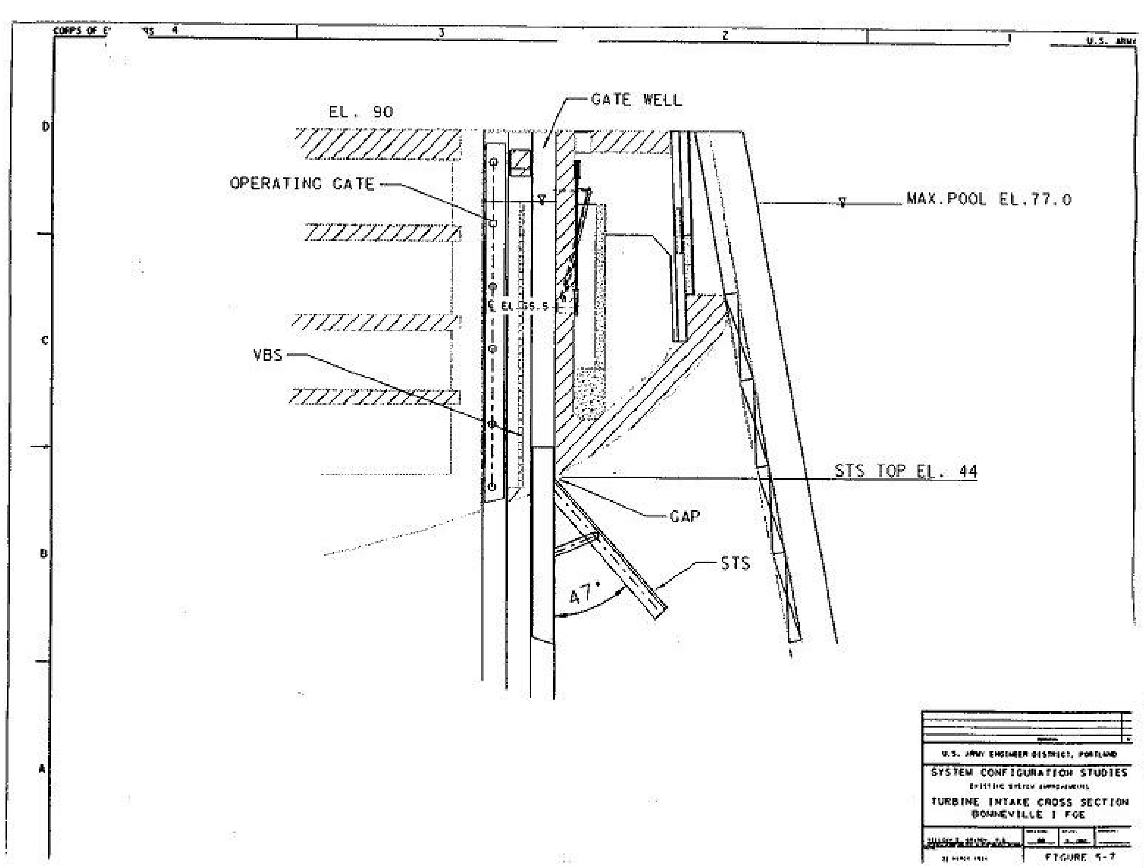

Figure 5-7. Turbine Intake Cross Section, Bonneville I FGE

On the downstream side of the VBS, when the operating gate is placed in the normally stored position, it provides an obstruction to flow for the full depth of the gatewell. This particular area is only 30 percent of the area available between the upstream side of the VBS and the gatewell wall, and only 50 percent of the area available between the top of the STS and the concrete corner for flow up into the gatewell.

The degree to which flow into and out of the gatewell is obstructed by the operating gate being in its stored position is evidenced by the increase in discharge during the tests by NMFS at the First Powerhouse in 1977. In that test, the estimated flow through the gatewell increased from 90 to 250 ft^3/s when the operating gate was raised and the cross-sectional area available for unobstructed flow out of the gatewell in back of the VBS frame was increased.

Because quantity of flow is related to FGE, it is assumed that there would be an increase in the number of fish guided up into the gatewell, and thus able to make passage through the JBS if the operating gates were raised above their normally stored positions.

h. Volume of Debris and Need for Handling.

Being the most downstream Columbia River Project, both floating and submerged debris are much greater in quantity at Bonneville Dam. The fact that the intakes at the First Powerhouse are proportionately taller than other projects having STS's installed makes the intakes more vulnerable to debris build-up and increases the potential for structural, operational, maintenance, and fish mortality problems. Material ranges from moss, grasses, wood chips, bark, and limbs up to trees 4 feet in diameter and 90 feet in length. Heavy debris periods occur when winter storms and snowfalls cause flood conditions in the more local tributary basins which generates large amounts of debris materials. Spring freshets generate large volumes of run-off from the very large drainage area upstream, which is then passed through the upstream projects and eventually arrives at Bonneville Dam. Thus, December through the completion of the spring freshets, which may reach into June are the months of heaviest debris loads. Extensive accumulation of debris in the intake gate wells at the First Powerhouse is presently an ongoing problem and requires considerable attention and labor for removal.

5.2. Selected Improvements.

a. General.

FGE can be affected by a combination of structural devices placed in the turbine intake area and approach flow conditions. Selected items to investigate for the improvement of FGE are presented below.

b. Approach Flow Conditions.

Modifications to the approach flow conditions can be made to improve the guidance of fish into the bypass.

c. Streamlined Trashracks.

Replace the standard trashracks with new streamlined trashracks.

d. Extended-Length Screens.

Replace the existing STS's on all units with 40-foot-long ESBS's.

e. Angled Vertical Barrier Screens.

Angle the VBS's in all units into the flow.

f. Raised Operating Gate.

Raise the operating gates in all units to a height to be determined by engineering studies.

g. Surface Skimming.

Replace the existing sluice gates with vertical slots which skim flow into the existing ice-and-trash sluiceway.

h. Sound Exclusion.

Use sound to move fish vertically and increase FGE.

5.3. Engineering Evaluation of Alternatives.

a. General.

The juvenile bypass system at this and other projects is used to reduce the number of smolts passing through the turbines on their journey to the ocean. FGE is a measurement of the percent of fish entering an intake that are successfully guided into the orifice. FGE studies conducted in 1981 exceeded the regional goal of 70 percent at this project. Subsequent tests in 1988 and 1989, however, had lower FGE counts. Additional tests in 1991 and 1992 confirmed these low numbers. Data taken at this and other projects indicates changes in FGE as a result of lowering fish screens, raising the operating gate and other structural changes.

b. Alternatives.

Alternative solutions to these problems are tied to approach flow conditions, trashracks, fish screens, vertical barrier screens, or the height the operating gate is stored at in the downstream gate slot.

(1) Approach Flows.

Numerous alternatives are available to modify approach flows. For have been identified for further consideration. They are: 1) modifying channel upstream; 2) flow alignment structures; 3) intake reconfiguration; and 4) pier extensions.

(a) Upstream Channel Modification.

Dredging and the placing of large groins in the channel upstream of the powerhouse in 1987 for the new navigation lock has modified the approach flows to the intake area. Additional dredging, placement of new groins may result in improved conditions at the intakes.

(b) Flow Alignment Structures.

Structures placed in the forebay such as flow vanes could be used to align the flow perpendicular to the powerhouse. Such structures would have to be out of the navigation channel and could be placed immediately in front of the powerhouse or further out in the forebay.

(c) Intake Reconfiguration.

The shape of the intake could be modified to provide different flow conditions leading to the screens. The roof line could be dropped, the intake could be lengthened, or the axial shape of the intake could be changed.

(d) Pier Extensions.

Extending the piers into the forebay would allow the flow to straighten out before entering the intakes.

(e) Wing Wall at Pier 7.

Pier 7 has been extended out into the forebay approximately 114 feet. This extension was originally done as part of the phased powerhouse construction at Bonneville. The pier could be shortened to improve approach flows.

(2) Trashracks.

The trashracks are designed to keep trash out of the turbines, and do not have modifications for juvenile passage. The hydraulically rough shape and abrupt angles lead to turbulence surrounding the trashrack that could potentially be minimized.

(a) Streamlined.

Placing hydraulically smooth crossbars in the trashrack and angling the bar parallel to the flow would result in less disruption near the trashrack.

(b) Relocated Upstream.

Moving the trashracks further into the forebay would reduce the impact their flow disruption has on the intake area. This option could be accommodated with pier extensions, and would otherwise require additional supporting structure to be put in place. Trashracks moved upstream would also allow for a longer fish screen to be put in place.

(3) New Fish Screens.

The existing 20-foot STS could be replaced by a variety of screen types and lengths. The intakes at Bonneville allow for a screen up to 45 feet in length.

(a) Forty-Foot Extended Submerged Bar Screens.

McNary and The Dalles Dam projects have performed prototype testing of these screens, and they have worked very favorably. Their ability to intercept a greater percent of the flow results in a greater flow up the gate slot. FGE also increases, but with a potential for increase in descaling and impingement. This technology could be used at the Bonneville First Powerhouse.

(b) Forty-Foot Extended Submerged Traveling Screens.

Extended traveling screens intercept a greater percentage of the flow. This interception could be used to potentially increase FGE.

(c) Submerged Bar Screens of Other Lengths.

Lengths other than the 20- and 40-foot screens that have been modeled and prototype-tested may prove to be beneficial.

(d) Submerged Traveling Screens of Other Lengths.

STS's could be constructed in lengths other than 20- or 40-foot.

(4) Vertical Barrier Screens.

Vertical barrier screens have proven effective in keeping the juveniles in the operating gate slot from following the return flow into the turbine intake. Guidance could potentially be improved by increasing the flow through the VBS. As a result of increased flow, flow through the VBS would have to be balanced against descaling and impingement.

(a) Change Porosities.

The porosity plates in the VBS's can be of a variety of combinations and porosities. Proper configuration of these plates can result in a greater flow up the slot, perpendicular velocities within criteria, and a flow net that is effective in guiding juveniles to the orifices.

(b) Change Screen Angle.

By angling the VBS's upstream, the flow can be guided up the slot toward the orifices, potentially minimizing time in the gatewell.

(c) **Turning Vane in the Gate Slot.**

A vane in the bottom of the gate slot can be used to effectively guide the flow up the gate slot. This has been model tested in the McNary sectional model, and hydraulically is very promising. It would require prototype testing to evaluate its effectiveness on juveniles.

(d) **Reduce Gap Area.**

A significant portion of the flow up the gate slot turns and reenters the main intake flow through the gap. This allows guided juveniles to circumvent the bypass system and pass through the turbines. A reduction in this area would reduce flow through the gap and presumably increase FGE.

(e) **Increase Screen Area.**

A limiting factor in flow up the gate slot is the maximum allowable velocity criteria through the VBS's. A potential solution to this problem is to increase the screen area by placing screens in non-traditional locations such as on the collection channel side with a return channel leading back to the turbine intakes. This procedure could increase the flow up the slot and presumably the FGE without violating screening criteria.

(f) **Increase Gatewell Throat Area.**

Cutting the concrete on the base of the gatewell into a hydraulically smooth shape would improve the flow characteristics in the gatewell.

(g) **Louvers.**

The use of louvers placed immediately behind the VBS could successfully control the amount and direction of flow through the VBS. These louvers could be fine tuned to maximize effectiveness, and could also be placed at an angle if that were beneficial.

(h) **Flow Turning Vanes.**

These fixed vanes could be used similarly to the louvers with the exception of fine tuning. They would be part of the VBS and would have a wire mesh screen immediately upstream to prohibit juveniles from passing through them.

(5) **Operating Gate.**

(a) **Raised Operating Gate.**

Raising the operating gate in the downstream gate slot reduces resistance to flow and increases flow up the gate slot.

(b) Remove Operating Gate.

Removal of the operating gate will increase the flow up the gate. The operating gates would then have to be stored somewhere, and an exclusion from the emergency closure requirement would need to be approved.

(c) Modify Downstream Gate Slot Exit.

The exit from the downstream gate slot could be cut and shaped to decrease resistance to flow and allow for more flow up the upstream gate slot.

(6) Surface Skimming.

Use the existing ice and trashrack sluiceway, and replace the sluice gates with vertical slots, pulling the surface flows into the ice-and-trash sluiceway.

(7) Sound Exclusion.

Place sound emitting devices at the intakes, creating a condition where the juveniles will avoid undesirable areas.

c. Assessment of Alternatives.

(1) Approach Flow Conditions.

The importance of hydraulic conditions in the movement of juvenile fish through a forebay has been well established, as demonstrated in the model study and prototype testing work that has been done at Bonneville Second Powerhouse. It was found that because of the shape of the upstream face of the powerhouse and intakes, large eddies occurred in the forebay which influenced the movement of downstream migrants into the powerhouse intakes for passage through the bypass system. Hydraulic conditions within intakes are very important factors influencing FGE.

By obtaining comprehensive prototype data within the First Powerhouse forebay and intakes, the hydraulic factors affecting FGE can be identified and quantified. These conditions could then be replicated in the existing Bonneville General Model in conjunction with a new sectional model of the powerhouse intake. The proposed modifications to the powerhouse forebay channel, the new flow alignment structures, and changes in intake geometry could then be model tested individually and in combinations. Testing of the combinations would allow the determination of forebay geometry changes which would lead to the improved passage of fingerlings through the forebay and into the intakes for interception by the STS's.

(2) Streamlined Trashracks.

Streamlining of trashrack cross members would reduce hydraulic turbulence behind the cross members. Replacement of the sharp edges with more rounded and streamlined edges would potentially reduce damage and descaling of fish. Reducing the size of the members would further reduce disturbance to the flow lines leading into the intakes.

Relocating taller racks further upstream would give a larger and more effective cross-sectional flow area, and would greatly reduce the turbulence deep inside the intakes, which is now caused by the racks. Being further upstream, there would be less disruption to the flow patterns within the intakes themselves as flow moves down along the curved intake roof. This could lead to soother interception of fingerlings by the STS's.

Relocating the racks further upstream would require extension of the intake piers or some other structural means of supporting the new racks. Because they would be located further upstream, a new larger crane for installation and removal of the racks might possibly be necessary. It would be advisable to test any structural changes to the trash racks in a sectional intake model to assure the desired hydraulic conditions before actual construction.

(3) Extended-Length Submergible Traveling Screens.

Extended STS's that are 40 feet in length have recently been prototype tested at both McNary and The Dalles Dams. Results have been the most favorable for the extended STS's at McNary and the extended bar screens at The Dalles. Both of these powerhouses have the same type of older and taller intakes as the First Powerhouse. This design produces a more gradual contraction as flow drops down along the intake roof. This similarity suggests that some type of extended screen would give similar beneficial results in the First Powerhouse intakes. Bar screens still present a viable option for guiding of fingerlings into the bypass system but, in view of the numerous potential combinations of structural modifications proposed above, as well as the raising of the operating gates, the hydraulic conditions that would be present at the entrance to the gate slots could be such that extended bar screens could offer better guidance than extended STS's.

The hydraulic conditions in the various Columbia River project intake geometries, and also intake approach conditions just upstream in the forebays, are unique to each project. Thus, before such an undertaking as installation of extended screens at the First Powerhouse could be begun, sectional model testing and limited prototype testing of the proposed screens would need to be done to assure the desired results.

(4) Vertical Barrier Screens.

Sectional model studies on the McNary gate slots in 1993 have shown that tilting the top of the screen forward from the vertical position creates more uniform flow patterns up into the slot and through the screen. Fine tuning of the screen angle and position, along with changing of screen porosity, addition of a turning vane device at the bottom of the screen, and possibly directional louvers behind the screen can improve hydraulic conditions. The throat area at the top of the STS and the gap area in back of the STS are critical to the volume of flow up through the gate slot. Structural modification of these specific areas could lead to major improvements in fish guidance, however, because of the integral natural of all the above items, testing would have to be done as a system in a sectional intake model for achievement of optimum hydraulic conditions.

(5) Raised Operating Gates.

Very large potential benefits could be achieved by raising of the operating gates in the gate slots. Past studies at the First Powerhouse indicate the benefits of increased flow up through the gate slots, and thus increased FGE. Further study of this operational modification could easily be carried out in the prototype without having to make structural changes. Gate slot flow conditions could also be studied in a sectional intake model in conjunction with other proposed modifications such as VBS angle, VBS porosity, louvers, vanes, and structural changes in the gate slot throat opening and downstream gap opening. Testing would determine optimum gate slot flow volumes and minimum hydraulic turbulence as a result of the positioning of the gate in the slot.

Because of the large dimensions of the gates, the massive weight, the flat shape, and the potential for buckling while being laid flat, handling of the gates is difficult. The relatively fragile rubber seals protruding 3 to 11 inches from all edges of the gate on both the upstream and downstream faces made it especially difficult to set the gates on end or to lay them down flat. Storing the gates at the top of the gate slots could possibly be done with construction of a structural supporting system on top of the powerhouse deck. However, hydraulic testing in the prototype could be done, and the benefits determined, before this construction would need to be done.

(6) Surface Skimming.

This process has proven effective at other projects, and could potentially be effective at Bonneville if used with other technologies such as fish screens or sound exclusion.

(7) Sound Exclusion.

This is an experimental technology but, if proven effective, would provide a substantial savings over structural solutions.

d. Recommendation.

FGE can be affected by many factors. It is recommended that the above alternatives presented herein be further investigated. Those that are deemed not effective should be eliminated from consideration. The alternative(s) that are promising should be further developed for implementation.

e. Design.

(1) Assumptions.

Where past prototype results and physical model studies have shown definitely beneficial results to fish passage, it is assumed that similar benefits would occur at the First Powerhouse with the appropriately designed modifications.

The hydraulic conditions within an intake are interdependent on all physical components present, and also can affect the conditions in the forebay immediately upstream. It is assumed that no modifications would be constructed until the integral system of proposed modifications is tested in the powerhouse prototype or in a physical model. Testing before construction would establish the certainty that any modifications made would give improved hydraulic conditions and produce increased FGE.

(2) Requirements.

The design would have to comply with all applicable regulations and standards. It would be subject to hydraulic criteria developed by the fishery agencies and subject to their review.

5.4. Impact of Improvements.

a. Physical.

Impacts to the turbine intake, operating gate slot, and forebay are potential physical impacts to the project.

b. Biological.

(1) Spreadsheet Modeling.

Benefits were estimated using a Corps spreadsheet model for Bonneville Dam. NMFS 1993 Biological Opinion flows of 200/160 kcfs spring and summer flows, and flows of 300/250 kcfs were modeled. The FGE ranges described in table 5-5 were used. Bonneville Second Powerhouse FGE's were ranged for pre-1993 estimates and for 1993. Model runs were made with Bonneville First and Second Powerhouse operation prioritized separately.

The estimated number of fish arriving at Bonneville Dam are shown in tables 5-1 and 5-2 (data from the Fish Passage Center and the CRiSP model).

Table 5-1 Average Hatchery Releases Into Bonneville Pool and Tributaries And Estimated Survival to Bonneville Dam			
Species	**Average Number Of Fish Released**	**Survival to Bonneville**	**Estimated Number of Hatchery Fish At Bonneville**
Yearling Chinook	6,209,000	0.6	3,725,000
Subyearling Chinook	15,600,000	0.6	9,360,000
Steelhead	251,000	0.6	151,000
Coho	6,872,000	0.6	4,123,000

Table 5-2 Estimated Number of Total (In-River and Hatchery) Fish Arriving at Bonneville				
Species	**Number of Fish Arriving at TDA**	**Survival From TDA to Bon (CRiSP)**	**Hatchery Input (Bonneville Pool)**	**Estimated Number of Fish Arriving at Bonneville**
Yearling Chinook	1,475,000	.89	3,725,000	5,038,000
Subyearling Chinook	2,943,000	.92	9,360,000	12,068,000
Steelhead	666,000	.88	151,000	737,000
Sockeye	119,000	.89	--	106,000
Coho	105,000	.89	4,123,000	4,216,000

(2) Spreadsheet Input Parameter Ranges.

To characterize the biological benefits of improving FGE, we estimated potential FGE levels three ways: the flow intercept relative, and absolute methods. All three were utilized to bracket the potential range in FGE improvement associated with extended screens. The flow intercept method takes the vertical distribution of fish within the intake and the elevation of the tip of the extended guidance device, less 10 percent for behavioral and hydraulic rejection at the screen top, and estimates the percentage of fish take would be intercepted by a 40-foot extended screen. The relative method takes the relative increase in extended screen FGE based on actual results from McNary Dam FGE testing, and applies this relative change to existing FGE values at Bonneville First Powerhouse. The absolute method takes the absolute increase in extended screen FGE based on actual results from McNary Dam FGE testing, and applies this absolute change to existing FGE values at Bonneville First Powerhouse.

(a) Flow Intercept Method.

This method of analyzing potential FGE was used because the hydraulic conditions up the slot and in the intake at Bonneville First Powerhouse are different from McNary. Accordingly, the relative and absolute methods may be more applicable to a standard intake such as John Day, than Bonneville First Powerhouse.

Based on fyke net catches, NMFS estimates that fish are distributed vertically in the Bonneville First Powerhouse intake, as shown in table 5-3 (personal communication, Bruce Monk, North Bonneville, Washington).

Table 5-3
Cumulative Percent Distribution at Bonneville First Powerhouse

Level	Sockeye	Yearling Chinook	*Subyearling Chinook		Coho	Steelhead
			Early	Late		
Gatewell	8	9	7	3	28	25
41'6" to 35'	47	45	40	11	58	56
35' to 28'6"	68	69	63	18	80	76
28'6" to 22'	83	84	78	29	91	87
22' to 15'6"	94	93	89	51	95	92
15'6" to 9'	97	97	94	76	100	99
9' to 2'6"	100	99	100	95	100	100
2'6" to -4'	100	100	100	100	100	100

*Early subyearling chinook migrate prior to June 15; late subyearling chinook migrate past Bonneville Dam after June 15.

As described in table 5-3, the low levels of FGE presently measured at Bonneville First Powerhouse are though to be caused in part by the small amount of flow being guided off the intake screen into the gate slot. If we assume that raising the operating gate will alleviate this problem, as proposed in this study, then we can eliminate the flow restriction up the slot as a factor limiting FGE. Under this condition, FGE would be determined by the percentage of fish intercepted by the guidance device. If we calculate the total number potentially guided by an extended screen based on flow intercept and vertical distribution, and subtract from this value an assumed reduction in FGE of 10 percent due to behavioral and hydraulic rejection at the screen tip based on observations made in numerous physical models at the Corps' Waterways Experiment Station, we can estimate the maximum FGE potentially produced by extended screens (table 5-4). The existing standard 20-foot STS's at Bonneville First Powerhouse have a pivot point elevation of 37.2 feet. The tip of the screen is at El. 26.8 when the screen is extended at 55 degrees. A 40-foot extended traveling or bar screen tip would rest at El. 16.9 feet, with the screen extended at 55 degrees. A 45-foot screen would fit at the project although it has not been tested.

Table 5-4
FGE Values Used to Estimate Biological Benefits

Species	Present	Flow Intercept	Relative	Absolute
Yearling Chinook	37*	86	64.8	68.3
Subyearling Chinook Before 6/15	39	84	70.0	62.3
Subyearling Chinook After 6/15	10*	63	17.5	32.5
Steelhead	56	87	86.1	86.5
Coho	63	89	81.5	81.5
Sockeye	23*	82	77.9	75.3

*Values provided by NMFS for Model Review Task (Letter from Tuttle to agencies dated January 25, 1993). All other present FGE values were taken from Portland District's FY 93 *Bonneville Project Operations Decision Document.*

(b) Relative Improvement Method.

Flow up the gate slot at Bonneville First Powerhouse with the head gates in their normal (stored) position is not comparable to McNary Dam where the gates have been raised. Therefore, the relative improvements to Bonneville FGE based on McNary extended screen FGE data should be applied to FGE determined for the raised gate condition at Bonneville. FGE data collected in 1991 under the gate raised condition suggest the FGE levels listed in table 5-4 are attainable with the gate raised. These are based on relative increases at McNary Dam of 31 percent for yearling chinook, 75 percent for subyearling chinook, 18 percent for steelhead, 35 percent for sockeye. Coho increases were assumed the same as yearling chinook (31 percent).

(c) **Absolute Improvement Method.**

Similarly, the absolute improvements to Bonneville FGE based on McNary data should be applied to FGE determined for the raised gate condition at Bonneville. FGE data collected in 1991 under the gate raised condition suggest the FGE levels listed in table 5-4 are attainable with the gate raised, and the absolute level of improvement from McNary extended screen research added to these values. These values are based on absolute increases at McNary Dam of 19 percent for yearling chinook, 23 percent for subyearling chinook, 14 percent for steelhead, 18 percent for sockeye. Coho increases were assumed the same as yearling chinook (19 percent).

Based on these estimates of potential increases in FGE, model runs were conducted using the CENPP Bonneville spreadsheet model to estimate potential survival benefits associated with FGE improvements. An upper and lower range of improvement to FGE were used to bracket the potential response. The flow intercept method defined the upper range, which we assume to be the optimum FGE possible. The lower range was comprised of both the relative and absolute methods, whichever was lower for each species (table 5-5).

Table 5-5
FGE Values Used In Modeling

Species/Stock	Base Case (Percentage)	Improved Range (Percentage)
Yearling Chinook	37	65 to 86
Subyearling Chinook Prior to 6/15	39	62 to 84
Subyearling Chinook After 6/15	10	18 to 63
Sockeye	23	75 to 82

(d) **Spreadsheet Model Results.**

The results are shown in tables 5-6 through 5-9.

Table 5-6
Estimated Project Survival With and Without B1-FGE, B1 Priority
(Bi-OP Flows of 200/160 kcfs)

Species	Base Case	Improved FGE
Yearling chinook	93	87 to 90
Subyearling chinook	92	83 to 90
Steelhead	92	87 to 89
Coho	92	87 to 89
Sockeye	93	87 to 90

Table 5-7 Estimated Project Survival With and Without B1-FGE, B1 Priority (Bi-OP Flows of 300/250 kcfs)		
Species	**Base Case**	**Improved FGE**
Yearling chinook	92 to 93	88 to 91
Subyearling chinook	92	83 to 90
Steelhead	92	87 to 89
Coho	92	88 to 91
Sockeye	92	88 to 91

Table 5-8 Estimated Project Survival With and Without B1-FGE, B2 Priority (Bi-OP Flows of 200/160 kcfs)		
Species	**Base Case**	**Improved FGE**
Yearling chinook	92	89 to 91
Subyearling chinook	91 to 92	86 to 91
Steelhead	92	89 to 91
Coho	92	89 to 91
Sockeye	92	89 to 92

Table 5-9 Estimated Project Survival With and Without Improved FGE, B2 Priority (Bi-OP Flows of 300/250 kcfs)		
Species	**Base Case**	**Improved FGE**
Yearling chinook	92 to 93	89 to 92
Subyearling chinook	91	87 to 91
Steelhead	92	89 to 92
Coho	92	89 to 92
Sockeye	92	89 to 92

Survival past the project decreases when only improvements to FGE at Bonneville First Powerhouse are made because of the assumptions of spillway and bypass survival. Higher FGE levels reduce the amount of water spilled for juvenile fish passage, reduces the number of fish passing over the spillway, and increases the number of fish passing through the bypass, which until improved, has a lower survival rate than the spillway. Consequently, based on our model assumptions, improving Bonneville First Powerhouse FGE in combination with reducing spill levels reduces project survival rates from 1 percent to 9 percent, depending on the species, river flow, and powerhouse operation. Spill levels used for base case ranged from 41 to 49 percent in spring, and 40 to 44 percent in summer, dependent on powerhouse priority and flow levels. With improvements, spill levels ranged from 0 to 30 percent in spring, and 0 to 38 percent in summer.

(3) CRiSP Modeling.

The Columbia River Salmon Passage (CRiSP) model was developed by the University of Washington, and tracks the downstream migration and survival of salmon and steelhead through the Columbia and Snake Rivers to below Bonneville Dam. The model recognizes and accounts for various reservoirs and dam passage parameters, integrating a number of subroutine models to arrive at final estimates of hydrosystem survival. For this analysis, arbitrary numbers of fish for the following stocks were input into the CRiSP model to estimate percent change from the base case for each stock:

Deschutes (Yearling Chinook)
Dworshak (Steelhead)
Hanford (Subyearling Chinook)
Methow (Yearling Chinook)
Wild Snake Spring (Yearling Chinook)
Rock Creek (Steelhead)
Wenatchee (Steelhead)
Methow Wells Index (Subyearling Chinook)
Wild Snake Fall (Subyearling Chinook)
Wild Snake Summer (Subyearling Chinook)

(a) Assumptions.

Input data for the base case used FGE values from the SOR and the Model Coordination Team (letter from Tuttle to fisheries agencies and tribes dated January 25, 1993), and are the same as those used for the Corps spreadsheet model (table 5-3). FGE improvements used in CRiSP are also the same values used in the spreadsheet model and shown in table 5-3.

(b) Results.

Based on the model input described above, where bypass survival is assumed to be high to start with (98 percent), CRiSP results indicate there were no statistically significant differences between the base case and the improved condition, suggesting the FGE improvements have no effect on survival. The change from the base case was plus or minus 1 percent. This is true for all the stocks listed above from point of origin to below Bonneville Dam and, for the conditions modeled, transportation both on and off; however, that does not mean the proposed improvements have no effect. Rather, CRiSP, the analytical tool used to pick up differences between the base case and the treatment, is not sensitive to relatively small changes in project passage conditions at Bonneville Dam since CRiSP is primarily a model of system-wide effects.

(4) Model Analysis Summary.

The CRiSP model shows no benefit from improving fish guidance efficiency levels into the bypass at Bonneville First Powerhouse, primarily because the model is a system-wide model that is relatively insensitive to small improvements in bypass survival at one project. The spreadsheet model developed by CENPP is a project-specific model and is more sensitive than CRiSP to changes in individual passage parameters at Bonneville Dam. The spreadsheet model indicates that survival past Bonneville Dam would decrease from 1 to 9 percent with the proposed improvements. This is because without simultaneously improving the bypass channel and outfall, the guided fish are subject to the poor bypass survival currently assumed. We estimate that annually 22 million fish arrive at Bonneville Dam and could benefit from the proposed juvenile bypass system improvements. Based on the significant number of fish arriving at Bonneville Dam and our best professional opinion that the proposed improvements will improve the number of fish entering the fish bypass system, the proposed improvements are warranted and recommended if combined with improvements to the collection channel and bypass outfall.

c. Economics.

(1) General.

The Bonneville First Powerhouse currently meets regional FGE criteria of 70-percent FGE for spring migrants and 50-percent FGE for summer migrants by spilling a percentage of river flow equal to the percentage FGE deficit over the spillway. To increase the project's FGE, the following project improvements have been proposed: 1) replace standard trash racks with new streamlined trash racks; 2) replace all 20-foot STS's with 40-foot ESBS's; 3) angle all vertical barrier screens into the flow to guide more juvenile fish into the collection channel orifice; and 4) raise the operating gate to increase flow up the gatewell slot.

The direct and indirect economic impacts of the proposed project improvements have been analyzed. Direct economic impacts are changes in project outputs, expressed as dollar values, while indirect economic impacts are changes in regional or local economic activity resulting from direct impacts. No indirect impacts are anticipated from this proposed project improvement.

(2) Hydropower.

Meeting the FGE criteria for spring and summer migrants may reduce or eliminate the need to spill for fish, thus creating the potential to change the project's hydropower output by increasing the volume of river flow available for hydropower production during downstream juvenile migration; or FGE criteria may be increased requiring continued spill for fish.

(a) Computer Modeling.

Computer modeling (HYSSR and PCSAM) of the river-system's hydropower output was performed to determine the impact on the project's hydropower production capability from installing 40-foot screens. The difference between the base case output and the with-improvements hydropower output is the change in the system's hydropower production capability. The existing (20-foot STS) and future (40-foot) conditions hydropower output was determined based on 50-year average river flows during the juvenile migration period. The project's hydropower output was evaluated under current spill levels and with spill eliminated to bracket potential hydropower production impacts.

(b) Changes in Hydropower Production Costs.

Changes in hydropower production capability translate into changes in system hydropower production costs. Reductions in project hydropower output requires replacement energy from more costly sources, usually combustion turbine while increases in hydropower production reduce the need for those more expensive energy sources. Installation of 40-foot screens at this project, under the current spill regime, resulted in annual system production costs increases of approximately $1,118,000. If the spilling for fish were eliminated in conjunction with the 40-foot screens, annual system production costs could be reduced by approximately $2,774,000.

5.5. Schedules and Costs.

a. Design and Construction Schedule.

The design and construction is shown as figure 5-8.

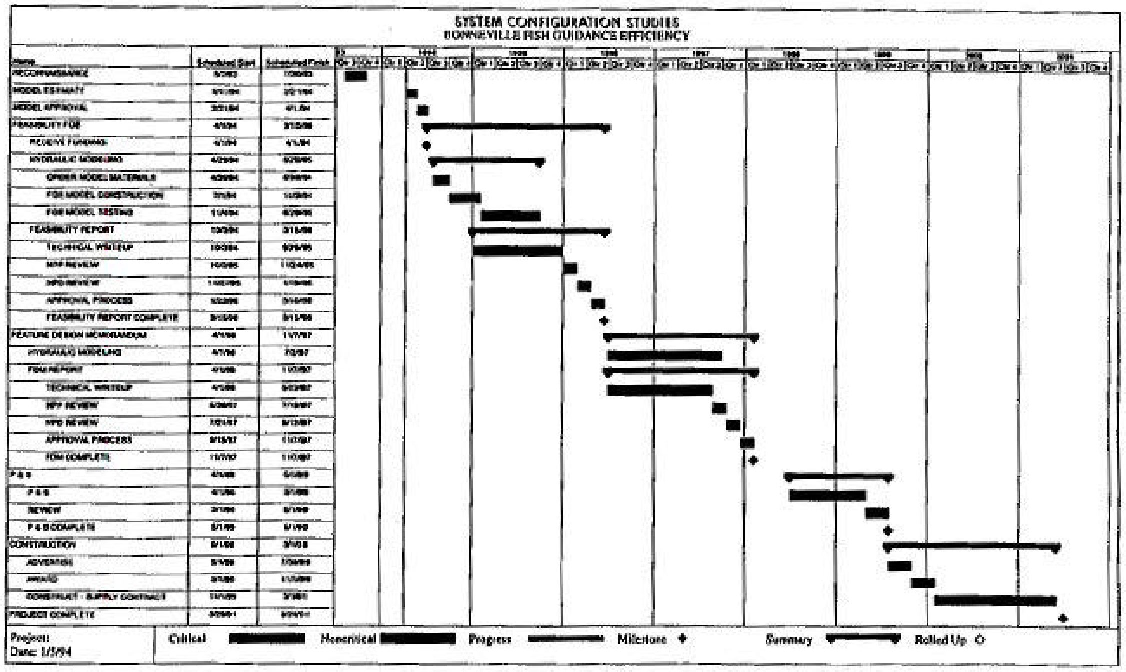

Figure 5-8. Bonneville Guidance Efficiency

b. Construction Costs.

Table 5-10 presents total estimated construction costs for the described improvements. Table 5-11 adds planning, engineering, and design costs and presents the fully-funded cost estimate based on the current schedule.

Table 5-10
Bonneville First Powerhouse Fish Guidance Efficiency
Construction Cost Estimate

Features	Quantity	Unit	Unit Price	Total Cost
40-Foot ESBS	1	EA	8,809,500	8,809,500
Change VB Screen Angle	1	EA	1,987,500	1,987,500
MOB-Demobilization	1	EA	240,000	240,000
Streamline Trashracks	1	EA	1,215,000	1,215,000
Miscellaneous	1	EA	360,000	360,000
Fish and Wildlife Facilities				$17,700,080
Contingency				$4,425,020
Total Construction				**$22,125,100**
Planning, Engineering, and Design				$3,540,000
Contingency				$885,000
Total Planning, Engineering, and Design				**$4,425,000**
Construction Management				$2,655,000
Contingency				$664,000
Total Construction Management				**$3,319,000**
Total Project Cost				**$29,869,000**

Table 5-11
Total Contract Cost Summary
Columbia River Salmon Mitigation Analysis System Configuration Study--Phase I
Bonneville I Fish Guidance Efficiency (FGE)
Columbia River, Oregon and Washington

Current MCACES Estimate Prepared: Effective Pricing Level:				Jan 94 Oct 93		Authoriz./Budget Year: 1995 Effect. Pricing Level: Oct 95				Fully-Funded Estimate				
Acct No.	**Feature Description**	**Cost ($K)**	**CNTG ($K)**	**CNTG (%)**	**Total ($K)**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Total ($K)**	**Feature Mid-Pt**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Full ($K)**
Fish and Wildlife Facilities														
06---		17,700	4,425	25%	22,125	6.8%	18,904	4,726	23,630	Apr 00	16.8%	22,080	5,520	27,599
	Total 06 Account	17,700	4,425		22,125		18,904	4,726	23,630			22,080	5,520	27,599
Functional Costs														
30---	Planning, Engineering, and Design	3,540	865	25%	4,425	8.9%	3,855	964	4,819	Nov 98	14.4%	4,410	1,103	5,513
31---	Construction Management	2,655	664	25%	3319	8.9%	2,091	723	3,614	May 00	21.0%	3,498	875	5,513
	Total All Accounts	23,895	5,974	25%	29,869	7.3%	25,650	6,413	32,063		16.9%	29,988	7,497	37,485
Total Project Costs:														**$37,485**

Estimate 30 account at 20% and 31 account at 15% of 06 account. Confirmed by designers.
Contingency on 30 and 31 accounts was estimated at 25% by CENPP-PE-C.
Authorization Year assumed to be FY 1995.

c. Operation and Maintenance Costs.

Operation and maintenance costs are based upon historical data. These costs assume all proposed improvements are implemented. Additionally, estimated maintenance costs are based upon one year of operation.

Mobilization and demobilization	$69,900
Maintenance (one year)	775,500
Miscellaneous	69,900

5.6. Phase II Study Requirements.

a. General.

Bonneville I FGE will require extensive study of alternatives in the feasibility phase. This will be primarily done through the use of sectional FGE models. Biological evaluations of these studies will be combined with hydraulic findings to provide a sound design capable of improving FGE at the project. This design will be evaluated for constructibility, operability, and soundness of design. A baseline cost estimate will then be prepared. Economic analysis of the selected alternative can then be performed to identify the impacts to other economic systems such as hydropower.

b. Alternative Development.

Most of the alternatives presented at the reconnaissance level will be studied to some degree in the feasibility report. Those that are determined to be undesirable will be eliminated as early as possible. From this report, alternative(s) that have merit can be further developed.

c. Biological Studies.

(1) General.

The Corps funded fish passage research on the Columbia River is developed, designed, administered, and implemented through the FPDEP. All aspects of research are developed with and coordinated through the regional fisheries agencies and tribes. It is the best professional judgement of the scientists and engineers involved with the development of this reconnaissance-level report, that the subject activities described herein will improve the survival of Pacific salmon stocks passing Bonneville Dam if used in conjunction with relocation or short-haul strategies, but biological uncertainties remain and warrant further investigation.

Bonneville First Powerhouse FGE improvements will incorporate the latest designs and knowledge regarding the behavior of fish in bypass systems, and be based on a substantial body of experience at numerous Corps fish bypass facilities throughout the Columbia River Basin. Additional biological studies, in addition to the physical studies described in this report, may be needed to complete the designs described herein. In addition, because of the uncertainty associated with the overall effect of current bypass designs on FGE and survival, post-construction evaluations of FGE and survival through the improved bypass systems are warranted.

(2) Prototype Testing.

Prior to construction, it is estimated that three years of biological evaluations of FGE will be required to test the designs developed under this study. These FGE investigations could include examining benefits associated with extended screens, redesigned trashracks, raised operating gates, and possibly lowered screens. Biological costs and schedules associated with these studies are listed in table 5-12.

Table 5-12
Biological Costs and Schedules

Fiscal Year	Biological Research	S&A ($)	Total ($)
1995	FGE - $300,000	25,000	325,000
1996	FGE - $300,000	25,000	325,000
1997	FGE - $325,000	25,000	300,000
2000	Final Report - $50,000	0	50,000
		Total	**$1,050,000**

(3) Additional Testing.

Additional FGE tests could be performed to verify the effectiveness of the design. Extensive post-construction testing will be done to determine the impacts the design changes have on the system. The results of these tests can be used to verify and modify the design to optimize FGE.

A post-construction survival study based on 3 years of coded-wire tagged and freeze-branded hatchery fish released through both powerhouse bypass systems, turbines, and the spillway are recommended to determine the overall survival performance of the FGE improvements in conjunction with other bypass systems improvements. The costs and schedules associated with such a study are described in the discussion of Section 8, 8.2.f.(3)(b).

d. Hydraulic Design.

(1) General.

Hydraulic design will be based primarily on physical model studies. Concepts will be evaluated through merit appraisals and tested if they appear promising.

(2) Sectional Model Construction and Testing.

(a) Model Construction.

A sectional hydraulic model will need to be constructed to perform the evaluation. The scale will be approximately 1:12, and will include one unit. The forebay will be accurately represented and allow for variance in approach flow conditions.

(b) Model Testing.

Testing will be of most of the alternatives listed herein. This hydraulic testing will need to be closely coordinated with the Corps biologists to interpret what impact certain hydraulic conditions have on fish. Dye can be inserted inside the model to indicate flow patterns. A laser velocimeter will be used to provide three-dimensional flow information.

Tests will be performed changing one parameter at a time to allow for isolation of its impact. This will eventually lead to a design that will optimize FGE.

(3) General Model Modification and Testing.

(a) Model Modification.

The general model was originally constructed for navigation studies. The level of detail and bathymetric accuracy in some areas may be too generalized for pinpointing localized hydraulic conditions impacting fish passage. Some portions of the model have been updated for other fish studies and is, therefore, quite adequate. Other areas must be increased in detail for fish studies.

(b) Model Testing.

The general model will be used to model the forebay conditions leading to the powerhouse. Model study schedules are shown in figure 5-8. Studies relating to forebay conditions can monitor the impacts of changes to the channel through dredging or fill. Floating flow vane-type structures can be placed in the forebay to evaluate their effectiveness in guiding flows into the intakes. Pier extensions or Shortened Turbine Intake Extensions (STIE) can also be evaluated.

e. Project Design.

(1) Mechanical.

The trashrack cleaning device will need to be developed to determine its feasibility for the various configurations considered. The additional requirements for handling extended screens, including a screen handling crane, will also be evaluated. Defining the requirements of a screen maintenance facility are also necessary. A raised operating gate will need to be evaluated and the restrictions for emergency gate closure defined to determine if removing the operating gate is a possibility. Other mechanical aspects of any and all alternatives must be closely examined to determine their feasibility. Operation and maintenance of all facilities must be determined.

(2) Electrical.

Electrical controls, monitors, instrumentation, and power requirements must be determined for the selected alternative. A source for meeting the additional power loads, particularly for ESTS's, needs to be identified. Potential electrical concerns shall be delineated, and may determine the feasibility of some alternatives.

(3) Structural.

Structural work will primarily consist of three products. They will be 1) calculations on structures proposed for model testing; 2) prototype designs/ and 3) the engineering appendix to the feasibility study.

The calculations on structures proposed for model testing will include checks for stability and allowable stresses, and would be preliminary in nature. Specific features that would be checked would be the intake configuration, prior extensions, STIE's, and the Pier 7 wing wall demolition for approach flow modeling; streamlined and relocated trashracks; new fish screens (if they vary from existing screen technology); VBS's; and operating gate slot modifications.

Prototype design includes preparation of design calculations, plans and specifications for a supply contract that fabricates and installs extended screens, fabricates and installs streamlined trashracks, raises operating gates, and lowers existing STS's. Plans and specifications would also be prepared for NMFS to fabricate new fyke net frames and other miscellaneous testing equipment.

f. Feature Design Memorandum Requirements.

The detailed design of modifications to improve FGE will take place in the FDM phase. Final engineering computations and analysis as well as biological analysis will be addressed at this level.

Section 6 - Turbine Passage Survival

6.1. Existing System Description and Operation.

a. General.

This report presents potential areas of study with regard to the causal agents of mortality to juvenile fish passing through the turbine environment. The methods used will include laboratory studies, numerical analysis, turbine design, and prototype testing. The goal of these investigations is to develop turbines that minimize the mortality of juvenile fish. If benefits associated with passage of juvenile fish through the prototype are favorable, there is the potential to investigate the replacement of some or all Corps turbines on the Columbia and Snake Rivers. These results may also lead to the rehabilitation or modification of existing turbines or unit operations.

b. Existing System Operation.

Turbine intake guidance screens are presently used to minimize the effects of turbine mortality by guiding juvenile salmon away from the turbines and placing them into specially designed bypass systems. These bypass systems either convey the juveniles to the tailrace area immediately below the dam or collect the juveniles for subsequent transportation around for to eight dams downstream.

The intake guidance screens are approximately 75-percent effective, leaving many juvenile salmon to endure the rigors of passing through the turbine environment. Therefore, the rehabilitation of existing turbines, modifications to unit operations, and the design and construction of new turbines using advanced turbine designs based on biological design criteria are areas that should be investigated. The goal is to increase the survival of unguided fish, improve survival past the project, and aid the recovery of listed Endangered Species Act and other stocks of Pacific salmon.

6.2. Proposed Improvements.

a. General.

The goal is to provide improved fish passage survival and reduced regulatory pressures on the operation of the Columbia River Federal hydrosystem by rehabilitating existing turbines, modifying operations, or designing new turbines based on biological design criteria. Laboratory studies, numerical analysis, and hydraulic model studies will be conducted to develop a thorough and fundamental understanding of the mechanisms of fish mortality acting within the turbine environment. This understanding will be used to generate biological design criteria which will then be used to develop advanced turbine designs.

b. Causal Agents of Fish Mortality.

Fish mortality associated with passage through a turbine has a direct component which occurs immediately and an indirect component which includes losses occurring after passage through the turbine. Direct mortality can occur when a fish strikes a turbine blade. Indirect mortality can be caused by an injury incurred during passage, stress from passage, or predation due to disorientation, weakening or injury of fish passing through the turbine. The mechanisms currently believed to be the causal agents of fish mortality within turbines are:

(1) Strike.

The probability and effect of fish impacting stay vanes, wicket gates, and runner blades (see). Strike is often considered an important component of overall passage mortality. The effect and probability of strike are governed by many variables including fish length, unit speed and discharge, number of runners, and the angle at which the fish approaches the runners. The items that are not known include the angle of approach which causes lethal strike for the species of concern, and the design changes that may reduce strike.

(2) Pressure.

The effect on fish passing through the pressure environment of a reaction turbine, especially the pressure drop associated with (on) the suction side of the runner. A primary source of fish mortality is likely due to the pressure drop on the suction side of the turbine runner. Swim bladders can be damaged or ruptured as the air in the bladder rapidly expands when the fish passes through areas that are below atmospheric pressure. Nitrogen from air in the swim bladder or nitrogen within the fish tissue or fluids can leave the tissue or solution and cause death through embolism in a vital organ.

(3) Cavitation.

The effect on fish of passing in a region of cavitation produced by the pressure environment in some areas of the turbine. Ideally, turbines are designed not to cavitate within criteria specified in the solicitation package. But in actual operation, cavitation still occurs, as evident by the annual need to perform cavitation repairs to blades and discharge rings.

The pressure wave associated with the implosion of the vapor pocket is similar to that of the shock wave produced by underwater blasting. It is possible that cavitation, which can result in pressures of up to 50,000 pounds per square inch (lb/in^2), is at least partially affecting fish as they pass through turbines. While the effect of the vapor pocket imploding against fish tissue is unknown, one can speculate that if these implosions can erode metal, fish tissues can be damaged as well.

(4) Shear.

The effect on fish when encountering rapidly changing water directions and the associated hydraulic forces. Shear is probably the most difficult potential mechanism of mortality to quantify. While it will be difficult to research shear and its effect on passage survival, it should not be overlooked. It may be possible that some actions designed to mitigate for losses associated with turbine passage may increase the level of shear and the incidence of shear effect. For instance, experimental Columbia River juvenile fish guidance screens in Kaplan unit intakes have a profound effect on intake flow patterns. Intake flows are redistributed toward the bottom of the intake, and are greatly accelerated. This may increase the level, incidence, and effect shear has on unguided fish passing through the unit.

(5) Stress.

The effect of the turbine environment inducing a debilitating level of stress which weakens the animal's resistance to disease and increases the susceptibility to predation. Stress associated with passage through turbines has not been widely studied, but can be an indicator used in designing effective turbine passage environments.

(6) Grinding.

The effect and loss of fish passing through the narrow gaps between turbine blades and the hub and discharge ring (see plate 6-2). The potential for mortality associated with passing through the gap between the distal end of the runner and the discharge ring is high. This is because fish could be drawn to this area by the high velocity of the leakage past the tip and, once there, are likely to be injured when passing through the small opening.

c. Alternatives.

Alternatives that are considered in this report are:

(1) Nonphysical Testing Methods.

These methods include numerical analysis as well as laboratory studies on fish.

(2) Physical Testing Methods.

These methods include existing prototype studies.

(3) **Turbine Replacement.**

This includes the following scenarios:

- Lower Columbia River turbines only.
- Snake River turbines only.
- All lower Columbia and Snake River turbines.

6.3. Engineering Evaluation of Alternatives.

a. General.

Prior to the replacement of existing turbine units non-physical and physical testing should be conducted. Based upon results of these tests, modifications to current operations may be necessary or new turbines can be designed, installed, and tested in Corps hydroelectric projects.

b. Alternatives.

For a complete and thorough investigation of fish behavior and survival associated within the turbine environment, it is proposed that the following three methods be implemented with the overall goal to increase fish survival. These methods are 1) non-physical methods; 2) physical methods; and 3) turbine replacement.

(1) **Non-Physical Methods.**

Information resulting from these studies include velocity distributions in the turbine area, pressure readings, and determination of operating efficiencies. Numerical analysis can be most useful prior to actual hydraulic modeling. Numerical analysis allows the designer flexibility in studying combinations of turbine parameters that can result in the most efficient operation as well as provide optimum juvenile fish passage survival. Results from the numerical analysis can then lead to a hydraulic model study of the turbine. Information obtained from the hydraulic model can be utilized as a basis for the prototype (physical method). Additionally, non-physical methods include laboratory studies with fish to evaluate the effects of cavitation, shear, stress, grinding, and pressure.

(2) **Physical Methods.**

Information gathered by this method on a prototype test unit can include observations of strike, stress on fish through the turbine environment, velocity distributions, pressure parameters, unit output, and efficiencies.

(3) **Turbine Replacement.**

If prototype tests are favorable, consideration should be given to the replacement of existing turbines at Corps hydroelectric projects. Three potential scenarios are 1) Lower Columbia River turbines only; 2) Snake River turbines only; and 3) all lower Columbia River and Snake River turbines only. Selection of a scenario for implementation is not addressed in this report, but can be made at a later date once results from prototype testing have been analyzed.

6.4. Impacts of Improvements.

a. Physical.

Turbine rehabilitation programs could also incorporate new runner designs that change the passage environment, resulting in safer fish passage conditions. The benefits would be increased passage survival and, in certain cases potential increases in power production due to a reduction in the amount of water spilled for juvenile passage mitigation.

b. Biological.

The benefits of a program to investigate mechanisms of mortality will vary by size, project size, and species and size of fish. A program that quantifies the mechanisms of turbine mortality provides 1) biologically-based design criteria; 2) an understanding of associated power impacts and engineering considerations; and 3) leads to the implementation of turbine redesigns that could provide numerous benefits. These benefits include:

- The survival of salmonids through the hydrosystem.
- A potential reduction in regulatory pressures on the Columbia River Federal hydrosystem.
- The future existence of power producing facilities if current fish mitigation activities do not provide satisfactory levels of protection, and decisions are made which favor fish protection over power production.

The benefit from such a program is to fish populations, including endangered species or stocks. While numerous mitigation measures are in place, many salmon stocks are not responding as expected to these measures. For example, significant numbers of juvenile salmon pass under intake guidance screens and through the turbines. Studies indicate that up to 92 percent of juvenile subyearling chinook salmon approaching powerhouses pass through turbines. This suggests that fish stocks could benefit from the proposed improvements to the turbine passage environment.

To estimate fish benefits associated with improved turbines, the CRiSP model was used. The CRiSP model was developed by the University of Washington, and tracks the downstream migration and survival of juvenile salmon and steelhead through the Columbia and Snake Rivers. The model recognizes and accounts for various reservoir and dam passage parameters, such as turbine survival, integrating a number of subroutine models to arrive at final estimate of hydrosystem survival. For this analysis, an artificial number of fish, large enough to allow the model to run, was input to estimate percent change from the base case for each stock:

Deschutes (Yearling Chinook)	Rock Creek (Steelhead)
Dworshak (Steelhead)	Wenatchee (Steelhead)
Hanford (Subyearling Chinook)	Methow Wells Index (Subyearling Chinook)
Methow (Yearling Chinook)	Wild Snake Fall (Subyearling Chinook)
Wild Snake Spring (Yearling Chinook)	Wild Snake Summer (Subyearling Chinook)

Input data for the base case and alternatives used FGE values from the SOR and the Model Coordination Team (Letter from Tuttle to fisheries agencies and tribes dated January 25, 1993). For the base case, fish survival through turbines is assumed to be 89 percent. To determine potential benefits associated with turbine improvements, the 89-percent value was increased to 91 percent, 93 percent, 95, and 97 percent; and modeled for each stock listed above with transportation on and off (in-river survival) and for the three scenarios modeled: all Corps and mid-Columbia PUD turbines, lower Columbia River turbines, and Snake River turbines replaced. All other variable were held constant.

Based on the model input described above, CRiSP results indicate there were no statistically significant differences between the base case and the conditions of improved turbine survival. This is because the confidence intervals around the estimates are large, and differences would have to be greater than 10 to 12 percent to be statistically significant. Also, transportation minimizes benefits associated with improved turbine designs because most Snake and mid-Columbia juvenile salmon are transported to below Bonneville Dam.

Many of the stocks, however, displayed increases in system survival on an absolute and relative basis, including stocks of Snake River origin. Even though these increases are not statistically significant, they indicate an increasing trend in fish survival through the hydrosystem with increased turbine survival. Tables 6-1 through 6-6 display the results.

Table 6-1
Estimated Survival of Juvenile Salmonids With Reductions in Turbine Mortality At All Projects (Snake and Columbia River)

Stock	Base Case	Modeled Turbine Survival (Percentage)			
		91	93	95	97
Deschutes (Yearling Chinook)	67	68	70	71	72
Rock Creek (Steelhead)	55	55	56	58	58
Dworshak (Steelhead)	48	47	48	48	48
Wenatchee (Steelhead)	30	33	34	37	39
Hanford Ferry (Subyearling Chinook)	62	63	65	66	67
Methow Well Index (Subyearling Chinook)	32	36	40	45	50
Methow (Yearling Chinook)	27	28	31	33	36
Wild Salmon River (Subyearling Chinook)	48	48	50	51	51
Wild Salmon River Stock (Summer)	41	41	42	42	43
Wild Salmon River Stock (Yearling Chinook)	40	40	41	42	42

Table 6-2
Estimated Survival of Juvenile Salmonids With Reductions in Turbine Mortality At Snake River Projects Only

Stock	Base Case	Modeled Turbine Survival (Percentage)			
		91	93	95	97
Deschutes (Yearling Chinook)	67	67	67	67	69
Rock Creek (Steelhead)	55	55	55	55	56
Dworshak (Steelhead)	48	48	48	48	49
Wenatchee (Steelhead)	30	31	31	31	31
Hanford Ferry (Subyearling Chinook)	62	62	62	62	60
Methow Well Index (Subyearling Chinook)	32	33	33	33	32
Methow (Yearling Chinook)	27	26	27	27	27
Wild Salmon River (Subyearling Chinook)	48	49	50	50	52
Wild Salmon River Stock (Summer)	41	42	42	42	43
Wild Salmon River Stock (Yearling Chinook)	40	41	42	42	41

Table 6-3
Estimated Survival of Juvenile Salmonids With Reductions in Turbine Mortality At Lower Columbia River Projects Only

Stock	Base Case	Modeled Turbine Survival (Percentage)			
		91	93	95	97
Deschutes (Yearling Chinook)	67	68	70	71	72
Rock Creek (Steelhead)	55	55	56	58	59
Dworshak (Steelhead)	48	48	48	47	47
Wenatchee (Steelhead)	30	31	31	31	32
Hanford Ferry (Subyearling Chinook)	62	63	64	66	67
Methow Well Index (Subyearling Chinook)	32	34	34	35	36
Methow (Yearling Chinook)	27	27	27	28	28
Wild Salmon River (Subyearling Chinook)	48	48	48	48	48
Wild Salmon River Stock (Summer)	41	41	41	41	41
Wild Salmon River Stock (Yearling Chinook)	40	40	40	40	40

Table 6-4
Estimated Survival of In-River Migrating Juvenile Salmonids With Reductions in Turbine Mortality At All Projects

Stock	Base Case	Modeled Turbine Survival (Percentage)			
		91	93	95	97
Deschutes (Yearling Chinook)	67	68	70	70	72
Rock Creek (Steelhead)	54	56	57	58	59
Dworshak (Steelhead)	27	28	29	30	31
Wenatchee (Steelhead)	33	35	37	39	42
Hanford Ferry (Subyearling Chinook)	45	47	49	51	54
Methow Well Index (Subyearling Chinook)	24	28	31	35	40
Methow (Yearling Chinook)	28	31	34	37	39
Wild Salmon River (Subyearling Chinook)	11	12	14	15	17
Wild Salmon River Stock (Summer)	31	32	33	35	37
Wild Salmon River Stock (Yearling Chinook)	25	26	28	29	32

Table 6-5
Estimated Survival of In-River Migrating Juvenile Salmonids With Reductions in Turbine Mortality At Lower Columbia River Projects Only

Stock	Base Case	Modeled Turbine Survival (Percentage)			
		91	93	95	97
Deschutes (Yearling Chinook)	67	69	70	71	72
Rock Creek (Steelhead)	54	56	56	58	59
Dworshak (Steelhead)	27	28	28	28	30
Wenatchee (Steelhead)	33	32	34	34	34
Hanford Ferry (Subyearling Chinook)	45	47	49	51	54
Methow Well Index (Subyearling Chinook)	24	25	27	27	29
Methow (Yearling Chinook)	28	29	30	31	31
Wild Salmon River (Subyearling Chinook)	11	12	13	13	14
Wild Salmon River Stock (Summer)	31	31	31	33	33
Wild Salmon River Stock (Yearling Chinook)	25	26	27	27	28

Table 6-6
Estimated Survival of In-River Migrating Juvenile Salmonids With Reductions in Turbine Mortality At Snake River Projects Only

Stock	Base Case	Modeled Turbine Survival (Percentage)			
		91	93	95	97
Deschutes (Yearling Chinook)	67	67	67	67	67
Rock Creek (Steelhead)	54	55	55	55	56
Dworshak (Steelhead)	27	28	28	28	29
Wenatchee (Steelhead)	33	32	33	32	32
Hanford Ferry (Subyearling Chinook)	45	45	45	44	45
Methow Well Index (Subyearling Chinook)	24	24	24	24	24
Methow (Yearling Chinook)	28	28	28	28	28
Wild Salmon River (Subyearling Chinook)	11	12	13	13	14
Wild Salmon River Stock (Summer)	31	31	31	32	33
Wild Salmon River Stock (Yearling Chinook)	25	26	27	27	27

Because of the variance associated with trying to model a complex system such as the Columbia River, the results can be bet used to indicate trends. Small differences of a few percentage points are considered model noise. The following conclusions are drawn from the CRiSP analysis:

- Fish survival is benefited from turbine improvements. The degree depends on the origin and species of fish and the number of turbines replaced. Fish with low FGE levels receive greater benefit, as expected.

- The absolute range in improvements is from slight (0 to 2 percent) to large (16 percent for in-river Methow subyearling chinook when all turbines are replaced).

- On a relative basis, the improvements range from 0 percent up to 67 percent (in-river Methow subyearling chinook when all turbines are replaced). The greatest relative improvements are made to in-river stocks, since these do not benefit from transportation. For example, wild in-river Snake River O's increase from 11 percent survival under the base case to 17 percent when all turbines are replaced and turbine survival is increased to 97 percent on a relative basis is an increase in survival of 55 percent.

- Even the most optimistic benefits to improved turbine survival do not raise the level of system survival for in-river migrating fish to that with transportation turned on. For example, the in-river survival of Snake River stocks ranges from 17 to 37 percent when all turbines are replaced with the most optimistic benefits to fish survival. This compares to system survival estimates of 40 to 48 percent for these same stocks when transported under today's conditions (base case).

c. Economic.

This potential project improvement outlines six likely causal agents of juvenile fish turbine mortality, and recommends studies to investigate how those agents occur in the turbine. Study results will be used to develop new turbine operation or designs to reduce juvenile fish mortality.

Those studies are not expected to have direct or indirect economic impacts within the region. Implementing a solution to or improvement in juvenile fish turbine survival that changes turbine design or operation is likely to affect hydropower production, but it is unclear at this time which way hydropower production will be affected.

It is estimated that it would take 9 years to assemble a study task force, investigate the causal agents, construct potential improvements, and test prototypes.

No indirect impacts to the local or regional economies are expected from this proposed project improvement. No direct impacts to navigation, recreation, flood control, or other project purposes are expected from this proposal to study ways to improve turbine passage survival.

6.5. Schedule and Cost.

a. Design and Construction Schedule.

A research schedule and potential design and construction schedule is shown on figures 6-1 and 6-2.

Figure 6-1
Project Cost Summary - Turbine Passage Survival
Current Working Estimate
Construction Cost Estimate

Feature	Quantity	Unit	Unit Price	Total Cost
Bonneville First Powerhouse				
Bonneville I, 1st Unit	1	EA	5,908,434	5,908,430
Bonneville I, 2nd Unit	1	EA	4,494,330	4,494,330
Bonneville I, 3rd Unit	1	EA	3,962,291	3,962,290
Bonneville I, 4th Unit	1	EA	3,682,270	3,682,270
Bonneville I, 5th Unit	1	EA	3,500,257	3,500,260
Bonneville I, 6th Unit	1	EA	3,360,247	3,360,250
Bonneville I, Misc. Items				1,080,320
Bonneville I, 8-10 Units	3	EA	3,262,239	9,786,720
Bonneville I, 7th Unit	1	EA	3,262,239	3,262,240
Bonneville Second Powerhouse				
Bonneville II, 1st Unit	1	EA	6,416,720	6,416,720
Bonneville II, 2nd Unit	1	EA	4,880,965	4,880,960
Bonneville II, 3rd Unit	1	EA	4,303,156	4,303,160
Bonneville II, 4th Unit	1	EA	3,999,046	3,999,050
Bonneville II, 5th Unit	1	EA	3,801,374	3,801,370
Bonneville II, 6th Unit	1	EA	3,649,319	3,649,320
Bonneville II, Misc. Items				1,185,420
Bonneville II, 8th Unit	1	EA	3,542,881	3,542,880
Bonneville II, 7th Unit	1	EA	3,452,881	3,542,880

The Dalles Dam				
The Dalles Dam, 1st Unit	1	EA	6,415,798	6,415,800
The Dalles Dam, 2nd Unit	1	EA	4,880,264	4,880,260
The Dalles Dam, 3rd Unit	1	EA	4,302,538	4,302,540
The Dalles Dam, 4th Unit	1	EA	3,998,471	3,998,470
The Dalles Dam, 5th Unit	1	EA	3,800,828	3,800,830
The Dalles Dam, 6th Unit	1	EA	3,648,795	3,648,800
The Dalles Dam, Misc. Items				2,024,470
The Dalles Dam, 7th Unit	1	EA	3,542,372	3,542,370
The Dalles Dam, 8-22 Units	15	EA	3,542,372	53,135,580
John Day Dam, 1st Unit	1	EA	5,912,727	5,912,730
John Day Dam, 2nd Unit	1	EA	4,501,934	4,501,930
John Day Dam, 3rd Unit	1	EA	3,968,995	3,968,990
John Day Dam, 4th Unit	1	EA	3,688,501	3,688,500
John Day Dam, 5th Unit	1	EA	3,506,179	3,506,180
John Day Dam, 6th Unit	1	EA	3,365,932	3,365,930
John Day Dam, 7th Unit	1	EA	3,267,759	3,267,760
John Day Dam, 8-16 Units	9	EA	3,267,759	29,409,830
John Day Dam, Misc. Items	1	EA	1,474,839	1,474,840

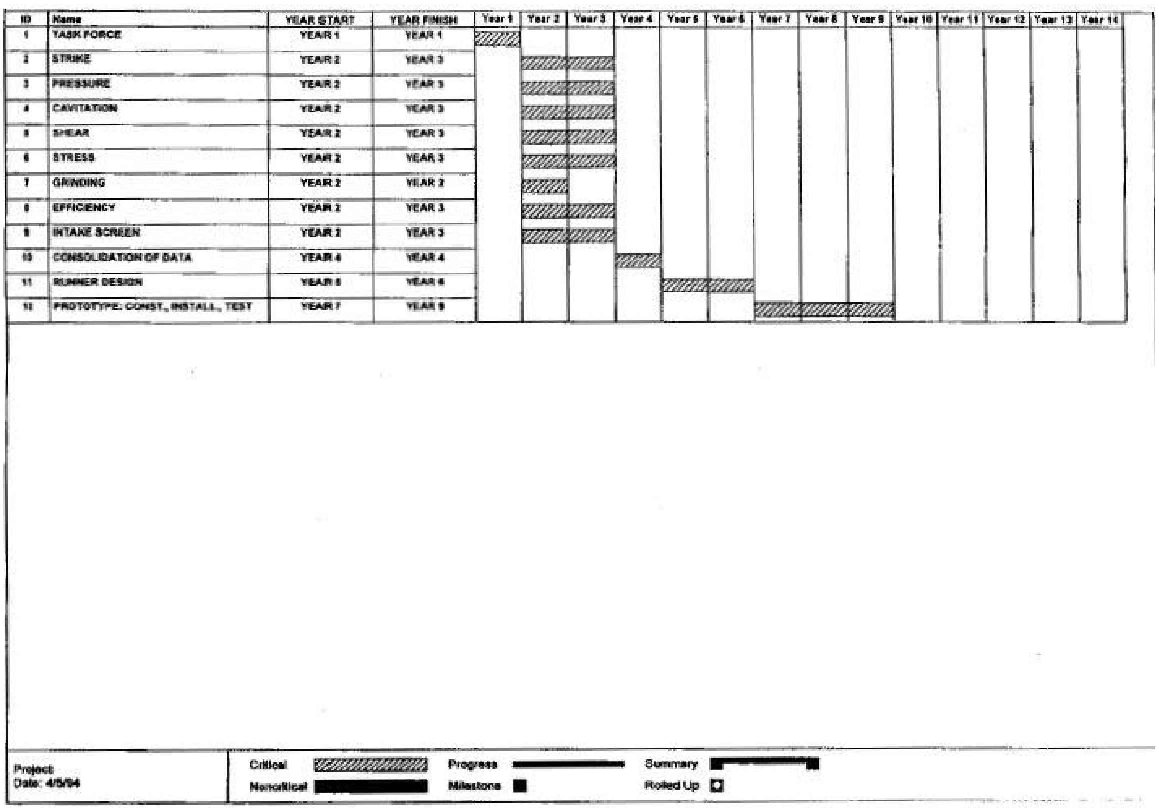

Figure 6-2. Turbine Passage Survival

b. Cost Estimates.

For the purposes of comparison, a cost estimate assuming replacement of turbines at Bonneville, The Dalles, and John Day has been prepared. The estimated costs are presented in figures 6-3 and 6-4. Figure 6-3 adds costs for testing and planning, engineering, and design. Figure 6-4 shows estimated costs for the replacement of individual turbine units at the respective projects.

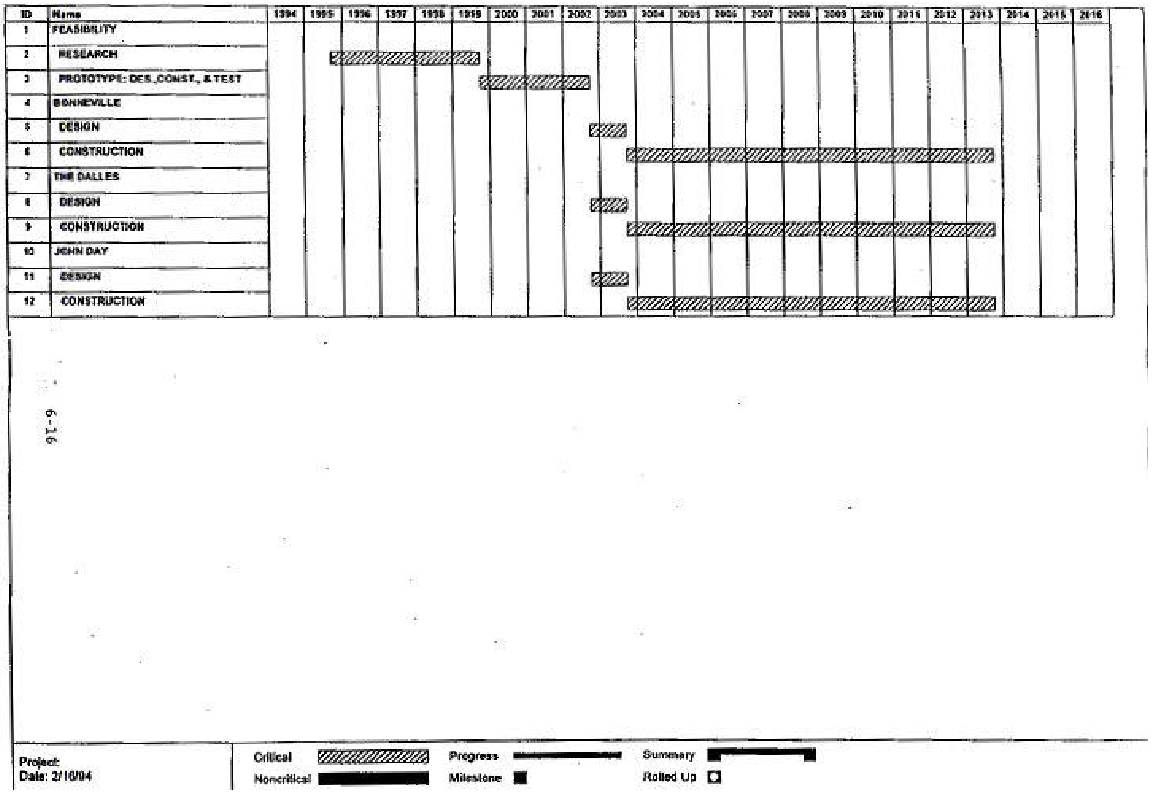

Figure 6-3. Turbine Passage Survival

Figure 6-4
Cost Summary Including Escalation and Contingencies

Current MCACES Estimate Prepared: Effective Pricing Level:				Dec 93 Oct 93		Authoriz./Budget Year: 1995 Effect. Pricing Level: Oct 95				Fully-Funded Estimate				
Acct No.	**Feature Description**	**Cost ($K)**	**CNTG ($K)**	**CNTG (%)**	**Total ($K)**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Total ($K)**	**Feature Mid-Pt**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Full ($K)**
Fish and Wildlife Facilities--Turbine Passage Survival Estimate Lower Columbia Projects														
06---	Bonneville I Powerhouse	39,037	9,769	25%	40,796	6.8%	41,703	10,426	52,129	Oct 04	41.1%	58,843	14,711	73,554
06---	Bonneville II Powerhouse	35,322	8,830	25%	44,162	6.8%	37,734	9,434	47,168	Oct 04	41.1%	53,243	13,311	66,554
06---	The Dalles Dam	85,749	21,437	25%	107,186	6.8%	91,606	22,901	114,507	Oct 04	41.1%	129,256	32,314	161,570
06---	John Day Dam	59,097	14,774	25%	73,871	6.8%	63,133	15,783	78,916	Oct 04	41.1%	89,081	22,270	111,351
06---	Subtotal	219,205	64,801		274,000		234,176	58,644	292,720			330,423	82,806	413,029
06---	Model Testing	800	200	25%	1,000	6.8%	855	214	1,068	Oct 04	41.1%	1,206	301	1,507
06---	Additional Model Testing	500	125	25%	625	6.8%	534	134	668	Oct 04	41.1%	754	188	942
	Total 06 Account	220,505	55,126	25%	275,631		235,565	58,891	294,456		41.1%	332,382	83,096	4125,478
Functional Costs--Planning, Engineering, and Design														
30---	E&D	7,200	1,800	25%	9,000	8.9%	7,837	1,969	9,797	Nov 02	41.8%	11,113	2,778	13,891
	Total 30 Account	7,200	1,800	25%	9,000		7,837	1,969	9,797		41.8%	11,113	2,778	13,891
Functional Costs--Construction Management														

31---	S&A	3,600	900	25%	4,500	8.9%	3,819	980	4,898	Nov 04	50.1%	5,002	1,470	7,352
	Total 31 Account	3,600	900	25%	4,500	8.9%	3,819	980	4,898	Nov 04	50.1%	5,002	1,470	7,352
	Total All Accounts	231,305	57,826	25%	289,131	6.9%	247,321	61,830	309,151		41.3%	349,377	87,344	436,722
Total Project Costs:														**$436,722**

Functional costs were provided by designer.
Contingency on 30 and 31 accounts was estimated at 25% by CENPP-PE-C.
Estimate 30 account mid point at Nov 2002 by CENPP-PE-C
Estimate 31 account mid point at Nov 2004 by CENPP-PE-C
Authorization: Year assumed to be FY 1995.

The fully-funded total cost for the design and construction of replacement turbines for Bonneville, The Dalles, and John Day Dams is $436,722,000. The engineering and design portion of the total is $13,891,000. Of this portion, $2,778,000 is the fully-funded estimate for research.

6.6. Phase II Study Requirements.

a. General.

Research should be conducted prior to the implementation of any modifications to the existing system. Model studies, laboratory studies, numerical analysis, video imaging, or a combination thereof, are potential methods of research.

b. Research and Estimated Costs.

The following outlines a possible research program with associated estimated costs.

(1) Task Force.

A task force comprised of engineers, turbine experts, and fish passage experts could be formed to develop schedules, scopes, and cost estimates. The estimated cost associated with this aspect is $100,000.

(2) Strike.

Investigation of strike would involve multiple steps. Video cameras would be installed in existing hydraulic models of turbines to observe the behavior of neutrally-buoyant particles or small fish. It is also possible to conduct video imaging in the prototype. However, this is limited due to such items as the clarity of the water, as well as the limitations on the equipment. The estimated cost associated with this study is $200,000.

(3) Pressure.

A laboratory research program should retest the pressure loss concept with modern, rapid, pressure-drop technologies. Various sizes, species, and conditions of fish could be examined, along with an evaluation of the effect on survival from the depth at which fish are accustomed. It is estimated the cost associated with this study is $200,000.

(4) Cavitation.

Numerical analysis of existing turbine configurations could be conducted to assist in determining areas of potential cavitation zones in the turbine environment. As part of a hydraulic model study of a turbine unit, studies could also be performed to identify potential cavitation zones. The estimated cost associated with this study is $200,000.

(5) Shear.

Each fish species will have different tolerances to shear effects, and each geographical area has species important to that region. Research could be conducted on salmon stocks such as sockeye and spring/summer chinook, since these species appear most sensitive to the rigors of passing through dam bypass systems, and presumably the turbine environment as well. Various sizes of each species could be examined. The laboratory environment could be used to develop tolerance criteria. Specifically, this means determining the level of shear or difference in velocity between flow patterns each age class and species can tolerate. Additionally, judgements would have to be made regarding what level of effect is considered acceptable.

Laser Doppler measurements of velocity in hydraulic turbine models and computational fluid dynamics modeling of turbine shear should be attempted to link tolerance criteria to conditions found in operating units. Judgements could be made regarding potential shear effect once the level of shear fish encounter in passing through a turbine is determined, based on hydraulic and computer modeling; and whether this level of shear is of significant concern, based on laboratory evaluations of fish tolerance to shear. The estimated cost associated with this study is $200,000.

(6) Stress.

The evaluation of stress associated with fish passage through various turbine designs would require a two-step process. Initial laboratory investigations would define the level of stress a species could tolerate and still withstand predator, osmoregulatory, and disease challenges to survival. Then the selected prototype turbine design could be field tested and stress parameters associated with passage through the prototype measured and compared to the criteria for conformance.

Assessing stress effects associated with a specific turbine design will be difficult and expensive, because a turbine will have to be constructed and installed before stress testing can be conducted. Any modifications to a design because of stress would then require a new turbine design. It is estimated that it will cost $250,000 for this study.

(7) Grinding.

Investigating the gap loss should occur in the initial stages of investigating the mechanisms of turbine mortality. Video camera imaging under prototype conditions could identify the level and outcome of gap passage. The estimated cost associated with this study is $100,000.

(8) Efficiency.

Fish survival is considered to be related to turbine efficiency. Consequently, it has been adopted to operate turbines within 1 percent of peak efficiency during the fish migration season. While there is general agreement that a relationship between efficiency and fish passage survival exists for Kaplan turbines, some important issues remain unanswered and warrant investigation. For example, investigations should be conducted to determine whether survival at a given efficiency is related to load or discharge (velocity).

Numerical analysis, turbine modeling and prototype testing could be conducted to assist in determining the effect this aspect has on fish passage survival. The estimated cost associated with this study is $400,000.

(9) Intake Screen Effects.

Unit efficiency may be substantially affected by the hydraulic disruption of intake flows caused by the installation of fish guidance screens in the intake. In addition, fish survival may be lowered through increased pressure drops across turbine blades and redistribution of juvenile fish away from the hub and toward blade tips. As with item (6), above, numerical analysis, turbine modeling, and prototype testing are possible methods available to assist in determining the effect intake screens have on fish survival through the turbine environment. The estimated cost associated with this study is $250,000.

(10) Turbine Runner Design.

With the results from the above research, engineering and fish passage experts will discuss data and determine which aspects of turbine design require refinement and possible modifications. The best overall design will be developed and evaluated for potential impacts to power production, efficiency, operations, maintenance, and cost. The estimated cost associated with this study is $750,000.

(11) Prototype Testing.

Utilizing the results from item (9), a prototype turbine can be constructed and installed at a selected site. Fish survival, stress, power production, and efficiency aspects can be evaluated. The estimated cost associated with this study is $5,800,000.

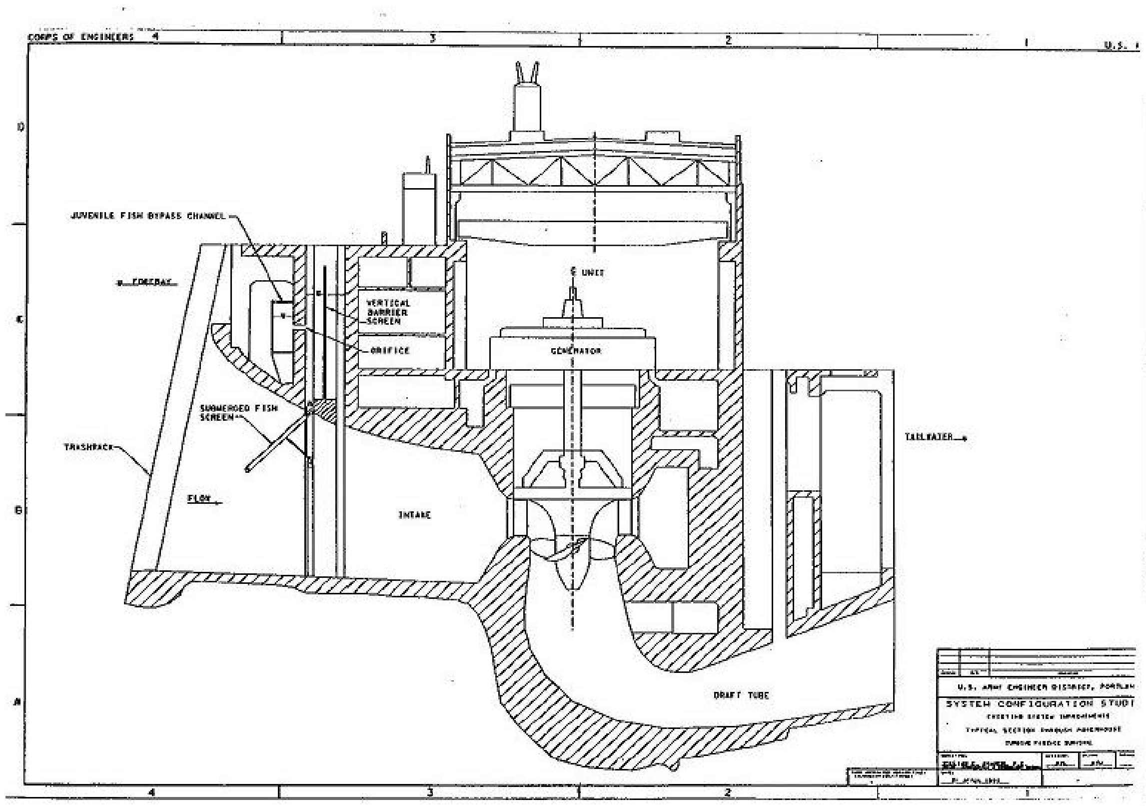

Plate 5. Typical Section Through Powerhouse

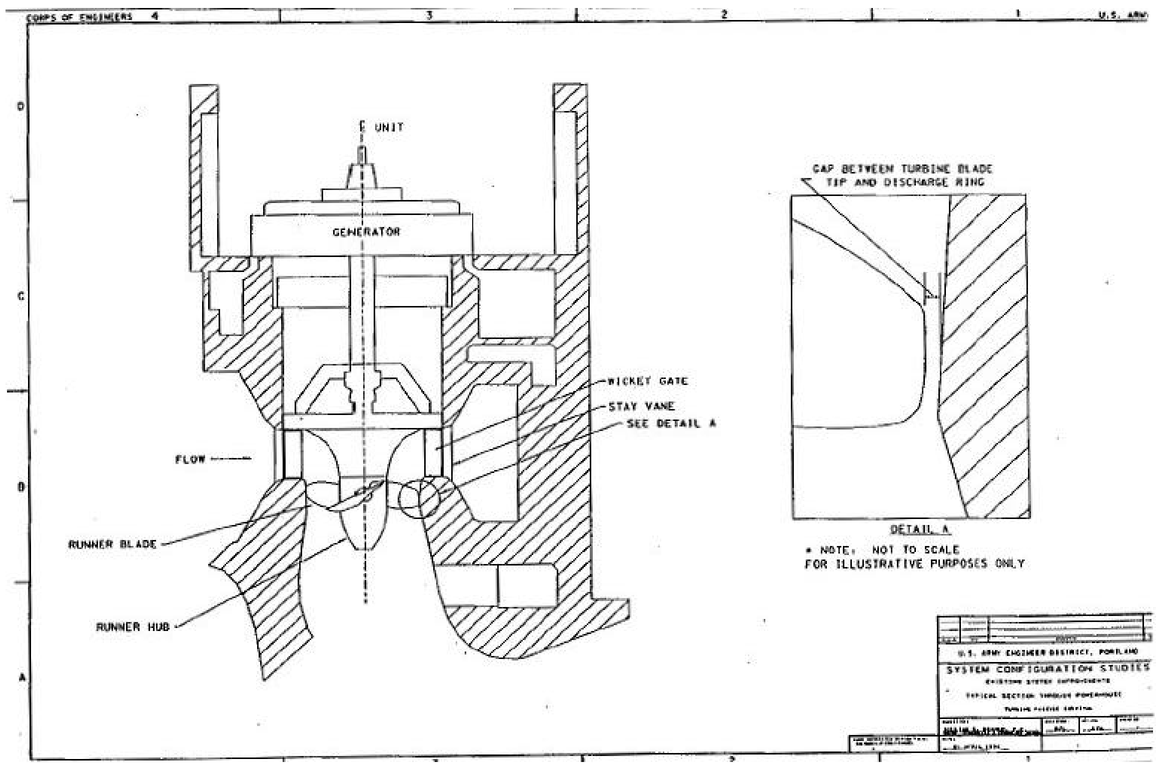

Plate 6. Typical Section Through Powerhouse

Section 7 - Spill Pattern at John Day

7.1. Existing System Description and Operation.

a. General.

John Day Dam is located at Columbia RM 215.6, and is the third hydropower project upstream of the river mouth. The project consists, from south to north, of a south shore fish ladder, powerhouse with 16 Kaplan turbine units, 20 bay spillway, north shore fish ladder, navigation lock, and non-overflow section, all of which combine to create a structure approximately 3,700 feet long.

(1) Adult Patterns.

Study began on the adjustment of the spillway pattern distribution for adult fish passage as early as 1966 and 1967 at Ice Harbor Dam on the Snake River, and shortly thereafter at The Dalles Dam on the Columbia River. In 1967 and 1968, prior to completion of the powerhouse at John Day Dam in 1968, it was estimated that serious unaccounted losses of adult salmonids were occurring between The Dalles and McNary Dams (Haas *et al.*, 1968). Several factors were thought to be responsible for these losses which include nitrogen supersaturation and delayed adult salmonid passage over John Day due to poor passage conditions. Adjustment of the spill patterns for adult fish passage were made in 1968, based on visual observations. Those observations were the basis for a report that was published in June 1972, which gives guidelines for setting spillway gates that would assist adult fish in locating the fish ladder entrance. At present, these settings are still in use at the project.

(2) Juvenile Patterns.

In the early 1970's, NMFS and other agencies were evaluating the effects of nitrogen supersaturation, and recommendations were made to add flip-lips to several Columbia and lower Snake River projects. Increased gas saturation was known to cause significant mortalities of juvenile and adult fish. Later, flip-lips were added to Bonneville, McNary, Lower Monumental, Little Goose, and Lower Granite Dams. Based on a recommendation from NMFS in 1975, flip-lips were not included at John Day Dam (Ebel *et al.*, 1975).

In 1979, the Corps began hydroacoustic monitoring of juvenile salmonid locations and concentrations at both the spillway bays and the turbine intakes. The present guidelines for juvenile spill patterns were established on the basis of that study. Further monitoring at the spillway was carried out by the Corps Fishery Field Unit from 1981 to 1985. In 1986, an agreement [Spill Memorandum of Agreement (MOA)] set the quantity of water to be spilled at approximately 20 percent of the total river flow during the summer outmigration at John Day Dam. This amount of water resulted in significant changes in the quantities of water for spillway increases. Further hydroacoustic monitoring studies were conducted from 1986 to 1988, but the spillway gate pattern has not been modified since the guidelines published in the original report of 1979.

From the later hydroacoustic studies, spillway effectiveness and efficiency were determined to verify that juvenile fish were using the spillway during spillway operation. Spillway effectiveness is defined as the number of migrants passing through spill divided by the total number of migrants passing the project (powerhouse plus spillway). Spillway efficiency is defined as the proportion of fish spilled (spill effectiveness) divided by the proportion of total project discharge passed through the spillway.

From the hydroacoustic studies, average spill effectiveness ranged from 19 to 32 percent, and spillway efficiency ranged from 1.0 to 1.3. That is, for every percent of discharge through spill, 1.0 to 1.3 percent of the migrants pass through spill.

b. Existing Patterns.

(1) Adult.

The adult patterns are used during 0500 to 2000 hours. At low flows, the spill pattern is set such that a greater proportion of flow is passed through the bays at the ends of the spillway. This spill pattern is intended to attract adult fish to the fish ladder entrances. As spill increases, the number of open spillway gates and the amount of gate opening increases toward the center of the spillway. This operation is used to minimize high tailwater velocities associated with large spill discharges that may keep the adult fish away from the fish ladder entrances.

(2) Juvenile.

During the juvenile passage period, spill for passage of juvenile fish is in effect during 2000 to 0600 hours. The current spill pattern schedule initially opens the south bay that is adjacent to the powerhouse. This arrangement enables the juveniles to take advantage of the powerhouse flows., follow the flow paths to the south spill bays and, thus, minimize the potential for delays to the downstream migration. Some of the bays are limited to nine stop openings. Once this maximum opening is reached, gates on the north side must be opened.

7.2. Proposed Improvements.

a. Modify Adult Spill Patterns.

A new spill pattern schedule will be developed with guidelines for use that will modify patterns for spill during adult passage season.

b. Modify Juvenile Spill Patterns.

A new spill pattern schedule will be developed with guidelines for use that will replace existing patterns for spill during the juvenile spill season. These patterns will be used by project personnel to operate the project in the described pattern for spills ranging from 0 to 300,000 ft^3/s.

c. Install Flip-Lips.

To minimize the potential of injury to juvenile and adult fish by gas bubble disease, installation of flip-lips to the spillway is proposed. The flip-lips will either be retractable or fixed type (see figure 7-1). Flip-lips may also assist in providing better tailrace flow conditions for both adult and juvenile passage.

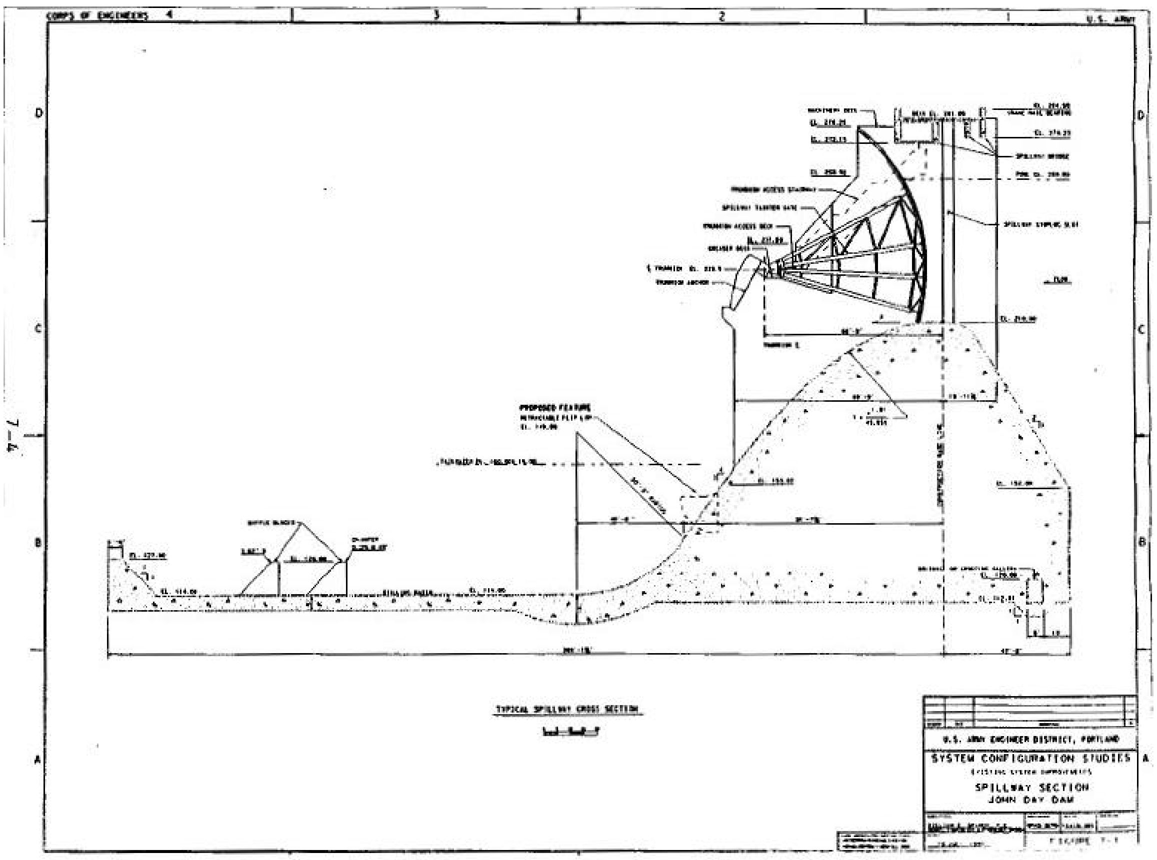

Figure 7-1. Spillway Section--John Day Dam

7.3. Engineering Evaluation of Alternatives.

a. General.

Spill occurs at the project during four particular events: 1) when river flow is greater than the capacity of the operating units in the powerhouse to produce power (forced spill); 2) to aid juvenile fish in their downstream migration past the project; 3) to provide attraction flow to fish ladder entrances for adult fish; and 4) during high flow, but low energy demand. The 20 spill bays are not randomly used to achieve a particular spill discharge or percentage (see figure 7-2). The project operators use a schedule indicating the distribution of spill amongst the 20 gates. Currently, there are different spill schedules for both adults and juveniles (see tables 7-1 and 7-2).

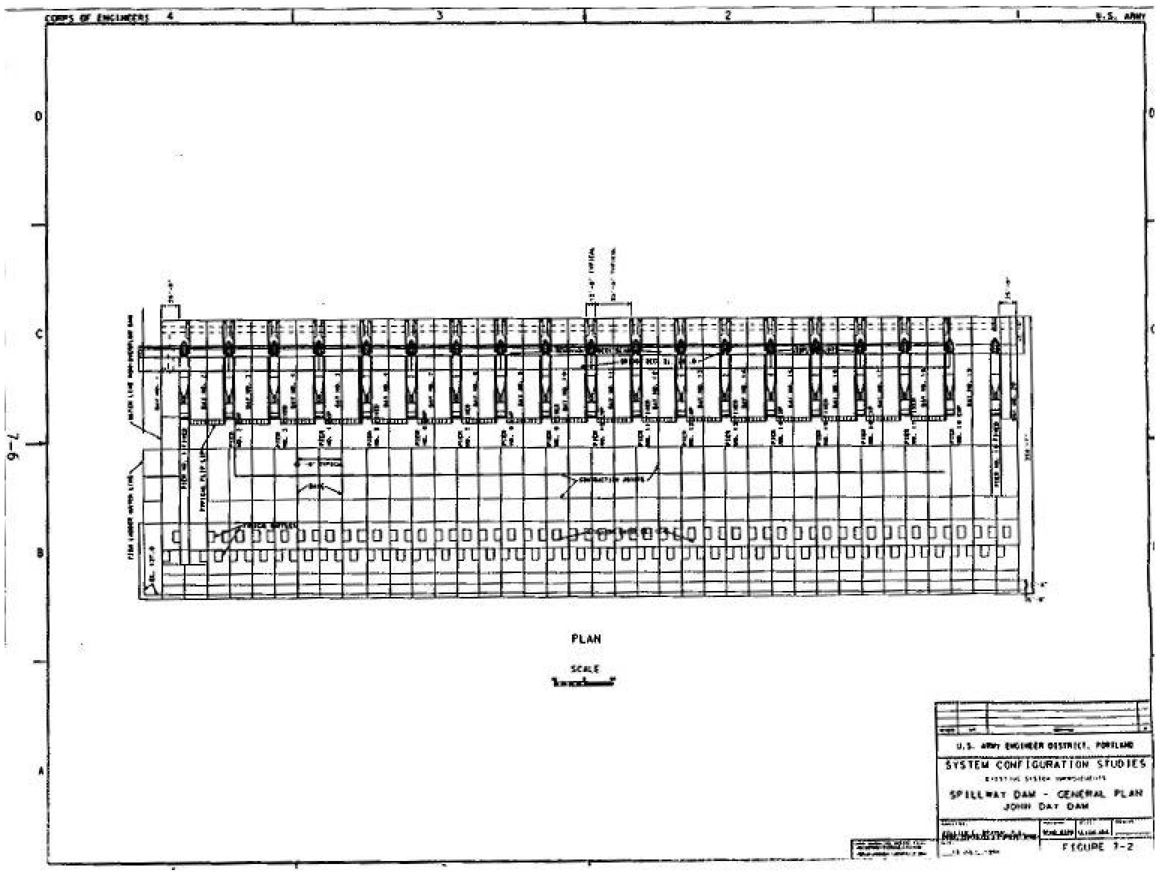

Figure 7-2. Spillway Dam--General Plan
John Day Dam

Table 7-1
Spill Schedule for Adult Fish at John Day Dam
(0500-2000)

Bay Number																				Stops	KCFS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
1																				1	1.6
1																			1	2	3.2
1	1																		1	3	4.8
1	1																	1	1	4	6.4
1	1	1																1	1	5	8.0
1	1	1															1	1	1	6	9.6
1	1	1															2	1	1	7	11.2
1	2	1															2	1	1	8	12.8
1	2	1														1	2	1	1	9	14.4
1	2	2														1	2	1	1	10	16.0
1	2	2	1													1	2	1	1	11	17.6
1	2	2	2													2	2	1	1	12	19.2
1	2	2	2													2	2	1	1	13	20.8
1	2	2	2													2	2	2	1	14	22.4
1	2	2	2	1												2	2	2	1	15	24.0
1	2	2	2	2												2	2	2	1	16	25.6
1	2	2	2	2											1	2	2	2	1	17	27.2
1	2	2	2	2											2	2	2	2	1	18	28.8
1	2	2	2	2	1										2	2	2	2	1	19	30.4
1	2	2	2	2	2										2	2	2	2	1	20	32.0
1	2	2	2	2	2									1	2	2	2	2	1	21	33.6
1	2	2	2	2	2									2	2	2	2	2	1	22	35.2
1	2	2	2	2	2	1								2	2	2	2	2	1	23	36.8
1	2	2	2	2	2	2								2	2	2	2	2	1	24	38.4
1	2	2	2	2	2	2							1	2	2	2	2	2	1	25	40.0
1	2	2	2	2	2	2							2	2	2	2	2	2	1	26	41.6
1	2	2	2	2	2	2	1						2	2	2	2	2	2	1	27	43.2
1	2	2	2	2	2	2	2						2	2	2	2	2	2	1	28	44.8
1	2	2	2	2	2	2	2					1	2	2	2	2	2	2	1	29	46.4
1	2	2	2	2	2	2	2					2	2	2	2	2	2	2	1	30	48.0
1	2	2	2	2	2	2	2	1				2	2	2	2	2	2	2	1	31	49.6
1	2	2	2	2	2	2	2	2				2	2	2	2	2	2	2	1	32	51.2
1	2	2	2	2	2	2	2	2			1	2	2	2	2	2	2	2	1	33	52.8
1	2	2	2	2	2	2	2	2			2	2	2	2	2	2	2	2	1	34	54.4
1	2	2	2	2	2	2	2	2	1		2	2	2	2	2	2	2	2	1	35	56.0
1	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2	2	1	36	57.6
1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	1	37	59.2
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	38	60.8
1	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	1	39	62.4
1	2	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	1	40	64.0
1	2	2	2	2	2	2	2	2	3	3	3	2	2	2	2	2	2	2	1	41	65.6
1	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2	1	42	67.2
1	2	2	2	2	2	2	2	3	3	3	3	3	2	2	2	2	2	2	1	43	68.8
1	2	2	2	2	2	2	3	3	3	3	3	3	2	2	2	2	2	2	1	44	70.4
1	2	2	2	2	2	3	3	3	3	3	3	3	3	2	2	2	2	2	1	45	72.0
1	2	2	2	2	2	3	3	3	3	3	3	3	3	3	2	2	2	2	1	46	73.6
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1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2	2	2	2	1	48	76.8
1	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	1	49	78.4

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1	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	1	51	81.6
1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	1	52	83.2
1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	1	53	84.8
1	2	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	2	1	54	86.4
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1	2	3	3	3	3	3	3	4	4	4	4	3	3	3	3	3	3	2	1	58	92.8
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2	4	6	6	6	6	6	6	6	7	7	7	6	6	6	6	6	6	4	2	111	177.6
2	4	6	6	6	6	6	6	7	7	7	7	6	6	6	6	6	6	4	2	112	179.2
2	4	6	6	6	6	6	6	7	7	7	7	7	6	6	6	6	6	4	2	113	180.8
2	4	6	6	6	6	6	7	7	7	7	7	7	6	6	6	6	6	4	2	114	182.4
2	4	6	6	6	6	6	7	7	7	7	7	7	7	6	6	6	6	4	2	115	184.0
2	4	6	6	6	6	7	7	7	7	7	7	7	7	6	6	6	6	4	2	116	185.6
2	4	6	6	6	6	7	7	7	7	7	7	7	7	7	6	6	6	4	2	117	187.2
2	4	6	6	6	7	7	7	7	7	7	7	7	7	7	6	6	6	4	2	118	188.8
2	4	6	6	6	7	7	7	7	7	7	7	7	7	7	7	6	6	4	2	119	190.4
2	4	6	6	7	7	7	7	7	7	7	7	7	7	7	7	6	6	4	2	120	192.0
2	4	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	4	2	121	193.6
2	4	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	4	2	122	195.2
2	4	6	7	7	7	7	7	7	7	8	7	7	7	7	7	7	6	4	2	123	196.8
2	4	6	7	7	7	7	7	7	8	8	7	7	7	7	7	7	6	4	2	124	198.4
2	4	6	7	7	7	7	7	7	8	8	8	7	7	7	7	7	6	4	2	125	200.0
2	4	6	7	7	7	7	7	8	8	8	8	7	7	7	7	7	6	4	2	126	201.6
2	4	6	7	7	7	7	7	8	8	8	8	8	7	7	7	7	6	4	2	127	203.2
2	4	6	7	7	7	7	8	8	8	8	8	8	7	7	7	7	6	4	2	128	204.8
2	4	6	7	7	7	7	8	8	8	8	8	8	8	7	7	7	6	4	2	129	206.4
2	4	6	7	7	7	8	8	8	8	8	8	8	8	7	7	7	6	4	2	130	208.0
2	4	6	7	7	7	8	8	8	8	8	8	8	8	8	7	7	6	4	2	131	209.6
2	4	6	7	7	8	8	8	8	8	8	8	8	8	8	7	7	6	4	2	132	211.2
2	4	6	7	7	8	8	8	8	8	8	8	8	8	8	8	7	6	4	2	133	212.8
2	4	6	7	8	8	8	8	8	8	8	8	8	8	8	8	7	6	4	2	134	214.4
2	4	6	8	8	8	8	8	8	8	8	8	8	8	8	8	7	6	4	2	135	216.0
2	4	6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	4	2	136	217.6
2	4	6	8	8	8	8	8	8	8	9	8	8	8	8	8	8	6	4	2	137	219.2
2	4	6	8	8	8	8	8	8	9	9	8	8	8	8	8	8	6	4	2	138	220.8
2	4	6	8	8	8	8	8	8	9	9	9	8	8	8	8	8	6	4	2	139	222.4
2	4	6	8	8	8	8	8	9	9	9	9	8	8	8	8	8	6	4	2	140	224.0
2	4	6	8	8	8	8	8	9	9	9	9	9	8	8	8	8	6	4	2	141	225.6
2	4	6	8	8	8	8	9	9	9	9	9	9	8	8	8	8	6	4	2	142	227.2
2	4	6	8	8	8	8	9	9	9	9	9	9	9	8	8	8	6	4	2	143	228.8
2	4	6	8	8	8	9	9	9	9	9	9	9	9	8	8	8	6	4	2	144	230.4
2	4	6	8	8	8	9	9	9	9	9	9	9	9	9	8	8	6	4	2	145	232.0
2	4	6	8	8	9	9	9	9	9	9	9	9	9	9	8	8	6	4	2	146	233.6
2	4	6	8	8	9	9	9	9	9	9	9	9	9	9	9	8	6	4	2	147	235.2
2	4	6	8	9	9	9	9	9	9	9	9	9	9	9	9	8	6	4	2	148	236.8
2	4	6	9	9	9	9	9	9	9	9	9	9	9	9	9	8	6	4	2	149	238.4
2	4	6	9	9	9	9	9	9	9	10	9	9	9	9	9	8	6	4	2	150	240.0
2	4	6	9	9	9	9	9	9	10	10	9	9	9	9	9	8	6	4	2	151	241.6
2	4	6	9	9	9	9	9	9	10	10	10	9	9	9	9	8	6	4	2	152	243.2
2	4	6	9	9	9	9	9	10	10	10	10	9	9	9	9	8	6	4	2	153	244.8
2	4	6	9	9	9	9	9	10	10	10	10	10	9	9	9	8	6	4	2	154	246.4
2	4	6	9	9	9	9	10	10	10	10	10	10	9	9	9	8	6	4	2	155	248.0
2	4	6	9	9	9	9	10	10	10	10	10	10	10	9	9	8	6	4	2	156	249.6
2	4	6	9	9	9	10	10	10	10	10	10	10	10	9	9	8	6	4	2	157	251.2
2	4	6	9	9	9	10	10	10	10	10	10	10	10	10	9	8	6	4	2	158	252.8
2	4	6	9	9	10	10	10	10	10	10	10	10	10	10	9	8	6	4	2	159	254.4

2	4	6	9	9	10	10	10	10	10	10	10	10	10	10	10	8	6	4	2	160	256.0
2	4	6	9	10	10	10	10	10	10	10	10	10	10	10	10	8	6	4	2	161	257.6
2	4	6	9	10	10	10	10	10	10	10	10	10	10	10	10	8	6	4	2	162	259.2
2	4	6	9	10	10	10	10	10	10	10	10	10	10	10	10	9	6	4	2	163	260.8
2	4	6	9	10	10	10	10	10	10	11	10	10	10	10	10	9	6	4	2	164	262.4
2	4	6	9	10	10	10	10	10	11	11	10	10	10	10	10	9	6	4	2	165	264.0
2	4	6	9	10	10	10	10	10	11	11	11	10	10	10	10	9	6	4	2	166	265.6
2	4	6	9	10	10	10	10	11	11	11	11	10	10	10	10	9	6	4	2	167	267.2
2	4	6	9	10	10	10	10	11	11	11	11	11	10	10	10	9	6	4	2	168	268.8
2	4	6	9	10	10	10	11	11	11	11	11	11	10	10	10	9	6	4	2	169	270.4
2	4	6	9	10	10	10	11	11	11	11	11	11	11	10	10	9	6	4	2	170	272.2
2	5	6	9	10	10	11	11	11	11	11	11	11	11	10	10	9	6	4	2	171	273.6
2	5	6	9	10	10	11	11	11	11	11	11	11	11	11	10	9	6	4	2	172	275.2
2	5	6	9	10	11	11	11	11	11	11	11	11	11	11	10	9	6	4	2	173	276.8
2	5	6	9	10	11	11	11	11	11	11	11	11	11	11	11	9	6	4	2	174	278.4
2	5	6	9	10	11	11	11	11	11	11	11	11	11	11	11	9	6	4	2	175	280.0

Continue as in rows above, opening from ends toward center, using 1 stop increments on innermost gate of gates 5 through 16 if necessary.
Gates 1, 2, 18, 19, and 20 limit at 9 stops.

Table 7-2
Spill Schedule for Juvenile Fish at John Day Dam
(0500-2000)

Bay Number																				Stops	KCFS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
																			6	6	9.6
																			7	7	11.2
																			8	8	12.8
																			9	9	14.4
																		5	5	10	16.0
																		5	6	11	17.6
																		6	6	12	19.2
																		6	7	13	20.8
																		7	7	14	22.4
																		7	8	15	24.0
																		8	8	16	25.6
																		8	9	17	27.2
																		9	9	18	28.8
																	6	6	7	19	30.4
																	6	7	7	20	32.0
																	7	7	7	21	33.6
																	7	7	8	22	35.2
																	7	8	8	23	36.8
																	8	8	8	24	38.4
																	8	8	9	25	40.0
																	8	9	9	26	41.6
																	9	9	9	27	43.2
																7	7	7	7	28	44.8
																7	7	7	8	29	46.4
																7	7	8	8	30	48.0
																7	8	8	8	31	49.6
																8	8	8	8	32	51.2
																8	8	8	9	33	52.8
																8	8	9	9	34	54.4
																8	9	9	9	35	56.0
																9	9	9	9	36	57.6
															7	7	7	8	8	37	59.2
															7	7	8	8	8	38	60.8
															7	8	8	8	8	39	62.4
															8	8	8	8	8	40	64.0
															8	8	8	8	9	41	65.6
															8	8	8	9	9	42	67.2
															8	8	9	9	9	43	68.8
															8	9	9	9	9	44	70.4
															9	9	9	9	9	45	72.0
														7	7	8	8	8	8	46	73.6
														7	8	8	8	8	8	47	75.2
														8	8	8	8	8	8	48	76.8
														8	8	8	8	8	9	49	78.4
														8	8	8	8	9	9	50	80.0
1														8	8	8	8	9	9	51	81.6
1	1													8	8	8	8	9	9	52	83.2
1	1	1												8	8	8	8	9	9	53	84.8
1	1	1	1											8	8	8	8	9	9	54	86.4

1	1	1	2											8	8	8	8	9	9	55	88.0
1	1	2	2											8	8	8	8	9	9	56	89.6
1	2	2	2											8	8	8	8	9	9	57	91.2
2	2	2	2											8	8	8	8	9	9	58	92.8
2	2	2	3											8	8	8	8	9	9	59	94.4
2	2	3	3											8	8	8	8	9	9	60	96.0
2	3	3	3											8	8	8	8	9	9	61	97.6
3	3	3	3											8	8	8	8	9	9	62	99.2
3	3	3	3	1										8	8	8	8	9	9	63	100.8
3	3	3	3	1										8	8	8	9	9	9	64	102.4
3	3	3	3	1										8	8	9	9	9	9	65	104.0
3	3	3	3	1										8	9	9	9	9	9	66	105.6
3	3	3	3	1										9	9	9	9	9	9	67	107.2
3	3	3	3	2										9	9	9	9	9	9	68	108.8
3	3	3	3	2									7	8	8	8	8	8	8	69	110.4
3	3	3	3	2									8	8	8	8	8	8	8	70	112.0
3	3	3	3	2									8	8	8	8	8	8	8	71	113.6
3	3	3	3	2									8	8	8	8	8	8	8	72	115.2
3	3	3	3	3									8	8	8	8	8	9	9	73	116.8
3	3	3	3	3									8	8	8	8	9	9	9	74	118.4
3	3	3	3	3									8	8	8	9	9	9	9	75	120.0
3	3	3	3	3									8	8	9	9	9	9	9	76	121.6
3	3	3	3	3									8	9	9	9	9	9	9	77	123.2
3	3	3	3	3	1								8	9	9	9	9	9	9	78	124.8
3	3	3	3	3	1								9	9	9	9	9	9	9	79	126.4
3	3	3	3	3	1							8	8	8	8	8	8	8	9	80	128.0
3	3	3	3	3	1							8	8	8	8	8	8	8	9	81	129.6
3	3	3	3	3	1							8	8	8	8	8	8	9	9	82	131.2
3	3	3	3	3	2							8	8	8	8	8	8	9	9	83	132.8
3	3	3	3	3	2							8	8	8	8	8	9	9	9	84	134.4
3	3	3	3	3	2							8	8	8	8	9	9	9	9	85	136.0
3	3	3	3	3	2							8	8	8	9	9	9	9	9	86	137.6
3	3	3	3	3	2							8	8	9	9	9	9	9	9	87	139.2
3	3	3	3	3	3							8	8	9	9	9	9	9	9	88	140.8
3	3	3	3	3	3							8	9	9	9	9	9	9	9	89	142.4
3	3	3	3	3	3							8	9	9	9	9	9	9	9	90	144.0
3	3	3	3	3	3						8	8	8	8	8	8	9	9	9	91	145.6
3	3	3	3	3	3						8	8	8	8	8	8	8	8	9	92	147.2
3	3	3	3	3	3	1					8	8	8	8	8	8	8	9	9	93	148.8
3	3	3	3	3	3	1					8	8	8	8	8	8	8	9	9	94	150.4
3	3	3	3	3	3	1					8	8	8	8	8	9	9	9	9	95	152.0
3	3	3	3	3	3	1					8	8	8	8	9	9	9	9	9	96	153.6
3	3	3	3	3	3	1					8	8	8	9	9	9	9	9	9	97	155.2
3	3	3	3	3	3	2					8	8	8	9	9	9	9	9	9	98	156.8
3	3	3	3	3	3	2					8	8	9	9	9	9	9	9	9	99	158.4
3	3	3	3	3	3	2					8	8	9	9	9	9	9	9	9	100	160.0
3	3	3	3	3	3	2					9	9	9	9	9	9	9	9	9	101	161.6
3	3	3	3	3	3	2				8	8	8	8	8	8	8	8	9	9	102	163.2
3	3	3	3	3	3	3				8	8	8	8	8	8	8	8	9	9	103	164.8
3	3	3	3	3	3	3				8	8	8	8	8	8	8	9	9	9	104	166.4
3	3	3	3	3	3	3				8	8	8	8	8	8	9	9	9	9	105	168.0
3	3	3	3	3	3	3				8	8	8	8	8	9	9	9	9	9	106	169.6
3	3	3	3	3	3	3				8	8	8	8	9	9	9	9	9	9	107	171.2
3	3	3	3	3	3	3	1			8	8	8	8	9	9	9	9	9	9	108	172.8
3	3	3	3	3	3	3	1			8	8	8	9	9	9	9	9	9	9	109	174.4

3	3	3	3	3	3	3	1			8	8	9	9	9	9	9	9	9	9	110	176.0
3	3	3	3	3	3	3	1			8	9	9	9	9	9	9	9	9	9	111	177.6
3	3	3	3	3	3	3	1			9	9	9	9	9	9	9	9	9	9	112	179.2
3	3	3	3	3	3	3	2			9	9	9	9	9	9	9	9	9	9	113	180.8
3	3	3	3	3	3	3	2		8	8	8	8	8	8	8	8	9	9	9	114	182.4
3	3	3	3	3	3	3	2		8	8	8	8	8	8	8	9	9	9	9	115	184.0
3	3	3	3	3	3	3	2		8	8	8	8	8	8	9	9	9	9	9	116	185.6
3	3	3	3	3	3	3	2		8	8	8	8	8	9	9	9	9	9	9	117	187.2
3	3	3	3	3	3	3	3		8	8	8	8	8	9	9	9	9	9	9	118	188.8
3	3	3	3	3	3	3	3		8	8	8	8	9	9	9	9	9	9	9	119	190.4
3	3	3	3	3	3	3	3		8	8	8	9	9	9	9	9	9	9	9	120	192.0
3	3	3	3	3	3	3	3		8	8	9	9	9	9	9	9	9	9	9	121	193.6
3	3	3	3	3	3	3	3		8	9	9	9	9	9	9	9	9	9	9	122	195.2
3	3	3	3	3	3	3	4		8	9	9	9	9	9	9	9	9	9	9	123	196.8
3	3	3	3	3	3	3	4		9	9	9	9	9	9	9	9	9	9	9	124	198.4
3	3	3	3	3	3	3	4	8	8	8	8	8	8	8	8	9	9	9	9	125	200.0
3	3	3	3	3	3	3	4	8	8	8	8	8	8	8	9	9	9	9	9	126	201.6
3	3	3	3	3	3	3	4	8	8	8	8	8	8	9	9	9	9	9	9	127	203.2
3	3	3	3	3	3	4	4	8	8	8	8	8	8	9	9	9	9	9	9	128	204.8
3	3	3	3	3	3	4	4	8	8	8	8	8	9	9	9	9	9	9	9	129	206.4
3	3	3	3	3	3	4	4	8	8	8	8	9	9	9	9	9	9	9	9	130	208.0
3	3	3	3	3	3	4	4	8	8	8	9	9	9	9	9	9	9	9	9	131	209.6

Spill bay openings are expressed in gate stops.
Use the same pattern trend for spill levels exceeding 210 kcfs (*i.e.*, 80% at south bays, 20% at north bays).

b. Alternatives.

(1) Modify Adult Spill Patterns.

The existing adult patterns could be modified to improve adult fish attraction. These patterns are used primarily during daylight hours during the adult passage season. Modifications to the spill patterns can result in decreased delay in passing the project. Stable, positive flow, with velocities of approximately 4 to 8 ft^3/s leading to the fish ladder entrances is a goal.

(2) Modify Juvenile Spill Patterns.

The existing juvenile spill patterns could be modified to improve juvenile bypass conditions. These patterns, used primarily during nighttime hours during the juvenile passage season, can result in decreased delay and predation to fish passing the project. Stable, positive downstream flow, with velocities at 4 ft/s or greater, fairly equally distributed with the majority of the flow away from the banks and other structures, would be a goal.

(3) Install Flip-Lips.

The primary purpose of the flip-lips are to reduce the impact of nitrogen supersaturation on juveniles contained in plunging spillway flows. A potential side benefit to flip-lips would be a skimming flow for spill and less boiling and other irregular flows, and a potential for reduced predation. Retractable flip-lips would provide even greater flexibility by allowing no flipping action at low spill quantities.

c. Assessment of Alternatives.

(1) Modify Adult Spill Pattern.

Engineering assessment with regard to this proposed improvement can be accomplished after information from hydraulic model testing has been evaluated. For further details, see paragraph 7.7.

(2) Modify Juvenile Spill Pattern.

Engineering assessment with regard tot his proposed improvement can be accomplished after information from hydraulic model testing has been evaluated. For further details, see paragraph 7.7.

(3) Installation of Flip-Lips.

Engineering assessment with regard to this proposed improvement can be accomplished after information from hydraulic model testing has been evaluated. Preference for retractable or fixed flip-lips will be based on the hydraulic characteristics of flip-lips versus no flips over the spill range. For further details, see paragraph 7.7.

d. Recommendation.

It is recommended that further studies be performed to determine the optimum spillway gate settings that will result in hydraulic conditions conducive for good upstream adult fish passage. It is also recommended that further studies be performed to determine the optimum spillway gate settings that will result in good hydraulic and biological conditions for juvenile fish passage. Furthermore, it is recommended that investigations and further study b conducted to determine the geometry and requirements necessary for the installation of flip-lips and the associate spill patterns to be used after installation of flip-lips. Development of new spill patterns with fixed flip-lips should be the basis for cost estimates and future studies.

e. Design.

(1) Assumptions.

- Historical flows during the adult and juvenile fish passage periods will be used to develop spill gate setting scenarios.
- Spill levels for fish would not exceed 300,00 ft^3/s.
- Spill for fish would not exceed 35 percent of instantaneous river discharge.

(2) Requirements.

(a) Modify Adult Spill Patterns.

The goal is to provide a good spillway flow pattern for attraction to the fish ladder entrances. This goal includes proper range of velocities, as well as proper location of the spillway discharge. Model studies will be required to assist in determining the optimum patterns for improved adult fish passage.

(b) Modify Juvenile Spill Patterns.

With respect to this proposed improvement, the requirements include: provide stable flow patterns in the downstream direction to minimize the potential of loss of fish due to predation, provide patterns that will result in tailrace hydraulic conditions and downstream velocities to minimize delay to the outmigrating juvenile fish. Model studies will be required to assist in determining the optimum patterns for improved juvenile fish passage.

(c) Install Flip Lips.

Requirements include: 1) provide a geometry that results in good aeration of flow to minimize nitrogen supersaturation; and 2) improved flexibility in implementation of juvenile and adult spill patterns. Model studies will be required to determine flip-lip geometries and their effect on the downstream flow conditions.

7.4. Impacts of Improvements.

a. Physical.

(1) Modify Adult Spill Patterns.

Potential physical impacts associated with this improvement include: operational changes to the present spillway gate settings, and changes in the distribution of flows in the tailrace.

(2) Modify Juvenile Spill Patterns.

Potential physical impacts associated with this improvement include: operational changes to the present spillway gate settings, and changes in the distribution of flows in the tailrace.

(3) Install Flip-Lips.

Physical impacts would include additional structure to be added to the downstream spillway face and change in distribution of flow in the tailrace. Additionally, flip-lips may require different spill patterns than that used without flip-lips.

b. Biological.

(1) Project-Specific Benefits.

Fish benefits were estimated using a CENPP spreadsheet for John Day Dam. Two flow rates for summer were evaluated, which included 160,000 ft^3/s (based on the NMFS biological opinion, 1993) and 250,000 ft^3/s chosen to evaluate the range in potential benefits. Fish arriving at John Day and other input values are described in appendix (XX).

Spill volume for juvenile fish passage for John Day Dam was based on the spill agreement in the NPPC's Fish and Wildlife Program, addressed in the Fish Spill Memorandum of Agreement (MOA), 1989. The spill agreement calls for 20-percent instantaneous spill during the summer for 10 hours per day at John Day Dam. The MOA allows for redistributing the spill for peak juvenile passage hours. In recent years, spill generally occurred for 10 hours (2000 to 0600 hours) during the summer. There is no juvenile spill in the spring at John Day. For this analysis, this equates to 50,000 ft^3/s (20 percent x 250,000 ft^3/s) and 32,000 ft^3/s (20 percent x 160,000 ft^3/s) spill.

Spill for juvenile salmonids does not currently occur at John Day Dam during the spring migration, but spill occurs during the spring as a result of water runoff in excess of hydraulic capacity of the turbine units or due to low power demand during spring runoff. In order to evaluate the effects of spill in the spring, historical water volume runoff was evaluated to determine the level of spill and percentage of the time that spill occurs at John Day Dam. The time period used for this analysis was 1978 through 1992. In addition, data from 1993 was used, including spill level, percentage spill to the total flow, and gas supersaturation levels at The Dalles forebay. From this information, it was possible to estimate juvenile mortality resulting from gas bubble disease. This calculation was accomplished by using the gas spill equations developed for the CRiSP model (University of Washington, 1993). This allowed for comparing 1993 to other water years with higher and lower annual runoff and spill at John Day Dam.

Two actions were evaluated for the spillway at John Day to improve juvenile survival, which include spill pattern modifications and the installation of flip-lips to reduce nitrogen supersaturation.

(2) Spill Pattern Changes.

For the summer spill period, modeled biological benefits are based on differences in indirect juvenile survival associated with new spill patterns at John Day Dam. We assumed that development of new juvenile spill patterns would provide better hydraulic conditions and result in increased survival for juveniles passing through the spillway than the current patterns. The Dalles and John Day Dams have similar spill patterns that concentrate the spill at one side of the spillway. Although the physical topography is much different at the projects, we assume that spreading the spill with additional spillbays operating will increase juvenile survival by providing better tailrace conditions for juvenile passage and not greatly reduce juvenile spillway efficiency.

Actual indirect mortality rates are not available for The Dalles or John Day Dams. The indirect mortality estimates used in this analysis are comparative estimates based on hydraulic conditions downstream of the spillway. Higher indirect survival rates correspond to flows in the stilling basin that have water speed in excess of 4 ft/s downstream of the basin, direction of flow which disperses downstream away from backwater or shoreline areas, and stays in deep water channels removed from shallow water habitat that squawfish inhabit. Relative differences in indirect survival correspond to spill conditions that do not meet these criteria.

Currently, there is no physical model available for John Day Dam. A physical model will be necessary in the next phase of this program. Due to the similarity in the spill patterns, we assumed similar levels of juvenile survival at The Dalles and John Day Dams.

For the juvenile spill pattern evaluation, we estimated The Dalles south versus north spill patterns at a difference of approximately 5 percent indirect mortality, with a total indirect mortality of 8 percent. It should be noted that these values were professional judgements based on the differences in water velocities and dispersal of flows downstream of the spillway. The relative value of the indirect survival estimates is based on information from the Bonneville Dam survival study conducted from 1987 through 1990. This study reported a 7-percent difference in mortality from the tailrace released fish to the fish released downstream. Also in 1987, the subyearling fish released 1.5 miles downstream had the lowest survival of all other release groups. The downstream group should have had the highest survival rate compared to the other release groups. The authors suggested this was due to the downstream control fish being released on the shoreline, and were apparently more severely preyed upon by predators inhabiting the shoreline areas than the other release groups. In subsequent years, the downstream fish release areas were located in mid-river with higher water velocities, and had higher survival rates than other release groups. Information from this evaluation suggested that hydraulic conditions downstream of the release site influenced juvenile survival.

In 1989, the spillway was evaluated as part of the Bonneville survival study. Juvenile recoveries from the spillway released fish indicated a higher survival rate than all other released fish, including the downstream control. For this test, the spillway was configured to provide the best possible hydraulic conditions for juvenile passage through the tailrace. From this evaluation, it appears reasonable that altering spill patterns can provide positive benefits to juvenile survival.

Information from the squawfish swimming performance evaluation suggested that water velocities for juvenile release sites should range from 3.3 to 4.3 ft/s or greater to assist in avoiding predators (Mesa and Olson, in press). The assumption made on predator-prey interaction is that water velocities in excess of predator swimming ability will reduce their prey capture rates.

Similarly, for John Day Dam summer spill, we estimate that indirect mortality with the new spill patterns will range from 1 percent to 8 percent with the base case or existing conditions being 8-percent mortality. We assumed 2 percent direct mortality and 8 percent indirect mortality, which equates to 90 percent spillway survival (2 percent + 8 percent mortality). Two percent direct mortality is the generally accepted value from the region for spillway passage. With improvements to the spill pattern, this may improve survival through the spillway from 90 percent to 97 percent (2 percent direct +1 percent indirect), with a range from 90 percent to 97 percent.

(3) Installation of Flip-Lips.

Flip-lips have been installed at five of the lower Columbia and Snake River dams. The primary objective of flip-lips is to reduce the amount of water plunge in the stilling basin which causes atmospheric air to be trapped deep into the stilling basin, where increased hydrostatic pressure dissolved the air into the water. The dissolved gas is supersaturated at depth relative to the conditions at the surface. Flip-lips have been somewhat effective in reducing gas supersaturation levels, but at higher spill levels or with concentrated spill, the flip-lips can be less effective in reducing gas supersaturation (Options Analysis EIS, 1991).

For the current spill provided under the MOA during the summer (20-percent summer spill), and the flow range evaluated for this analysis (160/25 kcfs), it does not appear that recommended levels of supersaturation will be greatly exceeded (recommended level: 110 percent) (Dissolved Gas Monitoring Report, 1991). Large volumes of spill, however, may still occur in the spring at John Day Dam during high runoff years. During spills above hydraulic capacity of the units, or due to the power demand, it is anticipated that flip-lips would reduce gas supersaturation during the high spill period. This gas supersaturation was evident in the spring of 1990, when a powerhouse fire required shutdown of all units at the powerhouse, and all flows went through the spillway. The resulting dissolved gas levels were approximately 140 percent immediately downstream of the dam. Although it was difficult to determine salmonid mortality levels, it appeared that adult salmonids were delayed and some mortality probably occurred.

Modeled biological benefits are estimated based on the potential for flip-lips to reduce total dissolved gas from spilling. We assumed that installation of slip-lips would reduce supersaturation by 25 percent. This was based on an evaluation of flip-lips to reduce gas supersaturation conducted in 1972 (Boyd, 1974). Under the conditions evaluated, the study indicated that dissolved nitrogen was reduced by approximately 65 percent at Lower Monumental Dam and 10 percent at Bonneville Dam. Although it is difficult to determine the amount of gas reduction possible with flip-lips at John Day Dam, 25 percent appears to be within the potential range of success.

Biological benefits for the spring were based on differences in survival associated with gas supersaturation due to the installation of flip-lips, direct mortality of juveniles passing through the spillway, and indirect mortality associated with changing spill patterns resulting in differences in predation rates on juvenile salmonids. Direct mortality on juveniles is assumed to be similar to summer, which are estimated to be 2 percent.

Mortality rates due to gas bubble disease at John Day Dam are based on levels of gas supersaturation taken in The Dalles forebay. We assumed that juvenile mortality begins at total dissolved gas levels greater than 108 percent. Fish distribution was assumed to be normal with passage beginning on April 1, peaking on May 15, and ending on June 15. Total flow, spill levels, and dissolved gas data were 1993 measured levels. Percent gas supersaturation levels are shown on figure 7-3. As would be expected, increasing total dissolved gas levels correspond to increasing spill levels. Mortality on juvenile salmonids was estimated to occur at rates defined by the equation:

$$M_n = a(N_{crit})^b$$

where:

N_s = percent nitrogen saturation (above 100%)

N_{crit} = threshold level below which no mortality related to gas saturation occurs

a = gas mortality coefficient

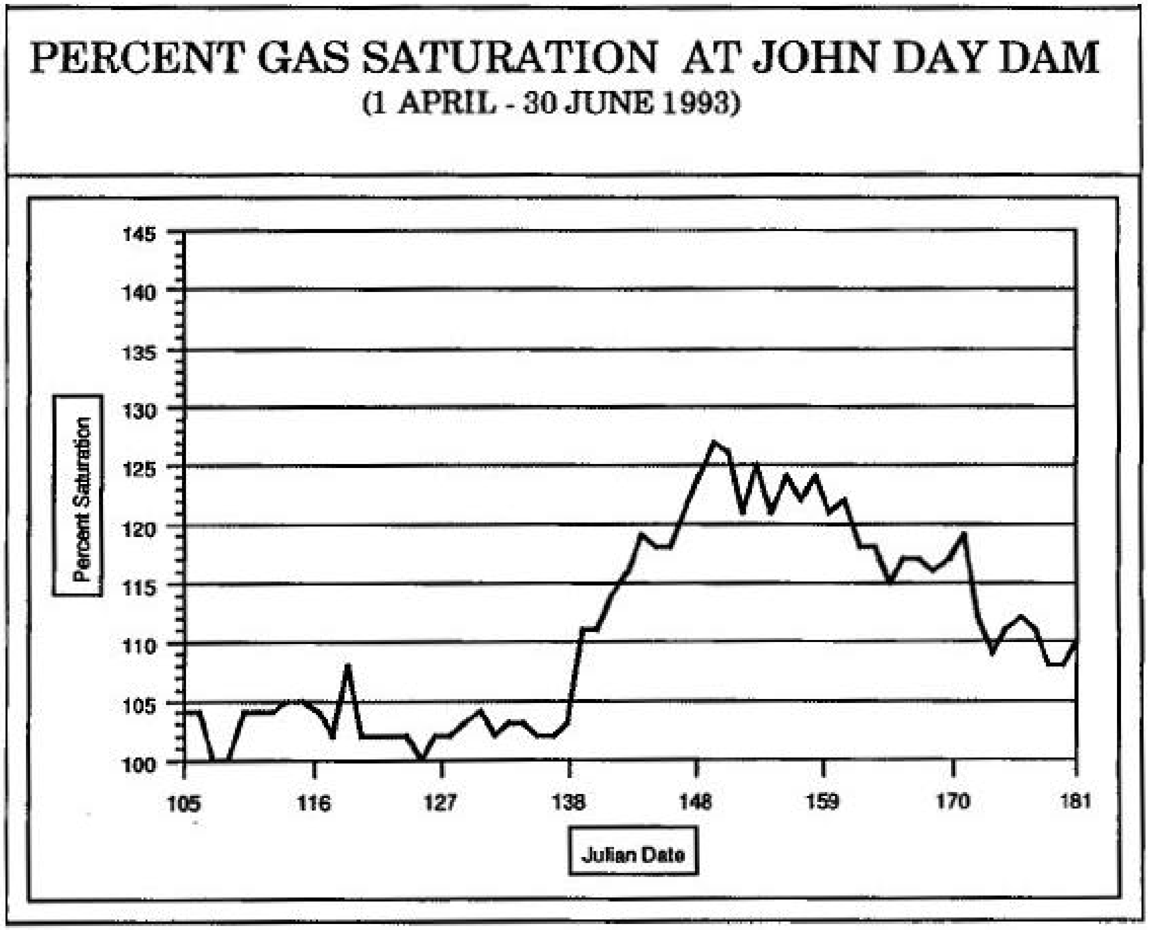

Figure 7-3. Percent Gas Saturation at John Day Dam (1 April to 30 June 1993)

The coefficients a and b were based on fitting the above equation to an empirical mortality rate curve based on work by Dawley *et al.* (1976) (a = .000003: b = 3.60).

For the 1993 time period from April 15 through June 15, cumulative mortality rates on yearling chinook were estimated at 2 percent (figure 7-4). Assuming a 25-percent reduction in gas supersaturation due to flip-lips, this reduces juvenile mortality associated with gas bubble disease to near zero for 1993 flows. Other factors affecting juvenile mortality would still be present.

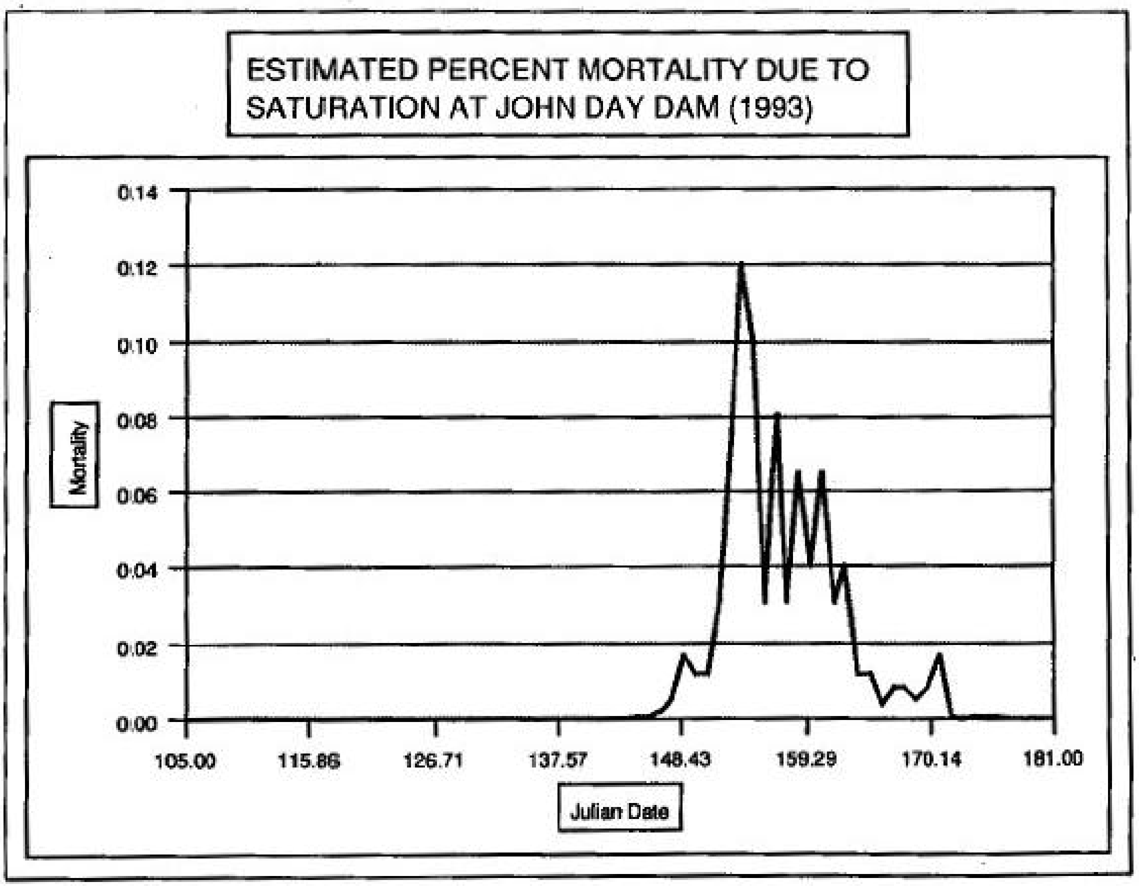

Figure 7-4. Estimated Percent Mortality Due to Saturation at John Day Dam (1993)

Flows in 1993 for the April through May period were approximately 81 percent of normal at John Day Dam. This estimate was based on water years from 196 to 1990. Although flows were estimated at 81 percent, May flows were approximately 105 percent of normal. Percent exceedance curves were also developed to determine the relative frequency of spill and volume of spill from 1974 to 1992 (figures 7-5 and 7-6). Based on this information, it is expected that spill will occur on a routine basis at values that will contribute to gas supersaturation levels in excess of state and Federal standards at the John Day project.

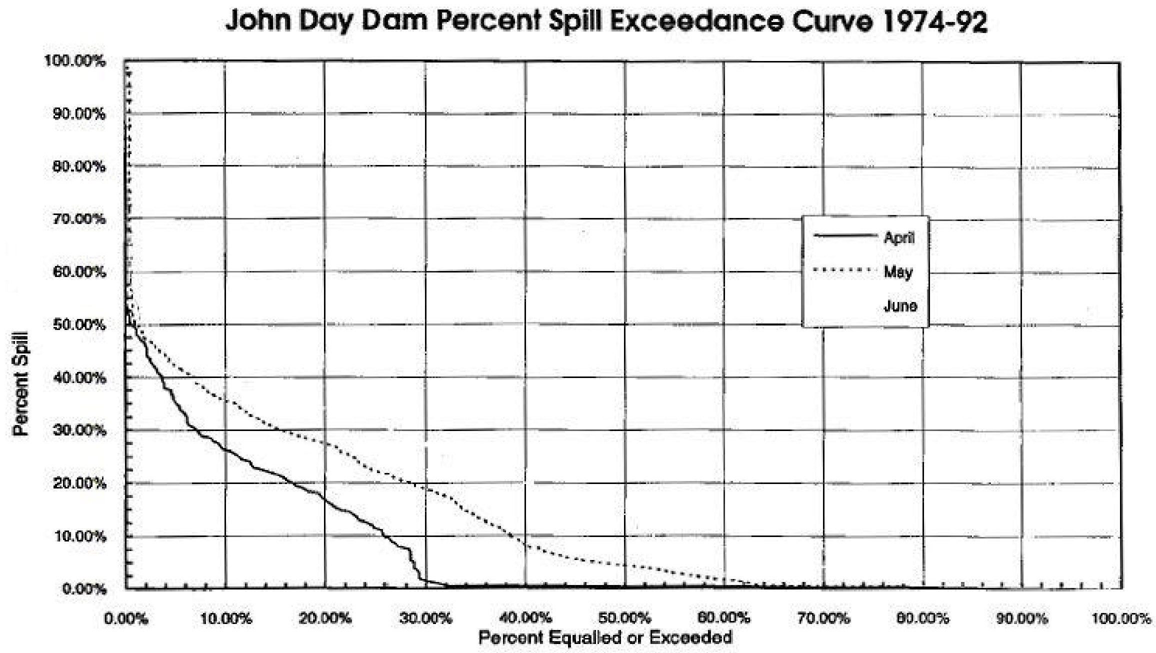

Figure 7-5. John Day Dam Percent Spill Exceedance Curve (1974 to 1992)

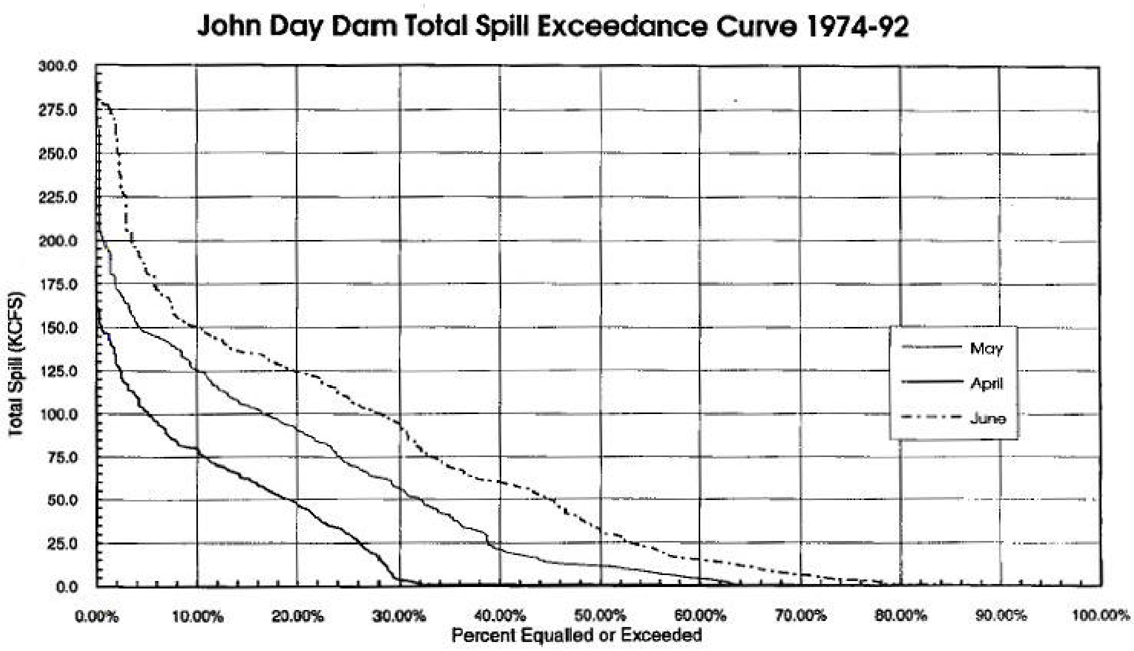

Figure 7-6. John Day Dam Total Spill Exceedance Curve (1974 to 1992)

Assuming a higher water year than 1993 for April through June, we estimated that gas supersaturation could increase by 25 percent over 1993 values. Estimates of juvenile mortality without deflectors would increase to 6 percent. Again assuming that spill deflectors reduce gas levels by 25 percent, juvenile mortality would decrease to 2 percent for the spring season.

Mortalities associated with indirect affects are primarily a result from predation on juvenile salmonids in the tailrace. Based on U.S. Fish and Wildlife Service model estimates of tailrace predation during the spring versus summer, we assume that yearling chinook tailrace mortality if 45 percent of the summer, or 8 percent x .45 = 4 percent. We assume that spill patterns modifications will reduce juvenile mortality in the spring similar to levels in the summer or 2 percent, with a range from 1 to 4 percent. We estimate juvenile spillway survival for April through June to be 92 percent. This estimate includes direct mortality (2 percent), gas supersaturation mortality in 1993 (2 percent), and indirect mortality (4 percent). Realize that gas supersaturation mortality will vary depending on the annual volume runoff and level of spill for a given year.

Combining the spillway improvements (spill pattern modifications and deflectors) for the spring, we estimate that juvenile mortality will decrease from 8 to 4 percent. This estimate assumes that spill pattern modifications will decrease mortality from 4 to 2 percent (indirect mortality), and spill deflectors will decrease mortality from 2 to 0 percent. This mortality reduction would increase overall spillway survival from 92 percent to 96 percent during the spring.

Based on the input parameters used for this analysis, it does not appear that installation of flip-lips will decrease salmonid mortality at John Day Dam during the summer (Ebel, 1975; Dissolved Gas Monitoring Report, 1991). This factor is because levels of spill used for this analysis (32,000 to 50,000 ft^3/s) result in dissolved gas levels that are at or below recommended safe levels for salmonids, but flip-lips may decrease dissolved gas levels and result in reduced juvenile and adult salmonid mortality during spill periods above turbine hydraulic capacity. Based on the information on the effectiveness of deflectors, their ability to reduce gas supersaturation needs further evaluation. Information from previous studies suggests that total dissolved gas may be reduced ranging from 10(Bonneville) to 65 percent (Lower Monumental). Several factors contribute to the relative success for deflectors to reduce gas supersaturation at a project, such as project head, spillway design, amount of change in project tailrace and forebay levels, and spill patterns. Additional information is necessary to understand the mechanisms that affect gas supersaturation at John Day Dam and their relationship to juvenile mortality. It does appear reasonable that installation of spillway deflectors at John Day Dam will assist in reducing levels of gas supersaturation during periods of high spill and result in reducing juvenile and adult salmonid mortalities associated with gas bubble disease.

(4) Spreadsheet Input Parameter Ranges and Model Results.

We estimated that mortality rates vary depending on tailrace hydraulic conditions below the spillway. Many factors may influence survival of juveniles through the spill, such as water temperature, shear zones, and level of spill. For this analysis, we assumed predation was the primary factor affecting indirect mortality. Juvenile passage near or in low velocity or backwater areas are assumed to have higher predation rates and result in higher mortality rates in comparison to juveniles passing in higher velocity areas. The other factors that may affect survival were held constant at 2 percent. There is little hydraulic information available as a physical model does not exist for John Day Dam. We assumed that we can improve tailrace hydraulic conditions and not substantially decrease juvenile spillway efficiency. Also, little information is available on indirect mortality through the spillway at John Day Dam. As every project has its own physical characteristics and unique tailrace environment, there is uncertainty in assigning mortality rates related to changing spill patterns. Due to this uncertainty, ranges in mortality rates were used to evaluate the potential changes in project survival.

For the development of new spill patterns at John Day Dam, we assumed the following:

Mortality Rates	**Percent**
Bypass Mortality	2
Direct Spill Mortality	2
Indirect Spill Mortality	1 to 8
Turbine Mortality	11

Percent fish through spillway = percent spilled = 8.3 percent

Percent fish bypassed = FGE x (1 percent spill) = 23.8 percent

Percent fish through turbine = 1 - (percent spill + percent bypassed) = 67.9 percent

Fish survival is (percent spilled x survival) + (percent bypass x survival) + (percent turbine x survival)

We estimate survival to be 91 percent with the existing conditions during summer spill. With development of the new spill patterns, total project survival will increase from 91 to 92 percent, and will vary from 91 to 92 percent.

(5) System Survival.

The CRiSP model was developed by the University of Washington, and tracks the downstream migration and survival of salmon and steelhead through the Columbia and Snake Rivers to below Bonneville Dam. The model recognizes and accounts for various reservoirs and dam passage parameters, integrating a number of subroutine models to arrive at final estimates of hydrosystem survival. For this analysis, arbitrary numbers of fish for the following stocks were input into the CRiSP model to estimate percent change from the base case for each stock;

Deschutes (Yearling Chinook)
Dworshak (Steelhead)
Hanford (Subyearling Chinook)
Methow (Yearling Chinook)
Wild Snake Spring (Yearling Chinook)
Rock Creek (Steelhead)
Wenatchee (Steelhead)
Methow Wells Index (Subyearling Chinook)
Wild Snake Fall (Subyearling Chinook)
Wild Snake Summer (Subyearling Chinook)

Model runs used input data for the System Operational Review (SOR) and the Model Coordination Team (letter from Tuttle to fisheries agencies and tribes dated January 25, 1993). For example, bypass mortality at all dams, including Bonneville, is assumed to be 2 percent. Based on this value of 98 percent survival, we assumed that improving the spill patterns at John Day Dam decreases mortality by 50 percent, from 2 percent to 1 percent. Under this condition, survival through the spillway in increased from 98 percent to 99 percent. CRiSP does not account for indirect mortality associated with each passage route. To run CRiSP and account for scientific uncertainty, spill survival estimates were ranged for each case.

(6) Results.

Based on the model input described above, where spill survival is assumed to be high to start with (98 percent). CRiSP results indicate there were no statistically significant differences between the base case and the improved condition, suggesting the improvements have no effect on survival. This point is true for all the stocks listed above from point of origin to below Bonneville Dam, and for the condition modeled, transportation on. We estimate that similar results will be produced when CRiSP is run with transportation turned off, but that does not mean the proposed improvements have no effect. Rather, CRiSP, the analytical tool used to pick up differences between the base case and the treatment, is not sensitive to relatively small changes in project passage conditions at John Day Dam, since CRiSP is primarily a model of system-wide effects.

(7) Model Analysis Summary.

The CRiSP model shows no benefit from improving the spill patterns at John Day Dam, primarily because the model is a system-wide model that is relatively insensitive to small improvements in spill survival at one project. The spreadsheet model developed by CENPP is a project-specific model, and is more sensitive than CRiSP to change in individual passage parameters at John Day Dam. The spreadsheet model indicates that total project survival past John Day Dam could be increased as much as 1 percent with the proposed improvements. We estimate that annually ?? million fish arrive at John Day Dam, and could benefit from the proposed juvenile spillway improvements. Based on the significant number of fish arriving at John Day Dam, our best professional opinion that the proposed improvements will passage conditions in the spillway stilling basin, and the benefits suggested by the spreadsheet model, the proposed improvements are warranted and recommended.

c. Economics.

Present spill pattern guidelines were designed to attract migrant adult fish into the fish ladders and aid migrant juvenile fish survival. Alternative patterns may improve migrant fish attraction and survival. Additionally, constructing flip-lips has been proposed to reduce gas supersaturation. The economic impact of investigating those proposed project improvements have been analyzed to provide information regarding their direct and indirect economic impact. Direct economic impacts are changes in project outputs, measured in dollars. Indirect economic impacts are changes in regional or local economic activity resulting from direct impacts. No direct or indirect impacts anticipated from this proposed project improvement.

d. Other.

There are no additional potential impacts associated with the implementation of the proposed improvements.

e. Mitigation Measures.

No mitigation measures will be necessary with regard to the implementation of the proposed improvements.

7.5. Schedules and Costs.

a. Design and Construction Schedule.

The design and construction schedule is included as figure 7-7.

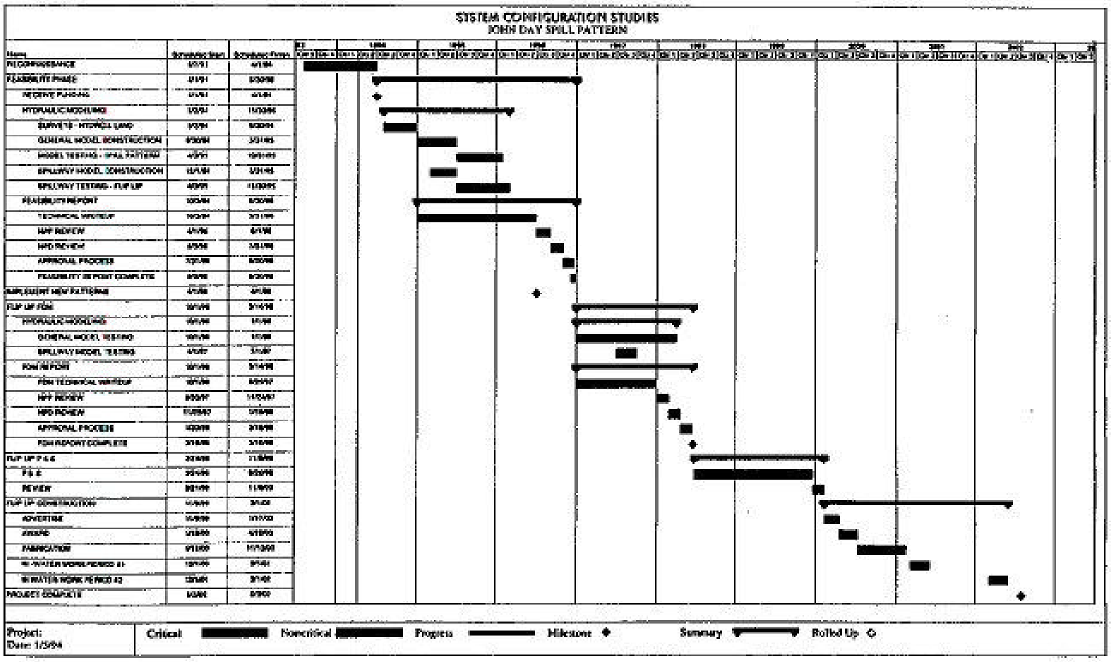

Figure 7-7. John Day Spill Pattern

b. Biological.

Table 7-3 presents the construction cost estimates for the flip-lips. Table 7-4 adds planning, engineering, and design costs and presents a fully-funded cost estimate based on the construction schedule.

Construction costs of the flip-lips include concrete placement by pump, concrete forms, waterstops, sandblasting, concrete saw cutting, chipping, water drain installation, concrete reinforcement placement, drill, and grout.

Table 7-3
Spill Pattern Modification at John Day
Construction Cost Estimate

Feature	Quantity	Unit	Unit Price	Total Cost
Concrete	220	CY	230	50,510
Drill and Grout	9,450	LF	13	124,200
Saw Cut	2,000	LF	88	175,590
Sandblast	20,000	SF	5	97,550
Chip Concrete	220	CY	403	88,570
Drains	10,000	LF	13	125,350
Water Stops	1,620	LF	42	68,790
Concrete Float Finish	16,500	SF	1	14,320
Concrete Forms	8,200	SF	16	128,660
Scaffolding	10,000	SF	6	57,230
Concrete Rebar	81,700	LF	2	148,970
Cofferdam	1,500	FT	2,722	4,083,290
Retractable Flip Lips	20	EA	325,770	6,315,410
Mob-Demob, Prime Contractor				229,490
			Fish and Wildlife Facilities	**11,707,960**
			Contingency	**5,689,970**
			Total	**$17,397,940**

Table 7-4
John Day Dam Spill Pattern Modification
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Retractable Flip Lips	20	EA	325,770	6,315,410
Mob-Demob, Prime Contractor				229,490
			Fish and Wildlife Facilities	**$11,707,960**
			Contingency	**$5,689,970**
			Total	**$17,397,940**
			Planning, Engineering, and Design	**$2,342,000**
			Contingency	**$585,000**
			Total	**$2,927,000**
			Construction Management	**$1,756,000**
			Contingency	**$439,000**
			Total	**$2,195,000**
			Total Project Cost	**$22,520,000**

c. Operation and Maintenance Costs.

No additional O&M costs will be incurred from the new spill patterns. Fixed flip-lips will have minimal O&M costs due to their lack of moving parts.

7.6. Phase II Study Requirements.

a. General.

Modifying the spill patterns at John Day Dam will require extensive model testing under a variety of conditions. Quality of a good spill pattern will be identified and these qualities will be a goal of the testing. By completion of feasibility, the new spill patterns will be developed well enough to implement. Flip-lip design will be to the point where the bays to have flip-lips will be identified, and the elevation and shape of these flip-lips will also be known.

b. Alternative Development.

The only structural alternative that will be examined that impacts spill is providing either fixed or retractable flip-lips. The inclusion or exclusion of these flip-lips will be the chief decision made. Modification of the current spill patterns will be done regardless of whether flip-lips are added. The spillway patterns are what will be developed.

c. Biological Studies.

(1) General.

The U.S. Army Corps of Engineers funded fish passage research on the Columbia River, which is developed, designed, administered, and implemented through the Fish Passage Development and Evaluation Program (FPDEP). All aspects of research are developed with and coordinated through the regional fisheries agencies and tribes. It is the best professional judgement of the scientists and engineers involved with the development of this reconnaissance-level report that the subject activities described herein will improve the survival of Pacific salmon stocks passing John Day Dam powerhouse, but biological uncertainties remain, and warrant further investigation.

(2) Computer Models.

Alternatives that seem promising will be run through program simulating fish passage numbers. These results will be compared to see which alternatives provide greater benefit within the uncertainties of the program.

(3) Prototype Testing.

Hydroacoustic evaluations should be conducted to determine the spillway effectiveness and efficiency of the juvenile spill patterns. This information will assist in setting spill levels, if appropriate, commensurate with existing levels. Changes to the spill patterns may increase or decrease spill efficiency and hydroacoustic studies will assist in determining changes in spillway efficiency. A two-year study is recommended following development of the new patterns with the general model. FPDEP costs associated with conducting this study are estimated as follows:

Year	Research Technique	Total ($)
FY 96	Hydroacoustic	300,000
FY 97	Hydroacoustic	300,000
Total		**600,000**

An evaluation of adult passage should also be conducted following development of the adult patterns. We recommend this study be incorporated into the adult passage study scheduled for 1995 through 1998 under the FPDEP program. The primary objective of this portion of the study will determine the potential delay of adult fish entering the adult entrances at John Day Dam relative to the new spill patterns. Three years of study will be needed to meet this objective. Costs associated with conducting this study are as follows:

Fiscal Year (FY)	Research Technique	Total ($)
96	Radio Tracking	100,000
97	Radio Tracking	100,000
98	Radio Tracking	100,000
Total		**300,000**

Additional biological studies prior to construction are not needed to complete the designs described in this report but, because of the uncertainty associated with the overall effect of flip-lips and changing spill patterns on juvenile survival, post-construction evaluations of survival through the stilling basin are warranted.

A survival study based on 3 years of PIT-tagged hatchery fish released under the old versus new spill patterns, and including flip-lipped and nonflip-lipped spillways, are recommended. The 3 years of releases will be followed by a final report. The study design recommended will utilize smolt monitoring facilities at The Dalles or Bonneville Dams, and will evaluate juvenile recoveries only. FPDEP costs associated with the conduct of this study are estimated as follows:

Fiscal Year (FY)	Research Technique	Total ($)
98	Smolt Monitoring	400,000
99	Smolt Monitoring	400,000
01	Smolt Monitoring	400,000
02	Final Report	75,000
Total		**1,300,000**

Total cost for the biological evaluation is $2,200,000.

d. Hydraulic Design.

(1) General.

A new general hydraulic model will be constructed at 1:80 scale. This model will cover a reach from Columbia RM 213.5 to RM 218. The model construction will be based on hydrosurvey information and as-built drawings.

A flip-lip model will also need to be constructed. It will consist of approximately three bays, and be at a 1:10 scale. This model of the spillway can be used for final design of the flip lips.

(2) General Model Construction and Testing.

(a) Model Construction.

The model will be constructed at WES. It will be capable of reproducing flows up to 700,000 ft^3/s, and will include operable features, including powerhouses and spillway, with fish ladder flows included. It will be necessary to acquire new hydrosurveys and photogrammetric surveys prior to beginning model construction. Construction will take approximately 9 months, and will be followed by a 3-month model verification period.

(b) Model Testing.

i. Without Flip-Lips.

Evaluation criteria for the model testing will be established by Corps engineers and biologists with the aid of discussions with fisheries agencies. Testing will initially evaluate existing patterns based on this criteria, and determine how they might be improved. Through testing over the agreed-upon rang eof flows and evaluating these flows visually and with video tracking techniques, tendencies will begin to appear. These tendencies will be refined until, ultimately, a new pattern is developed. This pattern will be demonstrated to the fisheries agencies and then, if necessary, modified to achieve the desired pattern for good fish passage.

ii. With Flip-Lips.

The testing with flip-lips in place will begin upon completion of the flip-lip sectional model. The flip-lips will be added to the general model, and spill evaluation will begin with them in place. Some additional modification of the flip-lips will likely be necessary due to impacts of adjacent bays and differences from varying topography. After final adjustment of the flip-lips, spill optimization testing can begin. Testing will start with the patterns established in the without flip-lip testing. Testing will then continue very similarly to that in the without flip-lips testing, except that position of (up or down) the retractable flip-lips will enter into the pattern at several points. Completion of this testing will occur during the FDM phase.

(3) Sectional Spillway Model Construction and Testing.

(a) Model Construction.

The model will be constructed in a flume with two bays modeled. The scale will be approximately 1:24 with a center bay and two half bays on either side. It will be desirable to have the sectional model located adjacent to or near the general model to quickly compare conditions. The model will be able to handle discharges up to 700,000 ft^3/s. Allowances will be made to have a movable bed below the spillway to model the impacts the flip-lips will have on the stilling basin.

(b) Model Testing.

Gas supersaturation can not be measured in the model, so direct comparisons with the prototype cannot be made. Visual observation of the model will give indications of how varying the flip-lip configuration changes gas bubbles within the stilling basin. Movement of material below the spillway can also be evaluated in the sectional model. Testing procedures will be similar to those carried out for Bonneville and Lower Granite sectional models. Concurrent testing in the general model will confirm some of the observations made in the sectional model.

e. Project Design.

(1) Project.

Coordination with project personnel will be required to ensure modifications can be implemented with minimum disruption to project operations.

(2) Structural.

Structural design will include flip-lip conceptual design for the sectional model and preparation of the engineering appendix in the phase II study report. The flip-lip conceptual design will consist of drawings, stability calculations, and comparisons of expected material stresses to allowable stresses. The engineering appendix will summarize the mechanical and fixed flip-lip designs and include text and plates.

(3) Mechanical.

If retractable flip-lips are used, the mechanical design will include design of mechanical hardware needed to retract and extend the flip-lips.

(4) Electrical.

If retractable flip-lips are used, the electrical design will include controls for operating the flip-lips.

f. Feature Design Memorandum Requirements.

(1) Feature Design Memorandum Report.

The detailed design of the flip-lips will be completed. The development of spill patterns with flip-lips in place will be completed during this phase.

(2) Prototype Evaluation of New Spill Patterns.

Field measurements at the project will be taken to compare measured velocities in the model with the prototype. This can be taken with velocity meters or visual timing of floats. Dye can be placed in the spill bays to visually compare with model spill patterns. Flip-lip design will be finalized in the sectional model. Spill patterns with flip-lips in place will be developed in the general model.

Section 8 - Bonneville First and Second Powerhouse - Downstream Migrant Systems

8.1. Bonneville First Powerhouse.

a. Existing System Description and Operation.

Bonneville First Power was constructed without separate facilities for the bypassing of juvenile salmonids. The downstream migrants were passed through the turbines and through the spillway. A DSM system was constructed here in 1983, and designed according to the biological criteria current at that time. The DSM has been in operation at the project ever since. For this study, we are only considering the portion of the DSM from the orifices downstream to the end of the dewatering screen. The areas upstream and downstream of this area will be evaluated in separate SCS studies.

The juvenile bypass system through the First Powerhouse was constructed inside the existing ice-and-trash sluiceway. The system is conceptually similar to bypass systems at the upstream Columbia and Snake River projects. One 12-inch-diameter orifice per gatewell slot, or three orifices per turbine unit, were installed 4.5 feet below minimum forebay elevation of 70 feet. Juvenile fish are guided up through the turbine intake gate slot by use of STS's, into a collection channel. The channel carries the juveniles to the north end of the powerhouses, where they pass over a dewatering screen which removes the excess flow (figure 8-1). Fish are then carried from a discharge well into a 24-inch-diameter conduit out to a submerged release point 300 feet downstream of the powerhouse.

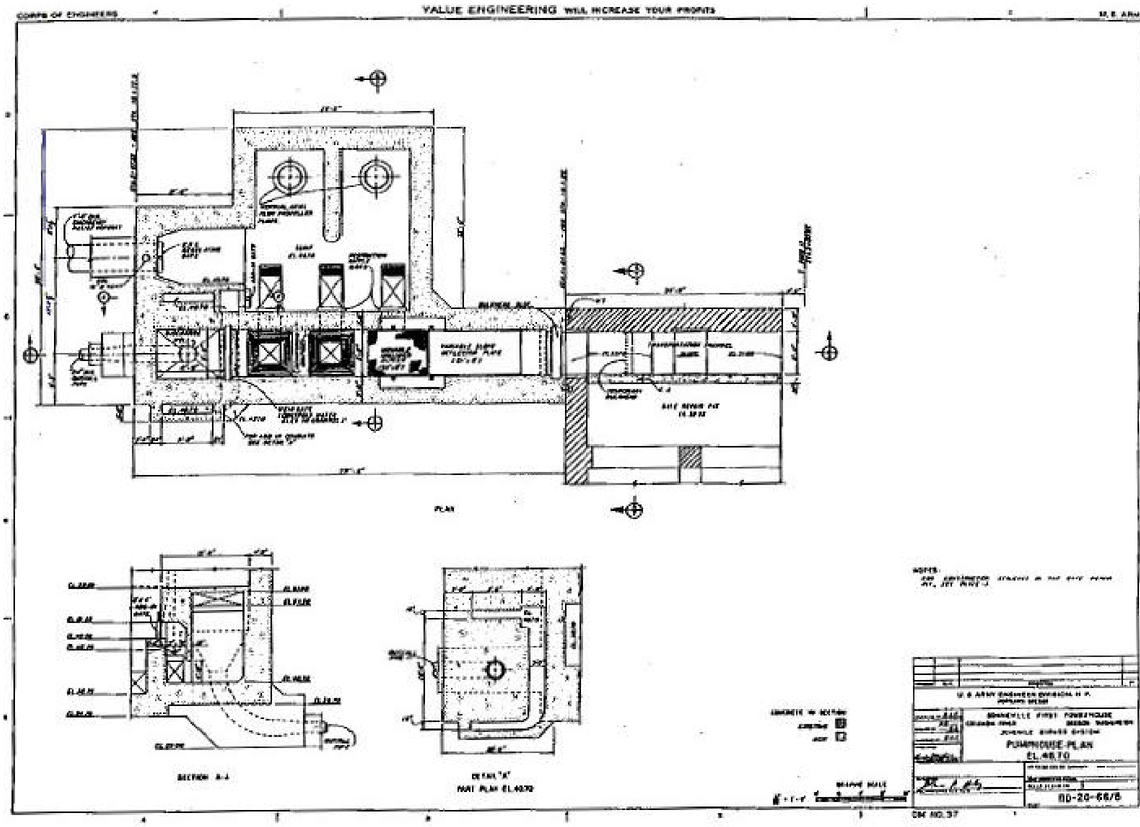

Figure 8-1. Juvenile Bypass System Pumphouse Plan (Elevation 46.70)

The dewatering screen consists of an inclined screen which slopes back towards the collection channel and rises 1 foot vertically for each 6 feet of horizontal distance proceeding downstream (figure 8-2). The screen areas is 8 feet wide by 35 feet long. At the downstream end of the screen, an overflow weir controls the water surface elevation across the length of the screen which, in turn, controls the water surface elevation further upstream in the powerhouse collection channel. The inclined screen can be raised or lowered over a range of 10 feet. Therefore, the desired head differential across the gate slot orifices can be maintained by raising and lowering the collection channel water surface as the powerhouse forebay elevation rises and falls.

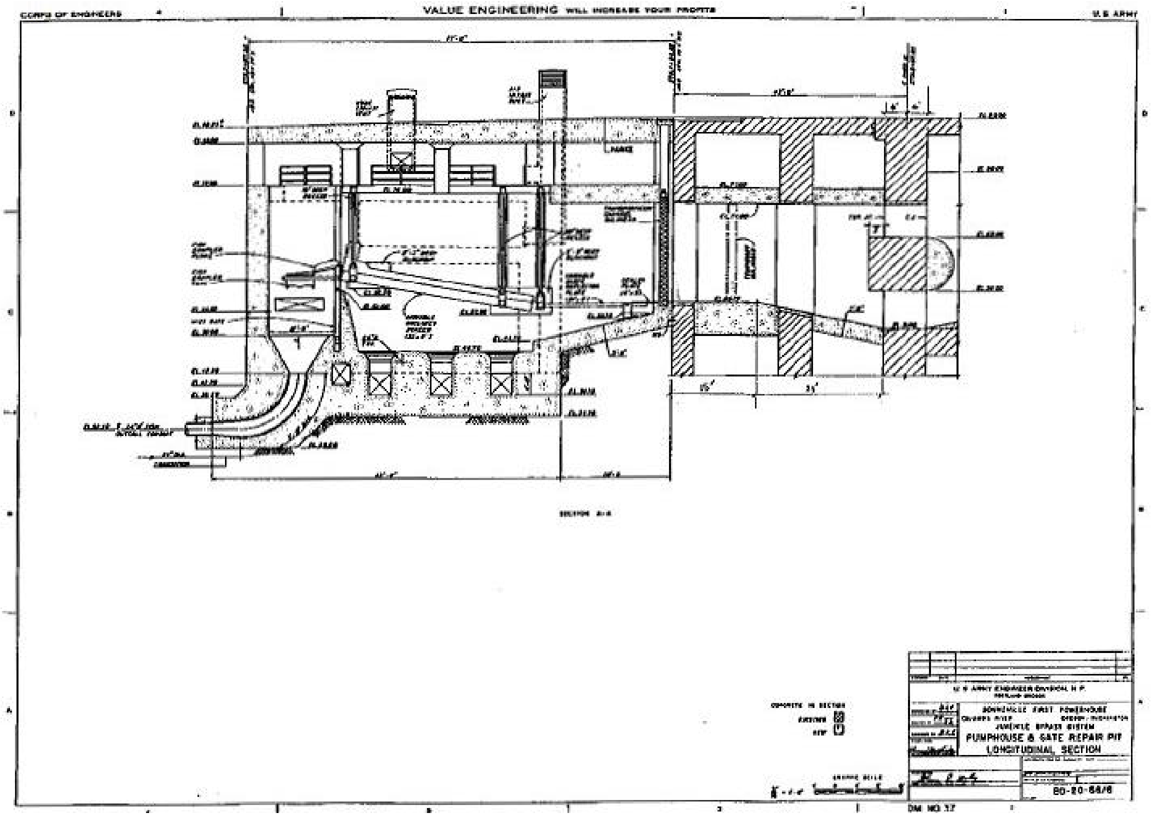

Figure 8-2. Juvenile Bypass System Pumphouse and Gate Repair Pit Longitudinal Section

The range of collection channel discharge for normal operation is 270 to 293 ft^3/s. The portion of this discharge which carries fish across the control weir at the downstream end of the moveable inclined screen is theoretically 26 ft^3/s at all times. The water allowed through the inclined screen is discharged to the tailrace. It ranges from 244 ft^3/s at high forebay with all turbine units operating to 313 ft^3/s at low forebay with all turbine units out of service, which is unlikely. These extremes give a total range in velocity through the mesh of the inclined screen of 0.87 to 1.12 ft/s respectively, but a large majority of the time, the system operates with screen velocities less than 1 ft/s.

The approach velocity to the screen is approximately 5.2 ft/s, and was designed to be between the minimum trapping velocity of 4.0 ft/s and the maximum safe velocity criterion of 6.0 ft/s. The inclined screen was designed for maximum velocity through the screen of 1 ft/s. Since then, the criteria for maximum allowable velocity through a dewatering screen has been modified to 0.4 ft/s.

Because of the updated biological criteria for velocities through a dewatering screen, a modification of the dewatering system is now necessary. Two possible options are: 1) the flow through the bypass system must be decreased; or 2) the amount of screening area must be increased. Reducing the amount of transportation channel flow is not an acceptable alternative, because orifice velocities would drop. Therefore, an increase in screen area to satisfy current criteria is considered here. To meet this criteria, the screen area will need to be increased by at least 150 percent.

b. Selected Improvements.

Replace the existing dewatering screen with a significantly larger screen of approximately 700 ft^2. Eliminate the deflector plate and extend the pumphouse building 35 feet to the north.

c. Engineering Evaluation of Alternatives.

(1) General.

Meeting the dewatering screen maximum velocity of 0.4 ft/s can be accomplished two ways. The screen area can be increased or the collection channel flow can be reduced. One alternative of each of these methods will be explored.

(2) Alternatives.

(a) Replace 12-Inch Orifices with 8-Inch Orifices.

Replace the existing 12-inch orifices with 8-inch orifices to reduce collection channel flow to approximately 124 ft^3/s.

(b) Replace Dewatering Screen With Larger Screen.

Remove and replace the existing 8-foot-wide by 33-foot-long dewatering screen with a screen of approximately 700 square feet of area.

(3) Assessment of Alternatives.

(a) Replace 12-IUnch Orifices with 8-Inch Orifices.

The smaller orifices result in orifice discharges of approximately 44 percent of the 12-inch orifices. The lower flow will result in delay of juveniles in the gatewell and is, therefore, considered unacceptable.

(b) Replace Dewatering Screen with Larger Screen.

Using the mean normal operating discharge of 280 ft^3/s, the gross area required for the 0.4 ft/s screen velocity is 700 ft^2. For the existing screen width of 8 feet, the new length of screen required would be 88 feet, which is 2.5 times the existing screen length of 35 feet.

Because the pumphouse at the north end of the powerhouse was designed to the minimum size for housing, the present dewatering screen, downwell, and other necessary dewatering equipment, space is not available for the required length of dewatering screen. The north end of the pumphouse would have to be extended further to the north. It is possible that the 20-foot-long deflector plate at the upstream end of the present dewatering screen, which aligns flow with the moveable inclined screen, could be eliminated. In this case, the necessary length of pumphouse extension would be 35 feet. Otherwise, the pumphouse would need to be extended at least the full 55 feet.

The discharge downwell located at the downstream end of the present screen would have to be moved towards the north a corresponding distance. This would also require a modification of the discharge pipe leading out to the tailwater for fish release. Either a bend would need to be made in the pipe, or a considerable length of the pipe would need to be reinstalled.

There are other complications that exist in modification of the dewatering system. At the north end of the powerhouse, there is a 10-foot-high by 11-foot-wide beam that cuts through the collection channel. During original system design, it could not be moved due to structural reasons. The collection channel floor was thus dropped in elevation some 4.7 feet to allow flow under this beam. The existing control weir was designed and positioned to provide for flow to pass smoothly under this beam at lower forebay elevations but, at forebay El. 72.5, water begins to flow over the top of the beam as weir flow. As pool elevations increase, the amount of flow over the beam increases and, at pool El. 77.0, 43 percent of the channel flow is across the top of the beam. Any changes to the hydraulic control for the channel water surface elevations, which is presently at the downstream end of the moveable inclined screen, will need to be carefully designed with consideration given to the existing physical restraints in the powerhouse structure.

If the gross cross-sectional area of the inclined screen is increased, it may also be necessary to make changes to the dewatering orifices immediately underneath the screen. Depending on where hydraulic control occurs, the dewatering orifices could possibly need to be changed in size, and possibly moved to slightly different locations.

(4) Recommendation.

There is no condition which will prevent the replacement of the existing inclined dewatering screen with a longer screen.

A complete design process would need to be carried out for the new screen. Significant, but not major, changes would need to be made to the pumphouse structure. Some modification would also need to be made to the downwell outlet, and possibly to the dewatering orifices underneath the existing screen.

(5) Design.

(a) Assumptions.

The fisheries criteria for dewatering screens will remain 0.4 feet/second.

(b) Requirements.

Meet the velocity criteria while maintaining stable plans through the screens. The new screen should minimize the occurrence of eddies or slow spots where juveniles may be doled.

d. Impacts of Recommended Alternatives.

(1) Physical.

Changes to the present system can be made in a single in-water work period. Changes will be made to the north end of the powerhouse.

(2) Biological.

(a) General.

In 1981, NMFS conducted FGE investigations at the First Powerhouse using the standard 20-foot STS's. A complete complement of STS's were installed, and a bypass system completed, in time for the 1983 fish outmigration.

The newly constructed bypass systems was then operated without evaluation until 1987, when activities associated with the construction of the new Bonneville Navigation Lock prompted further evaluations of FGE at the First Powerhouse. The 1987 to 1992 studies are described in section 5 regarding FGE at the Bonneville First Powerhouse.

In 1992, evaluations were conducted on the survival of summer migrating fish passing through the First Powerhouse turbines and bypass system, with comparisons to a downstream release and the Second Powerhouse turbines. Similar to the 1987 to 1990 studies at the Second Powerhouse, subyearling chinook salmon were released through various passage routes. Releases through turbines at the Second Powerhouse enabled comparisons with the 1987 to 1990 Second Powerhouse survival data. Juvenile recoveries from these releases show trends similar to the Second Powerhouse studies conducted from 1987 to 1990. Bypassed fish survival was 12 and 28 percent lower than the turbine and downstream releases, respectively.

Measurements of direct survival through the Bonneville First Powerhouse juvenile bypass system were conducted in 1993 to help isolate the source of the poor rate of survival observed during the 1992 indirect survival test. While data from these studies are still being evaluated, to date they indicate physical injury due to passage through the bypass system itself is not responsible for the high losses associated with bypass passage. The poor bypass survival of summer fish is probably a result of predation in the tailrace, and possibly fish exiting the bypass pipe in a stressed or fatigued condition. Similar to the Second Powerhouse, tailrace predation is likely caused by the high concentration of predators in the tailrace and bypass discharge flows passing along the shoreline habitat favored by northern squawfish.

To meet current fishery agency criteria of 0.4 ft/s velocity through the dewatering screen area, it will be necessary to remove and replace the existing dewatering structure. This action will decrease stress and fatigue associated with fish passing through the dewatering screen area. The existing structure is designed for 1.0 ft/s velocity through the screen area.

(b) Assumptions Used in the Spreadsheet Analysis.

i. First Powerhouse Summer Migrants.

Based on the NMFS indirect assessments of bypass survival conducted in 1992 on subyearling stock, we estimate that bypass mortality is 28 percent relative to the downstream releases. Of this 28-percent mortality, it was judged that one-third (9 percent) was attributable to the bypass system and two-thirds (19 percent) to the location of the outfall and tailrace. The releases for these studies were made in the bypass channel at Unit 9. Therefore, most of the bypass collection channel was not tested with this release. To account for impacts associated with the entire channel, an additional 2-percent mortality was arbitrarily added to the level of mortality in the bypass itself. This addition increases the total mortality attributable to the bypass from 9 percent to 11 percent. Adding this mortality (11 percent) to the tailrace mortality (19 percent) allows us to estimate bypass survival for summer fish to be 70 percent.

The improvements described in this study address the First Powerhouse bypass system inclined screen. The bypass is comprised of a collection channel, inclined screen, downwell, and pressurized pipe. For purposes of analysis, we assume that 25 percent of the mortality associated with the bypass system is associated with each component of the system, or 3 percent for the inclined screen. Therefore, improving the First Powerhouse inclined screen will increase subyearling chinook survival from 70 to 73 percent.

ii. First Powerhouse Spring Migrants.

Based on data from the NMFS direct assessment of injury and condition through the Second Powerhouse bypass system, river run yearling chinook had less than half the descaling level of river run subyearling chinook (12 percent versus 28 percent), lower levels of blood lactate (115 mg/dl versus 140 mg/dl), and peak cortisol levels that are approximately equal to river run subyearling chinook. Based on these observations, it was assumed that yearling chinook mortality attributable to the bypass system is half that of summer migrants, half of 11 percent, or 6 percent.

Based on U.S. Fish and Wildlife Service model estimates of tailrace predation during the spring versus the summer (personal communication, Tom Poe), we assume that yearling chinook tailrace mortality is 45 percent of the summer migrants, or 19 percent x 0.45 = 9 percent. Therefore, total bypass mortality of spring migrants is estimated to be 6 percent mortality attributable to the bypass itself, and 9 percent allocated to the tailrace, for a total of 15 percent mortality or 85 percent survival. We assume the improvements in bypass survival from replacement of the inclined dewatering screen will reduce bypass mortality by one quarter, from 6 percent to 5 percent. This mortality reduction would increase overall bypass survival from 85 percent to 86 percent.

iii. Results of Spreadsheet Analysis.

Data based on the results of spreadsheet analysis are shown on tables 8-1 and 8-2.

Table 8-1
Estimated Project Survival With and Without Improved DSM, B1 Priority
(Bi-Op Flows of 200/160 kcfs)

Species	Base Case	Improved DSM
Yearling Chinook	93	93
Subyearling Chinook	92	92 to 93
Steelhead	92	92 to 93
Coho	92	92 to 93
Sockeye	92-93	93

Table 8-2
Estimated Project Survival With and Without Improved DSM, B1 Priority
(Bi-Op Flows of 300/250 kcfs)

Species	Base Case	Improved DSM
Yearling Chinook	92 to 93	92 to 94
Subyearling Chinook	92	92 to 93
Steelhead	92	92 to 93
Coho	92	92 to 94
Sockeye	92	92 to 93

(3) Summary.

The spreadsheet runs indicate a small improvement in projects for all species would occur with installation of the proposed improvements. For yearlings, the improvement is 0 to 0.5 percent; for all other species, the survival rate is about 0.5 percent improvement.

(4) Economics.

Modifying the project's two downstream migrant systems has been proposed to improve the survival of bypassed juvenile fish. The direct and indirect economic impact of providing improved migrant fish survival has been analyzed. Direct economic impacts are change in project outputs. Indirect economic impacts are changes in regional or local economic activity resulting from direct impacts. No direct impacts to navigation, recreation or water supplies are expected from this potential project improvement, nor are any indirect impacts anticipated from this proposed project improvement.

(5) Mitigation Measures.

No mitigation will be required.

e. Schedule and Design.

(1) Schedule.

The schedule for design and construction is shown in figure 8-3.

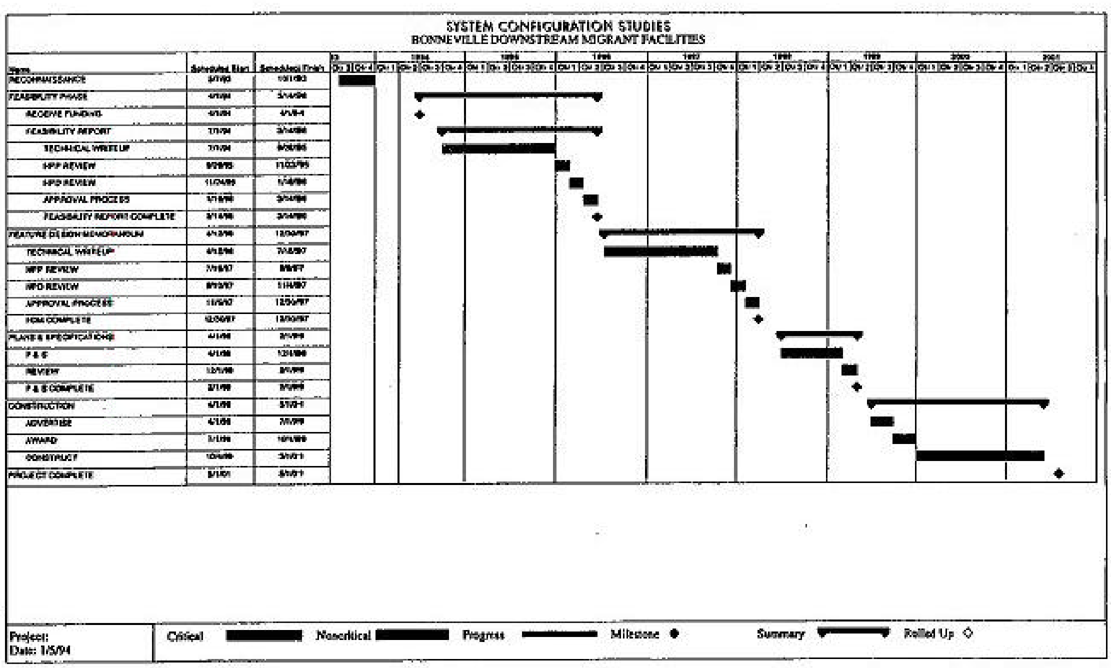

Figure 8-3. Bonneville Downstream Migrant Facilities

(2) Cost Estimate.

Table 8-3 presents the construction cost estimates for both Bonneville First and Second Powerhouses. Table 8-4 adds planning engineering, and design costs; and presents a fully-funded cost estimate based on the construction schedule. Operation and maintenance for the new dewatering screens will be $50,000 annually.

Table 8-3
Bonneville Dam Downstream Migrant System
Construction Cost Estimate

Feature	Quantity	Unit	Unit Price	Total Cost
Bonneville First Powerhouse				
Dewatering Facility, Bonneville I	1	EA	159,583	159,580
Mob-Demobilization, Bonneville I	1	EA	90,814	90,810
Miscellaneous Items, Bonneville I	1	EA	6,943	6,940
Pumphouse 35-foot Extension	1,190	SF	625	743,590
Bonneville Second Powerhouse				
Remove Existing Weir, Bonneville II	1	EA	9,709	9,710
Install Throttle Valve, Bonneville II	1	EA	69,402	69,400
Dewatering Facility, Bonneville II	1	EA	186,436	186,440
Raise Channel Floor, Bonneville II	1	EA	27,297	27,300
Miscellaneous Items, Bonneville II	1	EA	14,937	14,940
Install 3 US Orifice Flumes	1	EA	56,524	56,520
Install Emergency Cut-Off Valve	1	EA	28,882	28,880
Mob-Demobilization, Bonneville II	1	EA	97,687	97,690
Reduce Width of Channel Walls	1	EA	57,540	57,540
Raise Channel Walls Height	1	EA	16,468	16,470
Fish and Wildlife Facilities				$5,001,3001
Contingency				$1,307,230
Total Construction				**$6,308,540**
Planning, Engineering, and Design				$1,000,000
Contingency				$250,000
Total Planning, Engineering, and Design				**$1,250,000**
Construction Management				$235,000
Contingency				$59,000
Total Construction Management				**$294,000**
			Total Project Cost	**$9,103,000**

Table 8-4
Total Contract Cost Summary
Columbia River Salmon Mitigation Analysis System Configuration Study--Phase I
Spill Pattern and Flip Lips at John Day Dam
Columbia River, Oregon and Washington

Current MCACES Estimate Prepared: Effective Pricing Level:				Jan 94 Oct 93		Authoriz./Budget Year: 1995 Effect. Pricing Level: Oct 95				Fully-Funded Estimate				
Acct No.	**Feature Description**	**Cost ($K)**	**CNTG ($K)**	**CNTG (%)**	**Total ($K)**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Total ($K)**	**Feature Mid-Pt**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Full ($K)**
06---	Fish and Wildlife Facilities	11,708	5,690	49%	17,398	6.8%	12,504	6,077	18,581	Apr 01	21.2%	15,155	7,365	22,520
	Total 06 Account	11,708	5,690		17,398		12,504	6,077	18,581			15,155	7,365	22,520
30---	Planning, Engineering, and Design	2,342	585	25%	2,927	8.9%	2,550	637	3,187	Feb 99	15.5%	2,945	736	3,682
31---	Construction Management	1,756	439	25%	2,195	8.9%	1,912	478	2,391	May 01	24.7%	2,385	736	3,682
	Total All Accounts	15,806	6,714	42%	22,520	7.3%	16,967	7,193	24,159		20.8%	20,485	8,698	29,183
									Total Project Costs:					**$29,183**

Estimate 30 account at 20% and the 31 account at 15% of 06 account. Confirmed by designers.
Contingency's on the 30 and 31 accounts were estimated at 25% by CENPP-PE-C.
Authorization Year assumed to be FY 1995.

f. Phase II Study Requirements.

(1) General.

A feasibility-level report for the replacement of the First Powerhouse dewatering system will include the investigation and evaluation of the pumphouse extension and new dewatering screen. Computer models, prototype data from other projects, and prototype observation of the existing DSM system in operation will be extensively used in the design of the new screen. A physical hydraulic model of the dewatering system will be used to evaluate the hydraulic conditions leading to the inclined screen and through the screen itself. A comparison of the new screen design to existing dewatering systems now in operation at other projects will be done to identify and incorporate factors that have proven to be highly successful. Biological criteria will be clarified through meetings with fisheries agencies and tribes. Impacts to operations will be identified.

(2) Alternative Development.

Alternative screen designs will be studied in detail for the feasibility report. Any new design concepts that are found will be investigated. The potential designs will be evaluated, compared to existing systems, and individually refined until a single design can be chosen that best meets all known requirements and existing criteria.

(3) Biological Studies.

Additional biological studies would not appear to be warranted in developing the design modification of the Bonneville First Powerhouse DSM system. Post-construction evaluations of fish condition will be conducted through the BPA-funded smolt monitoring program.

(4) Hydraulic Studies.

(a) General.

Numerical computer models will be used to determine discharges, depths, and velocities across the dewatering screen and the hydraulic conditions resulting upstream in the existing collection channel. The complete range of operating conditions will be investigated to produce a system that will meet current biological criteria. The selected design will be developed to the point where there is confidence in the performance of the final screen design.

(b) **Model Testing of the Dewatering System.**

A physical hydraulic model of the dewatering system will be used to make a determination of the hydraulic conditions at the dewatering screen. The potential designs may be individually tested in the hydraulic model, and may be constructed to include the inclined screen and the related dewatering system components. Various configurations of the screens, the perforated plates behind the screens and approach conditions in the existing channel may be reproduced for thorough testing in the model. The model may be used to refine the screen design to the point where hydraulic conditions through the screen have been optimized.

(5) **Project Design.**

(a) **Project.**

Coordination with project personnel will be required to ensure the modifications can be implemented with minimum disruption to project operations.

(b) **Mechanical.**

The mechanical design will involve redesign of the moveable inclined screen and supporting mechanical hardware. The existing screen cleaning device for the inclined screen will need to be redesigned. Operation and maintenance requirements will also need to be identified.

(c) **Electrical.**

Controls for operating the new inclined screen will need to be redesigned. Operators for the inclined screen cleaning device and all new lights and controls will be included. Water surface level indicators and monitors should also be designed.

(d) **Structural.**

All structural modifications to the project will be provided by the structural designers. These include removal of existing items to be excessed, concrete for any channel modifications, supporting structure for the inclined screen and other dewatering equipment, walkways and handrails, and quantities for cost estimating purposes.

(6) **Feature Design Memorandum Requirements.**

The detailed design of the final DSM system will be documented in an FDM. Final hydraulic computations of the system will be completed and documented at this level. A detailed plan showing how the dewatering system modification work would be integrated with, and necessary outfall relocation work would be completed prior to the start of the FDM level design.

8.2. Bonneville Second Powerhouse.

a. Existing System Description and Operation.

The design of the Bonneville Second Powerhouse included provisions for a downstream migrant system (DSM). Project construction was completed in 1983. The purpose of the DSM is to provide passage for juvenile fish from forebay to tailwater without them having to pass through the turbines.

The existing channel was originally designed to accommodate flow from two 12-inch orifices per slot, resulting in a total discharge of approximately 700 ft^3/s approaching the DSM control weir and inclined screen. With both orifices in operation, the velocities in the channel would vary from 0.0 ft/s orifices in operation at the south end of the channel to 6.1 ft/s at the north end upstream of the DSM control weir.

With the prototype operation of two orifices per slot, the water surface along the length of the bypass collection channel was found to experience a larger amount of drawdown than was anticipated during design. As a result of the larger drawdown, orifice jets became unsubmerged to the point where the jet trajectories would impact the opposite channel wall. Deflectors would have had to be installed at each orifice to prevent this undesirable condition for a fish bypass system.

At the time of design of the DSM, the criteria for design of dewatering screens allowed for 1.0 ft/s velocity through the screen. This has since been revised to 0.4 ft/s. Consequently, the decision was made to operate only one orifice per slot, resulting in a reduction of the total discharge from the collection channel to about one-half the original 700 ft^3/s. With this operation, the DSM control weir is kept relatively high, and the drawdown along the channel is kept at a minimum. This procedure keeps the water surface profile up at a level to prevent the orifice discharge jets from striking the opposite wall. This operation results in a total discharge of approximately 350 ft^3/s at a El. 76.5 pool and 250 ft^3/s at an El. 71.5 pool. The corresponding velocities in the collection channel vary from 0.0 ft/s at the south end to approximately 3.0 and 2.1 ft/s upstream of the DSM control weir for the indicated forebay elevations, respectively. The current design criteria for minimum collection channel velocity is 2 ft/s. Under current operation, this would only be met through the lower half of the channel at a forebay elevation of 76.5. These less than desirable velocities under the current operation result in a potential for decreasing the travel time through the collection channel.

This report only considers the portion of the DSM between the orifices to the outfall transportation channel.

b. Proposed Improvements.

Since project construction, there have been various noted areas of concern in the DSM. Several biological studies involving live fish have been completed to determine specific problems with the system. The results of these studies have shown that fish condition has been affected, but attempts to isolate causal agents has proven to be unsuccessful. However, several major areas of concern have been identified as needing correction. A brief description for proposed improvements, proceeding from the upstream end of the system to the downstream end are as follows:

- Decrease orifice jet turbulence.
- Increase velocities along collection channel.
- Reduce turbulence in flow below control weir.
- Reduce velocities through inclined screen.
- Reduce turbulence and air entrainment in the downwell.
- Replace sharp downwell bend and reduce high velocities.

c. Engineering Evaluation of Alternatives.

(1) General.

These specific areas for improvement are briefly discussed in the following paragraphs, along with a description of the potential solutions applying to each specific area of improvement. Because the DSM system is complex and functions in an inter-dependent manner with one component of the system affecting hydraulic conditions in another component, any specific changes require conducting a full analysis of the system to ensure that the entire system will function successfully after a modification is made.

(2) Alternatives.

(a) Decrease Orifice Jet Turbulence.

The free-flowing orifice jets create a significant disturbance as they enter the collection channel. This disturbance can delay juveniles in the collection channel through disorientation and the creation of flow patterns not conducive for good fish passage. The jets can also impact the far collection channel wall if the jet trajectory is not properly controlled. Potential solutions of the problem involve:

i. Submerging of Jets.

The orifice elevation could be lowered so that the point of discharge is below the collection channel water surface elevation, or the collection channel water surface profile could be raised to an elevation such that the orifice discharges are submerged. In either case, a redesign of the orifices would be needed to ensure the appropriate discharge.

ii. Jet Deflectors.

Deflectors could be utilized to direct the jets in a downstream direction, and redirect the flow down along the channel axis and away from the opposite wall (figure 8-4). These have been used at McNary Dam, and consist of an elbow on the end of the orifice.

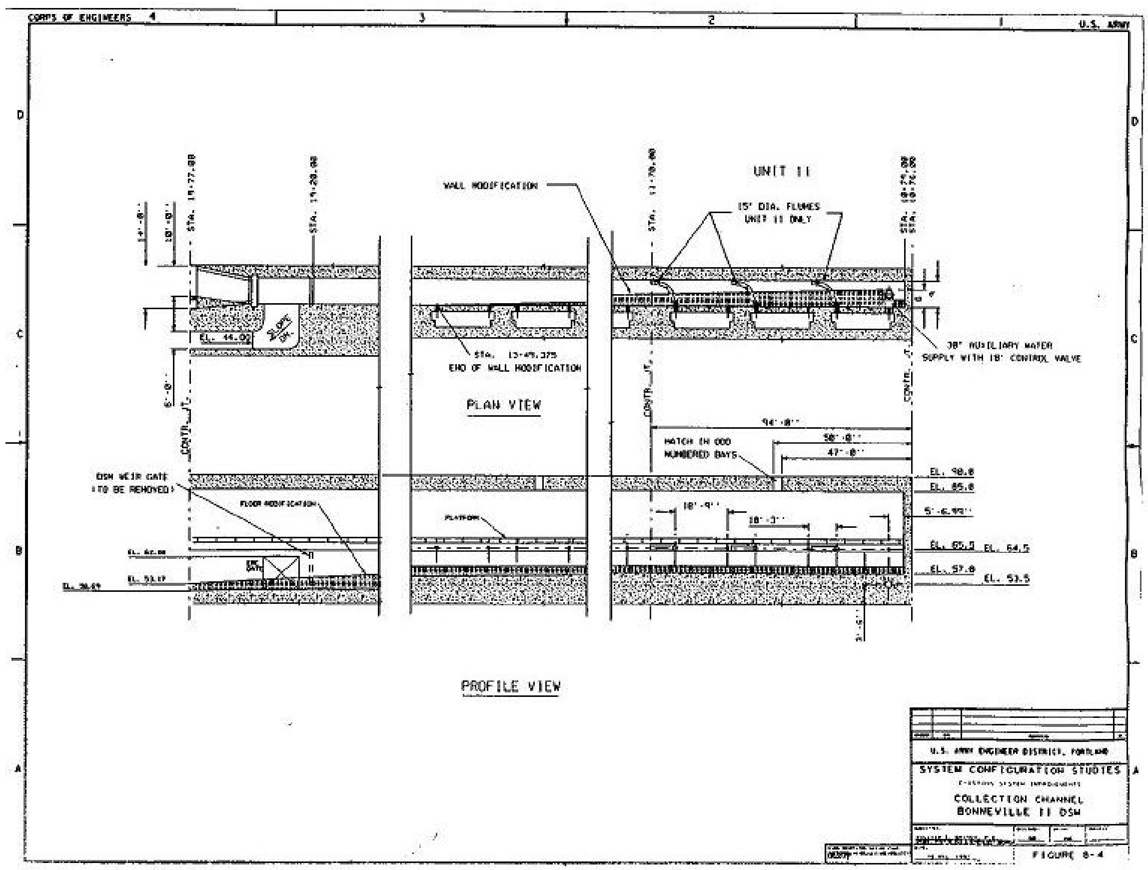

Figure 8-4. Collection Channel Bonneville II DSM

iii. Orifice Flumes.

Flumes are similar to jet deflectors except the radius of curvature is much larger. Flumes would be placed across the channel and turn the flow parallel to the channel.

iv. Angled Orifices.

Orifices directed in the direction of flow would replace the existing orifices that are perpendicular to the collection channel.

(b) Increase Velocities in Collection Channel.

The collection channel was originally designed for two orifices per intake operating simultaneously. At present, only one orifice in each slot is operated, resulting in a total of 26 orifices, and a discharge of 350 ft^3/s at the downstream end of the channel. The channel velocity currently ranges from 0.4 to 0.6 ft/s at the upstream end at Unit 11, and ranges from 2.1 to 3.0 ft/s at the downstream end after the fish water turbine units. A number of modifications to the system could be made in order to increase the flow velocities in the collection channel.

i. Operate Two Orifices Per Slot.

The second orifice in each slot could be used, and would approximately double the flow in the channel.

ii. Increase Orifice Size.

The diameter of the orifices could be increased to allow for more flow. An increase from the existing 12-inch to 14-inch orifices will result in velocities increasing by approximately 36 percent.

iii. Supply Additional Water at Upstream End of Collection Channel.

Increasing the flow upstream of Unit 11, while maintaining the current use of only one orifice per slot, would increase channel velocities. An existing 30-inch auxiliary water supply line coming off the gatewell with the same centerline as the south orifice in slot 11-A was installed during construction. It was originally designed as an additional supply for DSM flows. Installation of a valve by this existing AWS conduit would allow the additional flow to be increased and shut off if necessary.

iv. Modify Collection Channel Wall.

With the existing system discharge through operation of one orifice per slot, and the discharge of 350 ft^3/s, increasing channel velocities to meet criteria can also be achieved by reducing the cross sectional area of the channel. To produce greater velocities at the upstream end of the channel, the width of the channel at Unit 11 could be reduced. A new wall would be placed opposite the orifice side of the channel. The reduced channel width would gradually transition toward the original full width of 9 feet in the vicinity of Unit 16.

v. Modify Collection Channel Floor.

Increasing the elevation of the upstream end of the collection channel floor along the existing channel axis would also produce the same effect of increasing velocities along the channel as modifying the collection channel wall. A transition back to the existing floor would occur at the point where the magnitude of channel discharge supports minimum velocities.

vi. Modify Both Channel Wall and Floor.

The existing channel would be modified into the approximate shape of a square cross sectional area at the upstream end, and would transition out to the existing channel cross section further downstream. The channel width at the upstream end would be reduced to 3.5 feet. The channel invert would be raised 4.0 feet at the upstream end, giving a minimum depth of flow of 3.5 feet. Only one orifice per slot would be operated with no water added from the 30-inch pipe upstream of Unit 11.

vii. Modify Wall and Floor With a 12-Inch Auxiliary Water Supply Line.

The alternative is a combination of several of the above modifications. The width and depth of the upstream end of the channel would be reduced. The existing 30-inch auxiliary water line would be replaced by a 12-inch pipe or orifice to provide additional water upstream of Unit 11.

viii. Modify Wall and Floor With a 15-Inch Auxiliary Water Supply Line.

This alternative is similar to the alternative described above, except that the discharge added through the auxiliary line is increased. The existing 30-inch pipe would be replace by a 15-inch pipe or orifice to achieve the optimum flow upstream of Unit 11. The new collection channel wall would follow a straight line transition from 3 feet wide at Unit 11 to the existing 9-foot width. The floor invert would be raised 4 feet at Unit 11 and would slope along a straight line down to the existing channel floor. Orifice flumes or deflector devices would be required on some of the upstream orifices.

(c) Turbulence in Flow Below Control Weir.

The existing weir at the downstream end of the channel is a major source of turbulence. The purpose of this weir is to control the water surface elevations in the collection channel. Water falling over the control weir has a very short distance for the resulting turbulence to dissipate before approaching the inclined dewatering screen. This turbulent flow remains as it passes over the inclined screen. This flow possibly disorients and injures the fish. Listed below are possible modifications to correct the turbulence problem.

i. Eliminate Control Weir.

The existing weir can be removed from the channel. To accommodate this change, a new side channel weir could be placed further downstream of the existing weir and screen. The side weir could be part of the proposed new dewatering facility and utilized to maintain the collection channel elevation at the existing 64.5 feet. With the resulting increase in water surface elevation, the height of the channel walls below the existing weir would need to be raised.

ii. Extend Collection Channel.

The collection channel could be extended further at the north end of the powerhouse, allowing a greater distance for the turbulence to dissipate. It is envisioned that this would require a major modification to the present DSM system, including a redesign of the transportation flume leading to the outfall, which could be accomplished in conjunction with outfall relocation discussed in section 4.

(d) Reduce Velocities Through Inclined Screen.

The existing inclined screen was designed based on the criteria of the average perpendicular velocity of 1.0 ft/s. The current criteria is 0.4 ft/s. To meet the updated criteria, the inclined screen area would have to be increased. This screen area change necessitates increasing the screening area by 150 percent. If the maximum anticipated AWS of 78 to 102 ft^3/s, as addressed in paragraph c.(2)(c) were added at the upstream end, a screen area of approximately 1,130 square feet would be required. With no AWS screen, the area would have to be a minimum of 880 feet (figure 8-5).

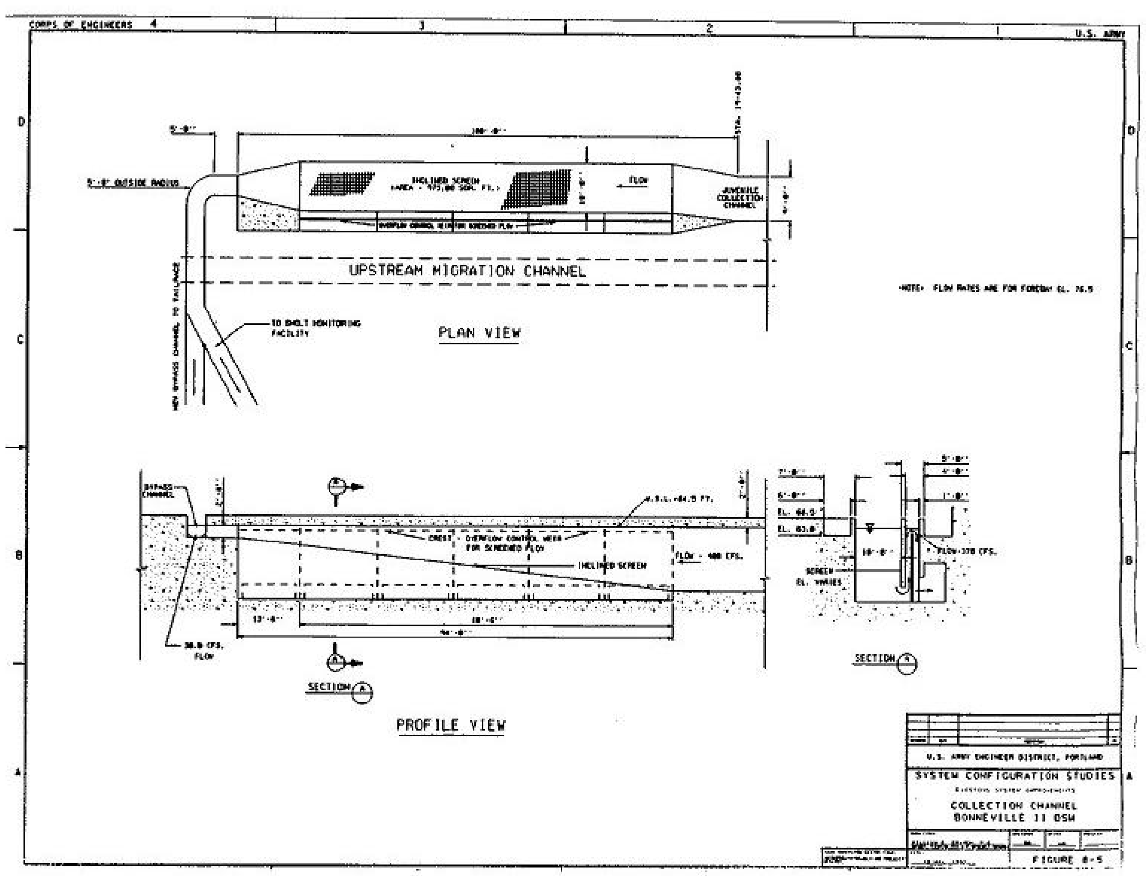

Figure 8-5. Collection Channel, Bonneville II DSM

(e) Reduce Turbulence and Air Entrainment in Downwell.

The large amounts of air being entrained in the water approaching the downwell, in addition to the high degree of uncertainty of fish behavior in the downwell, are areas of great concern.

i. Pool Water Through Downwell Bend.

The downwell could be modified to minimize the amount of air entrained by placing a constriction on the downstream side of the bend, and hydraulically forcing a pool to form on the upstream side of the bend. This would raise the water surface elevation on the upstream side of the bend and reduce the amount of air entrainment. This also would allow a larger pool area for turbulence in the flow to dissipate.

ii. Increase Size at Top of Downwell.

The entrance to the downwell could be enlarged. This would increase the horizontal surface area and geometrically alleviate the sharpness of the downwell bend by increasing the length of radius available to make the turn. This would improve hydraulic conditions through this critical area.

iii. Remove Control Weir.

This work was discussed above, and would require extensive modification of this portion of the DSM system.

(f) Sharp Downwell Bend, High Outfall Pipe Velocities.

Below the downwell is a sharp bend in the outfall conduit. The bend area has high velocities which entrain air into the outfall conduit and potentially disorient and injure fish. This item is addressed under Portland District's Project Improvements for Endangered Species (PIES) program.

This area is of much concern, due to the high water velocity resulting in potential injury to fish. In conjunction with other modifications described above it would be necessary to replace the existing DSM beyond the downwell. An open channel flume or conduit could be used to transport juveniles beyond this point.

(3) Assessments of Alternatives.

(a) Decrease Orifice Jet Turbulence.

A reduction of orifice jet turbulence is necessary for any alternative to be selected. This reduction is one of the major areas of concern in the DSM system. The following are alternatives to achieve this concern:

i. Submerging of Jets.

This alternative would significantly reduce the turbulence as the jet enters the channel, but with some negative impacts. Inspection of the orifices for blockage or proper flow would become very difficult and problems could go unrecognized for longer periods of time. Orifice debris sensors would likely have to be installed and these sensors have not proven to be as effective as visual inspection. Submerging the jets also reduces the head across the orifice and will result in reduced orifice flow.

ii. Jet Deflectors.

The deflectors can be very effective in aligning flow and reduction in delay in the DSM channel, but the deflectors themselves create shadow areas in the flow where juveniles may linger. The sharp head may also create some descaling and stress problems for the juveniles.

iii. Orifice Flumes.

The flumes would be beneficial in much the same way as the jet deflectors. Orifice flumes allow for a more gradual transition in direction of flow potentially reducing descaling and stress. The larger structure of the orifice flumes in the channel create larger dead spots.

iv. Angled Orifices.

The entrance condition at the orifice place would be very complicated hydraulically, and would require model studies to optimize. The exit condition would improve the condition in the collection channel.

(b) Increase Velocities in Collection Channel.

Increasing velocities can be done by two primary means. The discharge through the channel can be increased or the channel cross sectional area can be reduced. Several means can be used to adhere these ends including combinations of increased flow and reduced cross sectional area.

i. Operate Two Orifices Per Slot.

Increasing the flow to the original design conditions of two orifices per slot would greatly enhance flow characteristics. Concerns adverse to fish passage may accompany this operation, such as excessive drawdown through the channel, orifice jets becoming unsubmerged, and high velocities through the dewatering screen. These hydraulic problems would still have to be resolved.

Using only one orifice per slot, except at Units 11 through 13, could alleviate some of the problems. At these upstream units, both existing 12-inch orifices would be operated, giving additional flow from the second orifice in each of the 9 slots. The resulting channel velocities at minimum forebay would vary from 0.8 ft/s at the downstream end of Unit 11 to 2.6 ft/s at the downstream end of the channel. The total flow at minimum forebay would be increased by 60 ft^3/s.

ii. Increase Orifice Size.

Fourteen-inch orifices would increase velocities significantly, but would have to be used in combination with other alternatives to achieve channel velocity criteria. Larger orifices could potentially be used, but no experience exists from other projects and they would likely violate orifice velocity criteria. Larger orifices could also create a need for larger orifice tubes.

iii. Supply Additional Water at Upstream End of Collection Channel.

The addition of this supply with the existing flow would allow minimum channel velocities to be met by the most upstream unit. For forebays of El. 71.5 and 76.5, discharge through the collection channel would be increased by 78 to 102 ft^3/s, respectively. Minimum velocities would be increased from the existing range of 0.4 to 0.6 ft/sec to the range of 1.2 to 1.5 ft/s. The velocities downstream of the fish water turbine units would be increased to a range of 2.7 to 3.8 ft/s.

This alternative provides a direct way to increase the velocity at the upstream end of the existing channel where it is most needed. The velocities at the upstream end, however, would still be less than the minimum criteria of 2.0 ft/s.

iv. Modify Collection Channel Wall.

The most straight-forward solution to reducing cross-sectional area is to reduce the width in areas of low velocity, transitioning back to full width at the point in the channel when minimum velocities are met. Preliminary computations indicate that reducing the channel at the upstream end to 1.6 feet produces an average channel velocity of 2 ft/s at minimum forebay from the downstream side of Unit 11 to the downstream end of the collection channel. Due to maintenance concerns, however, a width of 1.6 feet is too narrow. A minimum width of 3 feet is considered necessary for adequate access for maintenance purposes Therefore, this alternative was not considered to be a feasible solution by itself.

v. Modify Collection Channel Floor.

To meet velocity criteria in the collection channel, the channel floor elevation would need to be raised to an elevation that results in a flow depth at the upstream end of 1.4 feet. This is shallow relative to the 9-foot-wide channel and does not provide a satisfactory depth for dissipation of the turbulence from the orifices. This alternative was also not considered to be feasible by itself.

vi. Modify Both Channel Wall and Floor.

It appears that the most favorable hydraulic conditions are produced by reducing the channel cross-sectional area by a combination of modifications to both the floor and wall. This alternative produced average channel velocities at minimum forebay of 2 ft/s from Unit 11 to the downstream end of the collection channel. Channel velocities at maximum forebay would be approximately 3 ft/s. Orifice flumes were found to be necessary with this alternative. No change in the screening area would be necessary.

vii. Modify Wall and Floor With a 12-Inch Auxiliary Water Supply Line.

The 12-inch line would supply an additional 15 to 25 ft^3/s at the upstream end of the collection channel. The total discharge in the channel would be increased from approximately 250 to 265 ft^3/s at minimum forebay, and from 350 to 375 ft^3/s at maximum forebay. Channel velocities would vary from 2.0 ft/s at Unit 11 to 2.2 ft/s at the downstream end of the channel. The screening area would need to be increased by 312 square feet for this alternative.

viii. Modify Wall and Floor With a 15-Inch Auxiliary Water Supply Line.

The added discharge would vary from approximately 34 ft^3/s at minimum forebay to 46 ft^3/s at maximum forebay. The increased auxiliary flow would allow the channel to return to the existing 9-foot-width sooner than the previous alternative. The velocities along the channel would range from 2.4 to 3.5 ft/s at minimum forebay and from 3.3 to 5.0 ft/s at maximum forebay. To meet screen criteria, approximately 375 ft^2 of screen area would need to be added to the existing screen area of 625 ft^2. A new side channel weir would be constructed adjacent to the new inclined screen for controlling collection channel water surface elevations.

Preliminary investigations indicate that this scenario would meet the present velocity criteria, and also provide favorable hydraulic conditions for fish passage through the collection channel.

(c) Decrease Turbulence in Flow Below Control Weir.

Reduction in turbulence will reduce the amount of air entrained in the flow. Delay in juvenile passage as a result of temporary eddies and other flow instability should also be reduced.

i. Eliminate Control Weir.

This alternative will result in higher water surface elevations and less turbulence below the point of the existing weir. Moving the hydraulic control downstream below the inclined screen will enable the channel to remain much more stable without the turbulence that currently exists.

ii. Extend Collection Channel.

The complexity of extending this facility to the north is such that relocating several facilities would be necessary, potentially including the adult bypass system. This alternative was not considered further.

(d) Reduce Velocities Through Inclined Screen.

The inclined screen would have to be replaced with any alternative chosen. Its area would be based on the amount of channel flow in the selected alternatives. In all cases, the proposed very large screen would require significant design changes to the downstream end of the collection channel and to the transportation channel system.

(e) Reduce Turbulence and Air Entrainment in Downwell.

Several undesirable flow characteristics exist through the downwell area. A complete redesign of this portion of the system could result in a much improved condition for juveniles. The use of an open channel flume would greatly increase flexibility in design and easily work with whatever upstream DSM modifications are made. The other modifications were not considered further.

(f) Sharp Downwell Bend High Outfall Pipe Velocities.

Addressed under the Portland District PIES program.

(4) Recommendation.

All feasible alternatives, plus any new alternatives identified should be studied in the feasibility phase. For purposes of cost estimating, alternative modification of wall and floor with a 12-inch water supply, as described in paragraph 8.2c(2)(b)(vii), will be used. This alternative meets the fisheries criteria, and appears to be the best selection for engineering considerations.

(5) Design.

(a) Assumptions.

Hydraulic criteria for design will be as stated in the 1993 fish passage plan. The outfall for the system will remain on the Washington shore.

(b) Requirements.

Design must be flexible enough to accommodate the proposed smolt monitoring facilities and new outfall.

d. Impacts of Improvements.

(1) Physical.

The improvements would have little impact on the powerhouse. The system will use slightly more water, which will then be unavailable for hydropower production. The major modifications to Bonneville Second Powerhouse will come as a result of separate studies for a new outfall and smolt monitoring facility.

(2) Biological.

(a) General.

Because FGE levels for subyearling migrants were consistently low and not increased by any of the spring migrant FGE improvements, a study of subyearling passage survival was initiated in 1987 to determine the survival of subyearling chinook passing through turbines, relative to the other passage routes available (spillway and bypass). Approximately 1.8 million subyearling fall chinook salmon from Bonneville Fish Hatchery were released each year from 1987 to 1990 through various passage routes and a site downstream from the project. The spillway release was conducted only in 1989, due to low flow conditions in the other years. Preliminary results were based on juvenile recoveries of a percentage of the test fish at Jones Beach (Columbia River Mile 46).

Results from 1987 indicated that mortality rates were 15 percent higher for bypassed fish compared to the lower and upper turbine releases. The downstream release mortality rate was greater than the mortality rate for the bypass system. NMFS theorized that the downstream control group had been compromised by predation at this shoreline release site, and the high bypass mortality was caused by predation at the bypass outfall, and possibly a problem within the bypass system itself.

In 1988, the downstream release site was moved to mid-river. A turbine boil front-roll release was added to determine if the mortality observed from bypass release groups was a problem with the bypass system itself, or from predation at the outfall site. Turbine passed fish survived from 15 to 17 percent better than bypassed fish, front-roll fish survived approximately 14 percent better than the bypassed fish. The survival of the downstream released fish improved by moving the release to the middle of the river.

In 1989, the same release locations were used, and higher river flow conditions facilitated the spillway release. The results were similar to 1987 and 1988.

Turbine released fish again were recaptured at a higher rate than bypass released fish (3 to 4 percent higher), although the differences were not statistically significant. Combining the 1988 and 1989 data, turbine released fish survived 8 to 9 percent greater than bypass released fish, and the differences were statistically significant. The 1989 front-roll released fish survived at rates 7 percent greater than bypassed fish, and 4 percent greater than turbine released fish. The spillway had the highest survival rate of all release sites.

In 1990, full powerhouse loading attempted to minimize impacts from resident predators. Also, release hoses were mounted on the bypass outfall to evaluate whether the poor bypass survival was a structural problem with the bypass system or a predation problem in the tailrace, or both. Survival through the bypass was slightly lower, but not statistically different, from the turbines.

The 1987 to 1990 studies indicate that in no year did the bypass outperform the turbines as a fish passage route, and in most years the bypass performed significantly worse. Based on these results, a direct capture net was installed at the submerged outfall in 1990 to test the condition of fish exiting the bypass system to distinguish between direct bypass mortality and tailrace-induced mortality. Once located, engineering solutions to the mortality problem could then be designed.

The direct survival measurements showed the system has varied effects on juvenile fish depending on tailwater elevation, temperature, fish species, hatchery versus run of river fish, and release location within the bypass system. The entire bypass system consistently showed higher descaling, injury, and mortality levels than releases made downstream of the downwell. Also, fish passing through the bypass system are fatigued/stressed at level related to their release point, further upstream being more fatigued.

In summary, the Second Powerhouse direct and indirect survival studies conducted between 1987 and 1991 indicate the bypass system is not functioning properly. Survival through the bypass is equal to or less than turbines. Fish using the bypass system are stressed and fatigued, particularly at low tailwater elevations, which likely contributes to the apparent high rate of tailrace predation.

Subsequent to these survival studies, engineering analyses have identified a number of areas within the bypass that are suspected of causing the poor survival conditions. Based on all the available biological and engineering information, poor survival of summer fish bypassed through the Second Powerhouse bypass system is caused in part by physical conditions within the bypass system that are causing fish to be stressed, fatigued, and susceptible to tailrace predation. These conditions include low water velocities in the collection channel, high turbulence in the channel from orifice jets, high turbulence over the dewatering screen due to energy dissipation over the channel control weir, air entrainment in the downwell, and negative pressures in the first elbow of the closed pipe.

In addition, even though the bypass outfall is located in an area of relatively high velocity and a large distance from structures, tailrace predation is a significant contributor to the poor performance of the bypass. The predation is a result of tailrace hydraulic patterns that cause bypassed fish to travel to and along the heavily protected and optimum predator habitat of the north shoreline. Relocating the outfall is addressed in section 4.

(b) Spreadsheet Models.

Benefits were estimated using a CENPP spreadsheet model for Bonneville Dam. NMFS 1993 Biological Opinion flows of 200/160 kcfs spring and summer flows, and the FGE ranges described in the SCS Bonneville First Powerhouse FGE Improvements (section 5) were used. Recent information on relative survival through the bypass systems, direct physical condition and injury, and professional judgement were used to estimate benefits associated with DSM improvements on species passing Bonneville Dam.

i. Second Powerhouse Summer Migrants.

Based on the NMFS indirect assessments of bypass survival in 1988, 1989, and 1990, we estimate that bypass mortality is estimated at 19 percent relative to the downstream releases. Of this 19 percent, the bypass to tailrace and tailrace to downstream release data indicate approximately 8 percent of the mortality is occurring in the bypass itself, and approximately 8 percent is occurring in the tailrace. The releases for these studies were made in the bypass channel at Unit 17. Therefore, most of the bypass collection channel was not tested with this release. To account for impacts associated with the entire channel, an additional 2-percent mortality was arbitrarily added to the level of mortality in the bypass itself. This increases the total mortality attributable to the bypass from 8 to 10 percent. Adding this mortality (10 percent) to the tailrace mortality (8 percent) allows us to estimate bypass survival for summer fish to be 82 percent.

This DSM study addresses improvements to the Second Powerhouse bypass collection channel, weir, inclined screen, and downwell. The buried, pressurized transportation pipe is not addressed in this study. For purposes of analysis, we assume that half the mortality associated with the bypass system is associated with the pipe, and half with the areas addressed in this study. Improving the Second Powerhouse bypass channel, therefore, will increase survival by 5 percent (1/2 of 10 percent) and overall survival through the bypass will increase from 82 to 87 percent.

ii. Second Powerhouse Spring Migrants.

Data from the NMFS direct assessment of the injury and condition of fish passing through the Second Powerhouse bypass system indicate river run yearling chinook had less than half the descaling level of river run subyearling chinook (12 percent versus 28 percent), lower levels of blood lactate (115 mg/dl versus 140 mg/dl), and peak cortisol levels that are approximately equal to river run subyearling chinook. Based on these observations, we assume that yearling chinook mortality attributable to the bypass system is one-half that of summer migrants, 1/2 of 10 percent, or 5 percent.

Based on U.S. Fish and Wildlife Service model estimates of tailrace predation during the spring versus the summer (personal communication, Tom Poe), we assume that yearling chinook tailrace mortality is 45 percent of the summer migrants, or 8 percent x 0.45 = 4 percent. Therefore, we estimate total bypass mortality of spring migrants to be comprised of an estimated 5 percent mortality attributable to the bypass itself, and 4 percent allocated to the tailrace, for a total of 9 percent mortality or 91 percent survival. Similar to the subyearling chinook estimates, the improvements in bypass survival addressed in this study would reduce the mortality in the bypass by 50 percent, from 5 to 2.5 percent. This mortality reduction would increase survival from 91 percent to 94 percent.

(c) Spreadsheet Input Parameter Ranges.

To estimate the potential range in effects, we assumed that the bypass improvements had no measurable effect, and double the estimate effect. Mortality in the Bonneville Second Powerhouse bypass pipe remains unaffected by the proposed improvements. The ranges cannot improve survival to a point where mortality to these unaffected portions of the bypass are reduced. When this upper limit is accounted for, the following ranges in bypass survival were used:

B2 summer: 82% to 87%

B2 spring: 91% to 94%

B1 summer: 70% to 76%

B1 spring: 85% to 87%

(d) Spreadsheet Model Results.

The results are shown in tables 8-5 and 8-6.

Table 8-5
Estimated Project Survival With and Without Improved DSM, B2 Priority
(Bi-Op Flows of 200/160 kcfs)

Species	Base Case	Improved DSM
Yearling Chinook	92	92 to 93
Subyearling Chinook	91 to 92	91 to 92
Steelhead	92	92 to 93
Coho	92	92 to 94
Sockeye	92	92 to 93

Table 8-6
Estimated Project Survival With and Without Improved DSM, B2 Priority
(Bi-Op Flows of 300/250 kcfs)

Species	Base Case	Improved DSM
Yearling Chinook	92 to 93	92 to 93
Subyearling Chinook	91	91 to 92
Steelhead	92	92 to 93
Coho	92	92 to 93
Sockeye	92	92 to 93

Based on the use of the CENPP spreadsheet model and the model assumptions described above, the increases in project survival produced by improving the First or Second Powerhouse DSM's are small. Project survivals with improvements ranged from 91 to 94 percent for all species under the various flow and powerhouse priority alternatives, with an absolute increase in project survival of from 0 to 2 percent, depending on the species.

(d) CRiSP Modeling.

The CRiSP model was developed by the University of Washington, and tracks the downstream migration and survival of salmon and steelhead through the Columbia and Snake Rivers to below Bonneville Dam. The model recognizes and accounts for various reservoirs and dam passage parameters, integrating a number of subroutine models to arrive at final estimates of hydrosystem survival. For this analysis, arbitrary numbers of fish for the following stocks were input into the CRiSP model to estimate percent change from the base case for each stock:

Deschutes (Yearling Chinook)	Rock Creek (Steelhead)
Dworshak (Steelhead)	Wenatchee (Steelhead)
Hanford (Subyearling Chinook)	Methow Wells Index (Subyearling Chinook)
Methow (Yearling Chinook)	Wild Snake Fall (Subyearling Chinook)
Wild Snake Spring (Yearling Chinook)	Wild Snake Summer (Subyearling Chinook)

i. Assumptions.

Model runs used input data for the SOR and the Model Coordination Team (letter from Tuttle to fisheries agencies and tribes, dated January 25, 1993). For example, bypass mortality at all dams, including Bonneville, was assumed to be 2 percent. Based on this value of 98 percent survival, we assumed that improving the bypass systems at both the Bonneville First and Second Powerhouses decreases mortality through each bypass by 50 percent, from 2 to 1 percent. Under this condition, survival through the bypass is increased from 98 to 99 percent. To run CRiSP and account for scientific uncertainty, bypass survival estimates were ranged for each case. Based on bypass estimates used in the System Operational Review study, base case bypass survival had a mean of 98 percent and a range of 92 to 99 percent, while Bonneville DSM Improvements had a base case of 99 percent and a range of 96 to 100 percent.

ii. Results.

Based on the model input described above, where bypass survival is assumed to be high to start with (98 percent), CRiSP results indicate there were no statistically significant differences between the base case and the improved condition, suggesting the improvements have no effect on survival. This point is true for all the stocks listed above, from point of origin to below Bonneville Dam, and for the condition modeled - transportation on. We estimate that similar results will be produced when CRiSP is run with transportation turned off. However, that does not mean the proposed improvements have no effect. Rather, CRiSP, the analytical tool used to pick up differences between the base case and the treatment, is not sensitive to relatively small changes in project passage conditions at Bonneville Dam since CRiSP is primarily a model of system-wide effects, and bypass survival was assumed to be 98 percent prior to the improvement.

iii. Model Analysis Summary.

The CRiSP model shows no benefit from improving the bypass channels (DSM) at both Bonneville powerhouses, primarily because the model is a system-wide model that is relatively insensitive to small improvements in bypass survival at one project. The spreadsheet model developed by CENPP is a project-specific model, and is more sensitive than CRiSP to changes in individual passage parameters at Bonneville Dam. The spreadsheet model indicates that survival past Bonneville Dam could be increased as much as 1 percent with the proposed improvements. We estimate that annually 22 million fish arrive at Bonneville Dam, and could benefit from the proposed juvenile bypass system improvements. Based on the significant number of fish arriving at Bonneville Dam and the benefits suggested by the spreadsheet model, the proposed improvements would appear to provide a small but important improvement to juvenile fish survival.

(3) Economic.

The additional 34 to 46 ft^3/s of flow into the collection channel is not expected to significantly decrease the project's energy output. No direct impacts to navigation, recreation or water supplies are expected from implementing these selected project improvements.

e. Schedules and Costs.

(1) Schedule.

Design and Construction Schedule is shown in figure 8-3.

(2) Cost Estimate.

Table 8-3 presents estimated construction costs for the improvement to the DSM systems. Table 8-4 adds planning, engineering, and design costs, and presents a fully-funded cost estimate based on the current design and construction schedule.

f. Phase II Study Requirements.

(1) General.

The design studies for the DSM will include the main body of the investigation and evaluation of the entire DSM system designs. Computer models, prototype data from other projects, and prototype observation at the Second Powerhouse will be extensively used to size the system. A physical hydraulic model of the dewatering system will be used to evaluate the hydraulic conditions leading to the inclined screen and through the screen itself. Comparison of the new DSM to existing systems at other projects will be done to identify and incorporate factors that have proven to be highly successful. Biological criteria will be clarified through meetings with fisheries agencies. Impacts to operations will be identified.

(2) **Alternative Development.**

Most of the alternatives identified at this reconnaissance level will be studied to some degree for the feasibility report. Those that are clearly undesirable will be eliminated as early as possible. Any new alternatives that demonstrate potential improvement will be evaluated. The alternatives being evaluated will be compared and individually refined until a single alternative is chosen that best meets all requirements.

(3) **Biological Studies.**

(a) **General.**

Corps of Engineers-funded fish passage research on the Columbia River is developed, designed, administered, and implemented through FPDEP. All aspects of research are developed with and coordinated through the regional fisheries agencies and tribes. It is the best professional judgement of the scientists and engineers involved with the development of this reconnaissance-level report that the subject activities described herein will improve the survival of Pacific salmon stocks passing Bonneville Second Powerhouse. However, biological uncertainties remain and warrant further investigation.

(b) **Prototype Testing.**

Bonneville Second Powerhouse bypass improvements will incorporate the latest designs and knowledge regarding the behavior of fish in bypass systems, and be based on a substantial body of experience at numerous Corps fish bypass facilities throughout the Columbia River Basin. Additional biological studies prior to construction are not needed to complete the designs described in this report. However, because of the uncertainty associated with the overall effect of current bypass designs on survival, post-construction evaluations of survival through the improved bypass systems are warranted.

A survival study, based on 3 years of coded-wire tagged and freeze-branded hatchery fish released through both powerhouse bypass systems, turbines, and the spillway, is recommended. The three years of releases will be followed by approximately four years of adult returns and final reporting. The study design recommended will afford comparisons of both juvenile recoveries and adult returns. The study could be conducted in conjunction with improvements to the Bonneville bypass outfalls and short-haul barging, as described in sections 4 and 9. FPDEP costs associated with the conduct of this study are estimated shown on table 8-7.

Table 8-7 Biological Costs and Schedules			
Fiscal Year	**Biological Research**	**S&A**	**Total**
1996	Juvenile release - $550,000	$15,000	$565,000
1997	Juvenile release - $550,000	$15,000	$565,000
1998	Juvenile release - $550,000	$15,000	$565,000
1999	Adult returns - $100,000	$10,000	$110,000
2000	Adult returns - $100,000	$10,000	$110,000
2001	Adult returns - $125,000	$10,000	$135,000
2002	Adult returns - $125,000	$10,000	$135,000
2003	Adult returns - $125,000 Final Report - $75,000	$10,000	$75,000
Total			**$2,260,000**

(4) Hydraulic Design.

(a) General.

Existing numerical computer models will be used or modified to describe the various collection channel alternatives. Discharges, depths, and velocities along the channel will be determined and documented. Different combinations of operating conditions will be run to demonstrate the ability of the system to meet biological criteria under all conditions. Development of the selected designs will be carried out to the degree that a large amount of certainty is involved in the selected alternative.

(b) Model Testing of the Dewatering System.

A physical hydraulic model of the dewatering system will be used to make a complete determination of the hydraulic conditions at the dewatering screen. The final alternatives will be individually tested in the hydraulic model that will be constructed to include the inclined screen and the related dewatering system components. Various configurations of the screens, the perforated plates behind the screens, and the channel design will all be able to be modified and tested in the model. The model will be used to refine the design so that hydraulic conditions through the screen can be optimized.

(5) Project Design.

(a) Project.

Coordination with project personnel will be required to ensure the modifications can be implemented with minimum disruption to project operations.

(b) Mechanical.

The mechanical design may involve valving for the add-in water. A device for cleaning of the inclined screen will need to be designed. Operation and maintenance requirements will also need to be identified.

(c) Electrical.

Controls for operating the new add-in water valves will need to be designed. Operators for the inclined screen cleaning device and all new lights and controls will be included. Water surface level indicators and monitors should also be designed.

(d) Structural.

Structural design for the modifications to the First Powerhouse will include conceptual design of the modifications to the dewatering screen and the associated extension of the DSM out of the north end of the powerhouse, including consideration of all appurtenant design details with respect to these modifications. The Second Powerhouse DSM conceptual design will include modifications to collection channel, orifice flumes, dewatering screens, sorting facility, and all design of all appurtenant design details. The outfall pipe and transportation conduit design will be considered under a different study. The design effort will identify limitations on conceptual designs and provide practical alternatives for construction of proposed geometry modifications. The conceptual designs will allow that further design will conform to the applicable engineering manuals and codes. Plates which effectively represent the primary structural changes, and quantities which represent these conceptual design considerations, will also be provided.

(6) Feature Design Memorandum Requirements.

The detailed design of the final DSM system will take place in the FDM phase. Final hydraulic computations and biological evaluations of the system will be completed and documented at this level. Prior to FDM level design work, a plan would need to be completed coordinating the DSM system reconstruction work with the relocation of the existing system downwell and outfall presently proposed under a PIES study.

Section 9 - Short-Haul Barging

9.1. Proposed Improvements to Existing Systems.

a. General.

Short-haul barging transports juveniles downstream of the tailrace to avoid predation at the outfalls and the general vicinity of the outfall. Each site that has short-haul baring will have five common characteristics They will be located near a sampling facility and consist of a hold area, a barge dock, and barges. The sampling facility will include the dewatering and sampling necessary for barging. Holding areas will consist of covered raceways, but direct loading the fish in barges would be an alternative that could eliminate this feature. The barge docks are based on three sheet pile cells at each site. The barges considered for each short-haul site would likely be self-propelled, and about one-half or one-fourth the size of the smallest barges currently used by the Walla Walla District transportation program.

b. The Short-Haul Concept.

Short-haul barging is conceived as a potential JBS outfall/release strategy. The concept is to allow downstream migrants time to recover from the stress/fatigue of bypass systems, so they are better fit and able to avoid predators. It would also provide for release into swift moving areas and away from structures, where predators are not able to hold for long periods of time. As conceived, juvenile fish would be collected into raceways or directly loaded onto barges docked below the dam. Fish could then be released into the reservoir below the dam each day or night to vary in both space and time how the fish are returned to the river.

The short-haul barging concept is derived from information regarding releases of Bonneville hatchery fish from Tanner Creek versus a mid-river release (Ledgerwood, unpublished data, 1990) that indicated that 33 percent more fall chinook survived when transported and released in mid-river (barged) compared to Tanner Creek released fish (in-river). The indirect survival study conducted by NMFS at Bonneville Second Powerhouse (1987 to 1990) suggested that short-haul transportation may provide increased juvenile survival (Ledgerwood *et al*., 1990).

9.2. Existing System Description and Operation.

No Portland District project (Bonneville, The Dalles, and John Day) currently has existing barging facilities, but another system configuration study included in these analyses is the possible transportation of downstream migrant salmonids from the John Day Project. Also, *The Dalles Juvenile Bypass System General Design Memorandum* (COE, 1993) contains a brief analysis on the use of short-haul barging as a juvenile bypass release strategy during low flow periods, when biological criteria for bypass outfall are not met at The Dalles dam. The Dalles juvenile bypass system has been designed to allow for the use of short-haul barging as an outfall release strategy. Since this release strategy has not been tested, the design work was prepared by a contract separate from The Dalles JBS GDM and FDM. This design work may be found in *Short Haul Barging and Sampling Facilities* for The Dalles Juvenile Bypass System Project (COE, 1992).

9.3. Potential Biological Effects.

Screened juvenile bypass systems designed and constructed to provide downstream migrant salmonids safe passage around hydroelectric facility turbines presently utilize single-site, fixed location outfall release structures. Benefits accrued to downstream migrant salmonids from being bypassed around turbine passage may be nullified by heavy predation at the outfall release sites (Matthews, 1992). Survival studies conducted by the National Marine Fisheries Service at Bonneville Dam have shown that survival of subyearling chinook salmon, *Oncorhynchus tshawytscha*, passing through the juvenile bypass system (JBS) was not increased over fish passing through the turbines of the Second Powerhouse. Ledgerwood *et al.* (1990, 1991) suggested that the cause of this lower than expected survival through the JBS was likely due to predation at the bypass outfall site.

Indirect survival studies through different passage routes at Bonneville Dam have shown that subyearling chinook released downstream had 19 percent greater survival than subyearling chinook passing through the bypass system at the Second Powerhouse (Ledgerwood *et al*., 1990, 1991). The first year of indirect survival studies at the First Powerhouse provided similar information showing that subyearling chinook salmon released downstream survived 28 percent greater than fish passing through the bypass system (Ledgerwood *et al*., unpublished data, 1993). Research to analyze the release of Bonneville hatchery fish into Tanner Creek show comparable results for a downstream mid-river release strategy. Juvenile chinook transported from the hatchery for mid-river release survived 33 percent greater than fish released into Tanner Creek (Ledgerwood memo, November 23, 1990).

9.4. Engineering Evaluation of Proposed Improvements.

a. General.

Short-haul barging was evaluated at four locations: Bonneville First and Second Powerhouses, The Dalles, and John Day.

b. Bonneville First and Second Powerhouses.

Two barging sites have been selected, one for the First Powerhouse and the other for the Second Powerhouse. A single site was considered, but rejected because the existing bypasses could require extensive modifications and the flume would have to cross over the spillway to combine and form a common barge loading site. Each site will use a triple cellular sheet pile dock. All fish will be directly loaded into a barge docked at the site or released at an outfall. Raceway holding or outfall sampling capability are not planned. The smolt monitoring facility designs are assumed to be designed to account for short-haul barging. New outfalls are planned to discharge the fish into the tailrace when the barges releasing juveniles are downstream. One barge per dock is planned.

c. The Dalles.

The short-haul barging concept shown in *The Dalles Juvenile Bypass General Design Memorandum No. 1*, dated November 1992, is presented in this study. The facility would be built after the JBS is completed and operational. Raceways are included, but could be deleted if additional studies show they are not beneficial. One barge is planned in this study.

d. John Day.

The short-haul barging facility proposed is exactly the same as the transportation facility proposed in the SCS studies. Raceways are included, but would possibly be deleted in the feasibility stage. One barge is planned in this study.

9.5. Alternative Bypass Release Strategy.

a. Basic Concepts.

Substantial benefits to downstream salmonid migrants may be accrued by decreased indirect mortality (predation) at the outfall site location, and immediately downstream (Ledgerwood *et al.*, 1990, 1991; Ledgerwood, memo, 1990). Other unquantified amounts of benefit to juvenile fish may be accrued due to possible improvements in stress/fatigue, fitness, and immune response (Shreck *et al.*, 1992; Congleton *et al.*, 1988; Bjornn, 1988). Also, the further downstream juveniles were transported, the greater the survival potential may be increased, again from decreased predation. A study prepared for BPA addressing in part density indexing, provided data that showed densities of northern squawfish between the estuary and Bonneville Dam exceeded those observed in other areas sampled, except for in the McNary tailrace boat restricted zone (BRZ). Also, consumption indices for northern squawfish between the estuary and Bonneville Dam exceeded those observed for John Day reservoir outside the immediate vicinity of the dams (Willis and Nigro, 1993).

b. Collection and Transportation Testing.

Over the last 10 years, considerable research has been conducted that provides insight concerning the short-term effects of collection and transportation of juvenile salmonids. These studies focused primarily on characterizing juvenile salmonid response to various components of the collection and transportation process using physiological indices of stress (primarily plasma cortisol). Concurrently, research has been conducted to quantify the incidence and severity of bacterial kidney disease (BKD) infection on yearling chinook salmon smolts.

In a comprehensive, 3-year study of the effects of collection and transportation on juvenile fall chinook salmon at McNary Dam, Maule *et al.* (1988) reported that plasma cortisol concentrations increased significantly during the collection process, but returned to base levels after 12 to 24 hours of raceway residence. Loading of fish into trucks or barges elicited another significant increase in plasma cortisol, but there was a net decrease in this stress index after 3 to 4 hours of transportation in both trucks and barges. During transportation, plasma cortisol concentrations remained low throughout the 15 hours of transport.

Congleton *et al.* (1984) reported similar results for juvenile spring/summer chinook salmon during collection and transportation from Lower Granite Dam on the lower Snake River. Plasma cortisol levels increased during collection and decreased during raceway residence. Analogous to the McNary Dam study, the loading process elicited a plasma cortisol response in juveniles that generally remained unchanged or declined during the 8 to 9 hours of truck transportation.

From 1984 through 1986, spring/summer chinook salmon smolts were sampled from different areas of the collection and transportation system at Lower Granite Dam, and subsequently held for observation in an artificial seawater recirculation system at the project (Matthews *et al.*, 1987). In all three years, the 43-day mortality was significantly higher for smolts that had passed through the collection system than for those that had not. However, there was no significant difference in mortality between those that had passed through the collection system and those that had both passed through the systems and had undergone truck transport. The authors reported the findings "implied that the stress associated with smolt movement through the collection system was the most important factor affecting short-term survival of collected and transported smolts."

These studies suggest that downstream migrant salmonid bypass and collection systems are not totally "fish friendly," and elicit a stressful response to juvenile salmon. In all of thee studies, various components of the collection and handling processes have been shown to elicit a physiological response in salmonid smolts as measured by plasma cortisol. However, in nearly all cases, short-term transportation did not elicit an additional response; on the contrary, plasma cortisol levels generally declined during transportation.

c. Testing Conclusions.

These findings would lead one to the conclusion that the use of short-haul barging as a JBS outfall release strategy could enhance the fitness of bypassed salmonid smolts by giving them time to recover from the rigors of bypass. This type of outfall release strategy could also benefit fish in other manners. During low-flow periods, it would insure migrants were released in high flow areas where predators can not hold for long periods of time. It would also insure bypassed migrants were not released near structures that cause slackwater areas where predators may hold. A fourth benefit would be the elimination of "point source" bypass outfall sites that predators are likely to key on. Fifth, the further distance migrants were moved from the project, the less time they would be within predator-infested waters, and the fewer predators migrant salmonids would encounter.

9.6. Biological Benefits.

a. Fish Input Numbers.

Currently there are no precise methods of directly enumerating numbers of juvenile salmonids passing Columbia River hydroelectric facilities. Therefore, numbers must be calculated indirectly using several sources of information, including the Fish Passage Center (FPC) passage indices, hatchery releases, and estimates of reservoir and stocking survival.

Numbers of fish arriving at Bonneville were calculated as follows:

[Numbers of fish arriving at The Dalles x survival to Bonneville Dam] +
[hatchery releases into Bonneville Pool x survival to Bonneville Dam]

Numbers of fish arriving at The Dalles were taken from the environmental assessment for The Dalles juvenile bypass system (COE, 1993). These numbers were obtained from estimates of in-river fish arriving at John Day, plus hatchery and Deschutes River input. Survival of in-river fish (fish passing John Day and The Dalles Dams) were estimated using CRiSP model runs conducted for System Operation Review (SOR) analysis. Data for hatchery releases was provided by the FPC (personal communication, 1993), and is an average of 1988 to 1992.

Post release and pool survival of hatchery fish was assumed to be 60 percent. Tables 9-1, 9-2, and 9-3 estimate numbers of fish arriving at John Day, The Dalles, and Bonneville, respectively.

Table 9-1
Estimated Fish Numbers Arriving at John Day Used For Biological Benefits Analysis
(5-Year Average From FPC, Plus Hatchery Production Input)

Species/Stock	Fish Numbers
Yearling Chinook	603,000
Subyearling Chinook	2,190,000
Steelhead	242,000
Sockeye	129,000
Coho	114,000[1]

[1] Coho salmon fish numbers at Bonneville were calculated using John Day steelhead FGE (86 percent). There is no FGE data specific to coho salmon at John Day, and FGE for coho salmon at other projects is generally similar to steelhead.

Table 9-2 Estimated Fish Numbers Arriving at The Dalles Used For Biological Benefits Analysis (5-Year Average From FPC, Plus Hatchery Production Input)	
Species/Stock	**Fish Numbers**
Yearling Chinook	1,475,000
Subyearling Chinook	2,943,000
Steelhead	666,000
Sockeye	119,000
Coho	105,000

Table 9-3 Estimated Fish Numbers Arriving at Bonneville Used For Biological Benefits Analysis (5-Year Average From FPC, Plus Hatchery Production Input)	
Species/Stock	**Fish Numbers**
Yearling Chinook	5,038,000
Subyearling Chinook	12,068,000
Steelhead	737,000
Sockeye	106,000
Coho	4,216,000

b. Biological Benefit Estimates.

(1) Baseline Survival Data.

Biological benefits were estimated for the Bonneville Project (first and second powerhouse priority). This was possible because of the project-specific baseline data available for indirect mortality at Bonneville. Four years of indirect survival studies at the Second Powerhouse, one year of indirect survival studies data the First Powerhouse, and information from Tanner Creek release strategies provided good baseline information (Ledgerwood, 1990; Ledgerwood *et al.*, 1990, 1991; Ledgerwood *et al.*, 1993). Although there is no baseline data available for John Day or The Dalles, it is assumed that similar benefits could be accrued for these projects with the use of an alternative bypass release strategy. Survival studies should be conducted for projects where baseline data is lacking. These types of studies better enable the region to evaluate where improvements are needed within the hydrosystem, and where the best increase in project-specific survival may be accrued.

(2) Transportation Assumptions.

The estimated increase in survival of downstream migrating juvenile salmonids arising from an alternative bypass release strategy takes into account several assumptions. First, more than one barge may be needed to ensure juvenile salmonids are loaded directly, to decrease the amount of handling. Second, the barge needs to be designed to insure the release mechanism is quick and not excessively stressful. To achieve the benefits of releasing a less stressed/fatigued, more fit migrant, fish may need to be held in the barge for a period of time. Finally, an unquantified (although alluded to) benefit could be added the further downstream migrants were released.

(3) Mortality Estimates.

As stated above, baseline data exists at the Bonneville project that enables a reconnaissance-level evaluation to quantify possible improvements to project-specific survival of downstream migrant salmonids. Based on the NMFS indirect assessment of bypass survival in 1988, 1989, and 1990, it is estimated that the second powerhouse bypass mortality for fall chinook salmon (summer migrants) is 19-percent relative to the downstream release site. Of this 19 percent, the bypass to tailrace and tailrace to downstream release data indicate that approximately 8 percent of the mortality is attributable to predation in the tailrace. For this analysis, it was estimated mortality attributed to tailrace predation could be reduced to 1 to 3 percent for summer migrants (fall chinook salmon), and 0 to 2 percent for spring migrants (all other species/stocks). Based on the NMFS assessment of bypass survival in 1992, it is estimated that the first powerhouse bypass mortality for fall chinook salmon (summer migrants) is 28 percent relative to the downstream release site. Of this 28 percent, 19 percent was attributed to the outfall location and tailrace mortality. For this analysis, it was estimated mortality attributed to tailrace predation could be reduced to 1 to 3 percent for summer migrants (fall chinook salmon), and 0 to 2 percent for spring migrants (all other species/stocks).

c. CRiSP Modeling (System Improvement.

Benefits to juvenile salmonids due to short-haul were calculated using CRiSP modeling. CRiSP is a fish passage model developed by the University of Washington to simulate and estimate juvenile fish survival through the Columbia River. Complete description of this model is found in *CRiSP.1 Manual*, release date: March 1993.

Reliability of this model (as with any model) is largely based on input parameters used in analysis. Input parameters were based on current data, research, and coordination with regional experts. Parameters relating to dam passage established by NMFS (Model Coordination Memo, January 1992) for use by the Model Coordination Team were used when applicable. Other model parameters (such as transportation survival) used were coordinated with the SOR Anadromous Fish work group. Due to limited data regarding sockeye salmon input parameters and transportation survival, CRiSP analysis was limited to yearling chinook, subyearling chinook, and steelhead.

Using this information, the CRiSP model was run using 50 (1928 to 1978) year water record to give an estimated "average" survival of juvenile salmonids with and without project improvements. The model was run using a monte carlo analysis to account for variability in many input variables. Differences in these conditions were considered the "benefit" of improvements to the system.

d. Spreadsheet Modeling (Project-Specific Improvement).

(1) General.

Fish passage models used in the region to estimate survival of juvenile salmonids through the Snake and Columbia River systems are designed to estimate system survival. These models are designed to simulate changes in system operations and are not sensitive enough to detect small changes in survival due to small improvements at individual projects. These models are also not sensitive to differences in project survivals between tailrace areas (specifically different outfall locations). Therefore, estimation of juvenile fish survival through Bonneville project was accomplished using a spreadsheet model developed by the Corps of Engineers, Portland District. This model was developed to simulate current project operations and constraints, as well as potential operations. This model also allows partitioning mortality into more areas (such as indirect versus direct causes of mortality) than the larger, more complex fish passage models.

(2) Method.

This model assumes dam passage to be by three potential routes; juvenile bypass system, turbine, or spillway. Proportion of fish passing each route is based on project operations, flow levels, FGE, and spill levels. The model calculates number of fish passing each route and, based on input parameters, associates each route with a survival. Total project survival for each stock/species is then calculated.

Input variables and values used for base case scenario are shown in table 9-4. These variables are established as inputs to allow analysis of varied project operations and flow levels.

Table 9-4
Input Variables and Estimates Used for "Base Case" Analysis
Of Systems Improvements at Bonneville Dam
(Bonneville 1 Priority)

Variable Name	Values Used for Base Case
Average Summer Flow	250 and 160 kcfs
Average Spring Flow	300 and 200 kcfs
Daily Percent Summer Spill	44/49% and 34/35%[1]
Daily Percent Spring Spill	40/44% and 38/39%[1]
Powerhouse Capacity	140/180 kcfs[2]
Minimum Powerhouse Flow	60 kcfs
Daytime Spill Cap	75 kcfs
Nighttime Spill Cap	none
Hours of Fish Spill	2100 to 0600 hours
B1 FGE	
Yearling Chinook	37%
Subyearling Chinook (prior to 6/15)	39%
Subyearling Chinook (after 6/15)	10%
Steelhead	36%
Coho	63%
Sockeye	23%
B2 FGE (2)	
Yearling Chinook	48 and 67%
Subyearling Chinook (prior to 6/15)	50 and 50%
Subyearling Chinook (after 6/15)	32 and 24%
Steelhead	41 and 62%
Coho	55 and 75%
Sockeye	37 and 37%
B1 Bypass Mortality	5.5 and 11%[4]
B1 Outfall Mortality	9.5 and 19%[4]
B2 Bypass Mortality	5 and 10/%[4]
B2 Outfall Mortality	4 and 8%[4]
Turbine Mortality	11%
Spill Mortality	2%

[1] High/Low flow, Bonneville 1 and 2, respectively.
[2] 1993 data and historic average data, respectively.
[3] First and second powerhouse, respectively.
[4] Spring and Summer, respectively.

This model was run for four scenarios for each alternative: 1) Powerhouse 1 priority, high flows; 2) Powerhouse 1 priority, low flows; 3) Powerhouse 2 priority, high flows; and 4) Powerhouse 2 priority, low flows. Runs were also made using both historical average and 1993 FGE values for Bonneville Second Powerhouse. Each scenario was run with a best case/worst case of assumptions regarding improvements. Low flows used were those prescribed in the Biological Opinion for system operations of 200 and 160 kcfs (spring and summer, respectively). High flows used were 300 and 250 kcfs, and were chosen to simulate a full range of possible flows. This results in a range of expected survivals which shows some degree of uncertainty in improvement estimates.

For all runs/alternatives all parameters not directly affected by improvements were held constant.

e. Results.

System-wide survival for downstream migrant juvenile salmonids with short-haul barging at Bonneville as analyzed with the CRiSP model, indicate no statistically significant difference between the base case and improved condition. No difference in system survival were realized for any species/stock utilized in the analysis from their respective point of origin to below Bonneville. This does not, however, mean the proposed improvement have no effect. The CRiSP model was developed to track the downstream migration of salmon and steelhead through the entire Columbia and Snake systems to below Bonneville Dam, and is not sensitive to relatively small changes in project-specific passage conditions.

Project-specific base case survival at Bonneville ranged from 91 to 93 percent. Project-specific survival increases with decreased indirect mortality from predation ranged from 2 to 4 percent for different species/stocks (tables 9-5 through 9-8). This analysis accounts for increased survival from the elimination of the downwell and pressurized outfall pipe at the first powerhouse. This is because these portions of the bypass system would need to be replaced for short-haul barging. This analysis also accounts for increased survival from the elimination of the pressurized outfall pipe at the second powerhouse, again due to this portion of the bypass needing changes for short-haul barging.

Table 9-5
Estimated Project Survival of Juvenile Salmonids at Bonneville With and Without Alternative Bypass Release Strategy (B1 Priority, Flows of 200/160 kcfs)

Species	Base Case Survival (Percentage)	Survival With Bypass Release Alternative (Percentage)
Yearling Chinook	93	95
Subyearling Chinook	92	94
Steelhead	92	95 to 96
Coho	92	95 to 96
Sockeye	92 to 93	93 to 94

Table 9-6
Estimated Project Survival of Juvenile Salmonids at Bonneville With and Without Alternative Bypass Release Strategy (B1 Priority, Flows of 300/250 kcfs)

Species	Base Case Survival (Percentage)	Survival With Bypass Release Alternative (Percentage)
Yearling Chinook	92 to 93	95
Subyearling Chinook	92	94
Steelhead	92	95 to 96
Coho	92	95 to 96
Sockeye	92	93 to 94

Table 9-7
Estimated Project Survival of Juvenile Salmonids at Bonneville With and Without Alternative Bypass Release Strategy (B2 Priority, Flows of 200/160 kcfs)

Species	Base Case Survival (Percentage)	Survival With Bypass Release Alternative (Percentage)
Yearling Chinook	92	94 to 95
Subyearling Chinook	91 to 91	93 to 94
Steelhead	92	94 to 95
Coho	92	95 to 96
Sockeye	92	93 to 94

Table 9-8
Estimated Project Survival of Juvenile Salmonids at Bonneville With and Without Alternative Bypass Release Strategy (B2 Priority, Flows of 300/250 kcfs)

Species	Base Case Survival (Percentage)	Survival With Bypass Release Alternative (Percentage)
Yearling Chinook	92 to 93	94 to 95
Subyearling Chinook	91	93 to 94
Steelhead	92	94 to 95
Coho	92	95 to 96
Sockeye	92	93 to 94

These results do not account for improvements to the other sections of the Bonneville first and second powerhouse juvenile bypass systems identified as needing refurbishment. These other areas are covered separately, in other sections of this analysis. A Bonneville combination (section 10) combines Bonneville Project JBS enhancements that further increase project-specific survival. What this analysis aspires to address is the need for further analysis of present procedures and attempts at increasing downstream migrant juvenile salmonid survival past Corps-operated hydroelectric facilities.

Bypassing downstream migrants does not make sense if, in turn, the fish are highly stressed/fatigued, and released in areas where indirect mortality primarily from predation nullify benefits accrued.

f. Summary - Alternative Bypass Release Strategy.

Tables 9-9 and 9-10 are presented to provide the region and decision makers the means to evaluate the maximum possible benefit estimated from these analyses. It must be stressed that these have been reconnaissance-level studies, and all increases in downstream migrant salmonid survival are estimates. Further studies are necessary to 1) determine the feasibility of an alternative bypass release strategy; and 2) to analyze the actual benefits accrued through prototype testing and post-construction testing.

Table 9-9
Estimated Maximum Project Survival Benefits With An Alternate Bypass Release Strategy (Short-Haul Barging) With First Powerhouse Priority

Species	Base Case (Percent)	Improved Survival (Percent)	Maximum Percent Change
Yearling Chinook	92 to 93	95	3
Subyearling Chinook	92	94	2
Steelhead	92	95 to 96	4
Coho	92	95to 96	4
Sockeye	92 to 93	93 to 94	2

Table 9-10
Estimated Maximum Project Survival Benefits With An Alternate Bypass Release Strategy (Short-Haul Barging) With Second Powerhouse Priority

Species	Base Case (Percent)	Improved Survival (Percent)	Maximum Percent Change
Yearling Chinook	92 to 93	94 to 95	3
Subyearling Chinook	91	93 to 94	3
Steelhead	92	94 to 95	3
Coho	92	95 to 96	4
Sockeye	92	93 to 94	2

These benefits to increased project-specific survival for downstream migrant salmonids were estimated for the Bonneville project only. This is primarily due to this being the only project with baseline data available on indirect mortality, primarily from predation. However, it is assumed similar benefits may be accrued at other facilities.

9.7. Additional Biological Research.

Existing baseline data on indirect mortalities, primarily from predation, exist from studies conducted at Bonneville. However, these studies were not conducted primarily with this type of data as the focus. Survival studies have not been conducted at the other seven hydroelectric facilities on the lower Columbia and Snake Rivers. This lack of sound, scientifically-based data prohibits a quantified estimate of the possible benefits that may be accrued to downstream migrant salmonids arising from alternate bypass release strategies. Transportation studies have shown that in most years, for most species, downstream migrant salmonids benefit from this bypass alternative. However, in order to rebuild wild salmonid stocks within the Columbia River Basin, new and innovative ideas need to be analyzed, and potential improvements need to be studied.

The use of alternative bypass release strategies may have the potential to increase the fitness of bypassed salmonids, thereby increasing their ability to survive. Alternative release in the form of short-haul barging could be an important improvement in downstream migrant fitness and survival. The proper mechanisms need to be designed and tested, and potential shortfalls eliminated. Below is a brief outline of needed research, including schedules and costs (table 9-11).

Table 9-11
Tentative Schedules and Budgets for Alternative Bypass Release Strategy (Short-Haul Barging) Prototype Testing

Fiscal Year	Biological Research	S & A	Total
1996	CWT* Release = $550,000		$565,000
1997	CWT Release = $550,000		$565,000
1998	CWT Release = $550,000		$565,0-00
1999	Adult Returns = $150,000	$15,000	$160,000
2000	Adult Returns = $150,000	$15,000	$160,000
2001	Adult Returns = $150,000	$15,000	$160,000
2002	Final Report	$15,000	$75,000
		$15,000	
Subtotal		$15,000	**$2,250,000**
1996	Biological Studies of Methods (Release Mechanisms, *etc.*)		$250,000
Total			**$2,500,000**

9.8. Economic Impacts.

The economic impact of collecting and transporting juvenile anadromous fish to release sites downstream of the tailrace during periods of low river flow has been analyzed to provide information regarding the improvement's direct and indirect economic impacts. Direct economic impacts are changes in project outputs. Indirect economic impacts are changes in regional or local economic activity resulting from direct impacts. No direct or indirect impacts are anticipated from this proposed project improvement.

9.9. Schedule and Cost.

a. Design and Construction Schedule.

The schedule is shown on figure 9-1. Juvenile releases from barges and control locations are scheduled in the biological testing portion of the schedule. Juvenile and adult recaptures are planned for evaluating the concept. Juvenile sampling results will be reported in the feasibility study. Adult results will be reported in the design memorandum. Model studies for The Dalles and Bonneville sites are shown on the schedule because these models are existing and can be fairly readily tested. John Day testing requires building a new general model, and will add 1 year to the schedule shown.

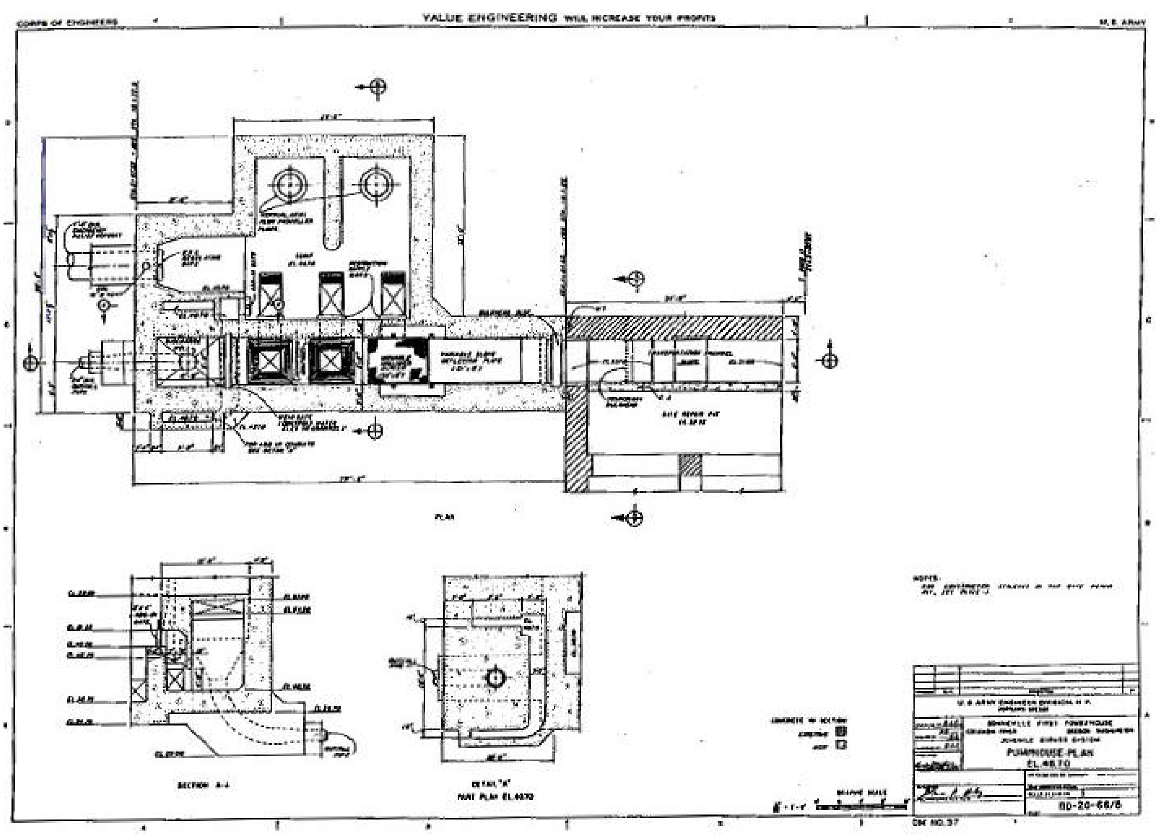

Figure 9-1. Short-Haul Barging Design and Construction Schedule

b. Total Contract Costs.

The total construction cost estimates are shown in table 9-12. Table 9-13 adds planning, engineering, and design costs; and presents the fully-funded cost estimate based on the current design and construction schedule. The total contract costs only include costs for the Bonneville short-haul barging. The Dalles and John Day barging costs would be similar to one powerhouse at Bonneville.

Table 9-12
Bonneville 1st and 2nd Powerhouse
Juvenile Short-Haul Barging
Construction Cost Estimate

Feature	Quantity	Unit	Unit Price	Total Cost
Bonneville 1st Powerhouse				
Downstream Docking Facility	1	EA	5,493,715	$5,493,715
Mobilization - Demobilization	1	EA	248,809	$248,809
Miscellaneous Equipment	1	EA	69,190	$69,190
Barge Water Supply	1	EA	66,423	$66,423
Elevated Flume	2000	FT	780	$1,560,000
Raceways	1	EA	712,090	$712,090
Sum Bonneville 1st Powerhouse				**$8,150,227**
Bonneville 2nd Powerhouse				
Downstream Docking Facilities	1	EA	5,966,305	$5,966,305
Mobilization - Demobilization	1	EA	273,518	$273,518
Miscellaneous Equipment	1	EA	75,142	$75,142
Barge Water Supply	1	EA	72,137	$72,137
Elevated Flume	2000	FT	929	$1,857,100
Raceways	1	EA	773,349	$773,349
Sum Bonneville 2nd Powerhouse				**$9,017,551**
Sum Bonneville 1st and 2nd Powerhouse				$17,167,778
Contingency				$12,857,000
Total Bonneville 1st and 2nd Powerhouse				**$30,024,778**
Barges, Bonneville 1st Powerhouse				$4,214,500
Barges, Bonneville 2nd Powerhouse	1	EA	4,214,500	$4,214,500
Barge Contingency	1	EA	4,214,500	$6,312,000
Total Barges				**$14,741,000**

Biological Research	$2,435,000
Research Contingency	$1,600,000
Research S & A	$65,000
S & A Contingency	$43,000
Total Fish and Wildlife Facility	**$48,908,778**
Planning, Engineering, and Design	$9,840,000
Contingency	$6,375,000
Total Planning, Engineering, and Design	**$16,215,000**
Construction Management	$1,800,000
Contingency	$1,043,000
Total Construction Management	**$2,843,000**
Total Project Cost	**$67,966,778**

Table 9-13
Total Contract Cost Summary
Columbia River Salmon Mitigation Analysis System Configuration Study--Phase I
Juvenile Fish Short-Haul Barging
Columbia River, Oregon and Washington (2 sites)

POC: Pat Jones, Chief, Cost Engineering Branch

Current MCACES Estimate Prepared: Effective Pricing Level:			Jan 94 Oct 93		Authoriz./Budget Year: 1995 Effect. Pricing Level: Oct 95					Fully-Funded Estimate				
Acct No.	**Feature Description**	**Cost ($K)**	**CNTG ($K)**	**CNTG (%)**	**Total ($K)**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Total ($K)**	**Feature Mid-Pt**	**OMB (%)**	**Cost ($K)**	**CNTG ($K)**	**Full ($K)**
Fish and Wildlife Facilities														
Contract A - Barging Facilities														
06---	Bonneville I and II	17,168	4,575	27%	21,742	6.8%	18,335	4,886	23,221	Mar 99	29.3%	23,707	6,317	30,025
Contract B - Barges (2)														
06---	Bonneville I and II	8,429	2,246	27%	10,675	6.8%	9,002	2,399	11,401	Mar 99	29.3%	11,640	3,102	14,741
	Subtotal Costs	25,597	6,821		32,417		27,337	7,284	34,622	Mar 99	29.3%	35,347	9,419	44,766
06---	Biological Research	2,435	487	20%	2,922	6.8%	2,601	520	3,121	Mar 99	29.3%	3,363	673	4,035
	Research S&A	65	13	20%	78	6.8%	69	14	83	Mar 99	29.3%	90	18	108
	Total 06 Account	20,097	7,321	26%	35,417		30,007	7,818	37,826		29.3%	38,800	10,109	48,909
Functional Costs--Planning, Engineering, and Design														
30F--	Feasibility Report	900	180	20%	1,080	8.9%	980	196	1,176	Mar 99	26.1%	1,236	247	1,483

30G--	**Functional Costs--Feature Design Memorandum**												
30G--	Barging Facility	2,500	500	20%	3,000	8.9%	2,723	545	3,267	Mar 99	26.1%	3,433	687	4,120
30G--	Barge	500	100	20%	600	8.9%	545	109	653	Mar 99	26.1%	687	137	824
30H--	**Functional Costs--Plans and Specifications**												
30H--	Contract A-- Barging Facility	3,500	700	20%	4,200	8.9%	3,812	762	4,574	Mar 99	26.1%	4,806	961	5,768
30H--	Contract B-- Barges	500	100	20%	600	8.9%	545	109	653	Mar 99	26.1%	687	137	824
30J--	Design Related Engr. Hyd. Models												
30J--	General Models	40	8	20%	48	8.9%	44	9	52	Mar 99	26.1%	55	11	66
30K--	Engineering During Construction	600	120	20%	720/F ONT	8.9%	653	131	784	Mar 99	26.1%	824	165	989
30L--	Value Engineering	100	20	20%	120	8.9%	109	22	131	Mar 99	26.1%	824	165	989
30S--	E&D Project Management	1,200	240	20%	1,440	8.9%	1,307	261	1,568	Mar 99	26.1%	1,648	330	1,977
	Total 30 Account	9,840	1,968	20%	11,808		10,716	2,143	12,859		26.1%	13,513	2,703	16,215

Functional Costs--Construction Management

31---	Contract A - Barging Facility	1,200	180	15%	1,380	8.9%	1,307	196	1,503	Mar 99	26.1%	1,648	247	1,895
31---	Contract B - Barges	600	90	15%	690	8.9%	653	98	751	Mar 99	26.1%	824	124	948
	Total 31 Accounts	1,800	270		2,070		1,960	294	2,254			2,472	371	2,843
	Total Costs	39,737	9,559	24%	49,295		42,683	10,256	52,939		28.4%	54,784	13,183	67,967
										Total Project Costs:				**$67,967**

Functional costs were provided by the design section.
Contingency's on 30 and 31 accounts were estimated at 25%.
Authorization: Year assumed to be FY 1995.

c. Operation and Maintenance Costs.

(1) Bonneville.

Operation and maintenance costs are shown in table 9-14. The costs at Bonneville include the two barging facilities with one barge and no raceways. Additional outfall and flume maintenance costs are included because this option is considered independently from the Bonneville outfalls alternative.

Table 9-14 Bonneville Short-Haul Barging Operations and Maintenance Costs			
Items		**Costs**	
		5-Year	**25-Year**
Barge and Dock Maintenance			
Labor (2,000 hours at $40 per hour)	$80,000		
Supplies	20,000		
Overhauls	120,000		
Subtotal	$220,000		
Barge Operation			
Labor (6,400 hours at $40 per hour)	$256,000		
Supplies	52,000		
Fuel	12,000		
Subtotal	$320,000		
Flume Maintenance			
Inspections - 50 trips (8 hours per trip at $40 per hour)	$16,000		
Repairs - 260 hours at $40 per hour	10,400		
Supplies	14,000		
Painting - 8.7 ft^2 ($0.50 per foot) (8,340 feet)		$36,000	
Clean up - 320 hours at $40 per hour	13,000		
Debris removal - 8 hours (2-man crew) (4 times) at $40 per hour	2,600		
Replacement - 420,000 pounds at $2,000 per pound			$840,000
Subtotal	56,000		
Totals	**$596,000**	**$36,000**	**$840,000**

[1]Sources of data for annual costs from Delivery Order No. 8, *Short-Haul Barging and Sampling Study for The Dalles Juvenile Bypass System Project Final Submittal*, dated December 10, 1992, prepared by Summit Technology, Seattle, Washington.
[2]Flume maintenance costs from study of transportation flume, *The Dalles Juvenile Fish Bypass System Delivery Order No. 7,* dated March 1992, by Ebasco Services, Inc., Bellevue, Washington.
[3]Flume painting is not required at 25 and 50 years.

(2) The Dalles and John Day.

Operation and maintenance costs for The Dalles or John Day are shown in table 9-15. Costs are being estimated to be the same for each project. Raceways are included, but could be deleted at a later date.

Table 9-15
The Dalles/John Day Short-Haul Barging Operation and Maintenance Annual Costs

Items	Costs
Barge and Dock Maintenance	
Labor (1,000 hours at $40 per hour)	$40,000
Supplies	10,000
Overhauls	60,000
Subtotal	110,000
Barge Operation	
Labor (3,200 hours at $40 per hour)	$128,000
Supplies	26,000
Fuel	6,000
Subtotal	160,000
Raceway Maintenance	
Labor (1,400 hours at $40 per hour)	$56,000
Supplies	25,000
Subtotal	81,000
Raceway Operations	
Labor (1,600 hours at $40 per hour)	64,000
Supplies	25,000
Subtotal	89,000
Annual Total	**$440,000**

[1]Sources of data for annual costs from Delivery Order No. 8, *Short-Haul Barging and Sampling Study for The Dalles Juvenile Bypass System Project,* Final Submittal, dated December 10, 1992, prepared by Summit Technology, Seattle, Washington.
[2]Estimated costs are the same at each project. Annual total is for one project only.

9.10. Phase II Study Requirements.

a. General.

Phase II will include a feasibility study and biological testing. This section describes the work planned to generally cover only one project (Bonneville, The Dalles, or John Day).

b. Feasibility.

(1) Economics.

An economic analysis will be included in the Phase II Study.

(2) Engineering.

The engineering appendix will primarily look at locating a barge dock; selecting the barge type and number of barges; and laying out the baring facility, dewatering facility, raceways, and sampling facilities. Results from the biological testing evaluations will be included.

Extensive effort is planned for incorporating the existing systems and proposed smolt monitoring facilities into the short-haul barging plans. Siting of the docks, navigation of the barges, and locating the outfalls at Bonneville and John Day will be the principle purposes of the proposed general models. Alternatives discharging the excess water into the adult water supply systems and small hydropower plants will be evaluated. The barging process will be outlined in detail to provide the baseline cost estimates and the basis of the feature design memorandums.

c. Biological Studies.

Fish with coded wire tags are scheduled to be released from the powerhouses and from barges. They will be collected at Jones Beach during the first 3 years of testing, and again as adults. This work will be conducted independently of the feasibility study, but will serve as justification of the projects.

9.11. Design and Construction.

Design memorandums, continued model studies, plans and specifications, and contracts will follow the Phase II studies.

a. Design Memorandums.

(1) Short-Haul Barging Facilities Features Design Memorandum.

These memorandums will cover the features developed in the feasibility study. Dewatering facilities, excess water removal, sampling facilities, smolt monitoring facility modifications, transportation flumes, raceways, outfalls, docking facilities and barge-loading equipment will be presented. Operation and maintenance procedures, costs, and worker requirements will be identified for estimating future project costs and estimating future work force needs. Further evaluations of the Jones Beach recoveries will be included.

(2) Barge Feature Design Memorandums.

The barge feature design memorandums will cover the barge designs, as well as their operating and maintenance procedures and costs.

b. Model Testing.

(1) General Model Construction.

General models for Bonneville Dam and The Dalles Dam currently exist, and were both designed for navigation testing. No additional construction for these models should be necessary other than cleanup and pump maintenance. They should both prove very important in evaluating short-haul barge mooring locations. John Day Dam does not have a general model currently constructed. However, there are several other potential studies that could benefit from model construction, and construction costs could be shared for various studies.

John Day general model would be from river mile 213.5 to 218.5 at a 1:80 scale. The dam is located at approximately river mile 216. The model would include flow through the sluiceway juvenile bypass outfall and fish ladder entrances and exits. The navigation lock would be constructed, but does not have to be operational. The spillway would be fully operational with each gate independently operable. The model should be able to simulate flows up to 700,000 ft^3/s and be capable of operating at a lowered pool condition.

(2) Model Testing.

Model testing would be performed with model fish barges operated with similar power and steerage capabilities of the prototype. Testing would be predominantly in the tailrace in areas adjacent to the juvenile bypass systems and downstream of smolt monitoring facilities. Testing would be performed at various project operational conditions, including spill. Testing would evaluate ease of entering and leaving the barge moorage/loading facility and identify potential areas of risk. Safety would be of utmost importance. Safeguards for slight misoperation would be built in. Moorage dolphins, sheet pile cells, breakwaters, and other devices will be evaluated to provide an effective moorage/loading facility design. The barges will make runs from the point their operation would need to vary from normal barging operations in the river up to the point they are safely moored.

c. Plans and Specifications.

(1) Short-Haul Barging Facilities Construction Contracts.

The design and preparation of plans and specifications are planned for the features selected in the design memorandum process. A final evaluation of the adult returns will be made prior to completing the contract designs.

(2) Barge Supply Contract.

The design and preparation of plans and specifications is planned for the barge or barges outlined in the design memorandums.

Section 10 - Combination of Bonneville System Improvements

10.1. Proposed Improvements to Existing Systems.

Detailed descriptions for individual system improvements are given in sections 4, 5, 8, and 9 of this report.

10.2. Existing System Descriptions and Operations.

Detailed descriptions for existing system improvements and operations are given in sections 4, 5, 8, and 9 of this report.

10.3. Biological Background.

a. Rationale.

This section gives the rationale for evaluating combinations of SCS studies for the rehabilitation of the Bonneville Project juvenile bypass systems. Four different areas/solutions were analyzed to increase survival for downstream migrant juvenile salmonids at the Bonneville project (Bonneville First and Second Powerhouse DSM, Bonneville First Powerhouse FGE, Bonneville First and Second Powerhouse JBS outfall site relocation, and Bonneville First and Second Powerhouse JBS alternative outfall release strategy). In the process of analyzing the separate studies, it became clear that no one area provided the magnitude of increased survival aspired. Separate system improvements realized a minimal increase in project-specific survival for downstream migrants, except for Bonneville First Powerhouse FGE, which decreased project-specific survival (spreadsheet model). Separate system improvements did not realize system wide increase in survival (CRiSP model). Since all aspects of the JBS are interrelated, it is obvious a collective approach may be favorable. Two combinations of improvements were modeled to assess the full range of increased survival possible.

b. Baseline Data.

The Bonneville project is unique in the amount of baseline survival data that is available for downstream migrant subyearling chinook salmon passage through the different passage routes. A thorough study was initiated at the Second Powerhouse in 1987, and continued through 1990 (Ledgerwood *et al.*, 1992). A similar study was initiated at the First Powerhouse in 1992 but, due to a lack of regional approbation, research at the First Powerhouse was not continued in 1993. What these survival and FGE studies have shown is that 1) both juvenile bypass systems consistently provided lower survival than turbine passage for subyearling chinook salmon; 2) FGE needs to be increased to meet regional goals; and 3) survival of fish released downstream was significantly greater than turbine or bypass-released fish. For a thorough review of Bonneville First Powerhouse FGE, Bonneville First and Second Powerhouse survival studies, Bonneville First and Second Powerhouse DSM improvements, Bonneville First and Second Powerhouse JBS outfall relocation, and Bonneville First and Second Powerhouse JBS outfall alternative release strategy, see sections 4, 5, 8, and 9.

10.4. Biological Evaluation.

a. General.

Two models were utilized to assess possible increases in downstream migrant salmonid survival with project improvements. CRiSP was used to assess possible increases to system-wide survival. A spreadsheet model designed by the Portland District was used to assess possible increases in project-specific survival.

b. CRiSP Model (System Survival).

Benefits to juvenile salmonids due to combining Bonneville system improvements were calculated using CRiSP modeling. CRiSP is a fish passage model developed by the University of Washington to simulate and estimate juvenile fish survival through the Columbia River. Complete description of this model is found in *CRiSP.1 Manual*, release date: March 1993.

Reliability of this model (as with any model) is based on input parameters used in analysis. Input parameters were based on current data, research, and coordination. Parameters relating to dam passage established by NMFS (Model Coordination Memo, January 1992) for use by the Model Coordination Team were used when applicable. Other model parameters (such as transportation survival) used were coordinated with SOR anadromous fish work group. Due to limited data regarding sockeye salmon input parameters and transportation survival, CRiSP analysis was limited to yearling chinook, subyearling chinook, and steelhead.

Using this information, the CRiSP model was run using the 50-year water record (1928 to 1978) to give an estimated "average" survival of juvenile salmonids with and without project improvements. The model was run using a monte carlo analysis to account for variability in many input variables. Differences in these conditions were considered the "benefit" of improvements to the system.

c. Spreadsheet Model (Project Survival).

Fish passage models used in the region to estimate survival of juvenile salmonids through the Snake and Columbia River systems are designed to estimate system survival. These models are designed to simulate changes in system operations, and are not sensitive enough to detect small changes in survival due to small improvements at individual projects. These models are also not sensitive to differences in project survival between tailrace areas (specifically different outfall locations).

Estimation of juvenile fish survival through Bonneville project, therefore, was accomplished using a spreadsheet model developed by the Corps of Engineers, Portland District. This model was developed to simulate current project operations and constraints, as well as potential operations. This model also allows partitioning mortality into more areas (such as indirect versus direct causes of mortality) than the larger, more complex fish passage models.

This model assumes dam passage to be by three potential routes; juvenile bypass system, turbine, or spillway. Proportion of fish passing each route is based on project operations, flow levels, FGE, and spill levels. The model calculates number of fish passing each route and, based on input parameters, associates each route with a survival. Total project survival for each stock/species is then calculated.

Input variables and values used for base case scenario are shown in table 10-1. These variables are established as inputs to allow analysis of varied project operations and flow levels.

Table 10-1
Input Variables and Estimates Used for "Base Case"
For Analysis of System Improvements at Bonneville Dam
(Bonneville 1 Priority)

Variable Name	Values Used for Base Case
Average Summer Flow	250 and 160 kcfs
Average Spring Flow	300 and 200 kcfs
Daily Percent Summer Spill	44/49% and 34/35%[1]
Daily Percent Spring Spill	40/44% and 38/39%[1]
Powerhouse Capacity	140/180 kcfs[2]
Minimum Powerhouse Flow	60 kcfs
Daytime Spill Cap	75 kcfs
Nighttime Spill Cap	none
Hours of Fish Spill	2100 to 0600 hours
B1 FGE	
Yearling Chinook	37%
Subyearling Chinook (prior to 6/15)	39%
Subyearling Chinook (after 6/15)	10%
Steelhead	36%
Coho	63%
Sockeye	23%
B2 FGE (2)	
Yearling Chinook	48 and 67%
Subyearling Chinook (prior to 6/15)	50 and 50%
Subyearling Chinook (after 6/15)	32 and 24%
Steelhead	41 and 62%
Coho	55 and 75%
Sockeye	37 and 37%
B1 Bypass Mortality	5.5 and 11%[4]
B1 Outfall Mortality	9.5 and 19%[4]
B2 Bypass Mortality	5 and 10%[4]
B2 Outfall Mortality	4 and 8%[4]
Turbine Mortality	11%
Spill Mortality	2%

[1]High/Low flow, Bonneville 1 and 2, respectively.
[2]First and Second Powerhouse, respectively.
[3]1993 data and historic average data, respectively.
[4]Spring and summer, respectively.

This model was run for four scenarios for each alternative: 1) First Powerhouse priority, high flows; 2) First Powerhouse priority, low flows; 3) Second Powerhouse priority, high flows; and 4) Second Powerhouse priority, low flows. Runs were also mad using both historical average and 1993 FGE values for Bonneville Second Powerhouse. Each scenario was run with a best case/worst case of assumptions regarding improvements. Low flows used were those prescribed in the Biological Option for system operations of 200 and 160 kcfs (spring and summer, respectively). High flows used were 300 and 250 kcfs, and were chosen to simulate a full range of possible flows, which results in a rang eof expected survivals showing some degree of uncertainty in improvement estimates. For all runs/alternatives, all parameters not directly affected by improvements were held constant, with the exception of spill levels. Current policy is to spill at Bonneville Dam to maintain a fish passage efficiency (FPE) of 70 percent for spring migrants and 50 percent for summer migrants. Therefore, when improves affected FPE, such as FGE improvements, spill levels were adjusted to meet 70/50 FPE goals.

d. Fish Input Number.

Currently, there are no precise methods of directly enumerating numbers of juvenile salmonids passing Bonneville Dam. Therefore, numbers must be calculated indirectly using several sources of information, including FPC passage indices, hatchery releases, and estimate of reservoir and stocking survival.

Numbers of fish arriving at Bonneville were calculated as follows:

ND = Number of fish arriving at The Dalles

SB = Survival to Bonneville Dam

HB = Hatchery releases into Bonneville Pool

Formula: (ND * SB) + (HB * SB)

Numbers of fish arriving at The Dalles were taken from the draft environmental assessment for The Dalles juvenile bypass system (USACE, 1993). Survival of in-river fish (fish passing The Dalles Dam) was estimated using CRiSP model runs conducted for SOR analysis. Data for hatchery releases was provided by the FPC (personal communication, 1993), and is an average of 1988 to 1992. Post release and pool survival of hatchery fish was assumed to be 60 percent (table 10-2). Estimated number of fish arriving at Bonneville are shown in table 10-3.

Table 10-2 Average Hatchery Releases Into Bonneville Pool and Tributaries And Estimated Survival to Bonneville Dam			
Species	**Average Number of Fish Released**	**Survival to Bonneville**	**Estimated Number Of Hatchery Fish At Bonneville**
Yearling Chinook	6,209,000	0.6	3,725,000
Subyearling Chinook	15,600,000	0.6	9,360,000
Steelhead	251,000	0.6	151,000
Coho	6,872,000	0.6	4,123,000

Table 10-3 Estimated Number of Fish Arriving at Bonneville				
Species	**Number of Fish Arriving At The Dalles**	**Survival From The Dalles to Bonneville (CRiSP)**	**Hatchery Input (Bonneville Pool)**	**Estimated Number of Fish Arriving At Bonneville**
Yearling Chinook	1,475,000	.89	3,725,000	5,038,000
Subyearling Chinook	2,943,000	.92	9,360,000	12,068,000
Steelhead	666,000	.88	151,000	737,000
Sockeye	119,000	.89	---	106,000
Coho	105,000	.89	4,123,000	4,216,000

10.5. Engineering Evaluation of Proposed Improvements.

Detailed descriptions of individual engineering evaluation of proposed improvements are given in sections 4, 5, 8, and 9.

10.6. Biological Benefits.

a. General.

Increasing FGE at the Bonneville First Powerhouse decreases project-specific survival of downstream migrant salmonids, because survival through the JBS is lower than survival through the turbines. Modifying the JBS (DSM) at Bonneville Second Powerhouse only increases project survival 0 to 1 percent, since guidance (FGE) is low. Increasing FGE, and modifying the DSM would decrease direct JBS passage mortality, but indirect mortality from predation at the outfall site remains significant. However, if FGE were increased, the DSM modified to decrease direct mortality and stress/fatigue, and either the JBS outfall relocated to a better hydraulic location, or an alternative outfall release strategy were used, project-specific survival may be significantly increased.

b. CRiSP Results.

Computer model (CRiSP) analysis of both Bonneville packages provided no increase in system survival. This model assumes a bypass survival of 98 percent, which only leaves a 2-percent increase possible. Indirect mortalities due to tailrace predation can not be separated out (different pools), hence no improvement in survival due to decreased predation was analyzed. If this variable could be decreased in the model, it is possible some increase in system survival would be realized.

c. Spreadsheet Results.

Two package analyses were conducted to assess the maximum project-specific and system-side increases in survival for downstream migrant salmonids for the Bonneville Project. The first package included improvements to Bonneville First and Second Powerhouse DSM, Bonneville First Powerhouse FGE, and Bonneville First and Second Powerhouse JBS outfall relocation. The second package included improvements to Bonneville First and Second Powerhouse DSM, Bonneville First Powerhouse FGE, and Bonneville First and Second Powerhouse JBS outfall alternative release strategy (short-haul barging).

Bonneville project-specific survival for downstream migrant salmonids increased 0 to 6 percent with B2 given priority, improved B1 FGE, improved DSM's, and an alternative release strategy (tables 10-4 and 10-5). Bonneville project-specific survival for downstream migrant salmonids increased -1 to 6 percent with B1 given priority, improved B1 FGE, improved DSM's, and an alternative release strategy (tables 10-6 and 10-7).

Table 10-4
Estimated Bonneville Project-Specific Survival
With and Without Improved DSM, B1 FGE, and Short-Haul Transport
(B2 Priority, Bi-Op Flows of 200/160 kcfs)

Species	Base Case (Percent)	Improved Conditions (Percent)
Yearling Chinook	92	92 to 97
Subyearling Chinook	91	92 to 95
Steelhead	92	92 to 97
Coho	92	93 to 98
Sockeye	92	92 to 95

Table 10-5
Estimated Bonneville Project-Specific Survival
With and Without Improved DSM, B1 FGE, and Short-Haul Transport
(B2 Priority, Bi-Op Flows of 300/250 kcfs)

Species	Base Case (Percent)	Improved Conditions (Percent)
Yearling Chinook	92 to 93	92 to 97
Subyearling Chinook	91	92 to 95
Steelhead	92	92 to 97
Coho	92	93 to 98
Sockeye	92	92 to 95

Table 10-6
Estimated Bonneville Project-Specific Survival
With and Without Improved DSM, B1 FGE, and Short-Haul Transport
(B1 Priority, Bi-Op Flows of 200/160 kcfs)

Species	Base Case (Percent)	Improved Conditions (Percent)
Yearling Chinook	93	92 to 98
Subyearling Chinook	92	92 to 96
Steelhead	92	92 to 98
Coho	92	93 to 98
Sockeye	92 to 93	92 to 96

Table 10-7 Estimated Bonneville Project-Specific Survival With and Without Improved DSM, B1 FGE, and Short-Haul Transport (B1 Priority, Bi-Op Flows of 300/250 kcfs)		
Species	**Base Case (Percent)**	**Improved Conditions (Percent)**
Yearling Chinook	92 to 93	92 to 97
Subyearling Chinook	92	92 to 95
Steelhead	92	92 to 97
Coho	92	93 to 98
Sockeye	92	92 to 96

Bonneville project-specific survival for downstream migrant salmonids increased 0 to 5 percent with B2 given priority, improved B1 FGE, improved DSM's and relocation of the JBS outfall (tables 10-8 and 10-9). Bonneville project-specific survival for downstream migrant salmonids increased -1 to 4 percent with B1 given priority, improved B1 FGE, improved DSM's, and relocation of the JBS outfall (tables 10-10 and 10-11).

Table 10-8 Estimated Bonneville Project-Specific Survival With and Without Improved DSM, B1 FGE, and JBS Outfall Relocation (B2 Priority, Bi-Op Flows of 200/160 kcfs)		
Species	**Base Case (Percent)**	**Improved Conditions (Percent)**
Yearling Chinook	92	91 to 96
Subyearling Chinook	91 to 92	91 to 93
Steelhead	92	91 to 96
Coho	92	91 to 97
Sockeye	92	91 to 94

Table 10-9
Estimated Bonneville Project-Specific Survival
With and Without Improved DSM, B1 FGE, and JBS Outfall Relocation
(B2 Priority, Bi-Op Flows of 300/250 kcfs)

Species	Base Case (Percent)	Improved Conditions (Percent)
Yearling Chinook	92 to 93	91 to 96
Subyearling Chinook	91	91 to 94
Steelhead	92	91 to 95
Coho	92	91 to 96
Sockeye	92	92 to 94

Table 10-10
Estimated Bonneville Project-Specific Survival
With and Without Improved DSM, B1 FGE, and SJBS Outfall Relocation
(B1 Priority, Bi-Op Flows of 200/160 kcfs)

Species	Base Case (Percent)	Improved Conditions (Percent)
Yearling Chinook	93	90 to 96
Subyearling Chinook	92	91 to 94
Steelhead	92	90 to 96
Coho	92	90 to 96
Sockeye	92 to 93	91 to 94

Table 10-11
Estimated Bonneville Project-Specific Survival
With and Without Improved DSM, B1 FGE,
and SJBS Outfall Relocation
(B1 Priority, Bi-Op Flows of 200/160 kcfs)

Species	Base Case (Percent)	Improved Conditions (Percent)
Yearling Chinook	92 to 93	91 to 96
Subyearling Chinook	92	91 to 93
Steelhead	92	91 to 96
Coho	92	91 to 96
Sockeye	92	91 to 94

Project-specific survival estimates with improvements ranted from 90 to 98 percent for different species/stocks (tables 10-4 to 10-11). These survival estimate were calculated as project-specific, and do not account for mortalities further downstream of the project. As stated in section 9, an alternative JBS release strategy (short-haul transport) may increase downstream fitness and survival with a lower river and/or estuary release site.

10.7. Economic Impact.

Detailed descriptions of individual system improvement economic impacts are given in sections 4, 5, 8, and 9.

10.8. Schedule and Cost.

Detailed descriptions of individual system improvements schedules and costs are given in sections 4, 5, 8, and 9.

10.9. Phase II Study Requirements.

Detailed descriptions of individual system improvements Phase II study requirements are given in sections 4, 5, 8, and 9. It is assumed that if these studies progress forward as package analyses, study requirements will be meshed and costs/needs will be minimized.

10.10. Conclusions.

Project-specific analyses demonstrate that a "package" approach will provide the greatest possible increase in survival for downstream migrant salmonids. All facets of a juvenile bypass system must function properly in order to reduce stress, fatigue, direct and indirect mortalities, and provide safe passage. It is recommended that Bonneville system improvements be treated as packages, and further analysis and testing move forward on these packages. As further modeling and testing progresses, the entire systems at both powerhouse can be fully analyzed.

It must be stressed that these have been reconnaissance-level studies, and all increases in downstream migrant salmonid survival are estimates. Further studies are necessary to 1) determine the feasibility of these downstream passage survival improvements; and 2) to analyze the actual benefits accrued through prototype testing and post-construction testing.

Section 11 - Summary of Improvement Costs and Survival Benefits

11.1. General.

This section provides summaries of the costs and the biological benefit potential of each proposed improvement. Costs are categorized as project and opportunity (no mitigation costs were identified for these project improvements). Project costs include engineering and design costs, construction outlays over time, interest during construction, and operation, maintenance, and replacement costs. Opportunity costs are changes in existing project outputs from construction and operating the proposed improvement. Opportunity costs can be positive or negative. Positive costs are reductions in project outputs, while negative costs are increases in project outputs. Project costs are described as average annual costs, and they were amortized over a 100-year period of analysis, using an 8.00 percent interest rate.

The biological benefit potential of each proposed improvement is described as the relative percentage change in juvenile fish survival between the current system configuration and the improved configuration. Each proposed improvement's benefit potential was calculated using the CRiSP model developed by the University of Washington and a spreadsheet model developed by Corps of Engineers, Portland District, staff biologists. The CRiSP model estimates system-wide juvenile fish survival by tracking their downstream migration from their point of origin through the Columbia/Snake Rivers to below Bonneville Dam. The spreadsheet model estimates juvenile fish survival at each project by simulating their passage through each project's juvenile bypass, spillway, and turbine passage routes.

Summaries of each project improvement's biological benefits and construction costs are presented in this section. Comparisons of each project improvement biological beneficial potential are provided in figures 11-1 through 11-4.

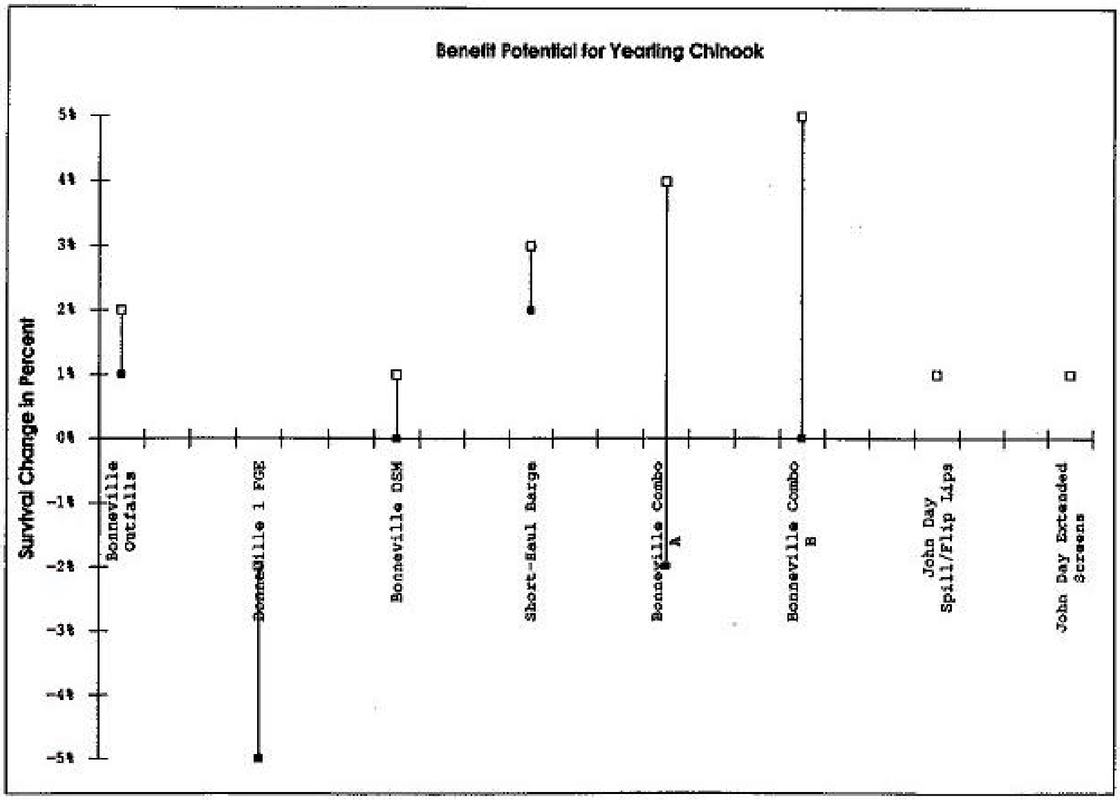

Figure 11-1. Benefit Potential for Yearling Chinook

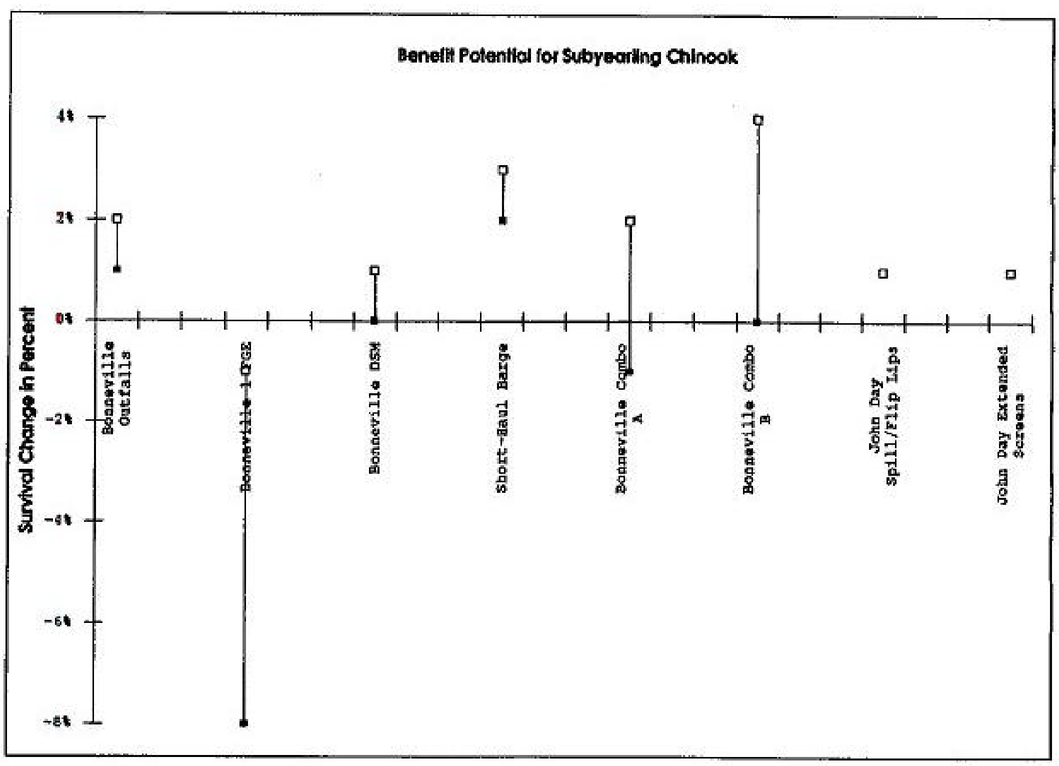

Figure 11-2. Benefit Potential for Subyearling Chinook

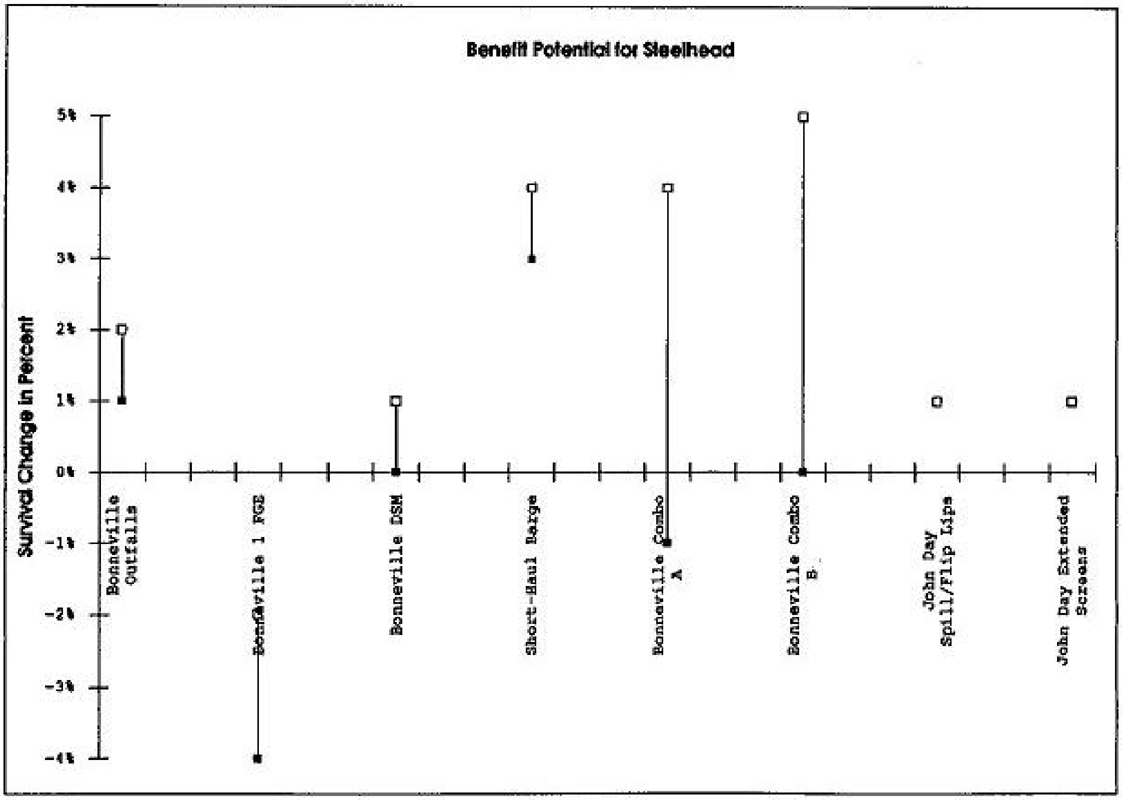

Figure 11-3. Benefit Potential for Steelhead

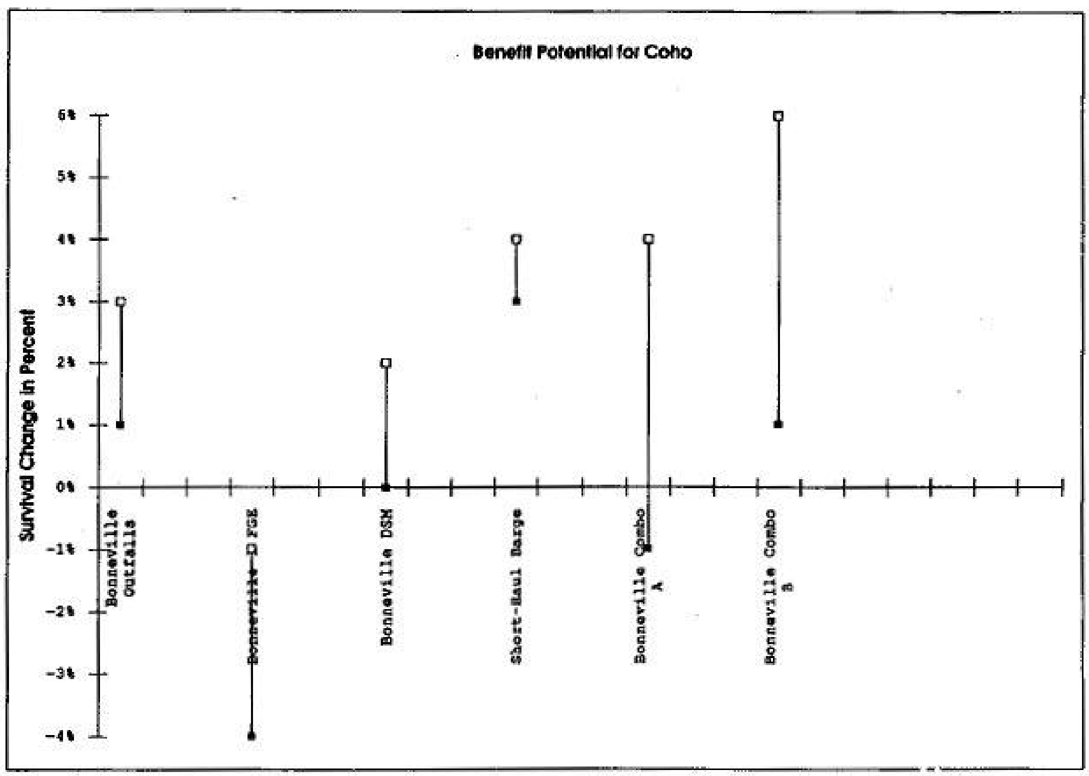

Figure 11-4. Benefit Potential for Coho

11.2. Extended Screens at John Day Dam.

a. Proposed Improvement.

Replacing the existing juvenile fish guidance with extended guidance screens has been proposed to increase the survival rate of the juvenile fish passing this project. The present John Day Dam juvenile bypass system consists of 16 standard length (20-foot) submersible traveling screens plus one spare screen, 32 vertical barrier screens (two for each turbine intake), one fish entrance orifice in each bulkhead slot, a collection channel, and an open transportation flume. New screens could be placed in some or all of the turbine intake, including the four skeleton bays. New vertical barrier screens will be needed to accommodate the greater flows in the gate slots from longer screens. The replacement screens could be either submersible bar or traveling screens, and they could be 40-foot or some other length, depending on results of model testing.

b. Improvement Costs.

Project construction costs were estimated to be $60,715,000. The estimated construction period is 7 years. Interest during construction would be $6,250,000. Total investment cost (sum of project and IDC cost) is $67,000,000.

Table 11-1 summarizes the costs of this improvement. Interest an amortization of the investment cost is $5,363,000.

Table 11-1
Cost for John Day Extended Screens

Items	Costs
Investment Cost	$60,715,000
Interest and Amortization	5,363,000
Opportunity Costs	-2,774,000
Operation, Maintenance, and Replacement Costs	487,000
Average Annual Costs	$3,076,000

(1) Opportunity Cost.

As discussed in Section 2, the opportunity cost of this proposed project improvement is the cost of replacing the energy lost from implementing the improvement. Under the current fish passage efficiency (FPE) criteria, an FPE deficit is met by spilling a percentage of river flow equal to the percentage FPE deficit over the dam's spillway. Increasing FGE for summer migrant juveniles may change the volume of spill required to meet FPE criteria, thus possibly increase the volume of river flow available for hydropower output. The estimated opportunity cost associated with discontinued spill for FPE is -$2,774,000.

c. Biological Benefits.

The potential improvement in FGE from extended screens was calculated using existing John Day FGE values plus the absolute and relative differences in FGE's realized from comparison tests of STS and ESTS conducted at McNary Dam (Berg *et al.*, 1992 and 1993), in order to bracket a potential range of FGE improvement. The John Day FGE values for salmon were specified by the National Marine Fishery Service memorandum outlining input parameters for computer simulation of Columbia River Basin migrant fish (January 1993). FGE values for steelhead passing this project are from studies conducted by Krcma *et al.* in 1986.

Based on the FGE improvement potential of extended screens, the biological benefit potential of extended screens was calculated using the spreadsheet model. Project-specific computer modeling indicated extended screens have the potential to increase project-specific survival by 1 to 2 percent. There was no difference in survival between low or high FGE. CRiSP system-wide computer modeling indicated no statistically significant benefit for any species/stock from their point of origin to below Bonneville.

11.3. John Day Juvenile Transportation.

a. Proposed Improvement.

A transportation system would consist of barges, fish tanker trucks, a three-cell sheet pile barge loading facility and dock, a truck loading area, covered concrete raceways, and employee parking. It will require new equipment and facilities replacing existing components of the bypass system, and all or part of the upgrades in the design of a proposed juvenile fish monitoring and sampling facility. The system would be capable of full-time, part-time, and short-haul barging of juvenile salmon.

b. Improvement Costs.

Project construction costs were estimated to be $37,500,000. The estimated construction period is 7 years. Interest during construction would be $3,018,000. Total investment cost (sum of project and IDC cost) is $40,518,000. No opportunity or mitigation costs are expected from this project improvement.

Table 11-2 summarizes the costs of this improvement. Interest and amortization of the investment cost is $3,241,000.

Table 11-2 Cost for John Day Juvenile Transport	
Items	**Costs**
Investment Cost	$40,241,000
Interest and Amortization	3,241,000
Opportunity Costs	0
Operation, Maintenance, and Replacement Costs	440,000
Average Annual Costs	$3,681,000

c. Biological Benefits.

The biological benefit potential of transporting juvenile fish from John Day Dam to release sites below Bonneville Dam was calculated using the CRiSP and Corps of Engineers models by comparing base condition survival (includes the current juvenile fish transportation program) to the with-improvement condition survival by allocating survival rates to transported fish and then "transporting" them to a downstream release location. The project-specific analysis assumed a higher survival rate for transportation than the CRiSP model, and resulted in greater biological benefits. CRiSP results showed a small improvement of 0 to 2 percent for subyearling summer and fall chinook salmon, but results for yearling spring chinook and steelhead show a 0 to -5 percent decline in survival. Stocks that showed benefits from transportation are mid-Columbia stocks of fall chinook. That benefit is likely due to the relatively lower survival of in-river versus transported survival used in this analysis. It is important to note that this analysis is highly sensitive to the assumptions regarding the survival rates for transported fish.

Project-specific computer modeling of transporting juveniles from John Day forebay to Bonneville tailrace indicated a biological benefit potential for all stocks/species. This analysis assumes a higher survival for transportation than CRiSP, which influenced the higher outcome. Improved survival ranged between 4 and 13 percent, depending on species. These increases should be viewed as the improvement's maximum biological benefit potential. Together, the results of CRiSP and project-specific modeling can be taken as the range of potential improvement from transporting juveniles from this project to below Bonneville. Additional studies are needed to resolve the uncertainty associated with transportation survivals.

11.4. Bonneville Bypass Outfalls.

a. Proposed Improvement.

Information from various studies examining the relative survivability of Bonneville's various passage routes indicate that a significant portion of juvenile fish mortality occurs in the tailrace, and is not attributable to the bypass system. Based on that information, new outfall design criteria have been adopted. To meet the new outfall criteria, two new juvenile bypass system transportation flumes and outfalls for Bonneville First and Second Powerhouses have bee proposed to replace the existing pressurized transportation conduit and underwater outfall. Both outfalls will include new transportation flumes and utilize the proposed juvenile fish monitoring and sampling facilities.

b. Improvement Costs.

Project construction costs were estimated to be $49,450,000. The estimated construction period is 6 years. Interest during construction would be $3,983,000. Total investment cost (sum of project and IDC cost) is $53,433,000. No mitigation costs are expected from this project improvement.

Table 11-3 summarizes the costs of this improvement. Interest and amortization of the investment cost is $4,521,000.

Table 11-3
Cost for Bonneville Bypass Outfalls

Items	Costs
Investment Cost	$53,433,000
Interest and Amortization	4,276,500
Opportunity Costs	0
Operation, Maintenance, and Replacement Costs	244,000
Average Annual Costs	$4,521,000

c. Biological Benefits.

Tailrace mortality is likely due to concentrating disoriented and stressed juvenile fish at one location, thus providing a large, stable supply of juvenile fish as prey for the predator fish. The biological benefit potential of relocating the bypass outfalls was calculated using the project-specific spreadsheet and the CRiSP models. The biological benefit potential of a proposed improvement is the difference between survival associated with the proposed improvements and the existing bypass systems.

Results of project-specific spreadsheet modeling indicate that relocating the outfalls and replacing the transportation conduits is expected to improve project-specific survival between zero to 3 percent, depending on the species river flow. The small increase in project-specific survival is related to changes in spillway flows versus powerhouse flows. By reducing tailrace mortality, the level of spill required to meet the region's 70/50 (spring/summer) fish passage efficiency goal is reduced, and reducing spill increases the number of migrant juvenile fish passed through the turbines and juvenile bypass systems, which are relatively more hazardous passage routes than the spillway.

CRiSP system-wide modeling indicated no statistically significant difference between base and improved condition survival for all stocks modeled. These results, however, indicate that this analytical tool is not sensitive to small improvements at a specific project.

11.5. Bonneville First Powerhouse Fish Guidance Efficiency.

a. Proposed Improvement.

The Bonneville First Powerhouse FGE is below the region's goal of 70-percent passage survival for spring migrants and 50-percent passage survival for summer migrants. To meet the region's current FPE goals, a percentage of river flow equal to the FPE deficit is spilled over the dam's spillway. To increase fish guidance efficiency (FGE), the following improvements have been proposed: 1) replace standard trash racks with streamlined racks; 2) replace the existing 20-foot standard STS's with 40-foot ESTS's; 3) angle the vertical barrier screens into the flow to guide more juvenile fish through the orifice into the collection channel; and 4) increase the flow up the gatewell slot by raising the operating gate a few inches.

b. Improvement Costs.

Project construction costs were estimated to be $29,869,000. The estimated construction period is 7 years. Interest during construction would be $1,754,000. Total investment cost (sum of project and IDC cost) is $31,623,000. No mitigation costs are expected from this project improvement.

Table 11-4 summarizes the costs of this improvement. Interest and amortization of the investment cost is $2,531,000.

Table 11-4
Cost for Bonneville 1 FGE Improvement

Items	Costs
Investment Cost	$31,623,000
Interest and Amortization	2,530,500
Opportunity Costs	1,200,000
Operation, Maintenance, and Replacement Costs	775,500
Average Annual Costs	$4,424,500

(1) Opportunity Cost.

Replacing the existing fish guidance screens with extended guidance screens may affect the project's hydropower production capability. The estimated opportunity cost of replacing the standard fish guidance screens with extended screens while continuing to spill for fish passage is $1,200,000. Considering the high percentage of river flow currently being spilled for fish passage at Bonneville, in the neighborhood of 40 percent, it is conceivable that the hydropower potential of that flow could exceed the hydropower potential identified in the analysis of extended screens at John Day Dam where the percentage of river flow spilled is much less. This potential hydropower production cost savings is not currently available. It would be expected to reduce the total average annual cost of the project.

c. Biological Benefits.

The biological benefit potential of this proposed project improvement was estimated using both project-specific and CRiSP simulation models. Estimates of potential FGE improvement for 40-foot guidance screens are based on results of prototype testing done at McNary Dam and assumed spillway, turbine, and bypass survival rates. They also incorporate Bonneville First and Second Powerhouse prioritized operations and spring flows of 200/160 and flows of 300/250 during the summer, as specified by the National Marine Fisheries Service. Simulations were run with Bonneville powerhouse operations prioritized according to the Memorandum of Agreement with the regional agencies.

CRiSP modeling indicated no statistically significant increase in system-wide survival. The results do not mean that the proposed improvement will not have an effect. Instead, because CRiSP measures system-wide changes, it is not sensitive to relatively small changes in project passage conditions.

Results of the project-specific spreadsheet model showed project survival decreased between zero and 9 percent for all flows and powerhouse priorities, based on input parameters for spillway and juvenile bypass system and turbine passage survival. Specifically, increased FGE decreases the amount of spill required to meet regional fish passage efficiency criteria and increases the number of juvenile fish passed through the bypass system, which is assumed to have a lower survival rate than spillway or turbine passage.

These results indicate that without simultaneously improving the bypass channel and outfall, the guided fish are subjected to the poor survivability of the existing juvenile bypass system, when compared with spillway or turbine passage. Based on the large number of fish arriving at the project and the analysts' best professional judgment, this proposed project improvement should be combined with the other proposed project improvements to the downstream migrant system and outfalls.

11.6. Turbine Passage Survival.

a. Proposed Improvement.

The existing juvenile bypass system guides many fish out of the turbine flow, but screens can not guide all juveniles. It has been proposed that the possible causes of turbine passage mortality be evaluated through physical and computer modeling.

b. Improvement Cost.

Project construction costs were estimated to be $289,131,000. The estimated construction period is 10 years. Interest during construction would be $151,664,000. Total investment cost (sum of project and IDC cost) is $440,800,000. No opportunity or mitigation costs are expected from this project improvement.

Table 11-5 summarizes the costs of this improvement. Interest and amortization of the investment cost is $35,300,000.

Table 11-1
Cost for Turbine Passage Survival

Items	Costs
Investment Cost	$440,803,000
Interest and Amortization	35,300,000
Opportunity Costs	0
Operation, Maintenance, and Replacement Costs	0
Average Annual Costs	$35,300,000

c. Biological Benefits.

CRiSP modeling was used to estimate system survival changes for the turbine improvement measure. A base condition turbine mortality of 89 percent was assumed. System survival changes for various Columbia/Snake River stocks were modeled for four potential levels of improvement to turbine passage survival, in 2-percent increments (*i.e.*, 91, 93, 95, and 97 percent). Also, the model was run for various combinations of projects that would be improved, and both with and without the existing transportation program. Because the vast majority of Snake River stocks are transported under the base condition, comparisons will be based on representative mid-Columbia stocks. For these stocks, and considering the mid-range of potential turbine survival improvement, the system survival changes were 1 percent for spring chinook and steelhead and 3 percent from summer and fall chinook. These values represent absolute survival changes. Relative system survival changes are discussed in the main report for comparison with other measures and alternatives evaluated using CRiSP.

11.7. John Day Spill Patterns and Flip-Lips.

a. Proposed Improvement.

New spill pattern guidelines and flip-lips have been proposed to aid passage for adult fish and to increase juvenile fish survival by helping adult fish locate the fish ladder entrances and decrease predation of juveniles by increasing velocity and directing the flow away from the shoreline. Flows of 4 to 8 ft^3/s at the entrance to the adult fish ladder would be the goal for adult fish attraction. Flip-lips are sloping, slide-like structures at the base of each spillway to deflect the spilled flow horizontally rather than allowing it to plunge into the tailrace pool. Flip-lips would be installed to reduce the impact of nitrogen supersaturation on returning adults and outbound juveniles passing the project. A potential secondary benefit of flip-lips is reduced predation by creating a less disorienting, smoother flow.

b. Improvement Costs.

Project construction costs were estimated to be $22,520,000. The estimated construction period is 5 years. Interest during construction would be $1,897,000. Total investment cost (sum of project and IDC cost) is $24,417,000. No opportunity or mitigation costs are expected from this project improvement.

Table 11-6 summarizes the costs of this improvement. Interest and amortization of the investment cost is $1,954,000.

Table 11-6
Cost for John Day Spill Patterns and Flip Lips

Items	Costs
Investment Cost	$24,417,000
Interest and Amortization	1,954,000
Opportunity Costs	0
Operation, Maintenance, and Replacement Costs	0
Average Annual Costs	$1,954,000

c. Biological Benefits.

Project-specific biological benefit potential of new spill patterns and flip-lips were estimated using the project-specific model.

d. Results.

The computer model calculated existing condition overall project survival to be 91 percent during the summer spill. With new spill patterns, overall project survival will increase from 91 to 92 percent, and will vary from 91 to 92 percent and, overall, increase from 0 to 1 percent.

The biological benefit potential of flip-lips was not calculated using the project-specific spreadsheet model. Flip-lips could be expected to reduce dissolved gas levels during periods when flows exceed the hydraulic capacity of the turbines or during periods of low demand for electricity. Section 7 provides discussion of the survival benefits for flip-lips.

CRiSP modeling of spill patterns and flips did not indicate a system-wide improvement in salmon survival.

11.8. Bonneville First and Second Powerhouses Downstream Migrant System.

a. Proposed Improvement.

Modifying the project's two DSM's has been proposed to improve survival of migrant juvenile fish at this project.

Engineering evaluations of both powerhouse bypass systems have identified potentially hazardous conditions. Analysis of the Bonneville First Powerhouse downstream migrant system identified excess velocity over the dewatering screen as a likely cause of the system's poor survivability. Analysis of Bonneville Second Powerhouse bypass systems have identified low flow in the collection channel, high turbulence in the channel and at the dewatering screen, air entrained in the downwell, and negative pressure in the first bend of the pressurized transportation pipe as likely cases of poor second powerhouse survival. These problem areas are believed to injury and fatigue bypassed fish, making them more susceptible to disease and predation.

b. Improvement Costs.

Project construction costs were estimated to be $9,103,000. The estimated construction period is 5 years. Interest during construction would be $937,000. Total investment cost (sum of project and IDC cost) is $10,040,000. No mitigation costs are expected from this project improvement.

Table 11-7 summarizes the costs of this improvement. Interest and amortization of the investment cost is $803,600.

Table 11-7 Cost for Bonneville DSM Facilities	
Items	**Costs**
Investment Cost	$10,040,000
Interest and Amortization	803,600
Opportunity Costs	0
Operation, Maintenance, and Replacement Costs	0
Average Annual Costs	$803,600

c. Biological Benefits.

The biological benefit potential of modifying features of the two existing juvenile bypass systems at Bonneville Dam were estimated using the two computer models. The CRiSP model showed no statistically significant change in survival for any species/stock.

Spreadsheet analysis of the proposed improvements for each species/stock and under both high and low flows and powerhouse operational priorities showed that project-specific survival could be improved between zero and 2 percent.

11.9. Short-Haul Barging.

a. Proposed Improvement.

Short-haul barging has been proposed as an alternative juvenile bypass system outfall/release strategy. Juvenile fish would be collected into barges or covered concrete raceways during periods of low river flows, and transported daily to release sites 1 to 4 miles below the tailrace and released. The facilities necessary for a short-haul barging program are covered holding area(s) for the fish, tanker barge(s), and a barge loading/moorage dock. The barge(s) would likely be self-propelled, about half to a quarter the size of the smallest barges being used to transport juvenile fish from lower Snake River collection facilities.

b. Improvement Costs.

Project construction costs were estimated to be $49,295,000. The estimated construction period is 6 years. Interest during construction would be $3,970,000. Total investment cost (sum of project and IDC cost) is $53,266,000. No opportunity or mitigation costs are expected from this project improvement.

Table 11-8 summarizes the costs of this improvement. Interest and amortization of the investment cost is $4,263,000.

Table 11-8 Cost for Bonneville Short-Haul Barging	
Items	**Costs**
Investment Cost	$53,266,000
Interest and Amortization	4,263,600
Opportunity Costs	0
Operation, Maintenance, and Replacement Costs	440,000
Average Annual Costs	$4,703,600

c. Biological Benefits.

The biological benefit potential of short-haul transportation was evaluated using baseline survival data from studies conducted at Bonneville Dam. Biological benefits of transporting juvenile salmon were calculated using the CRiSP and project-specific simulation models. The project-specific modeling indicated a 2- to 4-percent increase in survival, depending on species/stock. The CRiSP model showed no statistically significant increase in survival under any powerhouse/flow condition.

11.10. Combining Bonneville Improvements.

a. Proposed Project Improvement.

Improvements to components of Bonneville's First and Second Powerhouse juvenile bypass systems have been analyzed in previous sections of this study. While analyzing the biological benefit potential of the proposed improvements to Bonneville Lock and Dam juvenile bypass system, it became clear that improving single components of the project's bypass system provided little increase in survival and, in one instance, modifying a single component actually reduced overall survival rate of juvenile fish passing the project. Because each project improvement of an integrated juvenile bypass system, it is believed that combining those project improvements will increase survival for all juvenile migrant stock/species passing this Federal project.

Two combinations of project improvements were analyzed using the CRiSP and project-specific computer models in order to identify any change in project survival (biological benefit). Combination A incorporates improvements to both Bonneville First and Second Powerhouses DSM, Bonneville 1 FGE, and relocation of both First and Second Powerhouse DSM outfalls. Combination B incorporates two of the improvements in Combination A, but the difference is that this package substitutes short-haul barging for relocation of DSM outfalls.

b. Improvement Costs.

Project construction costs for combination A were estimated to be $88,422,000. The estimated construction period is 7 years. Interest during construction would be $6,674,000. Total investment cost (sum of project and IDC cost) is $95,096,000. Interest and amortization cost of this investment is $7,611,000.

Project construction costs for combination B were estimated to be $88,267,000. The estimated construction period is years. Interest during construction would be $6,662,000. Total investment cost (sum of project and IDC cost) is $94,929,000. Interest and amortization cost of this investment is $7,598,000.

No mitigation costs are expected from this project improvement. Tables 11-9 and 11-10 summarize the costs of each combination of improvements.

Table 11-9
Cost for Combination A

Items	Costs
Investment Cost	$95,096,000
Interest and Amortization	7,611,600
Opportunity Costs	1,100,000
Operation, Maintenance, and Replacement Costs	1,000,000
Average Annual Costs	$9,711,500

Table 11-10
Cost for Combination B

Items	Costs
Investment Cost	$94,929,000
Interest and Amortization	7,598,600
Opportunity Costs	1,200,000
Operation, Maintenance, and Replacement Costs	1,215,000
Average Annual Costs	$9,913,500

c. Biological Benefits.

The District's project-specific spreadsheet model identified improvements in project-specific survival for each package ranging between -1 and 6 percent. Package A provided project survival ranging from -1 to 4 percent, depending on the powerhouse priority and species. The wide range of biological benefits is related to the assumed range for indirect mortality from predation in the tailrace that is associated with stationary outfalls. Package B showed a higher biological benefit potential than Package A, due to reduced indirect mortality from predation in the tailrace associated with transporting juvenile fish. Package B showed project survival of between 0 and 6 percent, depending on powerhouse priority and species. It is important to note that the assumption of reduced spill for fish passage efficiency associated with these project improvements is inherent in this model analysis. Therefore, the biological benefits potential of both packages is somewhat dampened.

11.11. Comparison of Improvement Costs and Benefits.

a. Costs.

Table 11-11 displays the estimated costs and implementation schedules for the system improvement measures evaluated. Fully-funded costs shown are the estimated costs of implementing the measure, including inflation based on projected implementation schedules.

Table 11-11
Summary of System Improvement Costs

Measure	Implementation Period	Total Project Cost	Fully-Funded Cost	Total Average Annual Cost
John Day Extended Screens	7	$60,700,000	$83,100,000	$3,300,000
Bonneville Bypass Outfalls	6	$49,400,000	$59,900,000	$4,500,000
John Day Spill Patterns/Flip Lips	5	$22,500,000	$29,200,000	$1,900,000
Bonneville 1 FGE	7	$29,900,000	$37,500,000	$4,400,000
Bonneville DSM	5	$9,100,000	$11,400,000	$800,000
Short-Haul Barging	6	$49,300,000	$68,000,000	$4,700,000
Bonneville Combination A	7	$88,400,000	$108,900,000	$9,700,000
Bonneville Combination B	7	$88,300,000	$116,900,000	$9,900,000
John Day Juvenile Transportation	7	$37,500,000	$50,100,000	$3,700,000
Turbine Passage	10	$289,100,000	$436,700,000	$35,300,000

b. Biological Benefits.

Changes in survival for the turbine improvement and John Day transportation measures were obtained from the CRiSP modeling. These results will be used in the main report to compare with the proposed operation of John Day at its minimum operating pool (MOP). The report on the study of John Day operation at MOP is contained in Appendix B. Figures 11-1 to 11-4 display graphically the ranges of biological benefits resulting from the spreadsheet modeling of project-specific benefits for the various species/stocks summarize in the previous paragraphs and discussed in detail in previous sections of this appendix. Note that survival benefits for coho salmon were not evaluated form John Day improvement measures. The relative cost-effectiveness of these measures based on the preliminary analyses discussed in the appendix will be presented in the main report.

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