US Army Corps
of Engineers®
Walla Walla District

Columbia River Salmon Mitigation Analysis System Configuration Study Phase I

Appendix A
Lower Snake Reservoir Drawdown Technical Report

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DRAFT

Executive Summary

1. General

This Technical Report discusses the drawdown of lower Snake River reservoirs, a concept included in the System Configuration Study (SCS). The SCS is assessing various possible alternatives to improve conditions for anadromous fish migration in the Columbia/Snake River system. The study is being conducted in two phases. During Phase I, reconnaissance-level assessments of alternatives are being performed. The alternatives that display the most potential will be carried into Phase II, where detailed, feasibility-level studies will be conducted and a plan of action will be identified. The SCS is evaluating five separate groups of alternative measures, each with its own technical report. The alternatives being evaluated are part of the Northwest Power Planning Council's *Amendments to the Columbia River Basin Fish and Wildlife Program*, dated 11 December 1991.

Lowering pool levels at the four lower Snake River projects is under consideration as a means of improving the downstream migration of juvenile fish. The objective is to increase river velocities in order to potentially reduce the travel time it takes for smolts to transit the river system and reach the ocean. Travel time has been identified as a possible factor in smolt survival, and it is believed that a reduction in travel time may increase smolt survival.

This report is a comprehensive evaluation of proposed lower Snake reservoir drawdown alternatives. It includes engineering-related issues, environmental and socioeconomic impacts, and mitigation opportunities. This report accomplished the following purposes: 1) identifies and evaluates the technical feasibility of alternative long-term modifications to lower Snake River dams to allow operation under conditions of extreme reservoir drawdown, while still maintaining safe and effective juvenile and adult fish passage; 2) evaluates the feasibility of maintaining existing project purposes and uses under extreme drawdown conditions; 3) identifies the process and estimated cost of implementing each of the technically-feasible alternatives; 4) evaluates environmental effects, including potential anadromous fish benefits; 5) identifies potential mitigation opportunities; and 6) identifies economic effects.

This report was coordinated with the Northwest Power Planning Council's Drawdown Committee and the Technical Advisory Group (TAG). The Drawdown Committee was established by the Northwest Power Planning Council, as identified in their *Strategy for Salmon,* and serves in an advisory capacity to the Council. This committee is charged with coordinating analysis conducted by the Federal agencies, and oversees the development of the plans for drawdown on the Columbia and Snake Rivers. The committee facilitates regional involvement in ongoing Federal processes related to drawdown, and helps prevent duplication of efforts between Federal and Council-sponsored efforts. The TAG is a group of technical experts representing regional fish agencies and other interested parties. The TAG provided guidance in the development and screening of alternatives and fishway design criteria. The TAG also reviewed and commented on various drafts of this document.

2. Drawdown Alternatives

Twenty drawdown alternatives were identified and screened for feasibility. These alternatives included drawdowns ranging from 33 feet below maximum normal operating pool levels to alternatives that attempt to restore near-natural flow conditions. During initial screening, twelve alternatives were found to be unsuitable, as determined by the Technical Advisory Group (TAG). These twelve alternatives were then eliminated, and one additional alternative was added. Another alternative was added by Northwest Power Planning Council's Drawdown Committee late in the process. Alternatives that propose spillway-only operations are not feasible due to the adverse impact on adult fish passage, associated high dissolved gas levels, and problems associated with passing all juvenile fish over the spillways. Variable pool alternatives that require turbine operation below existing spillway crest elevations were eliminated due to unacceptable impacts to turbines, and unacceptable operational impacts to fish bypass system components. Ten alternatives, however, were evaluated in additional detail. These ten are outlined in table ES-1:

Table ES-1
Operating Pool Ranges
River Discharges 20,000 to 225,000 cfs

Description	Alt	Project			
		Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Natural River Option	4A	339.0*	429*	518*	618*
Variable Pool	5/9	391 to 410**	483 to 503**	581 to 601**	681 to 701**
Constant Pool 33-Foot Drawdown	13/17	410 to 415	502 to 507	600 to 605	700 to 705
	13A	437 to 440	537 to 540	633 to 638	700 to 705
Constant Pool 43-Foot Drawdown	14/18	400 to 405	492 to 497	590 to 595	690 to 695
Constant Pool 52-Foot Drawdown	15/19	391 to 396	483 to 488	581 to 586	681 to 686
Existing Spillway Crest Elevations	--	391	483	581	681
Pool Elevations--Existing Normal Operation	--	437 to 440	537 to 540	633 to 638	733 to 738

*Approximate water surface elevation for a river discharge of 20,000 cfs.

**Juvenile bypass system operation may not be biologically acceptable at the upper limit pool range proposed by this alternative.

3. Structural Modifications

Each of the drawdown alternatives requires significant modifications to various features of the four lower Snake River dams. Features requiring modification to accommodate drawdown operations include adult fish passage facilities, juvenile fish bypass facilities, spillways, and turbines. For some alternatives, new structures must be added. Additionally, features such as navigation lock guide walls and debris shear booms will require modification. Earth embankments, railroad fills, highway fills, and culvert outfalls will require additional riprap protection to accommodate drawdown operations.

The proposed dam modifications necessary for drawdown operations were developed with the following design philosophy: 1) minimize risks to fisheries during, and after, construction; 2) utilize proven technology wherever possible, especially with regards to fish bypass systems; 3) be consistent with current practices within the U.S. Army Corps of Engineers (Corps); and 4) maintain project integrity during, and after, construction. This study is limited to the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor projects.

4. Implementation Costs and Schedules

a. Costs

The reconnaissance-level, fully-funded project costs, including real estate, for the drawdown alternatives range from an estimated $87.2 million to $4.9 billion. The construction costs are based on an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, model studies, design memorandums, and engineering and design is included at an estimated 28 percent of construction costs. Construction management is estimated at 11 percent of construction costs. Contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study.

Estimated annual implementation costs range from $10 million to $524 million. These costs include interest and amortization of the project costs at an 8-percent interest rate (current Federal Discount rate), and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

The costs do not include required modifications to irrigation plants, recreation facilities, and port facilities; as well as hydropower losses, biological mitigation, and the costs of measures needed to protect cultural resources exposed during drawdown operations.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

b. Schedules

The implementation of a drawdown will vary depending on the alternative selected. Implementation includes feature design memorandums, engineering and design, construction, and post-construction evaluation. Implementation schedules, as presented, would begin following authorization and appropriation. Modifications to the four lower Snake River dams are anticipated to take from 14 to 17 years to fully implement, depending on the selected alternative, and assuming unlimited resources. Modifications to accommodate drawdown operations of the Lower Granite reservoir only (alternative 13A) are anticipated to take about 4 years from the date of authorization and appropriation. Resource limitations such as manpower, money, or materials may extend these time periods.

5. Economic Analysis

a. Alternatives and Conditions Evaluated.

(1) The Base Case (No Action).

This alternative reflects the current operation of the Snake River, with interim flow improvement measures made in response to the Endangered Species Act listing of Snake River salmon.

It includes 3.0 million acre-feet (AF) of flow augmentation water on the Columbia, additional water volumes from Dworshak in the spring and summer, flood control shifts from Dworshak and Brownlee to Grand Coulee, and up to 42,700 AF of additional upper Snake River water.

This alternative is very similar to the way the system operated in 1992, and reflects the results of Endangered Species Act Section consultation with the National Marine Fisheries Service in 1992. The strategy is consistent with the 1992 to 1993 operations described in the Corps' *Interim Columbia and Snake River Flow Measures Supplemental EIS (SEIS)*, dated 1993.

The base year, or beginning of the analysis period, for the SCS Phase I, is 2000. This is the first year an alternative could be implemented. National Economic Development benefit estimation in the Corps' planning process proceeds by comparing forecasts of economic conditions without the project to forecasts of economic conditions with the project. Therefore, all alternatives presented in the SCS Phase I report are compared against the base case to obtain the incremental change.

(2) Mitigation Opportunities.

All reservoir drawdown alternatives will impact natural resources, cultural resources, and commerce. The Northwest Power Planning Council, in amendments to the Columbia River Basin Fish and Wildlife Program (Phase 2), calls for the development of a mitigation plan consisting of measures to mitigate the impact of the reservoir drawdown strategy to the greatest extend practicable.

Analysis completed under SCS Phase I has identified opportunities to mitigate navigation, hydropower, irrigation, recreation, and cultural resource impacts associated with reservoir drawdown alternatives.

Where it is not possible to develop impacts and/or mitigation measures, they are identified as future study requirements in Section 10 of this report.

b. Overall Effectiveness of Alternatives.

An economic analysis for each of the drawdown alternatives was completed for the SOR. The analysis examined both a 2- and a 4.5-month drawdown period for each of the alternatives. The net economic costs of the drawdown alternatives range from $140 to $956 million annually. The following table is a summary of incremental economic costs by alternative. The incremental costs (net economic cost) is the additional cost of the drawdown alternative as compared to existing conditions (base case). The base case reflects the current operation of the Snake River with the interim flow improvement measures made in response to the ESA listing of Snake River salmon.

These costs include an analysis of each alternative by recreation, flood control, net farm income, increased municipal and industrial water use, shallow draft transportation, Dworshak log-trucking transportation, and system generation.

These costs do not include the entire costs associated with alternatives 5, 9, 14, 15, 18, and 19, since the above economic category analysis was not conducted. Additionally, no attempt as made to place monetary values on the endangered anadromous fish or their habitat. Mitigation costs for recreation and cultural resources also must be examined in the overall evaluation of the true cost of an alternative. The mitigation costs presented in this report are offered for consideration, and to show the possible scope of mitigation required.

The analysis did not take into account the different implementation dates of the various alternatives. Therefore, although the benefits and costs were amortized (using 8.25 and 8.0 percent, respectively) over 100 years, the values were not brought back to present value. These undiscounted values include all lower Snake River projects, as well as John Day to minimum operating pool.

Table ES-2
Comparison of Total Annual Economic Cost*

Alternative Description	Net Economic Costs (Change From the Base Case)
Base Case (No Action)	$0
4A, Natural River, 2 Months	$949,038,048
4A', Natural River, 4.5 Months	$956,387,609
5, Variable Pool with Existing Powerhouse/Existing Spillway, 2 Months	*1
5', Variable Pool with Existing Powerhouse/Existing Spillway, 4.5 Months	*1
9, Variable Pool, Modified Powerhouse with Existing Spillway, 2 Months	*1
9', Variable Pool, Modified Powerhouse with Existing Spillway, 4.5 Months	*1
13, Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 2 Months	$356,116,566
13', Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 4.5 Months	$360,348,712
13A, Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	$140,298,975
13A', Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	$152,625,957
14, Constant Pool, 43-Foot Drawdown with Modified Spillway, 2 Months	*2
14', Constant Pool, 43-Foot Drawdown with Modified Spillway, 4.5 Months	*2
15, Constant Pool, 52-Foot Drawdown with New Spillways, 2 Months	*2
15', Constant Pool, 52-Foot Drawdown with New Spillways, 4.5 Months	*2
17, Same as Alternative 13, With Modified Powerhouse	*3
17', Same As Alternative 13', With Modified Powerhouse	*3
18, Same As Alternative 14, With Modified Powerhouse	*4
18', Same As Alternative 14', With Modified Powerhouse	*4
19, Same as Alternative 15, With Modified Powerhouse	*4
19', Same as Alternative 15', With Modified Powerhouse	*4

*1 - Costs were not analyzed for recreation, flood damages, net farm income, increased M&I water cost, shallow draft transportation, Dworshak log-trucking, or the system generation. Therefore, net total economic cost is unavailable.
*2 - Costs were not analyzed for recreation, flood damages, shallow draft transportation, or Dworshak log-trucking. Therefore, net total economic cost is unavailable.
*3 - Costs were not analyzed for system generation. Therefore, net total economic cost is unavailable.
*4 - Costs were not analyzed for recreation, flood damages, shallow draft transportation, Dworshak log-trucking, or system generation. Therefore, net total economic cost is unavailable.

c. Regional Economic Development.

Regional economic activity is measured using input/output analysis, a method used to estimate the size of economic impacts to regions and communities. Many of the alternatives would affect local economies. For example, alternatives that decrease opportunities for recreation (through lowering reservoir elevations) may result in less recreation money spent in that region. The input/output model, IMPLAN, was used to conduct the regional economic analysis.

6. Environmental Effects.

a. Physical Effects.

(1) Water Quality.

Drawdown will cause substantial changes in water quality, but it is not possible to precisely predict the magnitude of those changes, and the extent of certain changes will vary among the specific drawdown alternatives. The effect of drawdown on some aspects of water quality is unknown. Turbidity will increase with all drawdown alternatives due to resuspension of sediments deposited within the reservoirs being re-exposed to precipitation, wind, and wave action. The natural river option will likely see the highest increases, but the effect will likely lessen as the river eventually erodes back to original bed material. Of the near spillway crest alternatives, the variable pool alternatives would likely cause the greatest increase in turbidity over the longest period of time. There will be some increases in turbidity as a result of construction of project modifications, including the installation of riprap along reservoir embankments.

Compared to existing levels for an equivalent river flow, dissolved gas levels will increase under the near spillway crest alternatives as powerhouse hydraulic capacity is reduced. It is not possible to predict the levels that will be reached, however, because conditions under a drawdown will be substantially different from existing conditions. While structures will be in place to maintain tailwaters at a similar elevation (drumgates or weirs), and there will be free-flowing river stretches below the dams, the frequency and amount of spill will be greater than under normal project operations, and all four projects will be spilling more often, thus increasing the cumulative effect. Some proposed project operation scenarios will result in higher dissolved gas levels than those that maximize powerhouse operation. The Lower Granite only option will result in the least increases in dissolved gas levels of the near spillway crest alternatives. Dissolved gas levels under the natural river option should be substantially lower than under full pool operations, since all flow would pass through the bypass structures rather than over the spillways. Completion of adult fish passage facility modifications at powerhouses for up to 2 years, resulting in a potential for substantial increased dissolved gas levels during the spring freshet.

The level of contaminants in the water column may increase as a result of resuspension of sediments to which they are attached. There are insufficient data on soil contaminants to predict effects. The effects on dissolved gas and nutrient cycling are not known.

The overall effects of the near spillway crest alternatives on reservoir temperature are unknown. Temperatures may increase slightly, or they may decrease. The natural river option should result in temperature regimes closer to that of the river prior to impoundment, although the effects of dams upstream of the Lower Granite reservoir will still be present.

(2) Water Velocity.

Water travel time will be reduced from 51 to 72 percent in the near spillway crest alternatives. The lower the pool is drafted, the higher the average velocities through the reservoir. Most of this increase is a result of returning the upper portion (approximately one-third) of the reservoirs to a free-flowing river stretch. Velocities in the remaining pool do not change substantially. The greatest reduction in water travel time occurs in the natural river option, which essentially returns the entire reservoir to a free-flowing river, with the exception of small areas immediately surrounding the dam structures. The natural river alternative results in a water travel time that is less than 10 to 20 percent (depending on flow) of normal pool levels. The natural river option is the only alternative that can meet the 140,000-cfs flow target proposed by the Columbia Basin Fish and Wildlife Authority in all flow years. All other alternatives would require some level of flow augmentation during low flow years to meet the proposed 140,000-cfs target.

(3) Other.

All drawdown alternatives would affect groundwater levels in the vicinity of the reservoirs. The lower the pool surface elevation, the greater the magnitude and range of effect. Extended drawdown would likely increase levels of dust in the atmosphere adjacent to the lowered reservoirs, but no health effects are anticipated.

b. Biological Effects.

(1) Anadromous Fish.

(a) Effects of Water Quality Changes.

Changes in water quality will affect anadromous fish but, since it is not possible to predict the water quality changes (at least not precisely), the extent to which anadromous fish will be affected is unknown. Increased turbidity has the potential for both positive and negative effects. Turbidity has the potential to cause gill damage to both adult and juvenile salmonids.

The extent of effects of high dissolved gas levels that occur as a result of normal pool operations are uncertain. Drawdown scenarios that increase dissolved gas levels are more likely to cause negative impacts to salmonids, thus resulting in a potential decrease in survival. All drawdown alternatives may result in increased mortality during the construction of adult fish passage modifications. The degree to which adult and juvenile salmonids can and do compensate for increased dissolved gas levels by lowering their position in the water column is unknown. Since the entrances to the collection channels and ladders are near the surface, adult salmonids are forced into shallower water where the impact of high dissolved gas levels is greater when they are seeking passage past the dams. Evidence of injury to adult salmonids from high dissolved gas levels has been observed at the lower Snake projects.

(b) Effects of Water Velocity Changes.

The increase in average reservoir velocity resulting from drawdown has the potential to reduce juvenile fish travel time through the lower Snake reservoirs. However, how the fish will respond to the change in *average* velocity is uncertain. Mathematical models were used to predict the change in travel time, which was greatest for spring Chinook. For the near spillway crest alternatives, reductions of 14 to 32 percent were predicted for spring Chinook salmon, depending on the assumptions used in the model and the flow (critical water years and the 50-year average were modeled). Reductions in travel time for summer and fall Chinook were predicted, but were less substantial. There are many uncertainties with the assumptions and the data used in the models, since there are many factors that affect fish travel time. In addition, the models do not take into account potential increased delay at the dams, or the effects of refill operations. The natural river option has the greatest potential for reducing juvenile fish travel time through the lower Snake reservoirs.

All near spillway crest alternatives are likely to increase adult travel time. All near spillway crest alternatives are likely to increase adult travel time. The net effect of the natural river option on adults is uncertain. Increases in average velocity through the reservoir stretch will increase the amount of time it takes adults to pass through what was formerly a pool area, but the elimination of time required to find and pass through adult fish passage facilities at the dams may result in a net decrease in travel time.

(c) Effects of Drawdown on Survival.

The relationship between juvenile travel time and survival is not clear. While there is a potential to increase juvenile salmon survival through a reduction in travel time resulting from lowered pool elevations, there are many factors that affect survival, and many of these may also be affected by drawdown. Negative impacts to juvenile and adult salmonids can occur during both construction of the modifications required to implement drawdown and during operation of the various drawdown scenarios. Dam passage facilities would be designed with state-of-the-art knowledge, but this is based on current operating conditions. Drawdown will result in substantial changes to project operating conditions. The effects of these changes on adult and juvenile travel time and survival are uncertain but are, based on initial evaluation, likely to have negative impacts.

Mathematical models were used to try to predict relative potential benefits of the proposed drawdown scenarios. The primary purpose of the salmon survival models is not to predict actual numbers of surviving juveniles, but to compare the results of different alternatives and options. The models used represent a range in interpretation of the existing flow, juvenile travel time, and survival data. However, there are many factors that these models do not take into account, or for which no data applicable to a drawdown scenario is available.

Increased migration rate (*e.g.*, decreased travel time) is expected to potentially increase the survival of smolts through the reservoir environment mainly because of the potential for decreased contact with predators. However, if overall smolt survival is to be increased, passage mortality must not be increased from current levels. Thus, smolt mortality during each route of dam passage (*i.e.*, bypass, turbine, and spill mortality) must not increase markedly during drawdown. Intuitively, the natural river option would decrease travel time, and decrease mortality from dam passage. No other alternatives would satisfy these assumptions, and expected benefits (if any) from implementation are debatable. The model results verify these conclusions. Based on existing mathematical models, only the natural river option shows a potential benefit, and then only to spring and summer Chinook stocks. Survival under any of the drawdown alternatives has not been compared with expected survival based on completion of all currently planned adult and juvenile fish facility improvements.

(2) Resident Fish.

Resident fish species that use shallow-water habitat for spawning, rearing, and adult feeding will be affected by reservoir drawdown. Smallmouth bass and channel catfish are introduced resident game fish of concern. Native species such as white sturgeon and northern squawfish prefer more lotic environments, and could benefit from a drawdown. Northern squawfish utilize shallow nearshore habitat for rearing. However, the increase in lotic habitat, preferred for spawning and adult habitat needs that will occur as a result of drawdown, could mitigate for the loss of juvenile raring habitat.

Two-month drawdowns could adversely affect smallmouth bass populations. The spawning success of smallmouth bass and channel catfish could be adversely affected if they were flooded off of their nests during the spawning period. Depending on water temperatures, spawning could occur after drawdown refill with little or no adverse effect. For resident fish that have already spawned, the stranding of fry and/or adults may occur because some species (*i.e.*, channel catfish and smallmouth bass) remain with their fry for a period of time after hatching.

Under a 4.5-month drawdown, most species could still spawn during the stable low flow period, because suitable shallow water habitat would still be present. This scenario would provide stable pool levels for spawning in a riverine environment that should be favorable to smallmouth bass. However, an extended drawdown may result in reducing the food items available to juvenile fish during and after reservoir refill. Zooplankton will decrease during an extended drawdown because less lentic area will be available during the productive season.

Constant pool drawdowns would be more beneficial to smallmouth bass than variable pool, because spawning habitat will be kept submerged over a longer period of time. There may be an increase in the amount of production to the early life-history stage. The amount of deepwater habitat is reduced under the near spillway crest alternatives from current operations. This may provide a good compromise for white sturgeon by limiting the depth of the drawdown and maintaining some deep holes for rearing, while still providing some high-velocity habitat for spawning. Since drawdown in these alternatives is not as deep as the natural river option, severe impacts to the benthos and other food production components may not occur.

Under the variable pool alternatives (near spillway crest), egg incubation success for smallmouth bass and channel catfish will be reduced substantially if the pool is fluctuated more than 2 to 3 feet during June and July. Variable pool elevations would likely increase stranding events.

If the natural river option were implemented, northern squawfish might benefit by having prey concentrated to a more confined water channel. The extreme (>115 feet) fluctuations on an annual basis would generally result in negative impacts to introduced resident fish in the Lower Granite reservoir. A 2-month natural river drawdown would have deleterious impacts to smallmouth bass because of the rapid rise in pool elevations during the spawning period. Flooding of bass spawning nests would place already spawned eggs in over 100 feet of water, with little chance of successful egg incubation, or would force adult fish off of the nests and prohibit spawning from occurring. This assessment also assumes that the substrate that exists at the lower elevation is suitable for spawning.

In the 4.5-month natural river drawdown, when the reservoir is refilled in September, a substantial change in the rearing environment will occur. This may force young-of-the-year fry in deep, open water for a short period of time. If the young-of-the-year do not reorient to the rising water level, they will have difficulty finding food, and might also be subjected to increased predation. Increased water velocities and riverine habitat should benefit sturgeon and northern squawfish spawning. Food production would be expected to decrease, primarily because of the loss of benthic production and crayfish under reduced reservoir conditions. If the reservoir level were kept down, more riverine, lotic-type invertebrates may colonize and provide forage for the lost production from the dewatered benthos.

White sturgeon reproductive success may actually be higher for drawdown than under current conditions because of increased lotic habitat. Crayfish, which are a major food source for white sturgeon, smallmouth bass, and northern squawfish, will likely decrease due to stranding. Plankton will be entrained downstream, thus reducing the food supply for juvenile centrarchidae. Less suitable spawning and rearing habitat might be available because of siltation effects of the reservoir. Predation on fry and yearling smallmouth bass could increase due to the lack of cover. All resident fish young-of-the-year and juveniles would be vulnerable to the rapid lowering of water levels. Drawdown will alter availability and complexity of specific habitat types for all resident fish young-of-the-year and juveniles. The physical flushing of young-of-the-year out of the reservoirs could be a serious problem with drawdown. Nest-building species that guard their nests (*i.e.*, channel catfish, sculpin, and smallmouth bass) will be vulnerable to stranding and desiccation if they spawn before drawdown. Resident catostomids and cyprinids (including northern squawfish) may benefit from an increase in the potential spawning habitat formed by additional high velocity habitat. This may result in the additional recruitment of subyearlings, and offset the loss of rearing habitat.

(3) Wildlife.

Wildlife habitat would be affected by the loss of hydrologic connection to the main river channel. The water supply for vegetation would be interrupted due to changes in the river channel and the water table.

Potential impacts to waterfowl nesting in the lower Snake River include: 1) reduction in nesting habitat or inundation of nests during the breeding season; 2) increased rates of predation due to land bridging; and 3) decreased forage (*e.g.*, benthic invertebrates) in shallow-water areas. In addition, water-level fluctuations can affect brood success through decreases in food availability or increases in energy demand caused by increased travel between feeding areas and cover. When complete drawdown occurs, aquatic invertebrates are eliminated or greatly reduced, and feeding conditions for breeding waterfowl deteriorate rapidly.

Impacts to raptors are not anticipated to be severe, because raptor species occurring in the lower Snake River generally use cliff and riparian habitat for nesting and perching, and forage in upland fields. The timing and duration of drawdown would have a greater impact on raptors due to the lost production of prey species that inhabit embayments, shallow-water areas, and riparian and wetland habitats during raptor breeding and nesting season. The overall goal, which is to increase smolt survival and the number of adults returning to the lower Snake River system, should provide the long-term benefit of increasing anadromous fish stocks for bald eagle foraging. Negative long-term effects on wintering bald eagles may result from the decreased production of waterfowl associated with reduced nesting habitat and reduced numbers of upland game birds.

It is anticipated that upland game bird habitat may be impacted by a drawdown. Effects to upland game bird habitat would be largely related to changes in riparian vegetation or changes in current land use on uplands adjoining the projects.

Insects, reptiles, and amphibians that are reliant on moist soils or waters of riparian and wetland habitats may be impacted by a drawdown. Because many of these species rely on microsites, impacts could be manifested in the loss or permanent displacement of the species.

Although a majority of small mammals are able to relocate temporarily, continued fluctuation of water levels would likely displace species permanently or result in reduced overall production potential. Impacts to furbearers as a result of drawdown will include the exposure of muskrat, beaver, and river otter dens during breeding season, a reduction in riparian and wetland habitat, and the exposure of riprap den sites. In addition to the exposure of furbearers along project shorelines, the change in spatial distribution of vegetation within riparian habitat may influence species-specific foraging efficiency (*e.g.*, beavers). The primary effects to mule deer would be associated with a reduction in riparian habitat and increased distance from forage to cover.

7. Mitigation Opportunities.

All reservoir drawdown alternatives will impact natural resources, cultural resources, and commerce. The mitigation measures described in this report identify the various means of dealing with the impacts associated with the reservoir drawdown alternatives. It is not the intent of this report to provide an in-depth impact assessment of each drawdown alternative or to present detailed mitigation measures. Where it is not possible to develop specific mitigation measures, sufficient data was collected to identify the magnitude of potential implementation or alternative action and cost.

The Northwest Power Planning council, in amendments to the Columbia River Basin Fish and Wildlife Program (Phase Two), calls for development of a mitigation plan consisting of measures to mitigate the impact of the reservoir drawdown strategy to the greatest extent practicable. This report addresses those measures and identifies the magnitude of mitigation actions. Mitigation and/or enhancement opportunities identified in the Fish and Wildlife Planning Aid Report, prepared by the U.S. Fish and Wildlife Service, were taken into consideration.

All navigation on the Snake River would cease during reservoir drawdowns unless physical modifications are made to existing navigation locks, the river channels below each lock and dam, and the existing port facilities; as well as creating a fleet of small barges. Based on limited opportunities, and the magnitude of physical modifications to mitigate the impact to navigation, and the potential need for a second fleet of smaller barges; physical modifications to maintain barge traffic during reservoir drawdowns are not considered. It is assumed that commodities would be shipped by an alternative method (either truck or rail), or not shipped at all during reservoir drawdown.

Reservoir drawdowns would reduce the operating head on the turbines, thus impacting hydroelectric production. Physical modifications to turbines and generators to improve efficiency and output are under consideration. However, such modifications will not mitigate the loss; they will only reduce hydropower generation losses. This report identifies the hydropower losses in terms of combustion turbines as a resource that would be acquired to meet system electrical load in months when system hydropower generation is decreased. Specifying exactly how losses will be replaced was not addressed by the SOR, and is not within the scope of this Phase I report.

Investigations revealed 31 active pumping facilities along this nearly 150-mile section of the lower Snake River. Twenty-nine of these stations will require some revisions to allow them to operate under the proposed drawdown alternatives. For the purpose of this study, it is assumed that all pump stations are vertical turbine platform stations, because the data collected shows that only two of the smaller stations vary from this design. The predominant modification recommended is to install low-head, submersible pumps to pump water from drawdown elevations to the existing pumping facilities. Construction costs range from $29 to $33 million for constant and variable pool drawdowns. The construction cost for a near natural river drawdown is about $38 million.

In addition to direct pumping from the river, a limited amount of irrigation comes from wells that pump from gravel benches along the river. The rate of withdrawal, dept of the well, proximity to the river, and duration of drawdown would affect the output of these wells. The analysis of this potential impact and mitigation is beyond the scope of this reconnaissance-level study.

Data collected suggests that overall recreation activity at Snake River recreation sites during drawdowns will be less than half of historic visitation. Mitigation for this effect ranges from complete rebuilding of park sties to providing only boat launching facilities for drawdown elevations. The choice between rebuilding a site or installing only boat launching facilities will depend on the recreation value of each site and the topography of the shoreline. Estimated construction costs may range from $23 million to about $46 million.

Mitigation of potential cultural resource damage would include testing each identified site, and choosing between the recovery of artifacts and data or *in situ* protection of the site. The choice of recovery or protection can only be determined following testing of each site after reservoir drawdown is completed. A total of 109 sites are known to exist under constant pool conditions, and 145 known sites would be exposed at near natural river conditions. Based on the number of sites, limited drawdown time, and availability of archaeologists, mitigation activities could take about 9 years for constant pool conditions and about 14 years for the near natural river conditions. The cost of mitigating cultural resources by testing and data recovery is about $82 million. Testing and protection-in-place is about $187 million for constant pool conditions. Mitigation costs for near natural river conditions are about $111 million for testing and recovery and about $334 million for testing and *in situ* protection.

Generally, the construction of mitigation measures would be completed during the same time period that other modifications are made to the Snake River projects. However, portions of mitigation work for pumping facilities, recreation facilities, and cultural resources can only be accomplished once the reservoirs are in a drawdown condition.

8. System Operation Studies.

System operation studies were conducted using a Bonneville Power Administration computer program called HYDROSIM, which is a program for computing power production. A number of alternatives were evaluated to show the effects on reservoir elevations and power production in the Columbia River system. There are two drawdown periods: 15 April through 15 June, and 15 April through Labor Day. The Columbia River system was modeled using a continuous operation (the results at the end of one year would be the starting condition for the next year). The computational period for each condition is from water year 129 through water year 1978.

9. Additional Required Studies.

If lower Snake reservoir drawdown is selected as an alternative to be further evaluated in the feasibility phase of the SCS, additional work will be necessary to provide more data to evaluate the concept. Engineering, environmental, system operation, economic, and mitigative studies will be initiated to further define and quantify unknown parameters.

10. Conclusions.

All drawdown alternatives will require substantial modifications to each of the four lower Snake River dams except for alternative 13A, which requires modifications to Lower Granite only. Construction cost estimates for the four reservoir drawdown alternatives range between $1.3 billion and $4.9 billion. The construction cost estimate for alternative 13A is $87.2 million. These costs are based on the October 1992 price level adjusted for inflation to midpoint of construction (using OMB inflation factors).

For the four reservoir drawdown alternatives, implementation timeframes are long, ranging from 14 to 17 years from the date authorization is enacted and construction funds are appropriated to construction completion. For the Lower Granite only alternative, implementation is anticipated at 4 years.

Economic effects of the four reservoir drawdown alternatives are substantial. The net economic costs of the drawdown alternatives range from $140 million (alternative 13A) to $956 million (alternative 4A) annually. These economic costs include both the cost of construction, as well as direct and indirect economic impacts to other system users. The economic costs include modification costs, recreation impacts, flood damage reduction charges, losses to farm income, impacts to municipal and industrial water supply, increases in transportation, and hydropower costs. These costs do not include potential mitigation opportunities for recreation, cultural resources, and fish and wildlife.

There are many negative environmental impacts that would result from the implementation of all reservoir drawdown alternatives. Impacts to resident fish and wildlife could potentially be mitigated by year-round drawdowns. However, using modeling results and currently limited biological information and judgment, only the natural river option shows a consistent potential benefit for anadromous fish, with the exception of fall Chinook. Percent relative change from base case for each of the alternatives is summarized in tables ES-3 (critical water years) and ES-4 (50-year average).

Table ES-3
Predicted Absolute Change in Relative Survival
From Base Case for Drawdown Alternatives in Critical Water Conditions
From the Head of Lower Granite Reservoir to Below Bonneville Dam

Stock	Four-Pool 33-Foot Drawdown "Worst Case"	Four-Pool 33-Foot Drawdown "Best Case"	Four-Pool 33-Foot Drawdown No Changes in Dam Passage Parameters	Four-Pool 52-Foot Drawdown "Worst Case" (PAM Only)	Four-Pool 52-Foot Drawdown "Best Case" (PAM), or No Change in Dam Passage Parameters (CRiSP)	Four-Pool Variable Pool Drawdown No Changes in Dam Passage Parameters	Natural River Option	Lower Granite Only, With No Changes in Dam Passage Parameters (CRiSP) or "Best" and "Worst" Case (PAM)
Spring Chinook (CRiSP)	-25	-4 to 8[2]	-10.9 to -12.3[2]	Not run	-7.8 to -8.8[2]	-7.6 to -7.9[2]	+8 to +11[2]	+3
Spring Chinook (PAM)[1]	-9.2 to -15.7	-1 to -7.5	Not run	-6 to -12.5	+5 to -1.5	Not run	-0.4 to +6.1	-0.7 to +6.3
Summer Chinook (CRiSP)	-25	-5	-10.9 to -11.2[2]	Not run	-7.9 to -8.9[2]	-7.7 to -7.9[2]	+8 to +9[2]	+2
Fall Chinook (CRiSP)	-29	-19 to -21[2]	Not run	Not run	Not run	Not run	-14 to -15[2]	+1 to +3[2]
Dworshak Steelhead (CRiSP)	-33	-17 to -18[2]	-16.6 to -17.6[2]	Not run	-11.3 to -13.2[2]	-2.2 to -12.5[2]	-1	+1

[1] Results are in a range because of two different assumptions about transport benefits. See SOR anadromous fish technical appendix.

[2] Results are in a range representing the 2- and 4.5-month scenarios. The PAM cannot model fall Chinook, therefore no 4.5-month scenarios were run.

Table ES-4
Predicted Absolute Change in Relative Juvenile Survival From Base Case for Drawdown Alternatives Over 50-Year Average Conditions From the Head of Lower Granite Reservoir to Below Bonneville Dam

Stock	Four-Pool 33-Foot Drawdown "Worst Case"	Four-Pool 33-Foot Drawdown "Best Case"	Four-Pool 33-Foot Drawdown No Changes in Dam Passage Parameters	Four-Pool 52-Foot Drawdown "Worst Case" (PAM Only)	Four-Pool 52-Foot Drawdown "Best Case" (PAM), or No Change in Dam Passage Parameters (CRiSP)	Four-Pool Variable Pool Drawdown No Changes in Dam Passage Parameters	Natural River Option	Lower Granite Only, With No Changes in Dam Passage Parameters (CRiSP) or "Best" and "Worst" Case (PAM)
Spring Chinook (CRiSP)	-25	-4	-10.5	Not run	Not run	-8.1 to -8.3[2]	+7 to +8[2]	+2
Spring Chinook (PAM)[1]	-3.7 to -9.7	+7.7 to +13.7	Not run	-1.9 to -739	+10.8 to +16.8	Not run	+11.4 to +17.4	-1.4 to +5.8
Summer Chinook (CRiSP)	-24	-1	-9.2 to -9.4[2]	Not run	Not run	-7 to -7.2[2]	+10	+2
Fall Chinook (CRiSP)	-40	-24 to -26[2]	Not run	Not run	Not run	Not run	-11 to -13[2]	+3 to +4[2]
Dworshak Steelhead (CRiSP)	-36	-20 to -21[2]	-13.7 to -13.8[2]	Not run	Not run	-10.7 to -10.8[2]	+2	+2

[1] Results are in a range because of two different assumptions about transport benefits. See SOR anadromous fish technical appendix.

[2] Results are in a range representing the 2- and 4.5-month scenarios. The PAM cannot model fall Chinook, therefore no 4.5-month scenarios were run.

Two mathematical models were used to attempt to quantify the potential relative benefits of reservoir drawdown alternatives. The models were run with a range of assumptions about the survival benefits of reduced juvenile travel time. Both were run with sets of optimistic and pessimistic reservoir mortality and dam passage parameters as a sensitivity analysis. Model results from the Passage Analysis Model (PAM) for Snake River spring Chinook indicated a potential maximum increase in juvenile fish survival of 14 percent for the four pool, 33-foot drawdown, and 16 percent for the 52-foot drawdown over the 50-year average water conditions, assuming dam passage conditions that are substantially better than those currently existing (which is unlikely given current information). However, in the critical low water years, PAM showed no measurable benefits and a potential decline in survival, even with optimistic dam passage conditions (a maximum of 5-percent increase in juvenile survival for the 52-foot drawdown, and as much as a 15-percent decrease in juvenile survival for the 33-foot drawdown). The Columbia River Salmon Passage (CRiSP) model results did not indicate any potential benefits for spring Chinook for the four-pool, near spillway crest alternatives. They also indicated substantial losses for fall Chinook, even with optimistic dam passage and reservoir mortality assumptions. The models do not account for many of the variables [see section 6.03.d.(1)(c)] that could have additional substantial negative impacts on anadromous fish survival as a result of drawdown.

The only near spillway crest drawdown alternative to show possible marginal benefits for all stocks was the Lower Granite only option, with transport. The CRiSP model showed only a 1- to 5-percent potential benefit in juvenile survival for this alternative, but these results could change with dam passage parameters adjusted to reflect worsened conditions for collection and bypass hydraulics during a drawdown. Survival could be substantially worse with these hydraulic changes associated with drawdown than under existing conditions for spring Chinook. The PAM showed a maximum gain of 6 percent under best case assumptions, and a potential loss of approximately 1 percent under worst case assumptions.

Both CRiSP and PAM showed potential benefits for spring and summer Chinook juveniles under the natural river option, for both the critical water period and the 50-year average. The CRiSP showed higher potential benefits in the critical water year (11 percent for spring Chinook and 10 percent for summer). The PAM modeling resulted in extremes of no change for spring Chinook to a gain of 6 percent, depending on assumptions regarding transport. The CRiSP estimated an 11- to 15-percent reduction in survival for fall Chinook, and no substantial change for steelhead (-1 to +2 percent).

While there are many uncertainties regarding the model parameters and results that could be tested and further refined, it is highly unlikely that these refinements would produce substantial additional benefits for drawdowns below minimum operating pool to spillway crest. The PAM model utilizes a strong positive relationship between flow and survival, and ascribes relatively low benefits to transportation. These are the two main areas where changes would drive higher benefits for drawdown alternatives. It is very unlikely that any further studies would modify these relationships to an extent that would result in higher potential benefits for minimum operating pool to spillway crest reservoir drawdowns. Tests of drawdown could only affirm the flow/travel time/survival relationship used in the PAM model, but this would not increase the potential benefit that PAM modeling would show for drawdown. Potential detrimental effects not accounted for by the models, including construction, drafting, refill, adult fish passage, and other areas of impact all could adjust both model results (PAM and CRiSP) substantially downward. In addition, the base case (for both PAM and CRiSP) used for comparison did not incorporate the potential benefits of ongoing improvements to existing fish passage facilities, including new juvenile fish bypass systems at Ice Harbor and The Dalles Dams, and extended-length screening devices at Lower Granite, Little Goose, and McNary Dams, *etc.* Adjusting dam passage parameters to reflect these improvements would result in higher survival for the base case, and a reduced potential improvement for reservoir drawdown alternatives.

Based on the identified potential impacts, as presented in the qualitative discussions contained in this report, the results of the fish models (with current limitations and assumptions) as a means for comparing potential relative benefits, and the limited utility of a test drawdown to obtain definitive information that would enhance the potential benefit that would reasonably be expected from minimum operating pool to near spillway crest drawdowns, it is recommended that the natural river option be the only drawdown option considered further in Phase II.

Pertinent Data

Ice Harbor Lock and Dam
Snake River, Washington

Pertinent Data

General

River mile	9.7
Drainage area, square miles	109,000
Normal hydraulic height, feet	100
Maximum structural height, feet	208
Overall length at crest, feet	2,790
Discharges, cfs	
Minimum of record (1958)	6,660
Mean annual	48,840
Standard project flood	420,000
Maximum of record (1894)	409,000
Spillway design flood	850,000
First power on line	December 1961
Concrete, cubic yards	1,330,000
Reinforcing steel, pounds	50,000,000

Estimated Cost

1992 Price Level Construction Cost (Assumes original construction procedures)	$680,000,000

Reservoir

Name	Lake Sacajawea
Length	31.9 miles
Average width	0.4 mile
Maximum width	1.0 mile
Normal operating range gauged at dam	437-440 feet msl
Maximum pool elevation (850,000 cfs)	446.4 feet msl
Surface area at elevation 440 (low flow)	8,375 acres
Storage between elevation 437 and 440 (low flow)	24,900 acre-feet

Dam	
Powerhouse, overall length	671 feet
Spillway, total length	590 feet
Navigation lock, overall width	173 feet
Concrete nonoverflow sections:	
Navigation lock to spillway, length	154 feet
Spillway to powerhouse, length	40 feet
Powerhouse to south shore, length	560 feet
Earth embankments, length (right)	624 feet
Total length of dam	2,822 feet
Maximum height of concrete section	213 feet
Maximum height of abutment section	123 feet
Deck elevation	453 feet msl

Powerhouse	
Number of hydro-generating units	
Initial installation	3
Ultimate installation (current operating units)	6
Turbines	
Type	Kaplan
Number of blades	6
Synchronous speed	
Units 1 through 3	90 rpm
Units 4 through 6	85.7 rpm
Runner Throat diameter	
Units 1 through 3	280 inches
Units 4 through 6	300 inches
Plant discharge at rated head and output (6 units)	94,000 cfs
Total rated generator capacity at 0.95 power factor	603,000 kW
15% total overload generator capacity at 0.95 power factor	690,000 kW

Spillway

Type	Ogee, concrete gravity, gate controlled
Maximum width at base, el 304 feet msl	139 feet
Maximum height, foundation to deck	141 feet
Number of bays	10
Overall length, including piers	590 feet
Clear length	500 feet
Crest elevation	391 feet msl
Gate seal elevation	389.07 feet msl
Top of gate in closed position	442 feet msl
Deck elevation	453 feet msl
Gate lip elevation at maximum opening	436 feet msl
Type of gates	Tainter
Size of gates	52.9 feet high by 50.0 feet wide
Method of operation	Individual electric hoists
Spillway design flood:	
Peak discharge	850,000 cfs
Pool elevation	446.4 feet msl
Tailwater elevation	374.0 feet msl
Gross head	72.4 feet
Maximum flood at normal pool, el 440:	
Discharge	685,000 cfs
Tailwater elevation	370.5 feet msl
Gross head	69.5 feet
Maintenance closure spillway bays	Stoplogs

Stilling Basin

Type	Horizontal floor
Width, perpendicular to flow	590 feet
Length, parallel to flow	168 feet
Floor elevation	304 feet msl
Baffles	1 row
Baffle size, H x L x W	8 ft by 10.5 ft by 10 ft
Height of continuous end sill	12 feet

Navigation Lock

Type	Single lift
Maximum lift (min pool McNary and 0 discharge Ice Harbor)	105 feet
Inside length	675 feet
Inside width	86 feet
Normal minimum depth over lower sill (T.W. elevation--337)	16 feet
Minimum depth over upper sill (minimum pool)	15 feet
Normal depth over upper sill (normal pool)	18 feet
Upstream lock gate (radial) height	25 feet
Downstream lock gate (vertical lift) height	91 feet
Normal filling time	11 minutes
Normal emptying time	14 minutes

Fish Passage Facilities

Width of ladders:	
North	16 feet
South	24 feet
Number of weirs (including orifice-control section)	103
Overflow weirs:	
Number	97
Height	6 feet
Orifice size:	
North	18 x 18 inches
South	21 x 23 inches
Slope:	
North	1 on 10
South	1 on 16
Exit of ladder, invert elevation	431 feet msl
Entrance of ladder, invert elevation	332 feet msl
Normal fishway flow (from forebay):	
North	74 cfs
South	142 cfs
Auxiliary attraction water pumps:	
North	3
South	8
Discharge per pump:	
North	250 cfs
South	300 cfs
Fishway entrances (all 12 feet wide):	
South	2
Nonoverflow	3
North	3
Powerhouse fish collection system:	
Number of orifice entrances (2 feet by 6 feet)	12
Length of channel	661 feet
Width of channel	17.5 feet

Lower Monumental Lock and Dam
Snake River, Washington

Pertinent Data

General

Stream miles from mouth of Snake River	41.6
River miles upstream from Ice Harbor Dam	31.9
Drainage Area, square miles	108,500
Length of dam at crest, feet	3,800
Height upper lake level to tailwater, feet	100
Discharge in cubic feet per second:	
Minimum of record, natural	9,000
Mean annual flow	48,950
Average annual peak flow	187,000
Maximum of record, June 1894	409,000
Maximum of record, June 1894, controlled by existing projects	340,000
Standard project flood, controlled by existing projects and Dworshak	420,000
Spillway design flood	850,000

Estimated Cost

1992 Price Level Construction Cost (assumes original construction procedures)	740,000,000

Lake

Elevations:	
Maximum, at dam, for spillway design flood	548
Normal operating range	540-537
Length, miles	28.7
Area at El. 540 (flat), acres	6,590
Lake capacity below El. 540, acre-feet	376,000
Lake capacity below El. 537, acre-feet	356,000
Relocation miles:	
Northern Pacific Railway (abandoned)	
Union Pacific Railroad	14.0
Railroad Branch Lines	15.0
State Highway	5.0
County Roads	4.2
Access Roads	5.0
Length of Shoreline, miles	78

Spillway

Number of bays	8
Bay width, feet	50
Pier width, feet	14
Overall width, feet	498
Overall length, feet	335
Crest elevation	483
Gate size, width by height above crest	50 x 59
Stilling basin length, feet	193
Deck elevation	553
Deck width, clear, feet	20

Powerhouse

Length overall, feet	656
Width overall, (transverse section), feet	243
Intake deck elevation	553
Tailrace deck elevation	460
Spacing - feet:	
Units 1 through 5	90
Unit 6	96
Erection bay	110
Turbines:	
Type	Kaplan, 6-blade
Runner diameter, inches	288
Revolutions per minute	90
Rating, horsepower	190,360
Generators:	
Rating (nameplate), kilowatts	135,000
Power Factor	0.95
Kilo-volt ampere rating	142,105
Overload capacity	155,000
Total number of units	6
Ultimate plant capacity, nameplate rating (kw)	810,000
Ultimate plant capacity, overload capability (kw)	930,000

Navigation Lock and Channels

Net clear length of lock, feet	650
Net clear width of lock, feet	86
Minimum water depth over sills	15
Maximum upper water surface elevation in chamber	540
Minimum water surface elevation in chamber	437
Top of lock walls, elevation	548
Upstream sill block elevation	522
Downstream sill block elevation	422
Upstream gate:	
Type	Submergible lift
Height, effective, feet	21
Downstream gate:	
Type	lift
Height, effective, feet	84
Maximum possible lift, feet	103
Lift with standard project flood, feet	87
Length of guard walls, feet	700
Downstream channel:	
Width, feet	250
Bottom elevation	421

Concrete Non-Overflow Sections

Clear deck width, feet:	
Right abutment	24
Between spillway and lock	412
Deck elevation	553

Abutment Embankments

Embankment elevation	558
Embankment top width, feet	32
Material	Rock and gravel fill with impervious core
Slopes, upstream and downstream	1V on 2H

Fish Facilities

Maximum design riverflow, cfs	225,000
Slope	1V on 10H
Ladder clear width, feet	16
Regulation for lake fluctuation	Orifice flow
Weir height, feet	6
Normal ladder flow, cfs	70
Diffusion chambers:	
Number in North Ladder	8
Number in South Ladder	7
Velocity through gratings, fps:	
Gross Area	0.25
Net Area	0.50
Powerhouse collection channel:	
Optimum transportation velocity, fps	2
Entrances, number:	
Submerged orifices	12
Overflow weirs	3
Velocities, fps:	
Through orifices	8
Over weirs	8
Diffusion chambers, number	12
Auxiliary water requirements, cfs, north shore, maximum design tailwater (Elev. 448)	1,709

Little Goose Lock and Dam
Snake River, Washington

Pertinent Data

General

River mile	70.3
Drainage area, square miles	103,900
Normal hydraulic height, feet	98
Maximum structural height, feet, powerhouse	226
Overall length at crest, feet	2,655
Discharges, cfs:	
Minimum of record (1937)	9,000
Mean annual	48,950
Standard project flood	575,000
Maximum of record (1894)	409,000
Spillway design flood	850,000
First power on line	26 March 1970
Gravel-fill embankment, cubic yards (estimated)	1,750,000
Concrete, cubic yards (estimated)	1,400,000
Reinforcing steel, pounds (estimated	52,500,000

Estimated Cost

1992 Price Level	
(assumes original construction procedures)	$650,000,000

Lake

Elevations:	
Maximum	646.5
Normal operating range	638-633
Length, miles	37.2
Area at elevation 638, acres	10,025
Relocations, miles:	
Camas Prairie Railroad	36
State highways	2.8
County roads	21.5
Access roads	11.8
Drawdown for power, feet	5
Capacity, power pondage, acre-feet	49,000
Recreational developments:	
Existing	5
Proposed	0
Length of shoreline, miles	9

Navigation Lock

Type	Single lift
Maximum lift, feet	101
Clear width, feet	86
Net clear length, feet	668
Minimum depth over sills, feet	15
Upstream gate	86' x 22' Tainter
Downstream gate	86' x 118' Miter
Downstream navigation channel	16' Minimum x 250'
Guide wall lengths, feet:	
Upstream	705
Downstream	736

Spillway

Deck elevation	651
Crest elevation	581
Overall length, feet	%12
Maximum structural height, feet	200
Number of bays	8
Control Gates:	
Type	Tainter
Size, width by height above crest	50' x 59'
Maximum design capacity, cfs	850,000
Stilling basin length, feet	200
Stilling basin elevation	471.5
Crane capacity, tons (joint-use with powerhouse)	100

Powerhouse

Initial installation:	
Number of units	6
Nameplate rating, kilowatts:	
Each	135,000
Total	810,000
Intake deck elevation	651
Tailrace deck elevation	558
Unit spacing, feet	90
Length, erection bay, feet	110
Length overall, feet	656
Turbines:	
Type	Kaplan
Runner diameter, inches	305
Revolutions per minute	90
Horsepower rating	212,400
Crane capacities, tons:	
Intake deck (joint-use with spillway)	100
Bridge, powerhouse interior	600
Tailrace deck	50

Abutments

Left	90' Concrete Gravity
Right	880' Gravel Fill with Impervious Core

Fish Facilities

Number of ladders	1
Ladder slope	1 on 10
Ladder width, feet	20
Water supply	3 pumps = 2,550 cfs
Maximum design riverflow, cfs	225,000

Lower Granite Lock and Dam
Snake River, Washington

Pertinent Data

General

Stream miles from mouth of Snake river	107.5
River miles upstream from Little Goose Dam	37.2
Drainage area, square miles	103,500
Length of dam at crest, feet	3,200
Height upper reservoir elevation to tailwater	100
Discharges in cubic feet per second:	
Minimum of record, August 1931	10,600
Mean annual flow	49,800
Average annual peak flow	199,000
Maximum of record, June 1894	409,000
Maximum of record, June 1894, controlled by existing projects	340,000
Standard project flood	
(controlled by existing projects and Dworshak):	420,000
Snake River below Clearwater River	295,000
Snake River above Clearwater River	150,000
Spillway design flood	850,000

Estimated Cost

1992 Price Level	
(assumes original construction procedures)	$750,000,000

Reservoir

Elevations:	
Maximum, at dam, for spillway design flood	746.5
Normal operating range	738-733
Minimum at dam	724
Length, miles:	
Snake River (to Asotin damsite)	39.0
Clearwater River	4.6
Area at El. 738 (flat) acres	8,900
Lake capacity below El. 738, acre-feet	483,800
Lake capacity below El. 733, acre-feet	440,200
Relocations:	
Railroad, miles	37.5
State Highway, miles	12.8
County road, miles	24
Length of shoreline, miles	91

Levees	
Top width, feet	12
Slopes, waterside and landside	1 on 2
Materials	Gravel and earthfill with impervious core
Top elevation	5 feet above backwater profile for standard project flood
Embankment length, miles:	
Lewiston	8.6
Installed pumping capacity, cfs:	
Lewiston levees	450.4

Spillway	
Number of bays	8
Overall length, feet (abutment centerlines)	512
Deck elevation	751
Ogee crest elevation	681
Control gates:	
Type	Tainter
Size	50 x 59
Stilling basin length, feet	188
Stilling basin elevation	580
Maximum design capacity, cfs	850,000
Bridge crane (joint use with powerhouse), capacity, tons	100

Powerhouse

Length overall, feet	656
Spacing feet:	
Units 1 through 5	90
Unit 6	96
Erection and service bay	110
Width overall, transverse section, feet	243.17
Intake deck elevation	751
Tailrace deck elevation	656
Maximum height (draft tube invert to intake deck), feet	228
Maximum head, feet	105
Turbines:	
Type	Kaplan, 6-blade
Runner diameter, inches	312
Revolution per minute	90
Rating horsepower	212,400
Generators:	
Rating (nameplate), kilowatts	135,000
Power factor	0.95
Kilovolt ampere rating	142,100
Units installed complete initially	3
Skeleton units provided initially	3
Ultimate unit installation	6
Initial plant capacity, nameplate rating, kilowatts	405,000
Ultimate plant capacity, nameplate rating, kilowatts	810,000
Crane capacities, tons:	
Intake (joint use with spillway)	100
Bridge	600
Draft tube gantry	50

Navigation Lock

Net clear length, lock chamber, feet	674
Net clear width, lock chamber, feet	86
Minimum water depth over sills	15
Maximum operating water surface elevation in chamber	738
Upstream gate:	
Type	Submersible tainter
Height, feet	23
Downstream gate:	
Type	Miter
Height, feet	122
Maximum operating lock lift, feet	105
Lift, feet (river flow 300,000 cfs, practical navigation limit)	88.2
Length of guide walls (from face of gate), feet:	
Upstream	750
Downstream	700
Downstream approach channel:	
Width, feet	250
Bottom elevation	617

Abutment Embankment

Embankment elevation	756
Embankment top width, feet	45
Material	Rock and gravel fill with impervious core
Slope, upstream	1 on 2
Slope, downstream	1 on 2

Fish Facilities

Maximum design river flow, cfs	225,000
Number of fish ladders	1
Slope	1 on 10
Ladder clear width, feet	20
Pumps for fish attraction water:	
Number	3
Total capacity, cfs	

Glossary of Technical Terms

100-year flood event:	This is a hydrologic term that identifies the probability of a flood of a certain magnitude occurring. A 100-year flood event is the river flow that has a 1-percent chance of occurring every year. Similarly, a 10-year flood event is the river flow that has a 10-percent change or occurring every year. The 10-year flood event on the lower Snake River has a magnitude of about 225,000 cubic feet per second (cfs), and has a 10-percent chance of occurring each year.
Bulkhead gates:	These gates are used to stop water flow through a turbine intake. They are similar to the operating gates, except that they are lowered by crane into the bulkhead slots when needed. There are only three of these gates per dam on the lower Snake River dams. They are usually only put into place when maintenance work is performed on a turbine unit. They can also be used under an emergency situation when water flow must be stopped from passing through a unit and, for some reason, the operating gates are inoperative.
Bulkhead gate slot:	An opening in the turbine intake area that allows bulkhead gates to be lowered to block water from flowing into a turbine intake. The bulkhead gate slots are similar to the operating gate slots, but they are located upstream from the intake gate slots.
Cofferdam:	A temporary dam to divert water or allow an area to be dewatered for construction activities. These can be made of a variety of materials. Sometimes cofferdams are built using sheetmetal circular cells filled with gravels, large rock, or concrete.
Collection channel:	On the lower Snake River dams, the juvenile fish bypass system is composed of an intake screening system (STS's, VBS's, and orifices). Fish that are guided by the intake screening system pass through orifices into a collection channel. This is a channel built into the dam that collects fish and water from all orifices, and transports the fish and water downstream of the dam.
Diffusers:	This is a part of the adult fishway. Extra water for fish attraction is introduced through diffusers into the fishway. These diffusers are located in the floor of the fishway, and act to dissipate excess energy and spread the water velocities evenly across the fishway.

Dissolved Gases:	When water is passed over a spillway and energy is dissipated in the stilling basin, large quantities of air are entrained in the resulting turbulence. The air is often carried by the turbulent action to the bottom of the water column in the stilling basin. The pressure of the water column on the air causes the air to be absorbed or dissolved in the water. This causes the water to have higher than normal quantities of oxygen and nitrogen gasses (the components making up the air we breathe). When pressures are sufficiently reduced, this excess gas will come out of solution. Fish that swim in the high dissolved gas water will take this excess gas into their blood stream. When the fish swim into lower pressure areas of the water column, this excess gas will come out of solution, and cause physical damage to gills and other parts of their bodies. If the damage is extensive enough, the fish will succumb.
Drumgates:	This is a different type of water-control gate. These gates are shaped like drums, hence the term "drumgate." They can be used on spillway or low-level dams to control water flow over the structure.
Embankment:	An embankment is an engineered earth fill. The embankments are composed of gravels, clays, and large rock. On the lower Snake River dams, earth embankments make up a part of each dam. They are used to connect concrete parts of the dam to the shoreline side of the river channel. They are specially engineered and constructed to prevent water leakage through or past them. Embankments or earth fills are also used at various points along the length of each lower Snake River reservoir. Railroads and highways are constructed on top of them in many areas.
Fish ladder:	Fish ladders are used to facilitate adult fish passage around the lower Snake River dams. They are built of concrete, and are composed of a series of small pools of water. Each pool of water is about 1 foot higher than the next adjacent pool. Water flows over concrete wall sections (weirs) from one pool to the next. Fish jump over each wall, or pass through holes (orifices) in the wall to get from one pool to the next higher pool.
Fishway entrances:	These are a part of the adult fish ladder system. The fishway entrances are locations where adult fish can enter the fish ladder system. They are located in the tailwater area, across the powerhouse, and along the shorelines of the lower Snake River dams.

Fishway exits:	These are part of the adult fish ladder system. The fishway exits are the locations where adult fish exit the ladder system. They are located in the forebay area of the lower Snake River dams.
Floating orifice gates:	On the Snake River dams, these are adult fishway entrances. They are located across the front of the powerhouse. These entrances are floating gates that self-adjust to changing tailwater elevations. A rectangular hole (orifice) through the gate allows adult fish to pass through the gate into the adult fish collection channel and fishway. The ability of the gate to float and self-adjust to changing tailwater elevations maintains the orifice within the gate at a set elevation below the tailwater elevation. Water (termed attraction water) passes through the orifice, and attracts adult fish to enter the collection channel and fishway.
Forebay:	This term refers to the water above or upstream of a dam. The term "forebay elevation" is also used, and refers to the water surface elevation immediately upstream of the dam.
Hydraulic jump:	This term refers to a physical phenomenon of flowing water. When the rapid change in the depth of flowing water is from a low stage to a high stage, the result is usually an abrupt rise of water surface elevation. It occurs frequently in a canal below a regulating gate, at the foot of a spillway, or at the place where a steep channel slope suddenly turns flat.
Operating gates (intake gates):	These are hydraulically-operated gates that can be lowered through the operating gate slot to stop water from flowing through a turbine. There are three operating gates per turbine unit on the lower Snake River dams. These gates are stored in the operating gate slot at all times. They can be remotely actuated to close or open.
Operating gate slot:	An opening in the turbine intake area that allows water control gates to be lowered in front of the turbine intake opening. When the gates are lowered through the slot, they stop water from flowing through the turbine. There are three operating gates and gate slots per turbine unit on the lower Snake River dams.
Orifice:	An orifice is an opening, with closed perimeter and of regular form, through which water flows. On the lower Snake River juvenile bypass systems, the orifices refer to 12-inch diameter pipes that pass through concrete walls from the bulkhead gate slot to the juvenile collection channel.

Orifice Passage Efficiency (OPE):	At the lower Snake River dams, juvenile fish are guided away from operating turbines by intake screens into bulkhead gate slots. The fish then pass from the bulkhead gate slots into the juvenile fish bypass system through openings called orifices. Orifice passage efficiency is a measure of how effective the orifices are in moving fish out of the gate slots.
Polyjet valves (ported sleeve valves):	These are valves used to control water flow from a pipeline. They are used in instances where a lot of energy from the flowing water must be dissipated. They dissipate the energy by converting potential energy to kinetic energy.
Stilling basins:	A stilling basin is usually constructed at the base of a spillway. It is a reinforced concrete slab set at an elevation lower than the river bottom. The purpose of the stilling basin is to dissipate energy from the water flowing over the spillway would erode river bed materials and eventually undercut the spillway, leading to catastrophic structural failure.
Stoplogs:	These are similar to bulkhead-type gates, except that they are composed of individual sections made of wood, concrete, or metal. The individual sections are stacked on top of each other until they block water flow through a channel or over a spillway. They are installed in stoplog slots. At the lower Snake River dams, stoplogs can be installed upstream from the spillway tainter gates, allowing maintenance to be performed on the tainter gates. They are also used within the adult fishway collection channel to allow dewatering and inspection of the channel.
Submersible Traveling Screens (STS's):	The STS's are turbine intake screens. They are installed in the bulkhead gate slots, and serve to guide fish away from operating turbines and upward into the bulkhead gate slots. There are three screens per turbine unit, one for each bulkhead gate slot. These screens are 20 feet in length, and are composed of a plastic mesh that rotates to keep debris off of the screen. The Corps is experimenting with 40-foot-long screens at McNary and Little Goose Dams.

Switch gate:	This is a mechanically-operated gate used within juvenile fish bypass systems on the lower Snake River dams. At several of the dams, it is possible to either bypass fish directly to the tailrace or pass them into a holding and loading facility for transport by barge or truck. The switch gate is mounted in a flume, and controls the direction of the water flow from a bypass mode to holding and loading mode.
Tailwater:	This term refers to the water immediately below or downstream of a dam. The term "tailwater elevation" refers to the water surface elevation immediately below or downstream of a dam.
Tainter gates:	These are semicircular gates that are normally used to control water flow over a spillway. On the lower Snake River dams, these gates are about 50 feet wide and 50 feet deep. They are installed on the spillway crest.
Vertical barrier screens (VBS's):	The VBS's are screens that are installed between the operating gate slots and the bulkhead gate slots. They confine juvenile fish (that are guided into the bulkhead gate slot by the STS's) to the bulkhead gate slot, thus preventing them from passing into the operating gate slot. There are three of these screens for each turbine unit. Each screen is composed of perforated and solid steel plate and plastic mesh panels. These screens work in combination with STS's and the orifices to make up a turbine intake screening system.
Weir:	This is a hydraulic structure that controls the depth of water flowing in a channel. It can be made of wood, concrete, or metal, and is simply a wall installed so that water is forced flow over the top of the wall (weir). The presence of the weir forces higher water surface elevation on the upstream side of the weir than on the downstream side.

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Section 1 - Introduction

1.01. Study Authority.

The system configuration component of the Columbia River Salmon Mitigation Analysis is being conducted under the existing authorities for the eight projects on the lower Columbia and lower Snake Rivers. For the Bonneville Project, that authority is the Rivers and Harbors Act of 1935, Public Law (PL) 74-409, dated August 30, 1935. For the John Day and The Dalles Projects, the authority is the Rivers and Harbors Act of 1950, PL 81-516, dated May 17, 1950. For all other projects, the authority is the Rivers and Harbors Act of 1945, PL 79-14, dated March 2, 1945.

1.02. Purpose.

Lowering pool levels at the four lower Snake River Projects is under consideration to improve downstream migration of juvenile fish. The objective is to increase river velocities in order to potentially reduce the travel time that it takes for smolts to transit the river system to the ocean. Travel time has been identified as a possible factor in smolt survival and it is believed that a reduction in travel time may increase smolt survival. The purpose of this report is: 1) to identify and evaluate the technical feasibility of alternative long-term modifications to the lower Snake River dams to allow operation under conditions of extreme reservoir drawdown, while still maintaining safe and effective juvenile and adult fish passage; 2) to evaluate the feasibility of maintaining existing project purposes and uses under extreme drawdown conditions; 3) to identify the process, schedule, and approximate cost of implementing each of the technically feasible alternatives; 4) to evaluate environmental effects, including potential anadromous fish benefits; 5) to evaluate the economic effects associated with drawdown; and 6) to identify potential mitigation opportunities.

1.03. Scope.

This study focuses primarily on the technical feasibility of the long-term project modifications required to provide safe and effective juvenile and adult fish passage under extreme drawdown conditions. The evaluations completed for this study were reconnaissance level (preliminary). This study is limited to the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor projects. Modifications required to protect structures, levees, railroads, highways, and drainage systems while the projects are operating under the drawdown conditions are examined. Operational descriptions, concept designs, implementation time, and construction costs estimates are presented. Environmental effects, including potential anadromous fish benefits are summarized. Processes to resolve environmental uncertainties are proposed.

Preliminary designs (with drawings), construction costs, and implementation schedules are included, which address these modifications. In addition, this study analyzes potential river operation changes, environmental and economic effects, and potential mitigation opportunities. It should be noted that this information is consistent with the *Strategy for Salmon*, which was developed by the Northwest Power Planning Council.

Section 2 - Existing Project Descriptions and Operation

2.01. General.

The four lower Snake River projects are located in southeastern Washington on the Snake River. The projects were authorized by Public Law 14, 79th Congress, 1st session, and approved on 2 March 1945. Ice Harbor Dam is the furthest project downstream, and is located 9.7 river miles (RM's) above the confluence of the Snake and Columbia Rivers. Lower Monumental Dam is the next project upstream from Ice Harbor Dam, and is located at RM 41.6. Lower Monumental Dam is followed by Little Goose Dam (RM 70.3), and Lower Granite Dam (RM 107.5). Plate 1 shows the geographical location of the four lower Snake River projects in relation to the overall Columbia River system. The authorized purposes of the lower Snake River projects are inland navigation, hydroelectric power generation, fish, wildlife, irrigation, and recreation. The Snake River projects allow inland navigation from its confluence with the Columbia River to Lewiston, Idaho. The projects were constructed during the period from 1961 to 1975.

2.02. Project Descriptions.

The features of the four lower Snake River projects are similar. The main structures of each include a powerhouse, concrete spillway and stilling basin, navigation lock, rockfill embankments, concrete non-overflow sections, and fish passage facilities.

a. Powerhouse.

Each project powerhouse contains six vertical shaft synchronous generators driven by adjustable blade Kaplan turbines. The capacity of the generating units at Ice Harbor is less than the generating capacities of the upper three projects. The total generating plant capacity (nameplate rating) for all four projects is 3,033,000 kilowatts. They hydraulic capacity (at normal operating pools) of the plants varies from 103,800 cubic feet per second (cfs) at Ice Harbor to 136,920 cfs at Lower Granite Lock and Dam.

b. Navigation Lock.

The single-lift navigation locks are similar at each project, with inside widths of 86 feet and lengths varying from 666 to 675 feet. The maximum lift of each lock varies from 101 to 105 feet. An average of 4 million tons of commodities is transported annually through the four lower Snake River projects. Lock outages, for maintenance, normally occur during a 2-week period in March of each year. This date, however, is flexible.

c. Spillway.

The ogee-crest, concrete-gravity, gated spillways, and their associated stilling basins are designed for a peak river discharge of 850,000 cfs.

d. Adult Fishways.

Each project is configured with one or two adult fish ladders that allow adult salmonids to migrate upstream past the projects to spawning grounds. The adult ladder systems were designed to provide adequate attraction flows and operate under normal pool fluctuations. Each ladder system consists of adult fish ladder entrances, a powerhouse collection channel, ladder sections, a fish exit, and an auxiliary water supply system.

e. Juvenile Fish Bypass.

Lower Granite Dam was originally designed with bypass facilities to facilitate downstream migration of juvenile salmonids. Little Goose and Lower Monumental Dams were also originally designed and constructed with juvenile fish bypass systems, but these were found to be ineffective. The Little Goose system was replaced during 1978 and 1979 with a then state-of-the-art facility. It was replaced again in 1990 with a new downstream facility, including a state-of-the-art, open channel flow, low-velocity bypass flume. New juvenile bypass facilities were constructed at Lower Monumental Dam in 1991 and 1992. Ice Harbor Dam currently bypasses juvenile fish through an ice-and-trash sluiceway. A new state-of-the-art bypass for Ice Harbor Dam is currently in the design stage, with construction scheduled to begin in 1994. The juvenile bypass facilities at Lower Granite, Little Goose, and Lower Monumental Dams consist of orifices, collection channels, submerged traveling screens (STS's), vertical barrier screens (VBS's), transport channels or pipes, fish separators, raceways, barge and truck loading facilities, and laboratories for fish monitoring and sampling.

2.03. Project Operation.

a. General.

Current annual operations of the lower Snake River projects are described in detail in the Water Control Manual for each project. The general objective of project operation is to provide maximum benefits from authorized project uses when the projects are regulated as a part of the Columbia River Basin system. To accomplish this objective, the lower Snake River projects are regulated as run-of-river projects with the primary functions of navigation and hydroelectric power generation, while also providing the best possible conditions for other project uses of flood control, fish and wildlife, and recreation. Flood control is not an authorized or planned function because of the limited amount of usable reservoir storage. The operation of Lower Granite project is unique in that the reservoir elevations are monitored at the confluence of the Snake and Clearwater Rivers. The confluence is 32 RM's above the dam. Reservoir elevations are monitored at this point to prevent the overtopping of the Corps' levees at Lewiston, Idaho.

b. Major Constraints.

(1) Pool Levels.

The following table lists the current maximum and minimum operating pool levels for each of the lower Snake River projects.

Normal Operating Pool Levels

Project	Maximum Feet	Minimum Feet
Ice Harbor	440.0	437.0
Lower Monumental	540.0	537.0
Little Goose	638.0	633.0
Lower Granite[1]	738.0	733.0

[1] Measurd at the confluence of the Snake and Clearwater Rivers.

(2) Minimum Discharge.

Minimum releases from Lower Granite Dam are determined by the requirement to protect the Lewiston-Clarkston population center from excessively high water surface elevations. Levees have been constructed to protect low-lying areas at Lewiston and Clarkston for all flows up to the standard project flood level of 420,000 cfs total inflow. The levees were provided with 5 feet of freeboard that must not be encroached upon for inflows of less than 420,000 cfs.

(3) Power.

The lower Snake River projects are operated for power within the foregoing pondage and release limitations, and in accordance with a working agreement between the U.S. Army Corps of Engineers (Corps) and Bonneville Power Administration (BPA), the marketing agency for Federally-generated power in the Pacific Northwest. Power scheduling for the projects is accomplished by BPA, in coordination with the Corps, North Pacific Division. Load factoring may be accomplished by making use of the storage between minimum and maximum water surface elevations when the reservoir inflow is less than powerplant hydraulic capacity. The normal operating range for these projects ranges from 3 to 5 feet.

c. Additional Constraints for Adult Fish Passage.

(1) Minimum Discharge.

Minimum project discharge limits ensure the safe passage of anadromous fish during their migration to spawning grounds. From December through February, "zero" minimum project discharge is permitted on a limited basis. Under an agreement between BPA and the fishery agencies, "zero" river flow is allowed for water storage during low power demand periods (nights and on weekends), but only when there are few, if any, actively migrating anadromous fish present in the Snake River. When adult fish are actively migrating during March through July and August through November, the minimum Ice Harbor project discharge will be 9,500 and 7,100 cfs, respectively, for power generation and conservation purposes. This minimum discharge is the approximate design discharge of one power unit operated at the continuous minimum generation limit of 70 megawatts (MW) at 9,500 cfs and 50 MW at 7,500 cfs. From March through November, the minimum project discharge is 11,500 cfs for power generation and fishery purposes at the Lower Monumental, Little Goose, and Lower Granite projects. This minimum discharge is the approximate design discharge of one power unit operated at the continuous minimum generation limit of 80 MW.

(2) Spillway Operation.

When spill operations are necessary during the adult fish passage season (1 March through 31 December), the spillway is operated to pass the desired discharge with the best practical hydraulic conditions in the vicinity of fish ladder entrances. Spillway gates are operated to establish a spill pattern in the tailrace that aids adult fish in finding ladder entrances.

(3) Powerhouse Operation.

As an aid to migrating adult fish, specific turbine units are operated according to priority schedules. The operation of certain units aids adult fish in finding ladder entrances.

(4) Minimum Pool.

The lower Snake River projects have been operated at near minimum pool during the juvenile migration period. Near minimum implies within 1 foot of minimum pool.

d. Additional Constraints for Juvenile Fish Passage.

(1) Ice Harbor.

Ice Harbor's juvenile bypass system is an ice-and-trash sluiceway that was originally designed to pass floating debris and ice. At Ice Harbor, water and fish are skimmed into the ice-and-trash sluiceway by spill over A-slot regulating gates. Approximately 2,700 cfs is routed through the ice-and-trash sluiceway for 24 hours per day during the juvenile fish passage season. A new state-of-the-art juvenile bypass system is currently under design for Ice Harbor. Construction is expected to begin in 1994, with operation scheduled for the spring of 1996.

(2) Lower Monumental.

In the past, Lower Monumental's juvenile bypass system was a very minimal facility. As a result, a juvenile fish spill program was implemented that was designed to help salmonids pass Lower Monumental Dam during their downstream migration to the Pacific Ocean. The spill program at Lower Monumental was a temporary measure until the installation of adequate permanent bypass facilities. In April of 1992, a new state-of-the-art juvenile bypass system went into operation at Lower Monumental Dam.

(3) Powerhouse Operation.

Generally, the power units will be operated to provide the greatest overall powerplant efficiency. This is in the interest of smooth and efficient turbine operation, but also provides more satisfactory conditions for any downstream migrating juvenile fish that pass through the turbines.

e. Special Regulations for Juvenile Fish.

(1) Water Budget.

Every spring, juvenile salmon and steelhead smolts leave spawning grounds and hatcheries on the Columbia and Snake Rivers and begin their downstream migration to the Pacific Ocean. These young fish use river currents to help them in their downstream migration. The dams constructed on these rivers may have created less than ideal conditions for the juvenile fish outmigration. Slower velocities in reservoirs and restricted downstream fish movement past the dams are suspected to be contributors to juvenile fish mortality. The spring runoff of 1973, which was one of the worst droughts on record, brought about a heightened awareness of the problems facing juvenile fish during their migration past Columbia and Snake River dams. During the 1973 spring runoff period, migrating juvenile fish suffered heavy mortalities, possibly as a result of the extended transit time through the system and the passage of most fish through the turbine units of the dams. The juvenile fish transport program was initiated in the late 1970's as a means of reducing passage mortality in reservoirs and at downstream projects. The Water Budget was established in 1982 to aid in the spring migration of smolts through the lower Snake River reservoir system. The Water Budget may be used during the 15 April to 15 June period when the major smolt migration is occurring. A total of 20 thousand cfs (Kcfs)-months [1.19 million acre-feet (MAF)] has been recommended for shaping spring flows under the Columbia River Basin Fish and Wildlife Program developed by the Columbia River Basin Fish and Wildlife Program developed by the Pacific Northwest Power Planning Council in 1982, and amended in 1984, 1987, 1991, and 1992. If the Snake River inflows to Lower Granite Dam are less than 85 Kcfs, additional water may be released from upstream reservoirs (Dworshak and Brownlee), if available. Additional water for flow augmentation above the specified water budget was provided in 1991 and 1992.

(2) Juvenile Fish Transportation Program.

At the Lower Granite, Little Goose, and Lower Monumental projects, juvenile fish are diverted at the turbine intakes into bypass and juvenile collection systems. The systems allow fish to be sorted by size, and either loaded directly onto a fish barge or held in raceways and then loaded onto a truck or barge for transport to points below Bonneville Dam. At Ice Harbor Dam, fish are bypassed through an existing sluiceway directly to the tailrace.

Juvenile collection facilities are currently operated from April through November each year. Juvenile fish transport has been a major program since the late 1970's, and is a means of decreasing juvenile travel time and eliminating passage mortality at, and in, downstream projects and reservoirs.

Section 3 - Proposed Project Operation and Alternatives

3.01. General.

This technical report addresses a proposal to change the current operation of the lower Snake River projects to decrease average water travel time through the reservoirs. Water travel time has been identified as a possible factor in juvenile fish survival. The method suggested for achieving a decreased water travel time involves reducing the reservoir cross-sectional area by operating the reservoirs at lower water surface elevations. The proposed operation would occur during the annual juvenile migration period, and would eliminate the existing juvenile fish transportation program on the Snake River, since navigation would not be possible with lowered reservoir water surface elevations.

3.02. Hydrology.

The summary hydrograph of inflows to Lower Granite reservoir (October 1975 through September 1990) is illustrated on plate 56. Existing fish facilities are currently designed to operate up to the 10-year flood event of 225,000 cfs (see both the Pertinent Data and plate 57, *Flood Frequency Curve*). For this report, it is assumed that any proposed modifications to adult and juvenile fish passage facilities should also be operational up to a river discharge of 225,000 cfs. The 225,000-cfs limit equals the 10-year flood event on the Snake River. Current criteria for Corps-designed fish passage facilities is to allow operation up to this 10-year event. It should be noted that more detailed evaluations that look at different design criteria, in an effort to optimize costs and fish passage benefits, would be conducted in Phase II (feasibility-level study). The effects associated with this operational change are discussed in appendix A.

3.03. Operational Alternatives.

a. General.

This study makes the following assumptions: 1) that all four lower Snake River reservoirs will be operated each year at drawdown levels during a part of (15 April through 15 June), or the total (15 April through Labor Day), juvenile fish outmigration period; and 2) that, following a drawdown operation, the reservoirs will be returned to normal operating pool levels. [Note: The assumption that pools will be lowered each year is made to simplify the analysis. If any of the drawdown alternatives are considered further, then other operational constraints can be examined (*i.e.*, early refill, different peak flow design levels, conditions under which drawdown would not occur, drawdown duration, timing, *etc.*).] A multitude of alternatives exist that could be examined. Each operational alternative will have associated drawdown and refill periods and volumes, and will be highly dependent on the type of modifications that can physically be made at each of the lower Snake River projects. Each operational alternative will have associated costs, benefits, and impacts on existing reservoir purposes and uses.

Lowering a single reservoir will create a reach of free-flowing river between it and the next dam upstream. However, all drawdown alternatives, with the exception of the natural river option, will still result in the presence of a substantial reservoir.

The various features at each dam were designed with set operating criteria, such as minimum and maximum water surface elevations. Changing operating criteria (as is proposed by the reservoir drawdown operational alternatives) affects operation of the existing fish passage facilities, stilling basins, spillways, powerhouses, and navigation locks. Modifications to key features will be required to maintain safe and effective operation if a drawdown alternative is implemented.

This section describes the operational drawdown alternatives that are being considered for the four lower Snake River projects.

b. Alternatives.

There are several different drawdown levels that could be examined. These range from normal minimum operating pool levels to a complete river bypass of the dams (near pre-dam river conditions). There are also numerous drawdown levels that could be examined between these two extremes. There are various ways each dam's operation could be modified to achieve any particular drawdown pool level. Under certain proposed drawdown levels, the drawdown condition can be achieved by passing water through the powerhouse, over the spillway, or both (depending on river discharge). There are also two different modes of operation that could occur once the drawdown level is substantially achieved. The pool level of each project could be maintained at near constant levels (±5 feet) or could be allowed to fluctuate as river flows fluctuate.

Twenty different alternatives were identified as potential methods for achieving drawdown conditions on the lower Snake River. The alternatives are defined by the drawdown level, and by the features at each dam that would be modified or newly constructed, and operated to achieve the drawdown level (refer to table 3-1). The alternatives are grouped according to the following five classifications:

- **Group 1--Variable pool with no powerhouse operation.**

  Four alternatives were identified within this grouping. These alternatives define modifications that could be made to the four lower Snake River dams to accommodate drawdown conditions. Alternatives within this grouping do not include powerhouse operation. The term "variable pool" refers to the reservoir pool elevation changing, depending on river discharge.

- **Group 2--Variable pool with existing powerhouse operation.**

  Four alternatives were identified within this grouping. The alternatives define modifications that could be made to the four lower Snake River dams to allow drawdown operations. These alternatives include the operation of existing powerhouses. The term "variable pool" refers to the reservoir pool elevation changing, depending on river discharge.

- **Group 3--Variable pool with modified powerhouse operation.**

  Four alternatives were identified within this grouping. These alternatives are identical to the alternatives in group 2, except that they provide for changing or modifying turbines within the powerhouse to allow for more efficient operation at drawdown levels. The term "modified powerhouse" refers to the installation of more efficient turbines in the existing superstructure of the powerhouse, or the modification of existing turbine-generator sets to improve efficiencies (see appendix B). The term "variable pool" refers to the reservoir pool elevation changing, depending on river discharge.

- **Group 4--Constant pool with existing powerhouse operation.**

  Four alternatives were identified within this grouping. These alternatives illustrate the modifications required to allow drawdown operations while still allowing existing powerhouses to operate. The term "constant pool" refers to the reservoir pool elevation remaining at a near constant level (±5 feet). This is similar to existing operational criteria.

- **Group 5--Constant pool with modified powerhouse operation.**

  The four alternatives within this grouping are identical to those in group 4, except that turbine/generators are modified or changed to provide for more efficient operation under drawdown operations. The term "modified powerhouse" refers to the installation of more efficient turbines in the existing superstructure of the powerhouse, or the modification of existing turbine-generator sets to improve efficiencies (see appendix B). The term "constant pool" refers to the reservoir pool elevation remaining at a near constant level (±5 feet).

Table 3-1
Proposed Alternatives

Number	Description	Drawdown Level (Feet)
Variable Pool--No Powerhouse Operation[1]		
1	Existing Spillway Only	28 to 57
2	Modified Spillway Only	38 to 67
3	New Low-Level Spillway Only	52 to 76
4	Auxiliary Regulating Outlet (ARO) Only	>76
Variable Pool With Existing Powerhouse		
5	Existing Powerhouse With Existing Spillway	28 to 57
6	Existing Powerhouse With Modified Existing Spillway	38 to 67
7	Existing Powerhouse With New Low-Level Spillway	52 to 76
8	Existing Powerhouse With ARO	>76
Variable Pool With Modified Powerhouse		
9	Modified Powerhouse With Existing Spillway	28 to 57
10	Modified Powerhouse With Modified Existing Spillway	38 to 67
11	Modified Powerhouse With New Low-Level Spillway	52 to 76
12	Modified Powerhouse With ARO	>76
Constant Pool With Existing Powerhouse		
13	Existing Powerhouse With Existing Spillway	33
14	Existing Powerhouse With Modified Existing Spillway	43
15	Existing Powerhouse With New Low-Level Spillway	52
16	Existing Powerhouse With ARO	52
Constant Pool With Modified Powerhouse		
17	Modified Powerhouse With Existing Spillway	33
18	Modified Powerhouse With Modified Existing Spillway	43
19	Modified Powerhouse With New Low-Level Spillway	52
20	Modified Powerhouse With ARO	52

[1] For reference, a 57-foot drawdown represents an upstream pool at a level equal to the existing spillway crest at Lower Granite Dam.

3.04. Screening.

The initial screening was accomplished utilizing known data and general opinions from fishery agencies and other experts. The screening was coordinated with the Columbia River Salmon Mitigation Analysis (CRSMA) Technical Advisory Group (TAG) and others. The TAG includes representatives from Federal and State agencies, Indian Tribes, and various interest groups. Refer to appendix D for pertinent correspondence.

Those alternatives (specifically, 1 through 3) using spill as the primary method for passing water through the dams were eliminated from further consideration. Spill creates adverse velocity currents in the tailrace that will disorient the adult fish, and result in substantial delays to adult fish passage. Likewise, spill will raise dissolved gas to unacceptable levels (generally considered to be 115 percent, based on previous National Marine Fisheries studies), and possibly cause physical injury (*e.g.*, descaling) to juvenile fish.

Alternative number 4, the Auxiliary Regulating Outlet, was considered to be a high risk alternative in regards to adult fish passage. The auxiliary regulating outlet, as proposed, consisted of a series of 30-foot-diameter conduits that would pass through the non-overflow embankments or through an abutment. The outlets would be gate-controlled on the intake side of the conduits, and would flow full when used. A stilling basin-type energy dissipation structure would be installed on the outlet side of the conduits. The general consensus of the Corps and TAG was to eliminate this alternative and add one proposed by the TAG. This alternative (4A) was termed the Natural River Option, and is a concept that would attempt to return the river to near free-flow conditions by constructing a river bypass around each dam. In addition, alternatives 8, 12, 16, and 20 were eliminated from further consideration, since they involve the use of an auxiliary regulating outlet.

Alternatives 6 and 7 were eliminated primarily because operation of existing powerhouses is not possible at such extreme drawdown levels (up to 76 feet). In addition, operation below existing spillway crests is likely to create unacceptable conditions on juvenile bypass vertical barrier screens (VBS's). (Refer to appendix A for explanation of VBS's.)

Alternatives 10 and 11 include replacement of turbines with the same operating levels as alternatives 6 and 7. It is conceivable that new turbines could be configured to operated under the extreme drawdown levels proposed by these two alternatives, but adverse conditions on juvenile bypass VBS's are likely to occur that may lead to juvenile fish injury or mortality. Therefore, alternatives 10 and 11 were also eliminated.

3.05. Alternatives Selected for Further Evaluation.

Nine alternatives selected for further study are shown in table 3-2 and discussed in detail in section 5.

Table 3-2
Initial Screening

No.	Description	Drawdown Level (Feet)	Recommended For Further Study
Variable Pool--No Powerhouse Operation[1]			
1	Existing Spillway Only	28 to 57	Eliminated
2	Modified Spillway Only	38 to 67	Eliminated
3	New Low-Level Spillway Only	52 to 76	Eliminated
4	Auxiliary Regulating Outlet (ARO) Only	>76	Eliminated
4A	Natural River Option	Near Freeflow	Added
Variable Pool With Existing Powerhouse			
5	Existing Powerhouse With Existing Spillway	28 to 57	Yes
6	Existing Powerhouse W/Modified Existing Spillway	38 to 67	Eliminated
7	Existing Powerhouse With New Low-Level Spillway	52 to 76	Eliminated
8	Existing Powerhouse With ARO	>76	Eliminated
Variable Pool With Modified Powerhouse			
9	Modified Powerhouse With Existing Spillway	28 to 57	Yes
10	Modified Powerhouse W/Modified Existing Spillway	38 to 67	Eliminated
11	Modified Powerhouse W/New Low-Level Spillway	52 to 76	Eliminated
12	Modified Powerhouse With ARO	>76	Eliminated
Constant Pool With Existing Powerhouse			
13	Existing Powerhouse With Existing Spillway	33	Yes
13A	Existing Powerhouse W/Existing Spillway-- Lower Granite Only	33	Yes
14	Existing Powerhouse W/Modified Existing Spillway	43	Yes
15	Existing Powerhouse With New Low-Level Spillway	52	Yes
16	Existing Powerhouse With ARO	52	Eliminated
Constant Pool With Modified Powerhouse			
17	Modified Powerhouse With Existing Spillway	33	Yes
18	Modified Powerhouse W/Modified Existing Spillway	43	Yes
19	Modified Powerhouse W/New Low-Level Spillway	52	Yes
20	Modified Powerhouse With ARO	52	Eliminated

[1] For reference, a 57-foot drawdown represents an upstream pool at a level equal to the existing spillway crest at Lower Granite Dam.

Section 4 - Alternatives Considered in Phase I

4.01. General

This section presents design criteria and describes and evaluates the ten drawdown alternatives selected for further evaluation. Each alternative is addressed in general terms in the following paragraphs. Table 3 is a matrix summarizing required modifications. More detailed technical information about individual features is contained in appendix A, *Feature Modifications - Technical Discussions*.

4.02. Fishway Design Criteria

a. General.

Existing fish bypass systems will require modification, and some new fish bypass systems will be required to accommodate various drawdown alternatives while still allowing satisfactory fish passage. The following design criteria for adult and juvenile bypass systems were used in developing the fishway designs. These criteria were reviewed by the TAG (see appendix D, *Pertinent Correspondence*).

b. Adult Fishway Criteria.

- Fishway entrances will provide a minimum attraction velocity of 8 feet per second (fps).
- Collection channel velocity range will be 2 to 4 fps.
- Maximum velocity through gross area of floor diffusers will be 0.5 fps.
- Maximum drop at any weir or baffle will be limited to 12 inches.
- Slope of ladder sections will be 1 vertical (V) on 10 horizontal (H).
- Width of fish ladder will be 20 feet.
- Height of overflow section of weirs will be 6 feet.
- Pool length of orifice-slot control section will be 16 feet.
- Minimum depth in fishway for normal operation will be 6 feet.
- Width of transportation and collection channels will be from 87 to 20 feet.
- Auxiliary water supply will be adequate to provide appropriate velocities at entrances and in collection channels.
- Fish ladder exit width will be 6 feet.
- Fish ladder discharge will be 75 cfs for design of new ladder systems and equal to existing systems for design of modifications to existing systems.
- Fish entrances will have a minimum depth of 8 feet and a minimum width of 6 feet.
- New ladders will include facilities for counting, trapping, and monitoring.

c. Juvenile Collection System Criteria.

- For constant pool alternatives, the juvenile collection channel will be designed to operate in an open channel condition similar to that of existing collection systems at the lower Snake River projects.
- Provide 36 12-inch-diameter orifices, with short tube (two per gatewell). During normal operations, operate one orifice per gatewell, or 18 total orifices.
- Recommended minimum attraction flow is 11 cfs per orifice at minimum forebay elevation.
- Provide air back-flush systems to remove blockage from orifices caused by debris.
- Size the collection gallery to optimize fish passage velocities. Optimum velocities are from 3 to 9 fps.
- Collection channel water surface elevations and discharge will be controlled by a dewatering structure.
- Collection channel width will be enough so that orifice jet impact on normal operating water surface elevations occurs 3 feet from the opposite channel wall.
- Transport channel will be a low-velocity flume similar to the existing Little Goose and Lower Monumental flume systems. Transport channel flow depth will not be less than 1 foot.
- Established minimum velocity criteria for release sites is 3 fps. If analyses of construction of these facilities is continued in Phase II, general hydraulic models will be constructed and data taken to identify optimum release points. Fish release to the tailrace will be above water ±10 feet, if possible, with a trajectory impact not to exceed 30 fps. In addition, adequate water depth is required at the release site to minimize possible physical injury.

4.03. Structural Modification Criteria

The criteria used in developing modifications to structures is identified below.

- There will be no reduction in existing project safety factors during, and after, construction.
- Risks to migrating salmon during construction activities will be minimized.
- The design of modifications will be consistent with current Corps practices.
- Modifications will be based on proven technology, where possible, to assure workable plans and realistic costs. The use of existing technology will minimize research and corresponding implementation time, as well as minimize risks to migrating salmonids by utilizing proven bypass technologies.

4.04. Alternative 4A--Natural River Option

a. Description.

This concept would produce the most extreme drawdown operation of any of the alternatives considered in this study. For river flows of 20,000 cfs, the total drawdown below normal maximum pool levels would be approximately 115 feet at Lower Granite, 114 feet at Little Goose, 108 feet at Lower Monumental, and 97 feet at Ice Harbor Dam. It consists of installing a river bypass structure and channel around each of the four lower Snake River dams. The structures would allow the pools to be lowered, and divert the river around each dam in an effort to achieve a near free-flow river condition. The reservoir pools would be operated at a drawdown level during the juvenile fish outmigration from 15 April through 15 June or from 15 April through Labor Day. Pools would be returned to normal operating levels for the rest of the year. Powerhouse, spillway, and navigation lock operations would cease during the drawdown period. The bypass structures would be designed so that the velocities through the structures are acceptable (less than an average of 9 fps) for adult fish passage during river flows up to 225,000 cfs. Plates 2 through 5 illustrate this concept applied to each of the four lower Snake River dams.

b. Operation.

(1) Drawdown.

The existing powerhouse and spillways will be used to lower upstream pool levels from full pool levels to near the existing spillway crest elevations. Below spillway crest elevations, the powerhouses and existing spillways will be inoperable. To further lower the pool to near-natural river elevations, the tainter gates on the new structures will be opened, throttling the flow to allow a controlled lowering of the upstream pool. As the pool reaches the natural river level, the tainter gates will be raised completely out of the water. Reservoir drafting will begin no later than February 16 in order to achieve the near-natural flow condition by April 15 each year. The reservoir drafting will be limited to 2 feet per day. The inflow to Lower Granite Reservoir during this period averages about 60,000 cfs. For inflows up to 190,000 cfs, the average discharge above inflows required at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor would be 3,800 cfs, 8,300 cfs, 11,300 cfs, and 14,500 cfs, respectively. The total reservoir system storage that would be evacuated during the drawdown is estimated to be 1,663,500 acre-feet (AF). The drawdown time from full pool levels is limited only by the rate of drawdown (2 feet per day), provided that average Lower Granite inflows are less than 210,000 cfs. The maximum mean daily inflow to Lower Granite for the period between October 1976 and September 1991 was 166,200 cfs.

The period of transition between normal operations and drawdown operations will begin prior to the juvenile outmigration period. This will preclude the need for a low-level juvenile powerhouse bypass system. Existing adult fish facilities will be modified to allow adults to pass the project during the transitional period when the powerhouse is in use. When the pool is between spillway crest elevations and near run-of-river, passage of adult fish will not be possible. Water flowing under the tainter gates will create velocities too high for adult fish to negotiate. Adult passage will be possible after the tainter gates are completely raised from the water.

(2) Refill.

following the drawdown period regulated discharges would be reduced, allowing the reservoir to fill. Adult passage will again not be possible until the reservoir pools reach spillway crest elevations, and existing ladder systems and powerhouses are once again operational. If reservoirs are maintained at near-natural river elevations during the April 15 to June 15 time period, refill of the reservoirs will begin on June 16. Refill will take approximately 10 days, with average inflows of 95,000 cfs. Given the maximum inflows of record (190,000 cfs), the refill time would be reduced to 5 days. However, the refill time will increase dramatically in low water years. Given the 1992 inflows, which averaged 20,000 cfs, refill of the reservoirs would take about 99 days. Shorter refill times can be achieved by drafting upstream storage. During this transitional refill period, juvenile bypass systems will be inoperable until normal pool levels are reached. If reservoirs are maintained at natural river elevations from April 15 to after Labor Day, refill of the reservoirs will begin around September 5. Refill will take approximately 46 days, given average inflows of 30,000 cfs. The time for refill will vary, depending on inflows. If maximum inflows of record (40,000 cfs) are achieved, refill could occur in as quickly as 29 days. If, however, the refill takes place during a low water year when average inflows may drop to as low as 18,000 cfs, the refill period could take up to 129 days. Shorter refill times can be achieved by drafting upstream storage, but a large portion of the September inflows into Lower Granite Reservoir generally come from drafts of Dworshak Reservoir already. In most years, Dworshak is drafted about 30 feet from full pool (about 500,000 AF) during September. These computations assume minimum project releases (all four lower Snake River projects) of 11,500 cfs during the refill period. The reservoirs will likely be filled in the following order: 1) Ice Harbor; 2) Lower Monumental; 3) Little Goose; and 4) Lower Granite. However, the order of refill will not usually impact the time for refill. Refill times at other flows can be found in chart 6.

c. Project Modifications.

(1) General.

This alternative will require major physical changes to the four lower Snake River dams. The installation of bypass and non-overflow structures and excavation of new river approach channels, both upstream and downstream of the new bypass structures, will be required. The installation will require relocation of roads and railroads, and removal of existing North Shore non-overflow embankments at Little Goose and Lower Granite Dams. At Lower Monumental and Ice Harbor Dams, major channel excavations will be required along the south shores of the projects. Additionally, modifications must be made to existing adult facilities, spillway stilling basins, earth embankments, and other miscellaneous features.

(2) Adult Facilities.

Existing adult fish facilities will require modifications to allow the movement of fish past the projects during the transition period between normal operation and drawdown/refill operations. These facilities will only function with pool levels between normal pool and spillway crest elevations, when powerhouses and spillways are operational. Auxiliary ladder exits, including false weirs, fish return flumes, and ladder water supply pumps, will be required. Additionally, lowered fishway entrances, lowered collection channels, and modified auxiliary water supply systems will be necessary. A possible alternative to lowering fishway entrances and collection channel involves the installation of rockfill weirs in the downstream river channel to control tailwater elevations. Secondary fish exits will not be needed for this alternative. (See appendix A, *Feature Modifications - Technical Discussions.*)

(3) Existing Spillway/Stilling Basin Modifications.

A hydraulic jump-type stilling basin, with end sill and training walls, will be installed at Little Goose Dam downstream of the existing spillway rollerbucket. Drum gates will be installed downstream of the stilling basin end sill at Lower Granite, Little Goose, and Lower Monumental Dams. Stilling basin training walls will also be extended, as required, for tailwater control by the drumgates. The drumgates will be used to adjust stilling basin tailwater elevations so that spillway flip-lips will be as effective as possible in reducing dissolved gas levels. A proposed alternative method for controlling tailwater elevations below the dams involves the installation of a rockfill weir system in the downstream river channel. If such a system is determined to be acceptable, the drumgate system would not be necessary. (Refer to appendix A, *Feature Modifications - Technical Discussions.*)

(4) Bypass Structure.

The bypass structure consists of ten concrete gravity monoliths resting on bedrock (refer to plates 26 and 27). The monoliths form ten outlets. Each opening will be 45 feet tall by 50 feet wide. Non-overflow monoliths will be provided between the outlet and the shoreline. On the opposite side of the outlets, a non-overflowing monolith will provide a tie to the adjacent existing concrete structure. The concrete section included in this report approximately represents the average conditions for the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor projects.

(5) Tainter Gates and Intake Bulkheads.

Submerged steel tainter gates will control flow through each bypass outlet. An upstream bulkhead will be used for emergency closure and tainter gate maintenance. Downstream of the tainter gate, stoplogs will be used during maintenance operations. Use of the upstream bulkhead and downstream stoplogs would allow for dewatering of the inside of the outlet works during maintenance and inspection of the facility during normal pool levels.

(6) Tainter Gate Operators.

Hydraulic cylinders will be used to open and close each of the 10 new tainter gates. Based on the preliminary weight estimate and geometry of the tainter gates, each tainter gate will required two 12-inch-diameter bores, a 5-inch-diameter rod, and 46-foot stroke cylinders operating at 2500 pounds per square inch (psi). Two hydraulic circuits will be provided with five gates per circuit. Only one gate per circuit will be operated at a time. The two circuits could be interconnected by strategically placed isolation valves, such that one of the hydraulic power units could be used to operate the entire system if the other power unit was inoperable. It is assumed that each power unit will be comprised of a 10-gallons-per-minute (gpm) pump, with a 1000-gallon reservoir and all necessary extras. A 10-gpm system capacity would result in a gate-closing speed of approximately 1 foot per minute (fpm). This speed is comparable to the operating speed of the spillway gates at Lower Granite Dam. Flow to each pair of hydraulic cylinders will be controlled by using an electric solenoid valve and a rotary flow divider to ensure equal flow to each cylinder. For a flow rate of 10 gpm, the "pressure" lines should be 1-inch-diameter hydraulic tubing with a velocity of 4 fps, and the "tank" lines should be 2-inch hydraulic tubing with a velocity of 1 fps.

(7) Gantry Crane.

To raise and lower the intake gates and bulkheads, a gantry crane will be required. The gantry crane will need a capacity of 350 tons to lift the intake gates. The crane will be used to move the intake gates to and from the dogged-off position, and to remove the gates for maintenance purposes. The crane rail system should allow the crane to travel a total of 800 feet; 600 feet along the length of the new structure, and 100 feet beyond each end. The crane may also be used to remove the tainter gate lifting equipment, and as an additional means of manipulating the tainter gates for maintenance and repair, if necessary.

(8) Construction Cofferdams.

Installation of the cofferdams will be the first phase of construction. Construction of the cofferdam will be under full reservoir pool levels. The site area can then be dewatered, and the embankment removed.

There are at least two different ways to construct cofferdams to facilitate the construction of the low-level bypass structure. Plates 2 through 5 indicate upstream and downstream construction cofferdams. Plates 22 and 23 illustrate an additional method possible at Lower Granite and Little Goose Dams. For this alternative, upstream cofferdams were assumed. If this alternative is selected for further study, cofferdam arrangements will be examined in more detail during Phase II, and the most cost-effective method will then be determined. (Refer to appendix A, *Feature Modifications - Technical Discussions*, for additional information.)

(9) Miscellaneous Modifications.

Miscellaneous features at the dam and in, or adjacent to, the associated reservoirs will require modification to allow operation or to prevent damage whenever pool levels are lowered below minimum operating levels. These features include the floating navigation lock guide walls at each dam, and the debris shear boom at Lower Granite. Drainage culverts and pipe outfalls along each reservoir require modifications or facilities to prevent bank erosion. Other facilities requiring modification include the water quality siphons at the Lewiston Levees and the adult fish ladder at Lyons Fish Hatchery.

(10) Relocations and Associated Real Estate Acquisition.

The relocation of roads, railroads, visitor facilities, and other facilities will be required to construct the new channels and bypass structures. These are defined in more detail in appendix A, *Feature Modifications - Technical Discussions*, sections 6 and 10.

(11) Embankment Protection.

Protection of embankments from erosion and failure will be required for this alternative. (See appendix A, *Feature Modifications - Technical Discussions*.)

d. Implementation Schedule.

Assuming that funds and resources are available when required, it is estimated that from the date authority is granted and funds are appropriated, it will take about 17 years to fully implement this alternative at all four lower Snake River dams. (Refer to plate 5.1.) Limitations on resources such as manpower, money, or materials may extend this schedule. In addition, if more study or research identifies any unforeseen technical problems, additional time may be required to obtain acceptable solutions.

Initially, design memorandums (DM's) for features such as relocations, adult fishway modifications, and bypass structures for each dam will be required. The DM's will identify and satisfy all engineering data requirements (*i.e.*, foundation explorations, design criteria, and survey information). In addition, coordination with fishery agencies concerning adult fishway modifications will be carried out during this process. Hydraulic models of each of the four lower Snake River projects will be required to obtain detailed design data on the new bypass structure. The models will also be used to identify strategic placement of construction cofferdams required to accommodate modifications to adult collection systems.

The DM for the bypass structure will need to be nearly completed in order to identify requirements for real estate and relocations. Once these are identified, relocations can proceed into the real estate acquisition, engineering/design, and construction processes. Construction of the relocations must occur prior to construction of the bypass structure.

The construction of modifications to spillways, stilling basins, and powerhouse adult fishway modifications will be phased throughout the construction period. Downstream cofferdams are required for each, and it would not be prudent to have both powerhouse and spillway capacity reductions occurring simultaneously. In addition, construction activities on existing stilling basins will be phased to minimize reductions of spillway capacities. Construction will only be allowed during annual low-water periods, from August through March. Contractors will be required to have all cofferdams removed, and all spillway bays operational, during the typical April through July runoff period.

The staggering of construction activities, relative to adult fishway and spillway/stilling basin modifications, was found to be the critical path for construction activities. Other modifications are somewhat independent.

Assuming unlimited resources, Lower Granite and Little Goose Dams will be modified at the same time, and are estimated to be completed approximately 11 years after initiation. Construction will be completed on these two projects prior to the start of construction on the remaining two dams in order to provide a 2-year period of post-construction evaluation on the Granite/Goose projects. The evaluation may identify problem areas in design or construction that could be remedied prior to, or during, construction of the Lower Monumental and Ice Harbor modifications.

e. Cost Estimate.

The reconnaissance-level, fully-funded project cost, including real estate, for alternative 4A, Natural River Option, is estimated at $4.9 billion. This fully-funded construction cost is based on an October 1992 price level, and escalated to midpoint of construction to account for anticipated inflation. The required biological research, feasibility studies, model studies, DM's, engineering, and design is included at an estimated 28 percent of construction costs. Construction management is estimated at 11 percent of construction costs. Contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study. A cost breakdown for this alternative is displayed in appendix C, *Cost Data.*

The annual cost for this option is estimated to be $524 million. This cost includes interest and amortization of the project cost at 8-percent interest rate (current Federal Discount rate), and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.05. Alternative 5--Existing Powerhouse and Existing Spillway - Variable Pool

a. Description.

This concept would produce variable pool operation with drawdown levels up to 57 feet at Lower Granite, Little Goose, and Lower Monumental Dams; and up to 49 feet at Ice Harbor Dam. The existing powerhouses would be operated to their hydraulic capacity, at pool levels not less than the corresponding existing spillway crest elevations. Flows in excess of powerplant capacity would pass uncontrolled (no gate control) over the spillway. The forebay water surface elevations would fluctuate above the spillway crests, depending on river discharge, and the flow would be split between the powerhouses and the spillways. The reservoir pools would be operated at a drawdown level during the juvenile fish outmigration from 15 April through 15 June, or from 15 April through Labor Day. Pools would be returned to normal operating levels for the rest of the year.

The hydraulic capacity for the Ice Harbor powerhouse, operating at spillway crest pool elevation (391), has been estimated to be about 62,000 cfs. At Lower Monumental, Little Goose, and Lower Granite Dams, operating with pool levels at spillway crest elevations of 483, 581, and 681, respectively, the powerhouse hydraulic capacity has been estimated to be about 86,000 cfs. For a river discharge of 62,000 cfs or less, the reservoirs can be drafted to the following pool elevations:

Project	Powerhouse Capacity	Pool Level	Spillway Discharge
Ice Harbor	62000	391.0	0
Lower Monumental	86000	483.0	0
Little Goose	86000	581.0	0
Lower Granite	86000	681.0	0

(Note: Hydraulic capacities of powerhouses operating at spillway crest elevations are estimates. Additional studies will be required to refine these estimates. Better estimates will cause corresponding adjustments to numbers presented in the following discussions.)

For a river discharge of 225,000 cfs, the following approximate conditions would exist. (The conditions below are approximate since, as the pool elevation increases, the hydraulic capacity of the powerhouse increases.)

Project	Powerhouse Capacity	Pool Level	Spillway Discharge
Ice Harbor	76,800	401	148,200
Lower Monumental	101,750	503	123,250
Little Goose	101,750	601	123,250
Lower Granite	101,750	701	123,250

As the river discharge increases, the pool elevation will increase. The approximate total pool elevation increases, as the river flow increases from 62000 to 225,000 cfs, is about 19 feet for Ice Harbor pool and 20 feet for the other three projects.

b. Operation.

(1) Drawdown.

Controlled reservoir drafting, along with the utilization of existing powerhouse and spillway operation to achieve the lower pool levels, will occur prior to the arrival of juvenile fish migrants. The existing juvenile fish bypass systems become inoperable below minimum operating pool levels, and operation of the new low-level juvenile bypass is not recommended until pools have been lowered to acceptable levels. While the new lower level juvenile bypass system could certainly pass water under the higher pool conditions, the rapid pressure changes within the system may be detrimental to the survival of juveniles that might pass through the system during this period. Existing adult fish facilities will be modified to allow adults to pass the project during the transitional period.

Reservoir drafting would begin no later than March 16 in order to achieve the target drawdown elevations by April 15 of each year. This assumes full pool conditions initially, a drawdown rate of 2 feet per day, and average inflows to Lower Granite Reservoir of less than 80,000 cfs. For years when average inflows are expected to be greater than these flows, the reservoirs cannot be drafted all the way to the spillway crest elevations. For years when inflows are grater than 90,000 cfs, the final drawdown elevations will be significantly higher than the spillway crests, and the drawdown can be started later than March 16. For instance, for an average inflow of 225,000 cfs, the drawdown could be started as late as March 26. The average project discharge above inflows required at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor will be 6,000 cfs, 13,100 cfs, 17,000 cfs, and 22,800 cfs, respectively. The discharges will be highest at the beginning of the drawdown period. Peak discharges above inflows at the four projects will be 8,400 cfs, 13,100 cfs, 27,000 cfs, and 35,300 cfs, respectively. The total reservoir system storage that will be evacuated from full pool elevations to the spillway crest elevations is estimated to be 1,313,300 AF. Reservoir drafting is limited to 2 feet per day to prevent embankment failure (see appendix A, *Feature Modifications - Technical Discussions*). This alternative proposes to operate the spillway without gate control, and allow flows in excess of powerhouse hydraulic capacities to pass over the spillways. Since the drawdown period will be occurring during the spring runoff months, it is likely that freshets will occur. These freshets will increase river flows and raise the water level above the existing spillway crests by more than 2 feet. Depending on the hydrograph recession, it may be necessary to implement gate control to prevent the reservoir pool from falling faster than 2 feet per day following the freshet.

(2) Refill.

If reservoir elevations are maintained at their drawdown levels during the April 15-to-June 15 time period, refill of the reservoirs will take approximately 8 days with average inflows of 95,000 cfs. Given the maximum inflows of record (190,000 cfs), the refill time will be reduced to 3 days. However, the refill time will increase dramatically in low water years. Given the 1992 inflows (averaging 20,000 cfs), refill of the reservoirs will take about 78 days. Shorter refill times can be achieved by drafting upstream storage. During this transitional refill period, juvenile bypass systems will be inoperable until normal pool levels are achieved. If reservoirs are maintained at their drawdown levels from April 15 to after Labor Day, refill of the reservoirs will begin around September 5, and will take approximately 36 days, given average inflows of 30,000 cfs. The time for refill will vary, depending on inflows. If maximum inflows of record (40,000 cfs) are achieved, refill could occur in as quickly as 24 days. If, however, the refill takes place during a low water year when average inflows may drop to as low as 18,000 cfs, the refill period could take up to 102 days. Shorter refill times can be achieved by drafting upstream storage, but a large portion of the September inflows into Lower Granite Reservoir come from drafts of Dworshak Reservoir already. In most years, Dworshak is drafted to about 30 feet from full pool (about 500,000 AF) during September. These computations assume minimum project releases of 11,500 cfs during the refill period. The reservoirs will likely be filled in the following order: 1) Ice Harbor; 2) Lower Monumental; 3) Little Goose; and 4) Lower Granite. However, the order of refill will not usually impact the time for refill. Information of refill times at other flows can be found in chart 7.

c. Project Modifications.

(1) General.

This alternative will require physical changes to each of the four lower Snake River dams to accommodate this operation. Plates 6 through 9 illustrate this concept as it is applied to each of the four lower Snake River dams. (Refer to appendix A, *Feature Modifications - Technical Discussions*, for more detailed discussion of individual feature modifications.) Structural modifications to juvenile and adult bypass systems, spillway stilling basins, earth embankments, and other miscellaneous features will be necessary.

(2) Low-Level Juvenile Bypass.

With the lowered pool levels, the existing juvenile bypass systems will be inoperable. A new lower-level juvenile bypass system will be required in order to collect and pass juvenile fish around operating turbines to the tailrace. Because of the magnitude of forebay fluctuation, the collection channel will be a pressurized system similar to that at John Day Dam. The juvenile collection system could possibly be designed to operate in an open channel mode from spillway crest elevation to 5 feet above spillway crest elevation. For higher flows, and corresponding higher pool levels, the channel would be operated in a pressurized mode. An 11-foot fluctuation range (from spillway crests to 11 feet above spillway crests), with full hydraulic capacity of powerhouses, would accommodate a river flow up to about 136,000 cfs. If one or more powerhouse turbines were out of service, the river flow (which would cause 11 feet of head on spillway crests) would be lower. The John Day juvenile bypass system operates acceptably with an 11-foot pool fluctuation, but the effect on juvenile fish passing through pressurized juvenile bypass systems operating over a greater pool range is unknown. Pressurized operation, for heads greater than 11 feet, may not be desirable since the rapid pressure changes within the system may be harmful to juvenile fish. In addition, the higher the pool rises over orifices within gatewells, the less efficient the orifices may be in attracting juveniles into the collection channel. Juvenile fish transportation will not be possible since navigation will be suspended. Floating surface collector systems have been identified as potential methods to augment juvenile collection and bypass. However, it is not expected at this time that they could replace the gatewell collection systems. Therefore, pressurized gatewell systems would still be necessary with a variable pool operation.

(3) Adult Facilities.

The adult fish ladder exits will be modified to work under the anticipated forebay fluctuation. At Lower monumental, Little Goose, and Ice Harbor, an auxiliary adult exit, consisting of a false weir and return flume, will be required to allow adult passage during the transition between full pool and lowered pool. Lower Granite has such a system, but it will require modification to accommodate a wider range in fluctuation. A secondary low-level ladder exit, with a vertical-slot control section similar to John Day Dam adult ladders, could be employed to provide a gravity feed ladder. The John Day system works under 11 feet of fluctuation. An 11-foot fluctuation range imposed on the lower Snake River dams, with full hydraulic capacity of powerhouses, would accommodate a river discharge of up to 136,000 cfs. River flows above this would require the gravity feed system to be shut down, and the auxiliary ladder exits (with fish return flumes) to be used.

With all four projects operating in the drawdown mode, the tailwater elevations will be lower than originally designed (except at Ice Harbor). Therefore, adult ladder facilities, including entrances and auxiliary water supply, will need to be modified. At all projects except Ice Harbor Dam, the existing adult collection system will be lowered to maintain adequate tailwater depth for operation of adult fish ladder entrances. Adult ladder entrances and water supply systems at Ice Harbor Dam will not need modification because tailwater elevations (McNary pool) will not change.

Downstream rockfill weirs have been identified to maintain a normal water surface in the tailrace area. These weirs would preclude the need to modify the adult collection system (entrances, auxiliary water, *etc.*). A preliminary analysis was conducted that indicated that these weirs would conflict with existing fish criteria. However, they may have some potential and need additional analysis (see appendix A, *Feature Modifications - Technical Discussions*).

(4) Existing Spillway/Stilling Basin Modifications.

At Little Goose Dam, a hydraulic jump-type stilling basin, with end sill and training walls, will be installed downstream of the existing spillway rollerbucket. At Lower Granite, Little Goose, and Lower Monumental Dams, drumgates will be installed downstream of the stilling basin end sill. Stilling basin training walls will also be extended, as required, for tailwater control by the drumgates. The drumgates will be used to adjust stilling basin tailwater elevations so that spillway flip-lips can be as effective as possible in reducing dissolved gas levels. A proposed alternative method for controlling tailwater elevations below the dams involves the installation of a rockfill weir system in the downstream river channel. If such a system is determined to be acceptable, the drumgate system would not be necessary. (See appendix A, *Feature Modifications - Technical Discussions*.)

(5) Construction Cofferdams.

Cofferdams will be required to implement modifications. (Refer appendix A, *Feature Modifications - Technical Discussions*.)

(6) Miscellaneous Modifications.

Miscellaneous features at the dams and in, or adjacent to, the associated reservoirs will require modification to allow operation and to prevent damage when pool levels are lowered below minimum operating levels. These features include the floating navigation lock guidewalls, culvert and pipe outfalls, debris shear boom, water quality siphons (Lewiston Levees), and the adult fish ladder at Lyons Ferry Hatchery.

(7) Embankment Protection.

Protection of embankments from erosion and failure will be required for this alternative. (Refer appendix A, *Feature Modifications - Technical Discussions*.)

d. Implementation Schedule.

Assuming that funds and resources are available when required, it is estimated that from the date authority is granted and funds are appropriated, it will take about 14 years to fully implement this alternative at all four lower Snake River dams. (Refer to plate 10.) Limitations on resources such as manpower, money, or materials may extend this schedule. Also, if additional study or research (hydraulic model studies) identifies any unforeseen technical problems, additional time may be required to obtain acceptable solutions.

Initially, DM's for features such as adult fishway modifications, and the new lower-level juvenile bypass systems for each dam will be required. The DM's will identify and satisfy all engineering data requirements. In addition, coordination with fishery agencies, concerning adult fishway modifications and new low-level juvenile bypass systems, will be carrier out during this process. Hydraulic models of each of the four lower Snake River projects will be necessary to identify strategic placement of the construction cofferdams required to accommodate modifications to adult collection systems. Construction cofferdams will be placed in a manner that offers the best achievable hydraulic conditions for continued adult fishway operations during construction. In addition, the models will be used to identify the most acceptable location for the juvenile fish bypass release points. Sectional hydraulic models of the spillways will be utilized to examine the operability of all proposed stilling basin modifications. The existing Lower Granite spillway sectional model is representative of both the Lower Granite and Little Goose projects. A new sectional model of the Lower Monumental spillway will need to be constructed.

The construction of modifications to spillway stilling basins and powerhouse adult fishway modifications will be phased throughout the construction period. Downstream cofferdams are required for each, and it would not be prudent to have both powerhouse and spillway capacity reduction occurring simultaneously. In addition, construction activities on existing stilling basins will be phased to minimize reductions of spillway capacities. Construction will only be allowed during annual low-water periods occurring from August through March. Contractors will be required to have all cofferdams removed and all spillway bays operational during the typical April through July runoff period.

The staggering of construction activities relating to adult fishway and stilling basin modifications was found to be the critical path for construction activities. Other modifications are somewhat independent.

Assuming unlimited resources, Lower Granite and Little Goose Dams will be modified at the same time, and are estimated to be completed approximately 11 years after initiation. Construction would be completed on these two projects prior to the start of construction on the remaining two dams. This would provide a 2-year period of post-construction evaluation on the Granite/Goose projects. The evaluation may identify problem areas in design or construction that could be remedied prior to, or during, construction of the Lower Monumental and Ice Harbor modifications.

e. Cost Estimate.

The reconnaissance-level, fully-funded project cost, including real estate, for alternative 5 is estimated at $1.3 billion. The construction cost is based on an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, model studies, DM's, engineering and design is included at an estimated 28 percent of construction costs. Construction management is estimated at 11 percent of construction costs. The contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study. A cost breakdown for this alternative is displayed in appendix C, *Cost Data*.

The annual cost for this option is estimated to be $133 million. This cost includes interest and amortization of the project cost at 8-percent interest rate (current Federal discount rate) and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.06. Alternative 9--Modified Powerhouse and Existing Spillway - Variable Pool

a. Description.

This alternative is the same as alternative 5, except for the powerhouse modifications described below.

b. Operation.

The operation associated with this alternative is identical to alternative 5.

c. Project Modifications.

(1) General.

The physical changes required by this alternative are identical to alternative 5, except that turbine/generator sets at each of the lower Snake River dams would be replaced with new equipment designed to work more efficiently at the drawdown pool levels (refer to plates 6 through 9).

(2) Powerhouse Modifications.

Operating existing turbine/generator units at low heads causes a loss in operating efficiency. This occurs because the turbines were designed and built to have peak efficiency at, or near, the heads they would be operated at most of the tine. Low efficiency operation due to lower heads can be mitigated wholly, or in part, in various ways (see appendix B, *Powerplant Report*). For this study, it was assumed that the installation of new turbine-runners would be the option of choice. New turbine-runners can be designed that will operate at peak efficiency at a lower head. The blades can be made of stainless steel and the discharge ring overlaid with stainless steel, thereby improving cavitation resistance. Utilizing existing units, efficiency would decrease an average of 5.3 percent. (This assumes that no screening systems, such as STS's, are in place. It is unknown how STS's affect turbine efficiencies.)

d. Implementation Schedule.

The implementation schedule for this alternative would be the same as for alternative 5, except that this alternative includes replacing the turbine-runners at the powerhouses of each of the four lower Snake River dams. The schedule includes research and preliminary design work, and assumes that replacement of the turbine-runners can be completed at all four dams simultaneously. Turbine-runner replacement is estimated to take about 9 years from authorization and appropriation. The majority of this work could take place at the same time as the adult fishway modifications (refer to plate 11).

e. Cost Estimate.

The reconnaissance-level, fully-funded project cost, including real estate, for alternative 9 is estimated at $1.7 billion. The construction cost is based on an October 1992 price level. Fully-funded implies that inflation is added to the construction cost (to the midpoint of construction). The required biological research, feasibility studies, model studies, DM's, engineering and design is included at an estimated 28 percent of construction costs. Construction management is estimated at 11 percent of construction costs. The contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study. A cost breakdown for this alternative is displayed in appendix C, *Cost Data*.

The annual cost for this option is estimated to be $174 million. This cost includes interest and amortization of the project cost at 8-percent interest rate (current Federal discount rate), and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.07. Alternative 13--Existing Powerhouse and Existing Spillway - Constant Pool

a. Description.

This alternative proposes a drawdown operation of 33 to 38 feet below normal maximum pools at Lower Granite, Little Goose, and Lower Monumental Dams; and a drawdown of 25 to 50 feet below normal maximum pool at Ice Harbor Dam. During the drawdown operating mode, the drawdown pool levels will be maintained at a near constant level (5-foot pool fluctuation). The reservoir pools would be operated at a drawdown level during the juvenile fish outmigration from April 15 through June 15, or from April 15 through Labor Day. Pools would be returned to normal operating levels for the rest of the year.

Water would pass through existing turbines until the hydraulic capacities of the powerplants are reached. River flows in excess of plant hydraulic capacity would then pass over the existing spillways. At these drawdown levels, spill in excess of powerhouse hydraulic capacities could be controlled by existing spillway gates. At the 33-foot drawdown level, the hydraulic capacity of the powerplants at Lower Granite (pool elevation 705), Little Goose (pool elevation 605), and Lower Monumental (pool elevation 507) is estimated to be 105,000 cfs. The capacity of the Ice Harbor powerplant is estimated to be 80,000 cfs at the 25-foot drawdown level (pool elevation 415).

The combined hydraulic capacity of existing powerhouses and spillways at pool levels 24 feet above existing spillway crests is estimated to be 225,000 cfs, assuming spillway gate control is maintained.

b. Operation.

(1) Drawdown.

The four lower Snake River projects will begin drafting no later than March 29 in order to reach the target drawdown elevations by April 15 each year. The drawdown pools must be achieved prior to the arrival of large numbers of juvenile fish, since the low-level bypass systems will not be operational until drawdown pool levels are reached. The date computed to begin the drawdown assumes full pools initially, a drawdown rate of 2 feet per day, and average inflows to Lower Granite reservoir of less than 225,000 cfs. The average project discharge above inflows required at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor is 6,800 cfs, 15,600 cfs, 21,000 cfs, and 26,400 cfs, respectively. The discharges will be highest at the beginning of the drawdown period. Peak discharges above inflows at the four projects will be 8,400 cfs, 18,300 cfs, 27,000 cfs, and 35,300 cfs, respectively. The total reservoir system storage that will be evacuated, from full pool elevations to the drawdown elevations, is estimated to be 900,000 AF.

(2) Refill.

If reservoir elevations are maintained at their drawdown levels during the April 15-to-June 15 time period, refill of the reservoirs will take approximately 6 days with average inflows of 95,000 cfs. Given the maximum inflows of record (190,000 cfs), the refill time will be reduced to 3 days. However, the refill time will increase dramatically in low-water years. Given the 1992 inflows after mid-June (averaging 21,000 cfs), refill of the reservoirs will take about 48 days. Shorter refill times can be achieved by drafting upstream storage. During this transition refill period, juvenile bypass systems will be inoperable until normal pool levels are reached. If reservoirs are maintained at their drawdown levels from April 15 to after Labor Day, refill of the reservoirs will begin around September 5. Refill will take approximately 25 days provided average inflows of 30,000 cfs are achieved. The time for refill will vary, depending on inflows. Given maximum inflows of record (40,000 cfs), refill will take approximately 16 days. During low-water years, when average inflows can drop to around 20,k000 cfs, refill will take up to 54 days. Shorter refill times can be achieved by drafting upstream storage, but a large portion of the September inflows into Lower Granite reservoir comes from drafts of Dworshak Reservoir already. In most years, Dworshak is drafted about 30 feet from full pool (about 500,000 AF) during September. These computations assume minimum project releases of 11,500 cfs during the refill period. The reservoirs will likely be filled in the following order: 1) Ice Harbor; 2) Lower Monumental; 3) Little Goose; and 4) Lower Granite. However, the order of refill will not generally impact the refill time. Information on refill times at other flows can be found in chart 8.

c. Required Modifications.

(1) General.

This alternative will require structural modifications to the four lower Snake River dams, as illustrated in plates 14 through 17. These modifications are described below, and include juvenile bypass and adult systems, spillway stilling basins, earth embankments, and other miscellaneous features.

(2) Low-Level Juvenile Bypass System.

With the lowered pool levels, the existing juvenile bypass system will be inoperable. A new lower-level juvenile bypass system will be required to collect and pass juvenile fish around operating turbines to the tailrace. Because of the restricted magnitude of forebay fluctuation, the collection channel will operate as an open channel system similar to that currently employed at the lower Snake River dams. The collection gallery depth will be controlled by a dewatering structure. Fish and water will pass to the tailrace through the dewatering structure and corrugated metal flume. Juvenile fish transportation will not be possible, since navigation will be suspended. A new set of VBS's will be required to provide for optimum levels of OPE. The new screens will be put in place prior to drawdown, and left in place during drawdown and refill. The existing VBS's would be put back into place after refill for improved efficiency at the normal operational range. (See appendix A, *Feature Modifications - Technical Discussions*, for additional information.) Floating surface collector systems have been identified as potential methods to augment juvenile collection and bypass. However, it is not expected at this time that they could replace the gatewell collection systems. Therefore, pressurized gatewell systems would still be necessary with a variable pool operation.

(3) Adult Facilities.

(Refer to appendix A, *Feature Modifications - Technical Discussions*, for detailed descriptions.) The addition of secondary low-level adult ladder exits and auxiliary exits would be required. Once the low-level (drawdown) operating pool has been reached, the secondary low-level ladder exit could be utilized. At Lower Monumental, Little Goose, and Ice Harbor, an auxiliary exit, with false weir and return flume, would be required to allow adult passage during the transition between full pool and lowered pool. Lower Granite has such a system, but it would require modification to accommodate a wider range in fluctuation.

With all four projects operating in the drawdown mode, tailwater elevations would be lower than originally designed (except at Ice Harbor). Therefore, adult ladder facilities, including entrances and auxiliary water supply, would need to be modified. At all projects except Ice Harbor, the existing adult collection system would be lowered to maintain adequate tailwater depth for the operation of adult fish ladder entrances. A possible alternative to lowering fishway entrances and collection channels involves the installation of rockfill weirs in the downstream river channel to control tailwater elevations (see appendix A, *Feature Modifications - Technical Discussions*, section 13). Adult ladder entrances and water supply systems at Ice Harbor would not need modification because tailwater elevations (McNary pool) would not change.

(4) Existing Spillway/Stilling Basin Modifications.

At Little Goose Dam, a hydraulic jump-type stilling basin, with end sill and training walls, would be installed downstream of the existing spillway rollerbucket. At Lower Granite, Little Goose, and Lower Monumental Dams, drumgates would be installed downstream of the stilling basin and sill. Stilling basin training walls would also be extended, as required, for tailwater control by the drumgates. The drumgates would be used to adjust stilling basin tailwater elevations so that spillway flip-lips would be as effective as possible in reducing dissolved gas levels. A proposed alternative method for controlling tailwater elevations below the dams involves the installation of a rockfill weir system in the downstream river channel. If such a system is determined to be acceptable, the drumgate system would not be necessary (see appendix A, *Feature Modifications - Technical Discussions*).

(5) Construction Cofferdams.

Cofferdams would be required to modify adult facilities and spillway stilling basins. (Refer to appendix A, *Feature Modifications - Technical Discussions*, for detailed descriptions.)

(6) Miscellaneous Modifications.

Miscellaneous features at the dams and in, or adjacent to, the associated reservoirs would require modification to allow operation, or to prevent damage when pool levels are lowered below minimum operating levels. These features include the floating navigation lock guide walls, culvert and pipe outfalls, debris shear boom, water quality siphons (Lewiston Levees), and the adult ladder at Lyons Ferry Hatchery.

(7) Embankment Protection.

Protection of embankments from erosion and failure would be required for this alternative (see appendix A, *Feature Modifications - Technical Discussions*).

d. Implementation Schedule.

Assuming that funds and resources are available when required, it is estimated that, from the date authority is granted and funds are appropriated, it will take about 14 years to fully implement this alternative at all four lower Snake River dams (refer to plate 17.1). Limitations on resources such as manpower, money, or materials, may extend this schedule. Also, if additional study or research (hydraulic model studies) identifies any unforeseen technical problems, more time may be required to obtain acceptable solutions.

Initially, DM's for features such as adult fishway modifications and new low-level juvenile bypass systems for each dam will be required. The DM's will identify and satisfy all engineering data requirements (*i.e.*, design criteria and survey information). In addition, coordination with fishery agencies, concerning adult fishway modifications and the new low-level juvenile fish bypass systems, will be carrier out during this process. Hydraulic models of each of the lower Snake River projects will be required in order to identify strategic placement of the construction cofferdams necessary to accommodate modifications to the adult collection systems. Construction cofferdams will be placed in a manner that offers the best achievable hydraulic conditions for continued adult fishway operations during construction. In addition, the models will be used to identify the most acceptable location for the juvenile fish bypass release points. Sectional hydraulic models of the spillways will be utilized to examine the operability of proposed stilling basin modifications. The existing Lower Granite spillway sectional model is representative of the Lower Granite and Little Goose projects. A new sectional model of the Lower Monumental spillway will need to be constructed.

The construction of modifications to spillway stilling basins and powerhouse adult fishway modifications will be phased throughout the construction period. Downstream cofferdams are required for both, and it would not be prudent to have both powerhouse and spillway capacity reductions occurring simultaneously. In addition, construction activities on existing stilling basins will be phased to minimize reduction of spillway capacities. Construction will only be allowed during annual low-water periods from August through March. Contractors will be required to have all cofferdams removed and all spillway bays operational during the typical April through July runoff period.

The staggering of construction activities relative to adult fishway and stilling basin modifications was found to be the critical path for construction activities. Other modifications are somewhat independent.

Assuming unlimited resources, Lower Granite and Little Goose Dams will be modified at the same time, and are estimated to be completed approximately 11 years after initiation. Construction will be completed on these two projects prior to the start of construction on the remaining two dams. This will provide a 2-year period of post-construction evaluation on the Granite/Goose projects. The evaluation may identify problem areas in design or construction that could be remedied prior to, or during, construction of the Lower Monumental and Ice Harbor modifications.

Because the modifications identified are considered to be extremely complicated, from a biological standpoint, the 2-year post-construction period is considered to be very important. However, in the unlikely event that this evaluation period is unnecessary, all four projects could be modified simultaneously.

e. Cost Estimate.

The reconnaissance-level, fully-funded project cost, including real estate, for alternative 13 is estimated at $1.3 billion. The construction cost is based on an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, model studies, DM's, engineering, and design is included at an additional 28 percent of construction costs. Construction management is estimated at an additional 11 percent of construction costs. The contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study. A cost breakdown for this alternative is displayed in appendix C, *Cost Data*.

The annual cost for this option is estimated to be $130 million. This cost includes interest and amortization of the project cost at 8-percent interest rate (current Federal discount rate) and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.08. Alternative 13A--Existing Powerhouse and Existing Spillway - Constant Pool, Lower Granite Dam Only

a. Description.

This section describes the necessary modifications, schedules, and costs associated with a 33-foot near constant pool drawdown (5-foot fluctuation) at Lower Granite Dam only.

b. Operation.

For a drawdown operation of the Lower Granite reservoir to target elevations 700 to 705 feet mean sea level, drafting will begin no later than March 29 in order to reach the lowered pool elevations by April 15. The storage being evacuated from full pool elevations to target drawdown elevations, is estimated to be 231,000 AF. If reservoir pool elevations are maintained at their drawdown levels during the April 15 to June 15 time period, refill of the reservoirs will take approximately 2 days with average inflows of 95,000 cfs. Given the 1992 inflows after mid-June, averaging 21,000 cfs, refill of the Lower Granite reservoir will take about 6 days.

c. Required Modifications.

(1) General.

This alternative will require changes to Lower Granite Dam, as illustrated on plate 62, and described in the following paragraphs. Since the Little Goose reservoir (pool) will not be lowered, the water surface elevations below Lower Granite will not be affected. Therefore, the modifications required at Lower Granite will be limited to the upstream forebay side of the dam. Structural modifications to juvenile and adult bypass systems, earth embankments, and miscellaneous features will be necessary.

(2) Modifications.

(a) Low-Level Juvenile Bypass System.

With the lowered pool levels, the existing juvenile bypass systems will be inoperable. A new lower-level juvenile bypass system will be required to collect and pass juvenile fish around operating turbines to the tailrace. Because of the restricted magnitude of forebay fluctuation at the drawdown level (5-foot pool fluctuation), the collection channel can be constructed as an open channel flow system similar to that currently employed at the lower Snake River dams. Fish and water would be passed directly to the tailrace, or to holding and loading facilities below Lower Granite Dam. Juvenile fish transportation can occur, since navigation below Lower Granite will still be possible with the Little Goose reservoir at normal pool levels. A new set of VBS's will be required to provide for optimum possible levels of OPE. The new screens will be put in place prior to drawdown, and left in place during drawdown and refill. The existing VBS's would be put back into place after refill for improved efficiency at the normal operational range. In addition to the proposed low-level juvenile bypass system, a surface flow collection system has also been proposed to improve juvenile fish bypass during normal and drawdown operations. For a full discussion of this proposed concept, refer to appendix A, *Feature Modifications - Technical Discussions*, section 16.

(b) Adult Facilities.

The addition of secondary low-level adult ladder exits and auxiliary exits would be required. Once the low-level (drawdown) operating pool has been reached, the secondary low-level ladder exit could be utilized. Since Lower Granite is the only reservoir pool to be lowered, tailwater elevations will not be changed. Therefore, no modifications to adult fish entrances, collection channels, or auxiliary water systems will be necessary.

(c) Existing Spillway/Stilling Basin.

Since Lower Granite is the only reservoir pool to be lowered, tailwater elevations will not be changed. Therefore, no modifications to the spillway or stilling basins will be necessary.

(d) Miscellaneous Modifications.

Miscellaneous features at Lower Granite Dam and in, or adjacent to, the reservoir will require modification to allow operation, or to prevent damage when pool levels are lowered below minimum operating levels. The features include the floating navigation lock guide wall, culvert and pipe outfalls, debris shear boom, and the water quality siphons (Lewiston Levees).

(e) Embankment Protection.

The protection of embankments upstream of Lower Granite Dam will be required.

d. Implementation Schedule.

Assuming that funds and resources are available when required, it is estimated that, from the date authority is granted and funds are appropriated, it will take about 4 years to implement the identified modifications of Lower Granite Dam (refer to). Limitations on resources such as manpower, money, or materials may extend this schedule.

e. Cost Estimate.

The reconnaissance-level, fully-funded project cost for the modifications of Lower Granite Dam is estimated at $87.2 million. These costs include planning, real estate, engineer and design, construction management, contingencies, and inflation to midpoint of construction.

The annual cost for this option is estimated to be $3.6 million. This cost included interest and amortization of the project cost, at an 8-percent interest rate (current Federal discount rate), and a project life of 100 years. In addition, interest during construction, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are based on an October 1992 price level, escalated to midpoint of construction. These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.09. Alternative 14--Existing Powerhouse and Modified Existing Spillway - Constant Pool

a. Description.

This alternative proposes to operate the four lower Snake River dams and reservoirs at a level 43 to 48 feet below normal maximum pool levels at Lower Granite, Little Goose, and Lower Monumental Dams; and 35 to 40 feet below the normal maximum pool level at Ice Harbor Dam. To achieve this drawdown level, the existing spillways would be modified by lowering the crests 10 feet. The powerhouses at each lower Snake River dam would be operated to their hydraulic capacity, with excess water passing over the modified existing spillways. During the drawdown operating mode, the drawdown pool levels would be maintained at a near constant level (5-foot pool fluctuation). The reservoir pools would be operated at a drawdown level during the juvenile fish outmigration from April 15 through June 15, or from April 15 through Labor Day. Pools would be returned to normal operating levels for the rest of the year.

At the 43-foot drawdown pool levels, the powerplant hydraulic capacity at Lower Granite (pool elevation 695), Little Goose (pool elevation 595), and Lower Monumental (pool elevation 497) is estimated at 97,000 cfs. The capacity of the Ice Harbor powerplant is estimated at 73,000 cfs at the 35-foot drawdown level (pool elevation 405).

The combined hydraulic capacity of existing powerhouses and modified spillways at the drawdown pool levels (24 feet above the spillway crests) is estimated to be 225,000 cfs, assuming that spillway gate control is maintained.

b. Operation.

(1) Drawdown.

The four lower Snake River projects will begin drafting no later than March 24 in order to achieve target drawdown conditions by April 15 each year. The drawdown pools must be achieved prior to the arrival of large numbers of juvenile fish, since the low-level bypass systems will not be operational until drawdown pool levels are reached. The date computed to begin the drawdown assumes full pools initially, a drawdown rate of 2 feet per day, and average inflows to Lower Granite Reservoir of less than 225,000 cfs. The average project discharge above inflows required at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor will be 6,500 cfs, 14,700 cfs, 19,800 cfs, and 25,400 cfs, respectively. The discharges will be highest at the beginning of the drawdown period. Peak discharges above inflows at the four projects will be 8,400 cfs, 18,300 cfs, 27,000 cfs, and 35,300 cfs, respectively. The total reservoir system storage that will be evacuated from full pool elevations to drawdown elevations is estimated to be 1,110,000 AF.

(2) Refill.

If reservoir elevations are maintained at their drawdown levels during the April 15 to June 15 time period, refill of the reservoirs would take approximately 7 days with average inflows of 95,000 cfs. Given the maximum inflows of record (190,000 cfs), the refill time will be reduced to 4 days. However, the refill time will increase dramatically in low-water years. Given the 1992 inflows averaging 21,000 cfs, refill of the reservoirs will take about 59 days. Shorter refill times can be achieved by drafting upstream storage. During this transitional refill period, juvenile bypass systems will be inoperable until normal pool levels are achieved. If reservoirs are maintained at their drawdown levels from April 15 to after Labor Day, refill of the reservoirs will begin around September 5, and will take approximately 31 days given average inflows of 30,000 cfs. The time for refill would vary, depending on inflows. If maximum inflows of record (40,000 cfs) are achieved, refill could occur as quickly as 20 days. If, however, the refill takes place during a low-water year when average inflows may drop to as low as 18,000 cfs, the refill period could take up to 75 days. Shorter refill times can be achieved by drafting upstream storage, but a large portion of the September inflows into Lower Granite reservoir usually come from drafts of Dworshak Reservoir already. In most years, Dworshak is drafted about 30 feet from full pool (about 500,000 AF) during September. These computations assume minimum project releases of 11,500 cfs during the refill period. The reservoirs will likely be refilled in the following order: 1) Ice Harbor; 2) Lower Monumental; 3) Little Goose; and 4) Lower Granite. However, the order of refill will not generally impact the refill time. Information on refill times at other flows can be found in chart 9.

c. Required Modifications.

(1) General.

This alternative will require physical changes to each of the four lower Snake River dams to accommodate this operation. Plates 18 through 21 illustrate this concept as it is applied to each of the four lower Snake River dams (refer to appendix A, *Feature Modifications - Technical Discussions*, for more detailed discussions of individual feature modifications). Structural modifications to juvenile and adult fish bypass systems, spillways and associated stilling basins, earth embankments, and other miscellaneous features will be necessary.

(2) New Low-Level Juvenile Bypass System.

With the lowered pool levels, the existing juvenile bypass systems will be inoperable. A new lower-level juvenile bypass system will be required to collect and pass juvenile fish around operating turbines to the tailrace. Because of the restricted magnitude of forebay fluctuation, the collection channel will operate as an open channel system, similar to that currently employed at the lower Snake River dams. The collection gallery depth will be controlled by a dewatering structure. Fish and water will pass to the tailrace through the dewatering structure and corrugated metal flume. Juvenile fish transportation will not be possible since navigation will be suspended. A new set of VBS's will be required to provide for optimum levels of OPE. The new screens would be put in place prior to drawdown, and left in place during drawdown and refill. The older VBS's would then be put back into place for operation at the normal range. In addition to the proposed low-level juvenile bypass system, a surface flow collection system has also been proposed to improve juvenile fish bypass during normal and drawdown operations. For a full discussion of this proposed concept, refer to appendix A, *Feature Modifications - Technical Discussions*, section 16.

(3) Adult Facilities.

The adult fish ladder exits will be modified to work under the new lowered forebay levels. Addition of secondary low-level adult ladder exits will be required. The existing ladder exits will also require the installation of auxiliary exits consisting of a false weir, adult return flume, and water supply system similar to the existing Lower Granite system. This will allow adult ladder operation during the period of transition from normal operating pool levels to drawdown pool levels. Once down to the low-level (drawdown) operating pool, the secondary low-level ladder exits can be utilized.

With all four projects operating in the drawdown mode, the tailwater elevations will be lower than originally designed (except at Ice Harbor). Therefore, adult ladder facilities, including entrances and auxiliary water supply, will need to be modified. At all projects except Ice Harbor, the existing adult collection system will be lowered to maintain adequate tailwater depth for operation of adult fish ladder entrances. A possible alternative to lowering fishway entrances and collection channels involves the installation of rockfill weirs in the downstream river channel to control tailwater elevations (see appendix A, *Feature Modifications - Technical Discussions*, section 13). Adult ladder entrances and water supply system sat Ice Harbor will not need modification, because tailwater elevations (McNary pool) will not change (see appendix A, *Feature Modifications - Technical Discussions*).

(4) Existing Stilling Basin Modifications.

At Little Goose Dam, a hydraulic jump-type stilling basin, with end sill and training walls, will be installed downstream of the existing spillway rollerbucket. At Lower Granite, Little Goose, and Lower Monumental Dams, drumgates will be installed downstream of the stilling basin end sill. Stilling basin training walls will also be extended, as required, for tailwater control by the drumgates. The drumgates will be used to adjust stilling basin tailwater elevations so that spillway flip-lips will be as effective as possible in reducing dissolved gas levels. A proposed alternative method for controlling tailwater elevations below the dams involves the installation of a rockfill weir system in the downstream river channel If such a system is determined to be acceptable, the drumgate system would not be necessary (see appendix A, *Feature Modifications - Technical Discussions*).

(5) Lower Spillway Crests.

From a preliminary examination of this proposed alternative, it appears that the modifications are feasible for the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor projects. The changes required at each project are identified in the following paragraphs.

(a) Spillway Crest Modifications.

The existing spillway crest will be lowered 5 feet below its final elevation. Reinforcing steel will then be grouted into the spillway monoliths. A 5-foot-thick layer of highly durable concrete will then be placed to achieve the final spillway crest shape. A proposed alternative method to lowering the existing spillway crests involves construction of a new side channel spillway. The proposed side channel spillway was found to be more expensive than lowering existing spillway crest (see appendix A, *Feature Modifications - Technical Discussions*, section 12, for the full evaluation of this concept).

(b) Structural Stability.

The lowering of the existing spillway crest will result in a reduction in the weight of the spillway monolith. The area of the spillway upstream of the tainter gates will have to be dewatered in order to perform structural modifications to the pier and the spillway crest. This eliminates the stabilizing effect from the weight of the water acting on the spillway. For these two reasons, the spillway monolith becomes more susceptible to overturning and sliding forces from upstream hydrostatic loads. Consequently, pre-stressed and grouted rock anchors will be placed through the spillway monolith, and down approximately 15 feet into the sound rock foundation below. This will help stabilize the structure by engaging the rock underneath. The anchors will be located to avoid the fishway channels and galleries within the monolith.

(c) Pier Modifications.

Because the spillway crests will be lowered 10 feet, the pier height will effectively increase 10 feet. This results in higher hydrostatic design loads than the piers were originally designed to resist. Also, the removal of spillway concrete reduces the embedment of the existing vertical pier reinforcing into the monolith below. This significantly reduces the effectiveness of the reinforcing. Furthermore, the removal of 10 feet of spillway concrete exposes what used to be a portion of the spillway monolith. This portion of the spillway monolith now forms the lowest 10 feet of the piers. There is no horizontal reinforcing in this new portion. For these reasons, additional concrete must be placed over the exposes what used to be a portion of the spillway monolith. This portion of the spillway monolith now forms the lowest 10 feet of the piers. There is no horizontal reinforcing in this new portion. For these reasons, additional concrete must be placed over the upstream face and sides of the piers. The new concrete will include additional horizontal and vertical reinforcing steel grouted into the spillway below. The reinforcing will be designed to resist the appropriate horizontal hydrostatic loads. The concrete will extend above the high water line created during high flows over the spillway crest.

(6) New Tainter Gates.

Because the spillway crest will be lowered and the pier widths increased under this modification, the existing tainter gates will not be usable. Therefore, they will have to be replaced with new steel tainter gates. The new tainter gates will resist larger hydrostatic loads than the existing gates. In addition to the new gates, new seal beams, hoisting equipment, and side seal heaters will be needed. Also, the trunnions will be relocated.

(7) Modified Trunnion Beam.

Because of the increased loads on the tainter gate and the relocation of the trunnions, the existing trunnion beam must be enlarged or replaced. This can be accomplished by placing concrete below the trunnion beam. The new portion of the beam will include new pre-stressing strands. Post-tensioned concrete anchors will be placed horizontally in the piers in an effort to transfer the loads from the tainter gates into the piers.

(8) Modification of Existing Stoplogs.

The existing stoplog guides will be extended down to the new spillway crest. Additional stoplogs will also be required.

(9) Construction Cofferdams.

(a) Dewatering of the Worksite.

Each spillway crest and pier must be dewatered to allow for construction. To accomplish this, steel stoplogs will be required on the upstream face of the spillway monolith, as well as on the cellular cofferdams on the downstream side of the spillway.

(b) Downstream Cellular Cofferdams.

The cofferdams will be installed in two phases. Phase one will include installing the cofferdams to allow dewatering of half the spillway bays and stilling basins, as required for each project. Following modification of the first half of the spillway bays, the cofferdams will be relocated to allow dewatering of the remaining spillway bays.

(c) Upstream Stoplogs.

The stoplogs will span between spillway piers on each side of the spillway bay, and will extend down to the riverbed. Guides will be installed underwater and placed on the upstream face of the piers. Following the installation of the stoplogs, the entire spillway bay may be dewatered. Only one spillway bay may be worked on at a time. Following completion of the construction work for one spillway bay, the stoplogs will be removed with a portable crane and placed in the adjacent spillway bay. This process will be continued until all bays have been modified.

(10) Miscellaneous Modifications.

Miscellaneous features at the dams and in, or adjacent to, the associated reservoirs will require modification to allow operation or to prevent damage when pool levels are lowered below minimum operating levels. These features include the floating navigation lock guide walls, culvert and pipe outfalls, debris shear boom, water quality siphons (Lewiston Levees), and the adult ladder at Lyons Ferry Hatchery.

(11) Embankment Protection.

Protection of embankments from erosion and failure will be required for this alternative (refer to appendix A, *Feature Modifications - Technical Discussions*, for an in-depth discussion).

d. Implementation Schedule.

Assuming that funds and resources are available when required, it is estimated that it will take about 14 years to fully implement this alternative at all four lower Snake River dams from the date authority is granted and funds are appropriated (Refer to plate 21.1). Limitations on resources such as manpower, money, or materials may extend this schedule. Also, if additional study or research (hydraulic model studies) identified any unforeseen technical problems, more time may be required to obtain acceptable solutions.

Initially, DM's for feature modifications at each dam will be required. The DM's will identify and satisfy all engineering data requirements (*i.e.*, design criteria and survey information). In addition, coordination with fishery agencies, concerning adult fishway modifications and the new low-level juvenile bypass systems, will be carrier out during this process. Hydraulic models of each of the four lower Snake River projects will be required to identify strategic placement of the construction cofferdams necessary to accommodate modifications to the adult collection systems. Construction cofferdams will be placed in a manner that offers the best achievable hydraulic conditions for continued adult fishway operations during construction. In addition, the models will be used to identify the most acceptable location for the juvenile fish bypass release points. Sectional hydraulic models of the spillways will be utilized to examine the operability of proposed spillway and stilling basin modifications. The existing Lower Granite spillway sectional model is representative of both the Lower Granite and Little Goose projects. A new sectional model of the Lower Granite and Little Goose projects. A new sectional model of the Lower Monumental spillway will need to be constructed.

The construction of modifications to spillways and spillway stilling basins and powerhouse adult fishway modifications will be phased throughout the construction period. Downstream cofferdams are required for both, and it would not be prudent to have both powerhouse and spillway capacity reductions occurring simultaneously. In addition, construction activities on existing stilling basins will be phased to minimize the reduction of spillway capacities. Construction will only be allowed during annual low-water periods (August through March). Contractors will be required to have all cofferdams removed and all spillway bays operational during the typical April through July runoff period.

The staggering of construction activities relative to adult fishway and spillway/stilling basin modifications was found to be the critical path for construction activities. Other modifications are somewhat independent.

Assuming unlimited resources, Lower Granite and Little Goose Dams would be modified at the same time, and are estimated to be completed approximately 11 years after initiation. Construction will be completed on these two projects prior to the start of construction on the remaining two dams. This will provide a 2-year period of post-construction evaluation on the Granite/Goose projects. The evaluation may identify problem areas in design or construction that could be remedied prior to, or during, construction of the Lower Monumental and Ice Harbor modifications.

e. Cost Estimate.

The reconnaissance-level, fully-funded project cost, including real estate, for alternative 14 is estimated at $2.4 billion. The construction cost is based on an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, model studies, DM's, engineering, and design is included at an estimated 28 percent. Construction management is estimated at 11 percent of construction costs. Contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study. A cost breakdown for this alternative is displayed in appendix C, *Cost Data.*

The annual cost for this option is estimated to be $243 million. This cost includes interest and amortization of the project cost at 8-percent interest rate (current Federal discount rate), and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.10. Alternative 15--Existing Powerhouse With New Low-Level Spillway - Constant Pool

a. Description.

This alternative proposes a drawdown operation of 52 to 57 feet below normal maximum pools at Lower Granite, Little Goose, and Lower Monumental Dams; and a drawdown of 43 to 49 feet below normal maximum pool at Ice Harbor Dam. To achieve this drawdown level, new low-level spillways would be constructed at each dam. The powerhouses at each lower Snake River dam would be operated to their hydraulic capacity, with excess water passing over the new low-level spillways. During the drawdown operating mode, the drawdown pool levels will be maintained at a near constant level (5-foot pool fluctuation). The reservoir pools would be operated at a drawdown level during the juvenile fish outmigration from April 15 through June 15 or from April 15 through Labor Day. Pools would be returned to normal operating levels for the rest of the year. Plates 22 through 25 illustrate this concept applied to each of the four lower Snake River dams.

At the 52-foot drawdown pool levels, the powerplant hydraulic capacity at Lower Granite (pool elevation 686), Little Goose (pool elevation 586), and Lower Monumental (pool elevation 488) is estimated to be 90,000 cfs. The capacity of the Ice Harbor powerplant is estimated to be 67,000 cfs at the 43-foot drawdown level (pool elevation 397).

The combined hydraulic capacity of existing powerhouse and modified spillways at the drawdown pool levels is estimated to be about 225,000 cfs, assuming spillway control is maintained.

b. Operation.

(1) Drawdown.

The four lower Snake River projects will begin drafting no later than March 20 to achieve the target drawdown condition by April 15 of each year. The drawdown pools must be achieved prior to the arrival of large numbers of juvenile fish, since the low-level bypass systems will not be operational until drawdown pool levels are reached. The date computed to begin the drawdown assumes full pools initially, a drawdown rate of 2 feet per day, and average inflows to Lower Granite Reservoir of less than 180,000 cfs. Inflows have been less than 120,000 cfs in all years of record. The average project discharge above inflows required at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor would be 6,200 cfs, 13,900 cfs, 18,800 cfs, and 24,200 cfs, respectively. The discharges will be highest at the beginning of the drawdown period. Peak discharges above inflows at the four projects will be 8,400 cfs, 18,300 cfs, 27,000 cfs, and 35,300 cfs, respectively. The total reservoir system storage to be evacuated from full pool elevations to the drawdown elevations is estimated to be 1,250,000 AF.

(2) Refill.

If reservoir elevations are maintained at their drawdown levels during the April 15 to June 15 time period, refill of the reservoirs will take approximately 8 days with average inflows of 95,000 cfs. Given the maximum inflows of record (190,000c cfs), the refill time will be reduced to 4 days. However, the refill time will increase dramatically in low-water years. Given the 1992 inflows (averaging 21,000 cfs), refill of the reservoirs will take about 67 days. Shorter refill times can be achieved by drafting upstream storage. During this transitional refill period, juvenile bypass systems will be inoperable until normal pool levels are achieved. If reservoirs are maintained at their drawdown levels from April 15 to after Labor Day, refill of the reservoirs will begin around September 5, and will take approximately 34 days, given average inflows of 30,000 cfs. The time for refill would vary, depending on inflows. If maximum inflows of record (40,000 cfs) are achieved, refill could occur in as quickly as 22 days. If, however, the refill takes place during a low-water year when average inflows may drop to as low as 19,000 cfs, the refill period could take up to 84 days. Shorter refill times can be achieved by drafting upstream storage, but a large portion of the September inflows into Lower Granite Reservoir come from drafts of Dworshak Reservoir already. In most years, Dworshak is drafted about 30 feet from full pool (about 500,000 AF) during September. These computations assume minimum project releases of 11,500 cfs during the refill period. The reservoirs will likely be filled in the following order: 1) Ice Harbor; 2) Lower Monumental; 3) Little Goose; and 4) Lower Granite. However, the order of refill will not generally impact the time for refill. Information on refill times at other flows can be found in chart 10.

c. Project Modifications.

(1) General.

Physical changes to each of the four lower Snake River dams will be required to accommodate this operation. Refer to appendix A, *Feature Modifications - Technical Discussions*, for more detailed discussions of individual feature modifications. Structural modifications to juvenile and adult fish bypass systems, existing spillway stilling basins, earth embankments, and other miscellaneous features will be necessary. In addition, relocations of railroads and highways will be necessary to accommodate a new spillway structure.

(2) Low-Level Juvenile Bypass System.

With the lowered pool levels, the existing juvenile bypass systems will be inoperable. A new lower-level juvenile bypass system will be required in order to collect and pass juvenile fish around operating turbines to the tailrace. Because of the restricted magnitude of forebay fluctuation, the collection channel will operate as an open channel system, similar to that currently employed at the lower Snake River dams. The collection gallery depth will be controlled by a dewatering structure. Fish and water will pass to the tailrace through the dewatering structure and corrugated metal flume. Juvenile fish transportation will not be possible, since navigation will be suspended. A new set of VBS's will be required to provide for optimum levels of OPE. The new screens will be put in place prior to drawdown, and left in place during drawdown and refill. The older VBS's would be put back into place for operation at the normal operating pool range. In addition to the proposed low-level juvenile bypass system, a surface flow collection system has also been proposed to improve juvenile fish bypass during normal and drawdown operations. For a full discussion of this proposed concept, refer to appendix A, *Feature Modifications - Technical Discussion*, section 16.

(3) Adult Facilities.

The adult fish ladder exits will be modified to work under the new lowered forebay levels. The addition of secondary low-level adult ladder exits will be required. The existing ladder exits will also require the installation of auxiliary exits consisting of a false weir, adult return flume, and water supply system similar to the existing Lower Granite system. This will allow adult ladder operation during the period of transition from normal operating pool levels to drawdown pool levels. Once down to the low-level (drawdown) operating pool, the low-level ladder exit can be utilized.

With all four projects operating in the drawdown mode, the tailwater elevations will be lower than originally designed (except at Ice Harbor). Therefore, adult ladder facilities, including entrances and auxiliary water supply, will need to be modified. At all projects except Ice Harbor, the existing adult collection system will be lowered to maintain adequate tailwater depth for the operation of adult fish ladder entrances. A possible alternative to lowering fishway entrances and collection channels involves the installation of rockfill weirs in the downstream river channel to control tailwater elevations (see appendix A, *Feature Modifications - Technical Discussions*, section 13). Adult ladder entrances and water supply systems at Ice Harbor will not need modification, because tailwater elevations (McNary pool) will not change.

(4) Existing Spillways/Stilling Basin Modifications.

At Little Goose Dam, a hydraulic jump-type stilling basin, with end sill and training walls, will be installed downstream of the existing spillway rollerbucket. At Lower Granite, Little Goose, and Lower Monumental Dams, drumgates will be installed downstream of the stilling basin end sill. Stilling basin training walls will also be extended, as required, for tailwater control by the drumgates. The drumgates will be used to adjust stilling basin tailwater elevations so that spillway flip-lips will be as effective as possible in reducing dissolved gas levels. A proposed alternative method for controlling tailwater elevations below the dams involves the installation of a rockfill weir system in the downstream river channel. If such a system is determined to be acceptable, the drumgate system would not be necessary (see appendix A, *Feature Modifications - Technical Discussions*).

(5) Spillway Monoliths.

This option includes six new low-level spillway monoliths resting on bedrock. The spillway monoliths will extend below surrounding bedrock elevations to provide necessary mass to resist the overturning and sliding caused by upstream water forces. As an option, rock anchors could be used in lieu of the added concrete mass. The feasibility of that option could be addressed in subsequent studies. Bridges will be constructed to span the top of each spillway. The bridges will provide for vehicular traffic, as well as for a gantry crane.

(6) Stilling Basin.

A new stilling basin will be provided for the new spillways. To resist hydrostatic uplift forces, rock anchors will be used to attach the stilling basin to the rock below.

(7) Structures Adjacent to Spillway.

Non-overflow monoliths will be provided between the spillway bays and the shoreline at each lock and dam. On the opposite side of the spillway, a non-overflow monolith will provide a tie into the adjacent existing concrete structure at the Lower Monumental and Ice Harbor projects. At the Lower Granite and Little Goose projects, an earthen fill will provide the tie into the adjacent existing structure. Wing walls will be used to hold the soil back from the spillway channel.

(8) Construction Cofferdams.

During construction, the worksite must be dewatered. At the Lower Granite and Little Goose projects, the existing earthen embankment will be utilized to hold back water upstream of the new spillways. Large cellular cofferdams will be used at the Lower Monumental and Ice Harbor projects to contain upstream waters. Smaller cofferdams will be used for each project to contain downstream waters.

There are at least two different ways of constructing cofferdams to facilitate construction of the new low-level spillway. Plates 2 through 5 indicate upstream and downstream construction cofferdams. Plates 22 and 23 offer an additional method for building cofferdams at Lower Granite and Little Goose Dams. For this alternative, the cofferdam method shown on plates 22 and 23 was used. If this alternative is selected for further study, cofferdam arrangements will be examined in more detail, and the most cost-effective method will be determined.

(9) Tainter Gates and Stoplogs.

A new steel tainter gate with operator will be required for each spillway bay. The tainter gate trunnion will be attached to a trunnion beam extending from the spillway monolith. Steel stoplogs will be provided upstream of the tainter gate to allow for dewatering of the spillway crest for maintenance. A new gantry crane will be required for setting stoplogs and tainter gate maintenance operations.

(10) Miscellaneous Modifications.

Miscellaneous features at the dams and in, or adjacent to, the associated reservoirs will require modification to allow operation or to prevent damage when pool levels are lowered below minimum operating levels. These features include the floating navigation lock guide walls, culvert and pipe outfalls, debris shear boom, water quality siphons (Lewiston Levees), and the adult ladder at Lyons Ferry Hatchery.

(11) Embankment Protection.

The protection of embankments from erosion and failure will be required for this alternative. An in-depth discussion is presented in appendix A, *Feature Modifications - Technical Discussions*.

(12) Relocations and Associated Real Estate Acquisition.

Relocations of roads, railroads, visitor facilities, and other facilities will be required to construct the new low-level spillways. These are defined in more detail in appendix A, *Feature Modifications - Technical Discussions*, sections 6 and 10.

d. Implementation Schedule.

Assuming that funds and resources are available when required, it is estimated that it will take about 17 years to fully implement this alternative at all four lower Snake River dams from the date authority is granted and funds are appropriated (refer to plate 25.1). Limitations on resources such as manpower, money, or materials may extend this schedule. Also, if additional study or research (hydraulic model studies) identifies any unforeseen technical problems, more time may be required to obtain acceptable solutions.

Initially, DM's for features such as relocations, adult fishway modifications, and new low-level spillway structures at each dam will be required. The DM's will identify and satisfy all engineering data requirements (*i.e.*, foundation explorations, design criteria, and survey information). In addition, coordination with fishery agencies, concerning adult fishway modifications and new low-level juvenile bypass systems, will be carried out during this process. Hydraulic models of each of the four lower Snake River projects will be required to obtain detailed design data on the new spillway structure, excavation of approach channels, and to identify specific areas requiring riprap protection. The models will also be used to identify strategic placement of the construction cofferdams necessary to accommodate modifications to the adult collection systems, and to identify acceptable release locations for the new low-level juvenile bypass systems. The construction cofferdams will be placed in a manner that offers the best achievable hydraulic conditions for continued adult fishway operations during construction. Sectional hydraulic models of the existing spillways will be utilized to examine the operability of proposed stilling basin modifications. The existing Lower Granite spillway sectional model is representative of both the Lower Granite and Little Goose projects. A new sectional model of the Lower Monumental spillway will need to be constructed.

The DM for the new low-level spillway structure will need to be nearly completed before requirements for real estate and relocation needs can be fully identified. Once these requirements have been assessed, relocations can proceed into the real estate acquisition, engineering and design, and construction process. Construction of the relocations must occur prior to construction of the new low-level spillway structure.

The construction of modifications to spillway stilling basins and powerhouse adult fishway modifications will be phased throughout the construction period. Downstream cofferdams are required for both, and it would not be prudent to have both powerhouse and spillway capacity reductions occurring simultaneously. In addition, construction activities on existing stilling basins will be phased to minimize the reductions of spillway capacities. Construction will only be allowed during the annual August through March low-water periods. Contractors will be required to have all cofferdams removed and all spillway bays operational during the typical April through July runoff period.

The staggering of construction activities relative to adult fishway and stilling basin modifications was found to be the critical path for construction activities. Other modifications are somewhat independent.

Assuming unlimited resources, Lower Granite and Little Goose Dams will be modified at the same time, and are estimated to be completed approximately 11 years after initiation. Construction will be completed on these two projects prior to the start of construction on the remaining two dams. This will provide a 2-year period of post-construction evaluation on the Granite/Goose projects. The evaluation may identify problem areas in design or construction that could be remedied prior to, or during, construction of the Lower Monumental and Ice Harbor modifications.

e. Cost Estimate.

The reconnaissance-level, fully-funded project cost, including real estate, for alternative 15 is estimated at $3.3 billion. The construction cost is based on an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, model studies, DM's, engineering, and design is included at an estimated 28 percent of construction costs. Construction management is estimated at 11 percent of construction costs. The contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study. A cost breakdown for this alternative is displayed in appendix C, *Cost Data*.

The annual cost for this option is estimated to be $364 million. This cost includes interest and amortization of the project cost at 8-percent interest rate (current Federal discount rate), and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.11. Alternative 17--Modified Powerhouse and Existing Spillway - Constant Pool

a. Description.

This alternative is the same as alternative 13, except for the powerhouse modifications described below.

b. Operation.

Project operation for this alternative is identical to alternative 13.

c. Required Modifications.

(1) General.

The physical changes required by this alternative are identical to alternative 13, except that turbine/generator sets at each of the lower Snake River dams will be replaced with new equipment designed to work more efficiently at the drawdown pool levels (refer to plates 14 through 17).

(2) Powerhouse Modifications.

Operating existing turbine-generator units at low heads causes a loss in operating efficiency. This occurs because the turbines were designed and built to have peak efficiency at, or near, the heads they would be operated at most of the time. Low efficiency operation due to lower heads can be mitigated wholly, or in part, in various ways (see appendix B, *Powerplant Report*). For this study, it was assumed that the installation of new turbine-runners would be the option of choice. New turbine-runners can be designed to operate at peak efficiency at a lower head. The blades can be made of stainless steel and the discharge ring overlaid with stainless steel to improve cavitation resistance. Utilizing existing units, efficiency will decrease an average of 5.3 percent. (This assumes that no screening systems, such as STS's, are in place. It is unknown how STS's affect turbine efficiencies.)

d. Implementation Schedule.

The implementation schedule for this alternative is the same as for alternative 13, except that this alternative includes replacing the turbine-runners at the powerhouses of each of the four lower Snake River dams. The schedule includes research and preliminary design work, and assumes that replacement of the turbine-runners can be completed at all four dams simultaneously. Turbine-runner replacement is estimated to take about 9 years from authorization and appropriation. The majority of this work could take place at the same time as the adult fishway modifications (refer to plate 17.2).

e. Cost Estimate.

The reconnaissance--level, fully-funded project cost, including real estate, for alternative 17 is estimated at $1.7 billion. The construction cost is based on an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, model studies, DM's, engineering, and design is included at an estimated 28 percent of construction costs. Construction management is estimated at 11 percent of construction costs. The contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study. A cost breakdown for this alternative is displayed in appendix C, *Cost Data*.

The annual cost for this option is estimated to be $171 million. This cost includes interest and amortization of the project cost at 8½-percent interest rate (current Federal discount rate) and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.12. Alternative 18--Modified Powerhouse and Modified Existing Spillway - Constant Pool

a. Description.

This alternative is the same as alternative 14, except for the powerhouse modifications described below.

b. Operation.

Project operation for this alternative is identical to alternative 14.

c. Required Modifications.

(1) General.

The physical changes required by this alternative are identical to alternative 14, except that turbine/generator sets at each of the lower Snake River dams would be replaced with new equipment designed to work more efficiently at the drawdown pool levels (see plates 18 through 21).

(2) Powerhouse Modifications.

Operating existing turbine-generator units at low heads causes a loss in operating efficiency. This occurs because the turbines were designed and built to have peak efficiency at, or near, the heads they would be operated at most of the time. Low efficiency operation due to lower heads can be mitigated wholly, or in part, in various ways (see appendix B, *Powerplant Report*). For this study, it was assumed that the installation of new turbine-runners would be the option of choice. New turbine-runners can be designed to operate at peak efficiency at a lower head. The blades can be made of stainless steel and the discharge ring overlaid with stainless steel to improve cavitation resistance. Utilizing existing units, efficiency will decrease an average of 5.3 percent. (This assumes that no screening systems, such as STS's, are in place. It is unknown how STS's affect turbine efficiencies.)

d. Implementation Schedule.

The implementation schedule for this alternative is the same as for alternative 14, except that this alternative includes replacing the turbine-runners at the powerhouses of each of the four lower Snake River dams. The schedule includes research and preliminary design work, and assumes that replacement of the turbine-runners can be completed at all four dams simultaneously. Turbine-runner replacement is estimated to take about 9 years from authorization and appropriation. The majority of this work could take place at the same time as the adult fishway modifications (refer to plate 21.2).

e. Cost Estimate.

The reconnaissance--level, fully-funded project cost, including real estate, for alternative 17 is estimated at $2.8 billion. The construction cost is based on an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, model studies, DM's, engineering, and design is included at an estimated 28 percent of construction costs. Construction management is estimated at 11 percent of construction costs. The contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study. A cost breakdown for this alternative is displayed in appendix C, *Cost Data*.

The annual cost for this option is estimated to be $283 million. This cost includes interest and amortization of the project cost at 8-percent interest rate (current Federal discount rate) and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.13. Alternative 19--Modified Powerhouse With New Low-Level Spillway - Constant Pool

a. Description.

This alternative is the same as alternative 15, except for the powerhouse modifications described below.

b. Operation.

Project operation for this alternative is identical to alternative 15.

c. Required Modifications.

(1) General.

The physical changes required by this alternative are identical to alternative 15, except that turbine/generator sets at each of the lower Snake River dams would be replaced with new equipment designed to work more efficiently at the drawdown pool levels (see plates 22 through 25).

(2) Powerhouse Modifications.

Operating existing turbine-generator units at low heads causes a loss in operating efficiency. This occurs because the turbines were designed and built to have peak efficiency at, or near, the heads they would be operated at most of the time. Low efficiency operation due to lower heads can be mitigated wholly, or in part, in various ways (see appendix B, *Powerplant Report*). For this study, it was assumed that the installation of new turbine-runners would be the option of choice. New turbine-runners can be designed to operate at peak efficiency at a lower head. The blades can be made of stainless steel and the discharge ring overlaid with stainless steel to improve cavitation resistance. Utilizing existing units, efficiency will decrease an average of 5.3 percent. (This assumes that no screening systems, such as STS's, are in place. It is unknown how STS's affect turbine efficiencies.)

d. Implementation Schedule.

The implementation schedule for this alternative is the same as for alternative 15, except that this alternative includes replacing the turbine-runners at the powerhouses of each of the four lower Snake River dams. The schedule includes research and preliminary design work, and assumes that replacement of the turbine-runners can be completed at all four dams simultaneously. Turbine-runner replacement is estimated to take about 9 years from authorization and appropriation. The majority of this work could take place at the same time as the adult fishway modifications (refer to plate 25.2).

e. Cost Estimate.

The reconnaissance--level, fully-funded project cost, including real estate, for alternative 17 is estimated at $3.8 billion. The construction cost is based on an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, model studies, DM's, engineering, and design is included at an estimated 28 percent of construction costs. Construction management is estimated at 11 percent of construction costs. The contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study. A cost breakdown for this alternative is displayed in appendix C, *Cost Data*.

The annual cost for this option is estimated to be $410 million. This cost includes interest and amortization of the project cost at 8-percent interest rate (current Federal discount rate) and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation opportunities are not included. Mitigation opportunities are discussed in section 8 of this report.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

4.14. Alternative Evaluation

a. Navigation.

All of the proposed drawdown alternatives will cause suspension of river navigation by tugs and barges on the lower Snake River except for alternative 13A, which calls for a drawdown of only the Lower Granite reservoir. Alternative 13A will allow navigation on the lower Snake River to Lower Granite Dam.

b. Turbine Operation.

Hydropower production and turbine efficiencies will decrease for all drawdown alternatives. Production will be least impacted by alternative 13A, which involves drawdown of Lower Granite Dam only. Those alternatives that involve deeper drawdowns will have the greatest impact on hydropower production and turbine efficiencies. Hydropower production will cease during the drawdown proposed by alternative 4A, the natural river option.

Variable pool alternative 5 proposes the operation of turbines to near spillway crest. Turbines are expected to operate at lower than the designed heads that will occur when the forebay elevations are lowered to levels approaching spillway crests. This is based on unit performance data contained in the model test reports for the respective turbines. Even though the model tests indicate that the units can operate at these low heads, there may be other reasons that would prohibit them from operating under these conditions. There is a possibility that unacceptable air-entraining vortices may form on the water surface near the trash racks. The units may run rough with excessive noise, vibration, and resulting cavitation damage. This will then result in a decrease of power production, in addition to the decrease caused by the reduced head. The survival of juveniles that pass through operating turbines has been related to turbine efficiency. Reductions in turbine efficiency may result in higher juvenile fish mortality for this fish that are not guided by intake screening systems and pass through operating turbines.

Alternatives 9, 17, 18, and 19 propose modifications to turbines. Replacing turbine-runners will improve turbine efficiencies for lower head operation. However, a reduction in efficiency (less than existing turbines) may occur when operating new turbines at normal heads. The survival of juveniles that pass through operating turbines has been related to turbine efficiency, and replacing the turbine-runners may allow survival to be increased when pools are operated in the drawdown condition. However, less survival could result if the same units are operated at normal pool levels. This is of particular concern if the drawdown only occurs during the proposed 2-month (April 15 to June 15) period, which covers only a part of the total juvenile outmigration.

c. Juvenile Fish Bypass Systems.

Each proposed alternative, except alternative 13A, will halt navigation and juvenile fish transportation operations during the period of drawdown below minimum operating pool levels. Juvenile fish will be passed through each dam and remaining reservoir from Lewiston to McNary Dam.

Juvenile fish bypass systems will be inoperable during transitional drawdown and refill operations for all alternatives.

Preliminary information from the Lower Granite three-bay sectional FGE model indicates that the FGE of existing STS's is likely to decrease during drawdown operations. This may result in more juvenile fish being passed through operating turbines, which will be operating less efficiently than under normal pool levels.

The variable pool proposed by alternatives 5 and 9 will require fish passage systems that are more complex and potentially less effective than those of the constant pool alternatives. Additionally, these alternatives may not provide for acceptable operation of juvenile fish bypass systems up to the 10-year flood event of 225,000 cfs. Pressurized juvenile bypass systems (similar to the John Day system) will be necessary, and are difficult to evaluate biologically because of high velocities and large flow volumes. With these types of systems, it is difficult to assess whether or not debris is blocking orifices during operation. Debris lodged in orifices can cause juvenile descaling and mortality. Allowing the pool to drop to spillway crest elevations while operating the powerhouse may cause unacceptable velocities on juvenile bypass VBS's. High screen velocities can cause descaling and juvenile fish mortalities. The OPE is expected to be similar to the John Day system under an 11-foot fluctuation range. The OPE for a wider fluctuating system is unknown, but is anticipated to be reduced.

The near constant pool elevations (5-foot pool fluctuation) proposed by alternatives 13, 13A, 14, 15, 16, 17, 18, and 19 will allow the use of state-of-the-art fish passage systems. These alternatives will also allow acceptable operation of juvenile fish bypass systems up to the 10-year flood event of 225,000 cfs. The OPE for these alternatives is expected to be similar to existing operating systems if VBS's are modified to accommodate lowered pool levels.

d. Adult Fish Bypass Systems.

Adult passage conditions throughout the construction periods (all alternatives except for alternative 13A) may suffer significant adverse impacts due to specific turbine units or spillway bays being inoperative, the presence of cofferdams, temporary passage facilities in lieu of permanent facilities, and other factors. Alternative 13A does not require the modification of collection channels and entrances, and will not require extensive cofferdams.

For alternative 4A, the natural river option, adult fish passage will be interrupted during transitional drawdown and refill operations for pool levels between spillway crest elevations and natural river elevations.

Adult passage conditions throughout the construction periods required by all alternatives may suffer significant adverse impacts due to specific turbine units or spillway bays being inoperative, the presence of cofferdams, temporary passage facilities in lieu of permanent facilities, and other factors. For variable pool alternatives 5 and 9, the operation of false weirs and adult fish return flumes (proposed auxiliary exits) over long periods may not be biologically desirable.

e. Project Operation.

The operation of the lower Snake River projects will be more complicated for all drawdown alternatives, but operation will be even more complex for variable pool alternatives 5 and 9. This is especially true during freshets, which would raise pool levels more than 2 feet. Receding flows would require the initiation of spillway gate control to prevent the pool from falling faster than the 2-feet-per-day limit.

f. Water Travel Time.

The water travel times for each of the various alternatives, from the confluence of the Snake and Clearwater Rivers to the mouth of the Snake River, are shown in the following table. Please note that, for all drawdown alternatives except the natural river option, reservoir pools still exist. Information on travel times at other flows can be found in charts 1 through 5.

Alternative	River Discharge 250,000 cfs		River Discharge 160,000 cfs	
	Total Hours	In Pool Time*	Total Hours	In Pool Time*
Normal Max Pool	820	820	130	130
Normal Min Pool	761	761	21	121
Alt 4A, Natural River Option	62	0	27	0
Alt 5/9, Variable Pool	229	211	60	51
Alt 13A, Lower Granite Only				
Alt 13/17, Constant Pool, 33-Foot Drawdown	379	372	72	69
Alt 14/18, Constant Pool, 43-Foot Drawdown	293	283	59	54
Alt 15/19, Constant Pool, 52-Foot Drawdown	231	215	50	42

*Reservoir pools still exist with all alternatives except the natural river option.
The number of hours spent within the remaining pools is shown in these columns.

4.15. Unknowns

Some of the unknowns associated with all of the drawdown alternatives are listed below (refer to section 6, *Environmental Effects*, for detailed discussions).

- The effect on juvenile survival of decreased turbine efficiency due to lower heads across the turbines is unknown.
- The effects of proposed project modifications on adult fish passage efficiencies are unknown.
- The effect of stilling basin changes on fish mortality, due to descaling and injury, is unknown.
- The effect of reservoir drawdown on juvenile FGE is unknown.

Section 5 - System Operation Studies

5.01. Introduction

This section will describe the system operation used in the drawdown alternatives. These alternatives were conducted using BPA's computer program, HYDROSIM, which is a program for computing power production. These alternatives were conducted to determine the effects on reservoir elevation and power production in the Columbia River system. There are two drawdown periods: 15 April through 15 June; and 15 April through Labor Day. The Columbia River system was modeled using a continuous operation (the results at the end of one year would be the starting condition for the next year). The computational period for each condition is from water year 1929 through water year 1978.

5.02. Base Condition

This condition has been referenced in many reports as the 1991/1992 operation. This operation consists of drafting Dworshak to supplement flow in the river for fish migration. The base condition is used to measure the changes each alternative makes due to operating at different pool conditions.

5.03. Natural River Option

To be added.

5.04. Existing Powerhouse and Existing and Variable Pool

To be added.

5.05. Modified Powerhouse and Existing Spillway--Variable Pool

To be added.

5.06. Existing Powerhouse and Existing Spillway--Constant Pool

To be added.

5.07. Existing Powerhouse and Modified Existing Spillway--Constant Pool

To be added.

5.08. Existing Powerhouse With New Low-Level Spillway--Constant Pool

To be added.

5.09. Modified Powerhouse and Existing Spillway--Constant Pool

To be added.

5.10. Modified Powerhouse and Modified Existing Spillway--Constant Pool

To be added.

5.11. Modified Powerhouse With New Low-Level Spillway--Constant Pool

To be added.

Section 6 - Environmental Effects

6.01. General

Lowering water surface elevations of the lower Snake River reservoirs during the annual juvenile salmonid outmigration has been proposed as a method of potentially improving the survival of the juvenile fish, thus increasing the returns of adult salmon to their streams of origin. This section discusses the major hypotheses proposed as reasons why a drawdown operation would improve juvenile salmon survival, as well as the various proposals for the operation of the projects during a drawdown scenario. These hypotheses and proposals are key to understanding the discussion of potential impacts that follow. In addition, the processes used to evaluate the potential environmental effects (physical and biological) of the various drawdown alternatives are presented.

Paragraphs 6.02, 6.03, 6.04, and 6.05 present a summary of environmental effects. Further information can be found in the Biological Plan (Technical Appendix G) and the various SOR Technical Appendices and environmental Impact Statement. An attempt is made to present all potential impacts, both positive and negative.

a. Drawdown Measures

The goal of reservoir drawdown is to increase juvenile salmonid survival through the system of reservoirs on the Snake and Columbia Rivers by potentially reducing their travel time. At this point in time, it is uncertain whether increasing the average reservoir velocity through reservoir drawdown will, in fact, reduce salmonid travel time. Existing data do not distinguish the effects of the reservoirs versus the dams. It is possible that the increased travel time subsequent to dam construction is a result of the dam itself, and not just the impoundment. In addition, the reduction in spring turbidity may play a role in increasing juvenile salmonid travel time, as well as increasing predation.

If travel time is reduced, the location of potential survival improvement and the relative importance of various other factors is not clear cut. Existing data do not reveal either where losses are currently occurring or the magnitude of these losses. Several hypotheses are discussed in the following paragraphs. It is believed that the benefits of drawdown, if any, may occur in one, two, or all three of the areas included in these hypotheses.

(1) Travel Time Through Reservoirs

A reduction in the travel time of fish through the reservoir system may result in decreased exposure time to predators throughout each of the reservoirs. In addition, the fish (particularly fall Chinook) could be exposed to higher water temperatures for lesser periods of time, resulting in less energy expenditure and increased resistance to disease organisms.

(2) Timing of Migration Through the Lower Columbia River

While predation occurs in each of the lower Snake reservoirs, the major benefit of reducing juvenile salmonid travel time through the lower Snake River system could be in their earlier arrival in the lower Columbia reservoirs, particularly John Day. Predation, especially by squawfish, increases as the water temperature rises. Passage through this portion of the river system during periods of cooler water temperatures may result in reduced total predation.

(3) Timing of Arrival to the Estuary

The arrival timing of the smolts to the estuary may be critical to their subsequent fitness and survival. The overall travel time of the fish through the reservoir system affects the timing of their entry into the estuary and the ocean and, potentially, their ability to make the transition to saltwater.

b. Proposals for Operation During Drawdown

There are several proposals for dam and project operation during a drawdown to accomplish the biological objective. The different types of operation result in different effects to environmental resources impacted by a drawdown. These proposals are outlined in the following paragraphs.

(1) Highest Survival

The dams on the Snake River system are currently operated to provide the highest juvenile and adult salmonid survival based on existing information available to the Corps. At projects that have a juvenile bypass system in place, and adequate FGE, powerhouse operation is maximized to provide the highest possible survival rates. Juvenile fish are diverted from the turbine intakes and subsequently bypassed back to the river or transported downstream. Where juvenile bypass facilities do not yet exist, a combination of sluiceway bypass and spill have been used to maximize survival.

Under a drawdown scenario, the project operation that provided the highest survival of juveniles while still providing efficient and safe adult fish passage would be the chosen method of operation. Survival rates through each potential passage route (spill, turbine, or juvenile bypass system) would be used to determine the project operation resulting in the highest survival.

(2) Juvenile Fish Passage Frequency

Existing data generally indicate that turbine passage is the least desirable route for passing fish past a dam. (This has been questioned for Bonneville Dam, based on a comprehensive survival study that showed the juvenile bypass system resulting in the lowest survival. However, data from juvenile fish bypass systems on the lower Snake River dams, which are of substantially different design than Bonneville Dam, show much higher survival.) Based on the majority of existing data, which support that turbines result in the highest mortality, the projects could be operated in whatever manner will result in the minimum number of fish going through the turbines, termed the highest "fish passage efficiency."

Under existing conditions at some projects, operating for the highest fish passage efficiency would be the same as operating for the highest survival. However, since all project conditions, including spill and bypass, will change under a drawdown operation, high fish passage efficiency may not equate to high survival (*i.e.*, spill mortality could substantially increase, while turbine mortality remained the same or increased only slightly). In addition, high juvenile fish passage efficiency may not be conducive to effective adult fish passage, because spill causes turbulence in the dam tailraces, making it more difficult for adult fish to find the entrances to the collection channel. Spill is used at projects lacking adequate juvenile bypass facilities, and is generally limited to night-time periods, when few adult fish are passing. It is assumed that the majority of juvenile fish pass the project during these hours. While this same practice could be employed during a drawdown, it is highly likely that substantial numbers of juvenile fish would still be passing the projects during daylight hours, based on analysis of Lower Granite collection facility data. Spill may or may not be as efficient at passing juvenile fish under a drawdown and, when large numbers of fish are passing a project, large numbers will pass through all routes no matter the percentage.

(3) Spill Majority of River Flow

One strategy that has been proposed is that spill alone be used to pass juvenile fish in lieu of constructing systems specifically designed to divert fish from the turbine intakes. This could be done t least until such systems are put in place.

(4) Timeframe

As noted previously in this document, reservoir drawdown is proposed for two different timeframes each year: April 15 through June 15, and April 15 through August 31. The shorter timeframe would increase average velocities for spring and summer Chinook, while the longer timeframe would apply to all stocks and species of Snake River salmonids. The two different timeframes can have different environmental effects. They are discussed separately, where applicable, in the following sections.

(5) Drawdown and Transportation

The National Marine Fisheries Service recovery team requested that the alternative of drafting only the Lower Granite reservoir, and continuing juvenile transport from the existing collector projects, be evaluated in this process.

(6) Water Year

The intent of reservoir drawdown is to improve water velocities through the reservoirs, particularly in low-flow years. However, the region has not made any type of decision about which types of flow years reservoir drawdown should be implemented, if it is agreed upon as a strategy. It has been suggested that it would be necessary in low or below average water years only, but this can be difficult to predict--especially in time to implement. Alternatively, it may be used every year, since higher velocities, event in higher flow years, could be better. The mathematical analyses performed for the SOR assume that drawdown would be implemented every year, regardless of flow.

c. Process For Impact Analysis

Analysis of the impacts of reservoir drawdown has occurred through several coordinated processes. These various processes are described in the following paragraphs.

(1) The CRSMA TAG

The CRSMA TAG was originally formed, following the Salmon Summit of 1990 and 1991, to develop the 1992 Reservoir Drawdown Test (Wik *et al.*, 1993). Following the completion of the 1992 test, the group's responsibilities shifted to technical oversight of the evaluation of potential impacts of reservoir drawdown on anadromous fish, resident fish, and wildlife.

The TAG provides technical assistance to the Drawdown Committee, a group called for in Phase 3 of the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program. It consists of representatives from the Corps; BPA; the Bureau of Reclamation; the states of Idaho, Oregon, and Washington; and regional Native American tribes. It is chaired by a State of Idaho council member. The Drawdown Committee is responsible for overseeing the efforts of the Federal agencies in their evaluation of the proposals and implementation of the lower Snake reservoir drawdown.

(2) Biological Plan

The TAG developed the outline for a "Biological Plan" for the Lower Snake reservoir drawdown called for by NPPC's Fish and Wildlife Program. This plan, to be developed in conjunction with the design, operations, and mitigation plans for the drawdown, evaluates the impacts of the lower Snake reservoir drawdown on anadromous fish, resident fish, wildlife, and related ecosystem effects. The plan also compares the potential benefits obtained by reservoir drawdown to the potential benefits of other measures under consideration in NPPC's program, as well as other programs, to improve salmonid survival. Other measures include additional upstream storage for flow augmentation, upstream collection and transport, and improvements to existing fish passage systems.

The Biological Plan was developed by Battelle-Pacific Northwest Laboratories (under contract to the Corps and BPA), with assistance from members of the Corps, TAG, and members of the scientific community. The Biological Plan contains both qualitative discussions and quantitative estimates of the potential effects of drawdown. The qualitative information is based on literature review, including results from the 1992 reservoir drawdown test and ongoing research.

(3) The U.S. Fish and Wildlife Service Planning Aid Report

The U.S. Fish and Wildlife Service, funded by the Corps as part of the Fish and Wildlife Coordination Act requirements, prepared a Planning Aid Report for the SCS. Information and evaluations from this report were incorporated into the evaluations of environmental effects.

(4) Mathematical Model Analyses

The comparison of potential benefits for anadromous fish has been done on a quantitative basis, using mathematical models run for the SOR process. These included the Passage Analysis Model (PAM) and Columbia River Salmon Passage (CRiSP) model for evaluating downstream passage of smolts through the dams and reservoirs, and the Stochastic Life Cycle Model (SLCM) for evaluating effects on the entire salmon life cycle. Some members of the TAG were also members of SOR work groups in an attempt to ensure consistency between the SOR and the SCS. The fishery agencies and tribes also have a set of models: Fish Leaving Under Several Hypotheses (FLUSH) for downstream passage, and the Empirical Life Cycle Model (ELCM) for life-cycle analysis. Results from these models could not be obtained for this Phase I report.

The models used for comparative analysis do not provide actual estimates of survival, because they have not been validated with actual data. Only parts of the models are calibrated with empirical data. The models represent a range of interpretations of existing data and assumptions and are, therefore, useful in comparing various operating scenarios as a relative estimate. Results from the model analyses are included in the impact analyses, where appropriate.

6.02. Physical

a. Water Quality

In the absence of data derived under pool elevation and flow conditions representative of the proposed drawdown scenarios, a qualitative discussion of water quality effects is presented, with appropriate results from SOR modeling efforts. Models used for predicting effects are constrained by a lack of operating experience with pool levels below minimum operating pool but, in some cases, are the only method of evaluation available. Results of the March 1992 Lower Granite/Little Goose reservoir drawdown test are discussed, where applicable.

(1) Turbidity

Turbidity will increase as a result of activities in preparation for drawdown, as well as during regular drawdown periods. The following paragraphs discuss potential sources of turbidity increase resulting from a drawdown.

(a) Construction

1. Cofferdams

The installation and removal of cofferdams to allow for project modification for all drawdown alternatives will increase turbidity levels in the immediate vicinity and for an unknown distance downstream. Installation and removal operations are projected to take place during normal in-water fisheries work windows (15 December to February, and 16 July to 15 August).

2. Installation of Riprap

The installation of riprap to protect engineered embankments along the reservoirs from wind and wave action would be accomplished prior to drawdown for all drawdown alternatives. The placement of materials would result in localized increases in turbidity during construction.

3. The Natural River Option

The natural river option requires the removal of substantial amounts of river channel material at four dams to relocate the channel through the new bypass structure. In addition, large amounts of earth and bedrock material, as well as dam earthen fill embankment materials, will have to be removed during construction of the bypass structure. These activities will increase turbidity substantially, but the spatial extent and duration are unknown.

4. Lower Granite Only

This drawdown alternative results in the minimum amount of construction activities. Riprap would be installed on embankments and shorelines of only one reservoir, and no cofferdams or downstream weirs would be needed.

5. Downstream Weir

The placement of rock and fill material for the series of downstream weirs will cause localized increases in turbidity. The extent of increase will depend on the type of material used, as well as the number of weirs constructed.

(b) Operation

1. General

Drawdown operations will increase reservoir turbidity through several sources. Engineered embankments would be protected by riprap prior to implementation of drawdown to limit erosion. However, as seen in the 1992 reservoir drawdown test, shoreline areas, including mudflats, exposed by drawdown will be subject to erosion by precipitation, wind, and wave action. Stream sand bank storage will channel through sediment deposits.

As pool levels are lowered, groundwater from exposed areas begins to drain from bedrock and surface sediments. This drainage increases pore water pressure in areas where it exits from deposited materials, resulting in reduced slope stability. A maximum rate of reservoir drafting of 2 feet per day will minimize embankment failure and sloughing, but will not prevent it. Shoreline erosion is increased with slow drafting, due to increased probability that wind and rain will occur, resuspending sediments deposited since impoundment.

Coarse materials will settle out within a relatively short distance, but finer materials (*i.e.*, silts and clays) will remain in the water column and increase the turbidity for extended distances. Areas of sediment deposition in the reservoirs would be altered and, therefore, the spatial distribution of turbidity is expected to change. With a decrease in the amount of time water spends in the reservoirs due to increased average velocities, less suspended sediment would settle, resulting in higher turbidity (lower water transparency). Heavier materials picked up in the free-flowing reaches would be deposited in the remaining pool (for the near spillway crest alternatives) or in the next downstream reservoir (for the natural river option). Higher flow and lower pool elevations that would occur during a long-term reservoir drawdown operation would scour finer materials deposited further downstream, resulting in more durable turbidity increases than the primarily sand input from the head of Lower Granite reservoir observed during the 1992 reservoir drawdown test.

The SOR Water Quality work group estimated that silt concentrations that could result from drawdown operations are up to two orders of magnitude greater than under existing conditions. It is likely that the first year of drawdown operations would create the greatest increases in turbidity, with substantial reductions occurring in subsequent years. The SOR analyses estimated that, in areas returned to free-flowing reaches, reservoir beds should be scoured down to original materials within approximately 5 years of repeated drawdowns. With the exception of the natural river option, the majority of material will be moved downstream, but will still remain within existing reservoirs. However, there will likely be times of very high turbidity.

2. Near Spillway Crest Alternatives

a. Constant Pool

The constant pool alternatives will result in the least increases in turbidity, with the greater increases occurring at the greater depths of drawdown. The alternative with the least impact on turbidity would be the Lower Granite only alternative.

b. Variable Pool

Since the water surface elevation will fluctuate throughout the drawdown period for alternatives 5 and 9, it is likely that turbidities resulting from shoreline sloughing and erosion will be slightly greater than the constant pool alternatives.

c. The Natural River Option

The natural river option would likely result in the highest turbidities of any alternative, since the largest areas of shorelines and sediment deposits will be exposed. Since velocities will be increased substantially throughout the entire lower Snake River reach, sediments will be carried downstream to Lake Wallula (McNary Dam reservoir).

(2) Dissolved Gas Supersaturation

Dissolved gas supersaturation increases above normal levels when spill occurs at the Columbia and Snake River dams. The extent of increase depends on the amount spilled, the project operating mode, and other factors (*e.g.*, temperature). The state and Federal water quality standard for dissolved gas is 110 percent. Dissolved gas levels under current conditions can exceed 140 percent during years of high spill. Increases in dissolved gas supersaturation associated with drawdown, relative to normal pool operating conditions, may result during construction activities, as well as during actual operation of the projects during a drawdown mode. Since there are many variables that will be acting to affect dissolved gas levels during a drawdown for which very little or no data exists, the following discussions are primarily qualitative. Calibration of existing water-quality models is inadequate for predicting dissolved gas levels for drawdown scenarios where water levels are dropped below minimum operating pool. Data from the 1992 reservoir drawdown test indicated that reducing the forebay elevation did not reduce the dissolved gas levels, as originally though possible.

However, the results from the test are not applicable to scenarios proposed under the SCS, since the spill tests conducted during March 1992 confirmed the need for a method to maintain tailwater elevations below the spillway. At spill discharges representative of the average spring freshet dissolved gas levels rose as the tailwater was lowered, and the potential for undermining the toe of the dam at lower tailwater and the same spill levels was confirmed (Wik *et al.*, 1993).

The effects of dissolved gas on aquatic organisms is discussed in paragraph 6.03.a.(1)(b).

(a) Construction

The construction of adult fish passage facility and stilling basin modifications will each require the installation of cofferdams in the tailrace. A portion of the powerhouse or spillway basin will be blocked off to allow for completion of the work. The installation will take place during an adult fish passage in-water work window, but the powerhouse cofferdams will remain in place for at least 1 year, and possibly up to 2 years. Spillway cofferdams will be removed each spring, prior to April, and reinstalled in August and September to ensure full use of the spillway during the spring runoff season.

Placing a cofferdam in front of the powerhouse reduces the capacity of the powerhouse to the remaining three to four turbines. During a low-flow year, such as 1992, it is unlikely that spring flows would exceed the powerhouse capacity. However, during an average or high-flow year, the capacity could be substantially exceeded and force higher than normal spill discharges. Maximum dissolved gas levels measured under current operating conditions could be substantially exceeded if a high-flow year occurs when the powerhouse cofferdam is in place.

(b) Operation

Water may be spilled as a result of a drawdown scenario: either because flows exceed the powerhouse capacity, or because spill is specifically chosen as a method for passing juvenile fish at a project or projects.

1. Near Spillway Crest Alternatives

The amount of spill that will occur under any of the near spillway crest drawdown alternatives depends upon the flows in a given year and the mode of operation chosen.

To minimize the effect of lowered tailwaters on increasing dissolved gases, drumgates are proposed to be installed downstream of the stilling basin. These devices should maximize flip-lip effectiveness for all spills. From a dissolved gas standpoint, this would be an improvement over the existing situation, where flip-lip effectiveness is reduced if spill occurs when flows through the powerhouse are not maximized and tailwater is, therefore, reduced.

a. Proposed Operation Modes

If spill only occurs when powerhouse capacity is exceeded, dissolved gas levels for any given amount of spill should be similar to those measured under current operating conditions. If reservoir drawdown is implemented during low to below average flow years only, dissolved gas supersaturation would be minimized unless spill is chosen as a primary mode of juvenile fish passage. However, powerhouse capacity is reduced under a drawdown scenario so, for any given total flow, dissolved gases will be higher under drawdown conditions than under current operations (if sill occurs because of flows in excess of reduced powerhouse capacity). The lower the drawdown level in the constant pool option, the higher the average dissolved gases would be because of decreasing powerhouse capacity. The variable pool options would be similar to the 33-foot constant pool alternative, since the reservoir elevations could rise as the flow increased, and powerhouse capacity would also increase. The alternative that will result in the least increase in dissolved gases over the base case is the Lower Granite-only drawdown scenario, since the powerhouse capacity would be reduced at only one project.

If spill is used to pass juvenile fish, either to provide the highest survival (in the case of bypass facility problems or poor FGE) or to provide high fish passage efficiency, dissolved gas levels are expected to be similar to those measured under current conditions during spill operations (approximately 115 to 140 percent), because of the installation of drumgates to maintain tailwater elevation. However, this would depend on the total spill and number of projects where spill was occurring. Cumulative effects through each project, not currently seen during years of average or below average flow since Lower Granite and Little Goose do not spill, could result in dissolved gas levels in excess of current maximums. Based on the results of the 1992 drawdown test, it is unlikely that the short reach of free-flowing river created below each project would have much effect in ameliorating dissolved gas levels resulting from spill.

If spill is used in lieu of a turbine bypass system to pass juvenile fish (*e.g.*, no, or minimal, powerhouse operation), dissolved gas supersaturation is likely to exceed current maximum concentrations and durations. Cumulative effects would occur through each successive project. Maximums would be expected to be in excess of 140 percent.

The results of the SOR modeling efforts indicated a reduction in levels of dissolved gas when compared to the base case. The model reflected a reduction in levels as a result of reduced hydraulic head. However, the results of the 1992 reservoir drawdown test did not show a reduction in dissolved gas levels as the head was reduced. Therefore, increased dissolved gas levels resulting from increased spill associated with drawdown and proposed operating modes will not be ameliorated by the lowered forebay elevations.

b. Downstream Weirs

The total effect of a series of downstream weirs on dissolved gas levels in a project tailrace, and throughout the reservoir system, is unknown. This method would be an alternative to installing drumgates to keep the tailwaters close to normal elevation, theoretically keeping gas saturation levels similar to existing conditions for any given level of spill. However, unlike the drumgates, the downstream weirs would not allow flip-lips to remain effective over the range of potential operating conditions. If spill was used to pass juvenile fish, and not just when powerhouse capacity was exceeded, flip-lips would be less effective due to lower tailwaters. (For example, under normal operations, for a flow of 100,000 cfs, the powerhouse would be operating, with no spill occurring. Thus, for operations with full powerhouse flow and 100,000 cfs spill, the river flow could be as high as about 230,000 cfs. In those circumstances, the tailwater would be around 5 higher than when 100-percent spill of 100,000 cfs is occurring.) In addition, the effect of changing the tailrace flow pattern on dissolved gas dilution is unknown. It is possible that supersaturated water resulting from spill would remain in the tailrace area for longer periods.

c. Lower Granite Only

Since powerhouse capacity would be reduced at only one project with this alternative, it would result in the least relative increase in dissolved gas supersaturation.

2. Natural River Option

The only time that spill through the existing spillways would occur with the natural river option would be if powerhouse capacity was exceeded during the drafting and refill periods between minimum operating pool and spillway crest level. Flow through the river bypass structure is not anticipated to increase dissolved gas levels.

3. Contaminants

Dioxins and furans, toxic compounds emitted to the environment through combustion and bleaching processes (such as from paper mills), are known to exist within Snake River sediments. However, very little evaluation of the amount and location of these compounds has been completed. Studies to determine levels in dredged sediments, and in a few other areas, have been conducted in Lower Granite reservoir. There are not enough results, however, to evaluate the potential for rerelease into the water column as a result of drawdown operations.

Model results from the SOR Water Quality work group indicate that lead within Snake River reservoirs will be carried downstream with the sediments to which it is attached. Some lead will go into solution and remain in the water column after associated sediments have been deposited. The water quality standard for lead [25 micrograms per liter µg/L)] is expected to be exceeded, on an average of up to 20 percent of the time on an annual basis, at Lower Granite and Ice Harbor Dams during the first 5 years of all drawdown strategies. In the natural river option, SOR model study results indicated that lead would be deposited with the sediments in Lake Wallula, and as far downstream as John Day Dam.

Dichlorodiphenyltrichloroethane (DDT) is also attached to sediments within the Snake River reservoirs. There are very few DDT data points available for Snake River sediments. The SOR Water Quality model results estimated that the water quality standard for DDT would be exceeded, on an average of 5 percent of the time on an annual basis, at Lower Granite and Ice Harbor Dams, during the first 5 years of the natural river option only.

4. Temperature

Drawdown operations could alter thermal regimes in the lower Snake River by changing the input, storage, and release of heat from project reservoirs. Inflow from upstream releases, including pulp mill effluent at the confluence of the Snake and Clearwater Rivers, and direct inputs of solar radiation are the primary sources of heat to lower Snake River reservoirs. Drawdown operations will significantly alter the depth and surface area of each of the reservoirs which, in turn, will alter the input-output and distribution of heat energy within the system.

The magnitude and direction of temperature change, however, is difficult to predict because of competing mechanisms that result from drawdown. In a drawdown operation, solar heating would be reduced as a result of decreased pool surface areas. Reduced reservoir volumes would result in lowered heat buffering capacity which, in associate with decreased hydraulic residence time, would act to lower overall average temperatures. In this case, as retention items within the reservoirs decrease, the temperature of inflowing waters will have a relatively greater affect on thermal regimes. Alternately, decreased buffering capacity and reduced reservoir mixing times could result in increased daily temperature maxims (Corps, 1992). It should be noted, however, that if increases in water velocity are sufficient to prevent thermal equilibrium with atmospheric temperatures, a slight decrease in water temperature would again be predicted.

5. Nutrients

It is likely that hydrological, chemical, and biological changes associated with drawdown will alter nutrient cycling and, in turn, affect the trophic structure of lower Snake River reservoirs. In general, flow-through systems with short residence times have reduced rates of primary production. The uptake of nutrients by phytoplankton, and subsequent deposition within the reservoirs via sedimentation, would be reduced following drawdown of the lower Snake River. This would be especially true if drawdown was accompanied by increased turbidity and reduced light levels that limit phytoplankton production. It follows then that fewer nutrients would be retained within the reservoirs, and instead would be flushed downstream into the Columbia River.

This may, however, be an oversimplification of the effect of water level changes on dissolved nutrients and uptake by aquatic plants. Many complex physical, chemical, and biological processes occur in natural waters that alter the form and availability of nutrients, as well as the major paths of nutrient cycling. A fraction of nutrients in Snake River reservoirs are likely absorbed to suspended particulates or sediments, and are unavailable to biota. Aerobic sediments, in particular, have demonstrate a high affinity for phosphates. While erosion and resuspension of sediments have been shown to be an important source of nutrients for biota in many reservoirs, over many years erosion and sedimentation reduce the productive capacity of littoral (shoreline) areas through sediment removal, especially in steep-sided reservoirs (Ploskey, 1986).

Assimilation and subsequent release of shoreline nutrients by decomposing vegetation have been shown to be problems in reservoirs with fluctuating water levels (Ploskey, 1983). Algal blooms following reflooding commonly occur in association with reservoir drawdown. It is unlikely that plant colonization would occur along exposed shorelines in the Snake River during the relatively short drawdown period, partly since new riprap material would be placed in large areas of shoreline for embankment protection. It is unknown whether aeration of exposed sediments during drawdown would enhance nutrient releases when water levels are raised. This would depend on the total surface area and composition of the sediments exposed during drawdown. However, it is likely that backwater areas would have a greater accumulation of organic matter than the steep, riprap-covered embankments that characterize most of the lower Snake River reservoir system. Anaerobic conditions are known to enhance rates of nutrient release. However, anaerobic sediments do not appear to be prevalent within the Snake River system (Funk *et al.*, 1979).

b. Water Velocity

(1) General

Reservoir drawdown will create reaches of free-flowing river between each dam and the next downstream pool. The average water velocity through each reservoir will increase. However, it is important to note that each drawdown alternative except the natural river option maintains a large pool, and water velocities are not substantially changed through the pools. The increase in the average velocity of the reservoir is most affected by the substantial increase in the free-flowing stretch. The length of the pools in the near spillway crest alternatives remain approximately two-thirds of their full-pool length and, of the total water travel time, 84 to 98 percent is within the pool, not the free-flowing river portion.

The drawdown alternatives result in a substantial decrease in average water travel time (as shown in table 6-1), based on mathematical modeling, which was confirmed by measurements taken during the 1992 drawdown test. The natural river option results in the greatest decrease in water travel time, essentially returning the river to almost a natural free-flowing state. The average water travel time ranges from 8 to 18 percent of what it would be at normal pool elevation for flows from 25,000 to 160,000 cfs. However, there will be areas within the reservoir system that will be pockets of very low velocity, primarily around the dams themselves (forebay and tailwater areas). (The model cannot simulate these and they may or may not be important.) See discussion of fisheries impacts in paragraph 6.03.a.(2).

Table 6-1
Water Travel Time (In Hours) For Each Drawdown Alternative
(Percentages are of Base Case Travel Time)

Alternative	Travel Time At 25 kcfs	Travel Time At 160 kcfs
No drawdown	820	147
Natural river option	62 (8 percent)	27 (18 percent)
5/9--Variable pool	229 (28 percent)	60 (41 percent)
13/17--33 feet below minimum operating pool	379 (46 percent)	72 (49 percent)
14/18--43 feet below minimum operating pool	293 (36 percent)	59 (40 percent)
15/19--52 feet below minimum operating pool	231 (28 percent)	50 (34 percent)

The Lower Granite only alternative is not included in this table since it is not designed to meet an in-river travel time, but to potentially increase the number of fish that are collected for juvenile fish transportation.

The reduction in water travel time with the near spillway crest alternatives is over 50 percent. The variable pool and 52-foot constant pool alternatives result in the greatest decrease at low flows, and the 52-foot at higher flows.

(2) Flow Targets

There are two regional proposals regarding the amount of flow that should be provided through the lower Snake River during the downstream juvenile outmigration. The fish agencies and tribes, through the Columbia Basin Fish and Wildlife Authority, have recommended that a minimum instantaneous/daily average of 140,000 cfs be maintained from April 15 to June 15; 80,000 cfs from June 16 to July 15; and 50,000 cfs from July 16 to August 31. The stated objective of their proposal is to maximize survival of the salmon by moving the juvenile fish from "freshwater to the estuary within the appropriate biological window" (CBFWA, 1991). As an interim measure, NPPC recommends achieving a water velocity that is equivalent to a minimum of 85,000 cfs in all but the lowest water years (NPPC, 1993).

Water travel time through the lower Snake reservoirs is approximately 150 hours at 140,000 cfs and 225 hours at 85,000 cfs (assuming normal pool elevations). Table 6-2 shows the lowest flows at which each of the drawdown alternatives can match the equivalent velocities of the two proposed flow targets.

Table 6-2
Flows At Which Equivalent Velocities Can Be Met

Alternative	85 kcfs Target	140 kcfs Target
Natural River Option	meets in all	meets in all
5/9--Variable Pool	25 kcfs	40 kcfs
13/17--33 Feet Below Minimum Operating Pool	43 kcfs	63 kcfs
14/18--43 Feet Below Minimum Operating Pool	33 kcfs	50 kcfs
15/19--52 Feet Below Minimum Operating Pool	25 kcfs	42 kcfs

The Lower Granite only alternative is not included in this table since it is not designed to meet an in-river travel time, but to potentially increase the number of fish that are collected for juvenile fish transportation.

To meet the average equivalent velocities of the proposed flow target of the fish agencies and tribes, in a water year like 1992 (average flow was 48,000 cfs during the April 15 to June 15 migration period), flow augmentation would be required. To meet the flow targets in a year equivalent to 1992, the volumes of water shown in table 6-3 would be required.

Table 6-3
Water Volume Required to Meet Flow Targets Through Lower Snake Reservoirs (In Thousand AF)

Alternative	Volume Required To Meet 85 kcfs Target	Volume Required To Meet 140 kcfs Target
13/17--33 Feet Below Minimum Operating Pool	300 to 400	2,500 to 3,000
14/18--43 Feet Below Minimum Operating Pool	80 to 120	1,000 to 1,400
15/19--52 Feet Below Minimum Operating Pool	0 to 10	300 to 500

Low end of range is best estimate of volume needed. The upper end of the range assumes minimum releases from Dworshak and Brownlee as a result of major power drawdown during the winter.

(3) Dworshak Usage

Depending upon the reservoir drawdown alternative chosen, water from Dworshak could be used to augment flows during the drawdown period (to meet target equivalent velocities) and/or for refill. However, there is a limited supply, and there would be tradeoff between these two usages. In other words, if water from Dworshak was used to increase reservoir velocities during the drawdown period, less would be available to assist with refill, thus extending the time period required.

(4) Lower Granite Only

The Lower Granite only alternative results in the least reduction in water travel time, but it is designed to be coupled with juvenile fish transportation, so the comparison is not valid.

c. Reservoir Volume and Surface Area

The physical characteristics of the Lower Granite reservoir were mapped using Integraph© Geographic Information System (GIS) methodology. There was no database available to do a similar analysis of other lower Snake River reservoirs. Modeled results indicated that reservoir volume decreased dramatically for the different drawdown scenarios. Changes in the amount of discharge did not change the relative proportion of reservoir volume when compared for each drawdown option.

The surface area of the Lower Granite reservoir also decreased with lowered surface elevation, but changes were not as dramatic as those observed for volume. For example, the natural river option had nearly the same surface area as the 52-foot drawdown option. The natural river option showed the greatest relative change with increased discharge regimes. Relative amounts of reservoir surface area changed little with increased discharge for the other drawdown options. In contrast, riverine surface area increased almost exponentially from normal pool to natural river option.

d. Groundwater

The 1992 reservoir drawdown test showed a decrease in the water table up to approximately ½ mile from the reservoir. This was based on an approximately 28- to 33-foot drawdown. The reservoir was lowered an additional 3 feet during a 3-hour spill test, but was refilled again immediately afterward. This short duration drawdown should not have had any incremental effect on the water table.

Groundwater conditions would be affected the most by the natural river option, which lowers the water in the reservoirs by approximately 100 feet. The zone of effect around each reservoir would be much wider, and probably extend up to 1 mile. This effect would last several months or more, depending upon the duration of the drawdown period (including drafting and refill). The conditions would affect shallow groundwater wells within the zone of water table reduction. Most of the wells that would be affected are in the Lewiston-Clarkston area, or near Ice Harbor Dam. Since some wells might go dry, alternate sources of water might have to be obtained; and the yield from other wells might be reduced.

The near spillway crest alternatives would also lower groundwater levels, but to a lesser extent than the natural river option. The zone of effect on groundwater wells for each reservoir would be similar to that seen in the 1992 drawdown test. If the Lower Granite only alternative was implemented, only wells hydraulically connected to the Lower Granite reservoir would be affected.

e. Air

Reservoir drawdown would expose shoreline areas that are normally underwater for subsequent drying from sun and wind. In the Snake River basin, most of the shoreline areas not covered with riprap are covered with fine sediments (*i.e.*, silt and clay) that would dry out as a result of exposure, and contribute to dust in the atmosphere.

Because most of the particulate matter is believed to be too large to be carried more than a short distance, it is believed that most impacts would be to residents and recreationists within about 1 mile of the shoreline. Chemicals from industrial, agricultural, and transportation activities emissions have accumulated in the Snake River Basin sediments. These chemicals are attached to sediments, and can become airborne along with the sediments.

Although dust could be a localized problem with all of the drawdown alternatives, it is not expected that air quality standards would be exceeded or that human health impacts would occur. Results of SOR analyses did not indicate any likely health problems, although data were lacking to fully evaluate each of the proposed scenarios.

6.03. Anadromous Fish

Drawdown effects on anadromous fish are broken down into two major areas, reservoir and dam, in the following discussion. The first is those effects resulting from changes in the water in which they carryout their life cycle. Drawdown effects on water resources (*i.e.*, quality and velocity) are covered in the previous section, but the specific potential impacts to anadromous fish are covered below. The second major area of potential effects are those resulting from changes in operation and/or configuration of the dams through which the fish must pass during their upstream and downstream migration.

a. Water Resource Effects

(1) Water Quality

(a) Turbidity

The effect of increasing turbidity on fish and other aquatic life following a drawdown of the lower Snake River system would depend on the concentrations of suspended sediment that organisms were exposed to and the duration of the exposure, as well as the life-history stage. Increasing the suspended sediment load in a river can have adverse impacts on fish communities. Potential impacts range from sublethal and chronic effects, including a reduction in growth rates and resistance to disease, physiological stress, and impaired reproduction; to death. Increased turbidity can result in changes in the natural movements and migrations of fish (Newcombe and McDonald, 1991). Additional negative effects of increased turbidity on fish might include habitat degradation, a reduction in prey resources, and behavioral changes (*i.e.*, changes in alarm and avoidance reactions, impaired homing, and abandonment of cover) each of which may result in increased vulnerability to predation. On the other hand, increased turbidity could also make it more difficult for predators to locate salmonid smolts and can act to flush fish through a system, reducing travel time.

The true impacts of turbidity are difficult to adequately evaluate. While reservoirs reduce turbidity by allowing heavier particles to settle out, it cannot be concluded that the subsequent increase in turbidity due to drawdown is not harmful. Turbidity levels prior to the construction of the lower Snake projects may have been higher than those measured subsequently, which could lead to the conclusion that drawdown turbidities may not be a serious problem. However, it is unlikely that pre-lower Snake and/or drawdown turbidities are representative of those found in the Columbia River system prior to human development. Habitat degradation and extensive farming have substantially increased the sediment load in the basin.

It should be noted that, while increasing turbidity is a likely outcome of each of the proposed reservoir drawdown options, it is not possible to accurately predict the range and magnitude of potential water-quality impacts that might be seen. This is primarily due to two factors: 1) there is insufficient information available to develop models that accurately forecast the concentration and quality (*i.e.*, particle size and composition of suspended materials, and the presence of adsorbed contaminants) of suspended sediment that would be produced by each of the drawdown alternatives; and 2) the relationship between suspended sediment concentration, duration of exposure, and effects on biota is poorly understood. Moreover, the previous discussion considers turbidity as an isolated impact when, in fact, it is the cumulative effect of many factors, including dissolved gas concentrations and water travel time, that must be examined to fully evaluate the effects on anadromous fish and other aquatic life.

The drawdown alternative with the potential for the highest impact on fish from turbidity is the natural river option. The Lower Granite only alternative is the least likely to impact anadromous fish because of increased turbidities. The near spillway crest alternatives also may have negative impacts on anadromous fish, particularly during the first few years of a regularly-implemented drawdown. Of the near spillway crest alternatives, the variable pool alternatives have the highest potential for impact, since shoreline sediment deposits would be exposed to the greatest amount of wind and wave action due to fluctuating pool elevations.

(b) Dissolved Gas

1. Summary of Mechanisms of Effect

Bouck (1980) defines gas bubble trauma as a non-infectious, physically-induced process caused by uncompressed, hyperbaric total dissolved gas (TDG) pressure, which produces primary lesions in blood (emboli) and in tissues (emphysema), and subsequent physiological dysfunctions. Supersaturation is traditionally listed as the causative agent of gas bubble disease, although hyperbaric gas pressure (*i.e*., dissolved gas pressure in excess of atmospheric pressure), not saturation, is the operative force (Bouck, 1980).

There is controversy over what levels of dissolved gas supersaturation are acceptable to anadromous fish. The Washington State water quality standard is 110percent, but this is currently exceeded whenever spill occurs. Estimates of 120 to 125 percent have been suggested as acceptable because of evidence that fish may sound (dive to deeper water) to compensate for the elevated levels, and gas bubble trauma in juvenile salmonids has not been observed at these saturation levels in recent years. However, the nature of fish sampling on the river system makes it impossible to ascertain if the population of affected fish has been sampled. Fidler (1985) found that teleost (*e.g.*, salmon) begin to lose control of the regulation of their swim bladder at a TDG level of 111 percent. In addition, others have noted an inability to detect and/or avoid supersaturation. This ability appears to vary among species and individual life stages, and may be related to other factors (*i.e.*, light, temperature, pressure, prey density, and predation) that evoke depth-selective behavior (Fickelsen and Schneider, 1976). Adult salmonids appear to be generally more tolerant of supersaturation than juveniles (Weitkamp and Katz, 1980). Gray and Haynes (1977) showed that adult Chinook salmon swam deeper in supersaturated water than in normally saturated water below Little Goose Dam, thus avoiding potentially lethal conditions. However, blinding and cranial blistering have occurred to adult salmonids during years of spill (Bjornn, 1993; and Jerry Harmon, National Marine Fisheries Service, personal communication).

Any attempt to estimate fish mortality due to supersaturation must take into account not only TDG concentrations and the natural depth distribution within the area of concern, but also a host of complex and poorly understood physiological and behavioral factors that determine the length of exposure and vulnerability of individual species to gas bubble disease.

2. Locations of Effects

As noted in paragraph 6.02.a.(2), dissolved gas supersaturation levels can increase as a result of potential increases in spill during the construction of modifications for implementation of a drawdown, as well as during the drawdown period. (Please refer to this section of the document as the following sections are read.) Negative impacts to juvenile and adult fish could occur throughout the reservoir during periods of elevated dissolved gas levels as a result of higher spill amounts (with the exception of the natural river option). In addition higher dissolved gas levels could result in the immediate vicinity of the dams, because of structural and operational modifications. These specific concerns regarding changes at the dams are discussed in the following paragraphs.

As noted previously, there is disagreement on whether or not adult and juvenile fish will sound to avoid high dissolved gas conditions. However, adult fish must enter shallow water conditions in order to enter adult fish passageways. This suggests that adult passage could be impacted during drawdown because of the potential for high gas concentrations in the tailrace. The location of fish passage entrances relative to tailwater depth is of concern at high gas concentrations.

a. Construction

Substantial impacts to adult salmonids could occur as fish attempt to locate the fishways entrances that remain available after cofferdams have been installed. If large quantities of spill occur as a result of reduced powerhouse availability, resulting high dissolved gas levels coupled with potential delay in finding entrances, could result in substantial negative impacts to adult salmonids.

b. Operation

Since spill will be increased during a drawdown operation, either voluntarily or involuntarily (with the exception of the natural river option), additional impacts to salmonids from dissolved gas supersaturation will likely occur. Shallower tailwater conditions will also result in a reduction in the depth to which a fish may sound. Changes in the depth of the tailwater may also result in changes in flow patterns. These changes could either serve to retain higher dissolved gas levels in this area for a longer time, or they could actually minimize retention.

c. Adult Fishway

Higher dissolved gas levels, as a result of drawdown will affect fish in the ladders and adult collection channels. At projects where water is withdrawn from the tailrace to supply the ladder entrances and collection channels, the water could be more highly saturated than that from the forebay. Dissolved gas levels in the adult fish passage facilities at those projects with ladders and collection channels fed from forebay water could also be higher, due to the increased probability of spill.

3. Summary of Dissolved Gas Effects

A ranking of the drawdown options with respect to dissolved gas levels, from least to greatest potential impact, is: 1) the natural river option; 2) Lower Granite only; 3) options 13/17; 4) options 14/18; and 5) options 15/19. This ranking would be the same whether reservoirs are operated at lowered levels during a portion of (April 15 to June 15) or the total (April 15 to August 31) juvenile fish outmigration period, although a longer drawdown cycle would be expected to have a greater negative impact if spilling occurred beyond June 15. The 43-foot (14/18) and 52-foot(15/19) drawdown options were ranked higher (they would have a greater negative impact) than the 33-foot option (13/17), because the lower the powerhouse hydraulic capacity, the higher the chance of spill and the more likely the increase in dissolved gas (as compared to the base case). In addition, based on modeling results, it is more likely that spill might be tried as a method to pass juvenile fish in the deeper drawdowns [because of lower FGE's--see paragraph 6.03.b.(1)(b)]. If flows are low and spill is not chosen as a preferred method of passage, the differences between the drawdown alternatives would be negligible.

(c) Contaminants

The potential effect of possible increased contaminant exposure is unknown. Data do not exist to allow prediction of possible exposure levels.

(d) Temperature

There is no evidence that drawdown would substantially alter present temperature regimes in the lower Snake River. The exception to this is the natural river option, which would most likely return the temperature regime to closer to that of pre-impoundment (effects of Dworshak, middle, and upper Snake dams would still exist). The natural river option could alleviate the current problems that are believed to result from temperature, including delay at the mouth of the Snake River, because of a temperature differential and increased disease incidence.

If the near spillway crest alternatives successful reduce the travel time through the Snake River reservoirs, and the temperatures during the migration season stay the same or are somewhat reduced, there is a potential that disease incidence and predation would be reduced.

(2) Water Velocity

(a) Travel Time

1. Juveniles

The actual in-river travel time for juvenile salmonids migrating from the head of Lower Granite reservoir to below Bonneville Dam is not known. Based on data collected in the 1970's (Bentley and Raymond, 1976; and Sims and Ossiander, 1981), estimates of 15 to 30 days for spring Chinook salmon are typically quoted, although these studies included data from free-flowing river stretches as well as stretches with dams in place. No study has measured the complete river stretch, either prior to dam construction or following.

Current downstream passage models based on the data estimate travel time of in-river fish (those not transported). These models were used to estimate travel time under both base case and drawdown scenarios for the SOR. Both the 50-year average water record and the five lowest flow years on record, called the critical water years, were modeled. Model results are presented in paragraphs a. through e., below, and are summarized in tables 6-5 and 6-6. More detailed results from the modeling can be found in the SOR Anadromous Fish Work Group technical appendix.

These models assume that producing higher velocities through drawdown will have the same effect on fish as increasing the flow. If this assumption is true, drawdown will result in reduced travel times for downstream migrating juvenile salmonids. However, whether or not fish will respond as predicted is unknown. In addition, the models are unable to account for other factors that may act on the fish (*i.e*., date of release, origin of stock, and fish condition), as well as environmental variables (*i.e.*, turbidity and temperature) that may change during drawdown. Travel time through portions of the reservoir may be reduced, but may be increased through other portions. For example, average water velocity in the am forebay is not substantially increased during drawdown, and velocities into the turbine intakes will be reduced because of lowered head. The net effect may be to offset decreases made in reservoir travel time by increases in travel time past the project, because of the reduced flow net in the forebay. Fish may have a more difficult time finding their way into the turbine intakes. Thus, if migration movement through the forebay/dam interface is a major determinant of total migration time between reservoirs, drawdown could do little to increase the overall migration rate of smolts.

a. Current Conditions

Over the 50-year water record, an average travel time of 17 to 21 days was estimated for Snake River spring Chinook (range between the two models) between the head of Lower Granite reservoir and below Bonneville Dam under existing flow improvement measures. In the critical water years, travel time is increased by an estimated 3 to 6 days. Summer Chinook and steelhead are estimated to take a little longer than spring Chinook to travel the same distance. Fall Chinook travel time is estimated to be 49 and 57 days for the 50-year average and critical water years, respectively. These fish move much more slowly through the reservoir system because they spend time feeding and growing (rearing) within the reservoirs).

b. Near Spillway Crest Alternatives

A four-pool drawdown of 33 feet on the lower Snake River (and John Day reservoir at minimum operating pool) reduced the travel time approximately 3 to 4 days for spring and summer Chinook, and 7 to 8 days for fall Chinook. Steelhead travel time was reduced 1 to 3 days. Water travel time for this option was reduced approximately 50 percent. The CRiSP and PAM models estimated reductions of 14 and 24 percent, respectively, for spring Chinook over the course of the 50-year water record; and 17 and 23 percent, respectively over the critical water year period. In the Planning Aid Report, the U.S. Fish and Wildlife Service predicted a 32-percent reduction in travel time in the Lower Granite reservoir, based on an equation developed using fish travel time and smoltification data collected at the Idaho Fish and Game's smolt trap on the Snake River at Lewiston, Idaho, and at the Lower Granite juvenile fish collection facility. The PAM estimated an additional 3- to 4-day reduction in travel times for the 52-foot alternative.

c. Natural River Option

The models estimated that the natural river option would result in a total travel time for spring Chinook of 8 to 15 days for the 50-year average, and 11 to 15 days for the critical water years. Travel times for summer and fall Chinook are substantially longer and, while reduced under a drawdown scenario, the percent reduction predicted by the models is substantially less. Water travel time is reduced an estimated 92 percent for the natural river option, whereas the maximum reduction in fish travel time is estimated at 48 percent (PAM results for spring Chinook during the critical water years), because of the influence of the lower Columbia reservoirs.

d. Lower Granite Only

The models estimated that the Lower Granite only alternative resulted in a 1- to 2-day reduction in travel time for in-river spring Chinook; a 0- to 1-day reduction for summer; and a 2- to 3-day reduction for fall Chinook. Steelhead travel times did not appear to be affected.

e. Refill

While average velocities increase during the drawdown period, velocities would be substantially reduced during refill periods. Depending upon river flows, refill times of 1 to 16 days per project would be required for the near spillway crest alternatives, and up to 25 days per project for the natural river option (see table 6-4). During the refill periods, if flows are low, velocities would be extremely reduced. Water travel time would be several hundred to over a thousand hours, getting slower through each pool as it filled. This could substantially increase the travel time of large numbers of hatchery and wild salmonids, depending upon when refill is initiated and the flow conditions at the time. In addition, the effect of reducing the flow into the Columbia could counteract any benefits potentially gained in the lower Snake reservoir reach.

Table 6-4
Refill Time (In Days Per Project)

Start Date	**June 6**			**September 1**		
Flows	**High (190,000 cfs)**	**Average (Average of 95,000 cfs)**	**Low (Average of 20,000 cfs)**	**High (Average of 40,000 cfs)**	**Average (Average of 30,000 cfs)**	**Low (Average of 18,000 cfs)**
NRO	1	3	25	7	12	32
Alts 5/9	1	2	20	6	9	26
Alts 13/17	1	2	2	4	8	14
Alts 14/18	1	2	15	5	8	19
Alts 15/19	1	2	17	6	9	21

Fall Chinook travel time is greater under the 4½-month drawdown than under the 2-month drawdown, because of the effect of refill on travel time through the lower Columbia River.

f. Summary

If velocities equivalent to 140,000 cfs at full pool are the actual desirable target for juvenile fish migration, then only the natural river option would provide the changes necessary. Some flow augmentation would be required during low to average flow years for all other alternatives.

Table 6-5
Estimated Travel Time (In Days) of Snake River Stocks
During the 50-Year Water Record

Stock	Current	Natural River 2 Months	Natural River 4.5 Months	33-Foot Drawdown 2 Months	33-Foot Drawdown 4.5 Months	52-Foot Drawdown 2 Months	Lower Granite Only 2 Months	Lower Granite Only 4.5 Months
Spring Chinook (CRiSP)	21	15	14	18	18	Not calc	20	20
Spring Chinook (PAM)	16.2	8.6	n/a[1]	12.3	n/a[1]	9.7	15.3	n/a[1]
Summer Chinook	24	19	198	22	22	Not calc	24	24
Fall Chinook	49	34	36	41	44	Not calc	46	46
Dworshak Steelhead	23	16	16	20	21	Not calc	23	23

[1] PAM is not designed to be used for timeframes later than June 15.

Table 6-6
Estimated Travel Time (In Days) of Snake River Stocks
During Critical Water Years

Stock	Current	Natural River 2 Months	Natural River 4.5 Months	33-Foot Drawdown 2 Months	33-Foot Drawdown 4.5 Months	52-Foot Drawdown 2 Months	Lower Granite Only 2 Months	Lower Granite Only 4.5 Months
Spring Chinook (CRiSP)	24	14	16	20	20	Not calc	22	23
Spring Chinook (PAM)	21.9	1.3	n/a[1]	17	n/a[1]	13.2	21.5	n/a[1]
Summer Chinook	29	22	21	26	26	Not calc	28	29
Fall Chinook	57	40	42	50	52	Not calc	55	54
Dworshak Steelhead	27	19	19	26	25	Not calc	27	27

[1] PAM is not designed to be used for timeframes later than June 15.

2. Adults

Reported migration rates for adult salmonids in the Columbia and Snake Rivers vary according to discharge, velocities, and water quality. Depending on the magnitude of increased velocities resulting from reservoir drawdown, a drawdown could decrease the rate of migration of adult salmonids (*e.g.*, increase the amount of time they take to pass through each affected reach to the fishway entrance). Battelle estimated total travel time for adult salmon to migrate through the lower Snake

River complex by using data on relative migration rates in reservoir and free-flowing environments and passage delay at individual dams. Hydraulic modeling studies indicate that the natural river option would result in increased velocities through the entire lower Snake River complex. As a result, the total travel time of migrating adults would be expected to increase when compared with travel time through impounded waters (existing conditions). However, adult salmon would not have to pass through fishways at the dams under the natural river option. This would eliminate, or at least reduce, the delay time associated with finding a passage route past the dam. (Total passage time was not estimated for adults under the natural river option.) It is estimated that adult travel time would likely increase 10 to 30 percent above existing conditions during the near spillway crest drawdown alternatives. The increased travel time results from salmon encountering higher velocities through the newly created free-flowing section of the river. Actual delay at each dam would depend on operating conditions and the ability of the fish to navigate the reconfigured fish ladder entrances.

(b) Changes in Survival as a Result of Water Velocity Changes

The migration behavior of juvenile salmonids is determined by a complex set of interacting factors. These factors may include specific environmental conditions, physical variables, physiological attributes, and ecological variables. Thus, no single factor can be singled out as a determinant, since they are interdependent in many cases. For example, physiological attributes related to migration behavior are largely influenced by environmental factors (*i.e.*, temperature and other seasonal conditions). Drawdown and associated flow regimes will affect the migration behavior and survival of juvenile salmonids, primarily because of changes in the physical and ecological conditions of the environment. Drawdown of lower Snake River reservoirs will increase velocities through most of the affected reach and, therefore, potentially affect the migration rate of juvenile salmonids.

Many researchers believe that existing data on survival are inadequate to infer correlation between travel time and flow. Past analyses have often relied on general system mortality estimates as a measure of smolt survival, and have provided no assessment of bias or measures of precision (Dauble *et al.*, 1993). During the spring of 1993, researchers from the National Marine Fisheries Service and the University of Washington conducted a pilot study in the lower Snake River to obtain estimates of travel time and survival for downstream migrant smolts. The experimental design included estimates of both reach and project survival. Results were promising enough that additional studies are planned to collect baseline survival and travel time estimates under existing operating conditions. These data would then be compared to those collected under a drawdown, if a test or full operation is implemented.

A basic premise for the drawdown is that decreased travel time will result in increased survival for salmonid smolts. However, factors other than travel time may affect the survival of fish through the lower Snake River reservoir complex, and drawdown may not alleviate those factors, or may reduce the effect of some but increase the effect of others. In addition to the water quality and dam passage effects, which are discussed elsewhere, the following paragraphs present some of the uncertainties associated with survival under drawdown scenarios.

1. Species Interactions

Any benefits of increased migration rates on juvenile survival could be negated if predation rates on smolts were increased. Changes in predation rates due to any of the drawdown operations will vary by operation. The species of predators, reservoir length and configuration, water velocity, time of year (*e.g.*, periods of prey availability to predators), and temperature all influence the overall rate of predation on juvenile salmonids.

The main predators of salmonid smolts in the lower Snake River are northern squawfish, smallmouth bass, and channel catfish (Bennett *et al.*, 1988, 1990, and 1991). Although there are data that document the prey preference of predatory fish, the mechanism by which predator fish consume juvenile salmonids, and how this mechanism might change under various drawdown operations, is not well understood. If other food sources for salmonid predators decrease, it is possible that predation on smolts could increase (Dr. David Bennett, University of Idaho, personal communication).

As the freshwater residence time of smolts increases, the chance of an encounter with a predator also increases. Migration delays can increase the exposure of juvenile salmonids to predators up to three times their original availability, when compared with the pre-dam environment (Ebel, 1977). Studies have shown that subyearling Chinook may be more vulnerable to predators because they move slowly through the reservoirs (Miller and Sims, 1984). Because they tend to remain near the shore, subyearling salmon would be less responsive to a drawdown. In Lower Granite reservoir, fall Chinook spend an extended time (2 to 4 months) in the reservoir because they rear as they move downstream.

Yearling spring Chinook salmon and steelhead appear to "stage" in Lower Granite reservoir, and this would also increase their exposure to predators. Drawdown will increase the average water velocity through the upper reservoir, including some of the staging areas of spring Chinook and steelhead smolts. If an increase in water velocity is assumed to equate to an increase in downstream smolt movement, these stocks would migrate through the upper reservoir faster than under present conditions. However, with the exception of the natural river option, drawdown is not expected to substantially increase the water velocities in the lower reservoir or in the immediate vicinity of the projects. Thus, all smolts could still be exposed to significant predation near the projects (*e.g.*, in the forebay). Further, drawdown may tend to concentrate predators and prey in a smaller volume of water near the projects. This could increase chance encounters between predator and prey, resulting in a potential increase in predation. Conversely, the predators might be saturated with smolts, and this could result in a decrease in predation since resident prey species will also be concentrated in the pool. Increased turbidity, especially during the initial years, could benefit smolts. The long-term effect on predation, as turbidity was reduced, would not be known.

The natural river option is most likely to reduce predation on all species because smolts will not be disoriented or concentrated due to project operations; water velocities will be higher and temperatures most likely lower in the vicinity of the projects; and travel time will be increased over the entire length of the lower Snake River rather than only in the upper sections of each reservoir. The characteristics of the lower Snake River would be altered significantly to riverine habitat. Predation of salmon smolts by northern squawfish seems to be less severe in riverine-type habitats (Buchanan *et al.*, 1981; and Kirn *et al.*, 1986). However, very large pools of low velocity water may form in the vicinity of the dams, upstream and downstream of the existing powerhouse and spillway structures. If juvenile salmonids stage in these areas, the predator concentrations could be fairly high. In addition, the ultimate distribution and survival of the present populations of predators during a natural river drawdown (concentration would also occur), and subsequent effects on salmon survival, are unknown.

A drawdown of Lower Granite reservoir may reduce predation of subyearling fall Chinook salmon by smallmouth bass in the upper reservoir, because shallow-water habitat would be reduced. This would potentially force juvenile fall Chinook salmon into the open water or concentrate them in or around the shoreline margins (Dr. David Bennett, university of Idaho, personal communication). However, since northern squawfish are open-water predators, the shift in habitat use may result in an increase in predation by northern squawfish on subyearling fall Chinook salmon.

Any drawdown scenario that increased turbine or spill passage would likely result in increased predation on juvenile salmonids by gulls. Turbine and spill passage disorient smolts, making them more susceptible to predation by gulls and other predators.

A drawdown could increase the survival of juvenile salmonids in areas other than the lower Snake reservoirs. Passage of downstream migrants through John Day reservoir (the longest reservoir in the system) earlier in the season may result in less predation, because of lower temperatures, when compared to current passage times. However, temperatures may not be substantially lower. Earlier arrival of in-river migrants to the estuary could result in a more adequate food supply, as well as reduced predation in the lower Columbia River reservoirs. On the other hand, if the estuary is an area of very poor survival because of habitat degradation, substantially reduced carrying capacity combined with substantially increased numbers of salmonids, as well as other species (*e.g.*, shad, *etc.*), changes in arrival timing may not provide any benefit. Data do not exist to adequately evaluate these hypotheses.

2. Stranding

Inshore areas may be exposed by receding water levels that may result in stranding or entrapment. The extent of impact to these areas will depend, in large part, on the extent and duration of the drawdown, the amount of shallow-water habitat exposed, physical features in the exposed area that contribute to the entrapment of juvenile fish, and the seasonal timing of the drawdown in relation to outmigration.

Juvenile fall Chinook are particularly vulnerable to stranding during the period when reservoirs are being drafted to drawdown condition. However, reservoir drafting at the rate of 2 feet per day is slow enough that stranding and/or entrapment of juvenile salmon would be limited to shallow areas or embayments with no access to the main channel. In addition, the relative abundance of juvenile salmonids in the lower Snake River reservoirs is low during late March. Thus, impacts to juvenile salmonids would be minimal during the initial drawdown interval. Drawdown alternatives 5/9 (variable pool options) are likely to result in wide fluctuations in pool elevations at the lowered pool levels. This operational strategy would increase the likelihood of subyearling salmonids and other fish, as well as forage and benthic species, residing in nearshore areas to be stranded during the spring rearing and migration period.

3. Downstream Weir

The construction of a series of downstream weirs to maintain tailwater elevations below the lower Snake River projects during a drawdown scenario could result in an increase of predator habitat and a potential increase in predation. Velocities behind the weirs are expected to be low.

b. Effects on Dam Passage

Highlights of the effects of specific drawdown alternatives on anadromous fish passage are summarized, by alternative, in 6.04. The effects are covered by topic in the following paragraphs. Juvenile and adult life stages are covered separately, and then potential impacts during construction and operation are covered. The discussions on operations are broken down into pertinent parts of the dam and potential impacts to fish resulting from changes to those parts.

(1) Juveniles

(a) Construction

Effects on juvenile fish during the construction period from changes in the bypass system are expected to be negligible. Existing bypass facilities would be left in place and remain operational until lower-level facilities were complete and drawdown was implemented, although minor changes may have to be made to allow connection between the existing and the new. However, changes to the tailrace areas during construction of the stilling basin and adult fish passage facility modifications may result in a higher mortality due to physical injury and gas bubble trauma, resulting from potentially increased spill (see paragraph 6.02.b.).

(b) Operation

1. Bypass System

The potential impacts of reservoir drawdown on various components and aspects of the juvenile bypass systems at the lower Snake River dams are discussed in the following paragraphs. Facility operability during a drawdown, and possible changes to the STS's, VBS's, gatewells, and OPE are discussed. Since the natural river option does not include modified juvenile fish passage facilities, the discussion of the different elements of the bypass systems is applicable only to the near spillway crest alternatives.

a. Facility Operability

(i) Drafting and Refill

Drafting of the reservoirs would begin as early as February 16 each year for the natural river option, and somewhere between March 16 and March 29 each year for the near spillway crest options (variable pool would start the earliest, depending upon river flows). Once the reservoir is lowered below minimum operating pool, neither existing or lower-level juvenile fish bypass facilities will be functional. While the juvenile fish facilities for the variable pool alternatives could pass water under the higher pool conditions, the rapid pressure changes would likely create unacceptable impacts to fish.

Juvenile fish migrating downstream between the start of the drafting and the time when the lower-level collection facility is operational would have to be passed at the project via alternative methods, including manual gatewell removal and potentially spill. If spill was used to pass a portion of the juvenile fish during the drafting period, impacts from dissolved gas supersaturation [see paragraph 6.03.a.(1)(b)] and/or injury from tailrace structures [see paragraph 6.03.b.(1) to 6.03.(3)a.(ii)] could occur.

The number in the gatewells would be dependent on whether or not submerged screens were installed prior to the initiation of drawdown and, if so, the FGE of the screens, and the amount and effectiveness of spill. If screens were not installed, the number of fish entering the gatewells would be less, but the number going through the turbines would be higher (see turbine impacts section for related discussion).

The number and type of fish this would impact varies from year to year. In 1989, very few wild spring Chinook had reached Lower Granite prior to April 15 (Matthews *et al*., 1990). However, by April 13, 1990, 10 percent of the PIT-tagged wild Chinook had passed the Lower Granite juvenile fish facility detector (Matthews *et al.*, 1992). Fish counts at Lower Granite, during the proposed drafting period, range from approximately 20,000 to 270,000 spring Chinook; and 1,000 to 16,000 steelhead. The majority of these may be wild fish. The numbers arriving at the dam can be affected by hatchery release dates, flows, and temperatures, *etc.*, which would vary from year to year. However, consideration should be given to beginning the drafting period earlier, thus allowing bypass facilities to be operable sooner than April 15. Gatewell dipping, while possible for low numbers of fish, is still stressful, and would not be acceptable for larger numbers. In addition, it may not be acceptable to subject listed stocks to the stresses of gatewell dipping.

For all of the near spillway crest options, refill poses the same problem of non-functional bypass facilities once water levels are higher than the bypass facility is designed to accommodate. If the lowered pool is maintained throughout the summer (the 4½-month proposal), very few juvenile fish would be affected because of the low numbers still migrating later than August 31. However, refill times are much longer, so more fall Chinook juveniles would be impacted. However, if refill is initiated on June 16, potentially substantial numbers of juvenile fish would likely be diverted into the gatewells with no outlet. The number of days that fish would not be able to pass the dam via the bypass facility ranges from 1 to 16 days (per project) for the near spillway crest options. (The variable pool option would fill the slowest under low flows, since the reservoir elevation depends upon flows. The lower the flow, the longer the refill time. See Table 6-4.) Shorter refill times could be accomplished by drafting reservoir storage. [Numbers that could be impacted were not estimated. Existing collection facility estimates may not be valid for estimating numbers since, if fish do respond to the higher average velocities, they may be farther downstream than existing records exist for (*i.e.*, within the Ice Harbor or Lower Monumental pools.))] It is likely that at least a small percentage of the fish stocks will be impacted during refill.

(ii) Range of Flows

The variable pool alternatives may not facilitate operation of juvenile bypass systems to the 10-year flood event (225,000 cfs). If high flow conditions occur, the variable pool bypass system will not function within fish passage criteria, potentially causing physical harm to juvenile salmon.

b. Fish Guiding Efficiency

The percentage of fish entering the turbine intakes that are diverted from the turbine blades, by submerged screens, into the juvenile bypass and collection facilities is known as FGE. The FGE at Lower Granite Dam ranges from approximately 30 to over 90 percent, depending upon the species and stock if fish; and degree of smoltification, powerhouse operation, *etc.* In general, FGE at Little Goose Dam is somewhat higher. Fall Chinook guidance efficiency is unknown for the Snake River projects but, based on measurements at lower Columbia projects, is believed to be at the low end of the range.

Members of the TAG believe that FGE will be reduced under a drawdown scenario, but the degree to which it would be reduced is unknown. The Planning Aid Report supports this conclusion by noting that lowered forebay elevation would change the vertical distribution of juveniles approaching the powerhouse, as well as the angle of interception of the submerged screening devices. Preliminary model studies at the Corps' Waterways Experiment Station, using dye released from different depths in the water column, would suggest that FGE decreases as the water surface elevation is lowered. However, fish behavioral response to the large set of variables that will change under a drawdown scenario is impossible to predict.

Current plans under the Columbia River Juvenile Fish Mitigation Program call for the installation of extended-length submerged screening devices to be installed at Lower Granite and Little Goose Dams by 1996. It is anticipated that these devices will raise FGE under normal pool operations but, as with the standard-length screens, the effect of drawdown is likely to reduce the FGE.
The following paragraphs discuss the methods that have been proposed to ameliorate the effects of reduced FGE during a drawdown operation.

(i) Spill

Spill could be used as a means of increasing fish passage efficiency if FGE is substantially reduced under a drawdown scenario. However, such an operation would have to be balanced by concern for juvenile mortality resulting from changed spillway conditions, adult fish passage efficiency during spill operations, and dissolved gas levels.

(ii) Surface Flow Collector

An alternate fish collection system located near the water surface in the dam forebay has also been considered as a possible means of improving juvenile fish passage around the lower Snake River dams. A forebay collector system, located above and anterior to existing turbine intakes, would provide migrating juvenile salmonids with another passage route around operating turbines. This system could be operated independently of, or in conjunction with, the existing bypass and collection system. The forebay collection system could result in higher levels of FGE, and could also reduce the amount of time the fish spent in the forebay area, because the majority of fish can be found in the upper portion of the water column. However, it is also possible that the lower the reservoir is drafted, the closer fish are to the turbine intakes. They may then be drawn into the turbines rather than the surface flow collector.

The surface flow collector could potentially be used to collect some of the fish (an unknown percentage) and route them through a spillway bay. This could potentially reduce the number of fish collected in the gatewells during drafting and refill procedures, lessening the impact of gatewell dipping/removal systems on the stocks.

The surface flow collector concept was developed based on experience with existing sluiceways and the bypass system at Wells Dam. The collection efficiency and survival at Wells is believed to be high, although comprehensive survival tests have not been completed. However, this design is quite different, and would need to be evaluated following construction to ensure that survival was within acceptable limits.

c. Submerged Traveling Screens

Model studies completed at Waterways Experiment Station indicate that velocities across standard-length STS's will be reduced under a drawdown scenario, since there will be less flow through the turbine intake (because of reduced head). Additional studies using the extended-length screens will be completed for any drawdown alternatives carried forward into detailed evaluation.

d. Vertical Barrier Screens

Model studies completed at Waterways Experiment Station indicate that velocities through the *existing* VBS's in a drawdown scenario should be within an acceptable range to prevent the descaling and impingement of juvenile fish. However, if VBS's are modified to include solid panels that provide for adequate OPE, the resultant loss of open area in the screen may cause velocities through the remaining open area, as well as at the bottom of the screen, to exceed those acceptable for juvenile passage. The design of VBS's capable of operating over the range of the variable pool alternatives will be much more difficult. Further studies using a gatewell model (1:12 scale) are planned to resolve this question.

e. Gatewells

Visual observations by project biologists during the 1992 reservoir drawdown test indicated that conditions in the gatewells were more turbulent than under normal pool conditions. This is likely the result of the reduced water column depth over which the energy of vertical water flow can be dissipated. However, conditions that will exist in the gatewell under a drawdown scenario, with modified VBS's, are unknown. Further studies, using a large-scale model (1:12) of a gatewell, are planned to determine the potential gatewell conditions with various proposed modifications.

f. Orifice Passage Efficiency

Existing VBS's contain solid panels to provide a sanctuary area for juvenile fish prior to exiting the gatewell through the orifice(s). Current plans include the modification of VBS's in an attempt to provide this same sanctuary at a lowered pool elevation. However, the effects on OPE of the combination of reduced water column depth, reduced VBS area, and other changes resulting from a drawdown are unknown. Physical scale model studies can be used to guide modification but, if drawdown is implemented, research on OPE and possible methods of improving it will likely be needed, particularly in the case of the variable pool alternative. The OPE would likely be similar to that of the John Day system over the first 11 feet of the range (flows up to 136,000 cfs), but would likely be reduced at beyond that (fluctuation range of these alternatives is 19 to 20 feet).

g. Collection Channel, Flume, and Downstream Facilities

Lower-level juvenile fish facilities will be state-of-the-art designs for the lower Snake River dams. For the near spillway crest alternatives, it is anticipated that mortality would be very minimal through these portions of the bypass facilities, similar to existing conditions. However, post-construction evaluation would be necessary to confirm that survival was within acceptable levels.

The variable pool alternatives require a pressurized juvenile bypass system, which is considered to be less desirable for fish passage for a variety of reasons. Pressurized systems force the fish to pass through atmospheric pressure changes. These systems are difficult to evaluate biologically, because of high velocities and large flow volumes. In addition, it is difficult to assess whether debris is blocking orifices, potentially resulting in physical injury to the fish. The Corps is currently replacing pressurized bypass systems with state-of-the-art open-channel flumes.

h. Bypass Release Point

Mortality resulting from predation at existing bypass release sites is unknown (bypass from juvenile collection facilities currently occurs only at Little Goose and Lower Monumental when average flows are greater than 100 kcfs; Lower Granite does not bypass fish unless collection numbers exceed raceway and barge-holding capacity combined). Lower-level collection facilities for the near spillway crest alternatives would have to be designed to release fish in areas of adequate velocity. The potential of accomplishing this will have to be evaluated through physical scale model studies. Locating a bypass pipe outfall to higher velocities during low-flow conditions may cause difficulties in dam operations under normal operations. If adequate locations are not available, increased predation mortality may result.

2. Turbines

Drawdown could result in three major changes in turbine conditions: shear flow, draft tube vortices, and increased cavitation. Each of these conditions directly affect efficiency, and all of them may impact the survival of any juvenile fish that pass under the screens during the drawdown periods, including drafting and refill. Decreased turbine efficiency, due to lower head during a drawdown, may reduce juvenile survival. Methods of improving turbine efficiency during a drawdown (*i.e.*, new turbines, different blade design, *etc.*) may ameliorate this impact. However, turbine efficiency could then be reduced at normal pool operation. This could impact juvenile fish during part of the season (for the 2-month drawdown), or fish throughout the migration, if drawdown was not implemented in every type of flow year. Increased cavitation as a result of lowered tailwaters may also reduce juvenile survival, but the extent is unknown.

3. Conditions Over the Spillway and in the Stilling Basin

a. Near Spillway Crest Alternatives

(i) Spill Efficiency

Estimates of the percentage of fish passing through the spillway relative to the percentage of flow varies for existing conditions. Although typically assumed to be a 1:1 ratio, some evidence exists that spill is more efficient at passing juvenile fish than the powerhouse flow (Giorgi *et al.*, 1988). There is a potential that this efficiency could either be increased or decreased under a drawdown operation. As the pool elevation is lowered, fish will be closer to the spillway crest, but they will also be closer to the ceiling of the turbine intakes. The net effect is unknown and would have to be tested.

(ii) Drumgates

The installation of drumgates, designed to maintain flip-lip effectiveness during lowered tailwater conditions resulting from drawdown, would create an obstacle that juvenile fish spilled past a project would have to cross over. Juvenile fish may not be able to maintain their neutral buoyancy in the turbulent and highly-aerated waters of the stilling basin, and may be injured on these structures. (A tramway, left over from construction, was recently removed from below the stilling basin at Ice Harbor because of this concern. These drumgates would be in a location at each dam similar to where this tramway was.) In addition, the changes in turbulence in the area of the stilling basin and the potential for increased disorientation are unknown.

(iii) Downstream Weirs

Conditions in the area of the downstream weir (proposed in lieu of drumgates and adult fish facility modifications), and the potential impacts on juvenile fish, are unknown. Flow patterns and conditions across the surface and in the pools below would need to be evaluated following construction.

b. Natural River Option

Drafting the reservoirs for the natural river option results in unknown impacts although they are expected to be minor. The existing powerhouse and spillway would be used to draft the pool to spillway crest level. This period of drafting would occur much earlier than that planned for the spillway crest alternative, therefore affecting a negligible amount of anadromous fish. Once the pool reached spillway crest, the tainter gates on the river bypass structure would be opened. While these gates are being opened and the pool is being drafted to river level, impacts to juvenile fish could occur as a result of shear plane forces through these gates, but mortality would not be expected to be higher than for existing spillways. During this time, velocities would be quite high, although they would be reduced as the numbers of juvenile fish migrating downstream increased. Once the pools are drafted to river levels, open-channel flow conditions would exist with velocities that would not exceed those suitable for adult passage. Thus, during the drawdown period, there should be no adverse impacts on juveniles.

4. Juvenile Fish Transportation

Juvenile fish transportation will be impossible during drawdown because of the suspension of navigation.

(2) Adults

(a) General

While drawdown modifications would be completed to attempt to maintain adult passage conditions similar to those already in existence, there are many changes that would nevertheless result from a drawdown scenario. Potential impacts to adult fish passage discussed in the following paragraphs.

(b) Construction

Construction of adult fish passage facility and stilling basin modifications required for all drawdown alternatives will each require the installation of cofferdams in the tailrace. A portion of the powerhouse or spillway basin will be blocked off to allow for completion of the work. The installation will take place during an adult fish passage in-water work window, but the cofferdams will remain in place for at least 1 year, and possibly 2 years. Removal would also occur during an in-water work window to minimize impacts to adult fish.

A cofferdam in front of the powerhouse reduces the capacity of the powerhouse to the remaining three to four turbines. During a low-flow year, such as 1992, it is unlikely that spring flows would exceed the powerhouse capacity. However, during an average or high flow year, the capacity could be substantially exceeded, and force higher than normal spill discharges. In addition to increasing dissolved gas levels [see paragraph 6.02.a.(2)(a)], primary entrances to the adult fishway will be blocked for at least 1 year. The total number of entrances will be reduced over a period of at least 2 years. Water flow patterns in the tailrace will be substantially altered by the presence of the cofferdams, which may serve to further delay adult fish in their attempt to pass the projects. Depending upon the schedule for completion (number of dams under modification at any given time), there may be cumulative effects.

If downstream weirs are selected in lieu of modifying the stilling basin and adult fish passage facilities, the installation of cofferdams would not be necessary, thus eliminating the particular potential impacts mentioned above.

During construction, temporary entrances and sections of ladders will be required to allow modification to the permanent structures. The temporary facilities may not be as effective as the existing ones.

(c) Operation

1. General

All drawdown alternatives would require that adult fish ladders be modified to work under the forebay fluctuations and lowered tailwater depths. Auxiliary exits with false weirs and return flumes will be required for adult passage during the transition drawdown and refill periods. Secondary lower-level exits would be constructed for all alternatives. At all projects except Ice Harbor Dam, the adult collection system would be lowered; and adult fish ladder facilities, including entrances and auxiliary water supply, would have to be modified. All new facilities would be state-of-the-art and designed to fit the existing passage criteria established by the various fisheries management agencies.

The fishway used by adult Chinook salmon (at those projects with more than one) and the rate of passage are influenced by the number and placement of entrances, current and water velocity, spill patterns, and the effectiveness of the attraction flows at the entrance to the fishway (Bjornn and Perry, 1992). Modifications required for the implementation of reservoir drawdown alternatives may affect some or all of these variables, as discussed in the paragraphs below. Any factors increasing the amount of time it takes for adult fish to complete their upstream migration may subsequently lower their survival and spawning success. Research to develop optimum fish passage with existing facilities is still ongoing. The potential to increase adult fish delay by making major modifications to the existing systems is quite high.

a. Fallback

Fallback, or downstream passage of adult salmonids, is a concern with the proposed drawdown scenarios. The rate of fallback of adult migrants over a dam varies with flow and spill, with the dam, and with the fish species. Changes in the rate of adult mortality due to fallback would depend on the passage route, operational conditions, and the ability of engineered structures to safely pass fish. Conditions that increase the proportion of adults passing through the turbines could result in increased mortalities when compared with conditions resulting in downstream passage through bypass or spill routes. An extensive drawdown of forebay water level elevations will likely cause adult salmon and steelhead to migrate lower in the water column. This would decrease the percentage of adults diverted via STS's (adult FGE under existing conditions is unknown), and would likely increase mortality rates for adults that fall back through the turbine intakes.

b. Changes in Hydraulic Conditions Below the Powerhouse

Each of the various drawdown alternatives will influence conditions at the fishway entrances, including maintenance of sufficient tailwater depth and proper hydraulics for adult attraction. The nature of tailrace flow patterns is likely to change under a drawdown scenario. These conditions may impact the ability of adult migrants to find and navigate the fishways.

c. Changes in Facilities for Normal Operation

Modifications currently proposed for all drawdown alternatives (except the installation of downstream weirs; see later paragraphs) will be designed to meet the same criteria under normal operating conditions as the existing facilities. However, since the collection channels will be substantially deeper(17 feet), a much larger amount of water will be needed to provide adequate channel velocities during normal pool elevations. All attempts will be made to ensure adequate velocities under both conditions, but fishway conditions will change from those already in existence.

2. Near Spillway Crest Alternatives

The potential impacts related only to near spillway crest alternatives are discussed in the following paragraphs.

a. New Facilities

While the new facilities designed to function under drawdown conditions will be built to existing criteria, these criteria were developed based on experience under current operating conditions. If drawdown is implemented, there is the potential (as noted above) that altered tailwater conditions may result in the need to modify fishway criteria and potentially fishway design, following the initial modification.

b. Drawdown and Refill

Modified adult fish passage facilities will function over the entire range of pool elevations occurring as a result of drawdown. Adult fish passing the project during drafting and refill periods will exit the fish ladder through a false weir and chute system. The false weir at Lower Granite Dam appeared to pass fish successfully during the 1992 drawdown test, although there were relatively few fish, and no Chinook or sockeye were passing during the test period. The efficiency of the weir was not measured. The chute system, redesigned for a greater depth fluctuation, will have to be evaluated for the effects on fish condition following installation.

c. Proposed Operations and the Effects on Fish

If spill is used to pass juvenile fish in lieu of maximizing powerhouse operations, adult fish passage could be impacted. Where there is little or no spill, few fish use the fishway entrances near the spillway. Small amounts of spill may increase the use of entrances near spillways, but large spills can result in substantial delay (Turner *et al.* 1983; and Dr. Ted Bjornn, University of Idaho, personal communication) of adult fish passage or even potential blockage. Physical scale modeling efforts at Waterways Experiment Station indicate that as little as 15-percent spill can create undesirable tailrace flow patterns. At low flows, maximum powerhouse operation would be required to minimize adult fish delay. This type of impact could be ameliorated by spilling during non-adult fish passage periods of the day if there are adequate juvenile fish passage facilities available and dissolved gas supersaturation is not a problem.

d. Drumgates

There is a potential for injury of adult fish from impact on drumgates in the stilling basin. In addition the drumgates are likely to change flow patterns in the tailrace area. The effects of these changes on adult fish passage efficiency are unknown.

e. Downstream Weirs

Adult fish passage would be inhibited by the construction of rockfill weirs proposed for installation in the river channel downstream from lower Snake River projects. Three concepts have been suggested for additional valuation as part of the SCS : two, three, or five rockfill weir installations (Corps, 1993). Construction of these weirs would provide adequate tailwater control for the adult fish passage system operation at the lowered pool levels occurring during drawdown, up to flows of 180,000 cfs. However, adult passage over the weirs themselves could be restricted because of the high water surface differentials and potentially high velocities. While velocities would not exceed burst speeds (Orsborne, 1983), it is likely that in order to pass the weirs under higher flows, fish would have to maintain fast swimming speeds over relatively long distances, resulting in excessive fatigue. Additionally, severe eddy conditions may be created above the weirs, and this could cause delays in fish migration.

f. Variable Pool Alternatives

The secondary low-level exit installed for the variable pool alternative would employ a vertical-slot control section similar to the John Day Dam adult ladders, providing a gravity feed ladder. This system would work up to a river flow of 136,000 cfs. At flows above this, the gravity feed system would be shut down and the auxiliary ladder exits (with return flumes) would be used.

3. Natural River Option

a. Facilities During Drafting and Refill

Adult passage will be impossible when the pool is between spillway crest and near run-of-river during both drawdown and refill. Between normal and near spillway crest elevations, the uncertainties regarding the impacts of modified facilities on adult fish passage discussed above apple here, as well.

Under the natural river option, the bypass structure and river channel around each dam would need to be designed so that velocities through the structures are suitable for adult passage (<9 fps at river flows up to 225,000 cfs) once the reservoir elevation is at the near natural river level. Modeling studies are currently underway at Waterways Experiment Station to design these bypass structures.

c. Effects on Habitat

(1) Effects of Drawdown on Reservoir Ecology

The drawdown alternatives may affect the performance and subsequent survival of juvenile salmonids in ways other than those relating to travel time and passage. For example changes in environmental conditions (*i.e.*, dissolved gas, turbidity, or velocity profiles--see section 2) may influence smolt performance by affecting their ability to exploit optimum habitats or avoid predators. Indirect effects associated with changes in predation risk could also occur during drawdown. Small fish could take refuge in secondary habitat, even though open water habitat would be a more profitable area to forage. Competition and predation are two important factors in shaping the fish community of the lower Snake River reservoirs, and ultimately affect the survival of migrating smolts.

(2) Habitat Use

(a) General

The greatest potential for impacts to the habitat used by juvenile salmonids will likely occur in shallow inshore areas exposed by receding water levels. To assess these impacts, the extent of shallow-water habitat in the Lower Granite reservoir (*e.g.*, areas with <15 feet of water depth) was modeled, using GIS techniques. The model study found that the extent of shallow-water habitat varied throughout the reservoir. For example, the normal minimum operating pool scenario revealed extensive shallow-water habitat in the upper third of the reservoir, upstream of

Steptoe Canyon (RM 128), with prominent shallows also occurring at Silcott Island (RM 131) and the Port of Wilma (RM 134). The 33-foot drawdown scenario revealed shallow-water benches near Lower Granite Dam (RM 128). The 52-foot drawdown revealed significant shallow-water zones at RM's 110, 120, and 127. Significant shallow-water zones were evident at RM 120 for each of the drawdown scenarios except the natural river option. This indicates that this area could be an important rearing area for juvenile fish.

National Marine Fisheries Service and Washington department of Wildlife found 22 juvenile salmonids, including subyearling Chinook and sockeye salmon, stranded in the Lower Granite reservoir and tailrace areas (Dauble and Geist, 1992). Low densities of subyearling fall Chinook salmon were previously collected in the Little Goose pool (Bennett *et al.*, 1983 and 1993). This observation, along with recent sightings of fall Chinook redds in the tailrace of Lower Granite and Little Goose Dams, indicates that low numbers of juvenile fall Chinook could be present in lower Snake River reservoirs during drawdown. Presumably, many of these subyearlings pause in shallow water areas to feed and grow prior to outmigration. The extent to which subyearling fall Chinook salmon use shoreline ecosystems in other reservoirs of the lower Snake River is not well known.

(b) Downstream Weirs

Construction of downstream weirs would take place in the vicinity of recently discovered fall Chinook spawning habitat below the dams (mentioned above). These structures would likely eliminate current spawning habitat, and velocities in the newly-created habitat would probably not be adequate.

(3) Primary Production

(a) General

Decreased water depth may affect primary production both positively and negatively. For example, lowering water levels beyond the riprap zone would adversely impact periphytic communities attached to this substratum. However, periphyton will rapidly reestablish (within 3 weeks) once refilling has been completed, and the loss of this community as a food base for rock-dwelling invertebrates (*i.e.*, chironomids and caddisfly larvae) will likely be a short-term event.

Conversely reduced water levels will allow sufficient light to penetrate to levels previously too deep to accommodate algal growth, thus promoting new growth (assuming suitable substrate are available) in these areas. However, dewatering that extends beyond the riprap rock zone, where periphyton can attach themselves, will preclude development of a new periphytic community.

It is unlikely that DO concentrations would be changed to a degree that would adversely impact primary or secondary producers. Whether or not the drawdown would mobilize nutrients, such as nitrogen and phosphorus, is also unknown. Oxygen depletion, if it occurs in the deeper reaches,` can result in the release of phosphorus from sediments. It is unlikely, however, that oxygen depletion will occur under drawdown conditions because of the increased circulation of water in the deep reaches and the increased water velocities.

Mobilization of fine sediments could have two impacts on periphyton communities that are not dewater: 1) increased turbidity might negate the penetration of light that could stimulate new production; and 2) the suspended sediments could act as scouring agents to remove periphytic growth from riprap substrate.

Increased velocities are unlikely to have a significant direct impact on primary producers. Phytoplankton will be flushed through the reservoir system at a faster rate, but this should not decrease absolute populations or primary productivity. However, if the drawdown period is extensive and residence times of phytoplankton are reduced, lentic forms may decrease as a result. Losses of this nature, although probably important to overall primary production in the system, would not likely contribute substantially to salmonid survival.

Macrophyte beds may be significantly impacted by repeated drawdown, and the resulting effects may contribute to changes in their physical and temporal extent. This could significantly alter predator/prey relationships for those species dependent on macrophytes for cover or food. In systems where drawdown has been used to control nuisance growths of macrophytes, problems with subsequent algal blooms resulting from the release of nutrients has been encountered (Kadlec, 1962; and Cooke, 1980). However, it is unlikely that the macrophyte beds found in the lower Snake River reservoirs are extensive enough to cause this, especially with the relatively rapid rate of turnover of the water column. Lantz *et al.* (1967) (cited in Hildebrand *et al.*, 1980) reported that 90 percent or more of the macrophytic vegetation was eliminated from the littoral zone by lake drawdown when drawdown lasted 3 or 4 months during a winter or summer period, but that neither a single short drawdown nor a spring drawdown eliminated the vegetation.

A GIS analysis showed that the available photic zone increased with each drawdown scenario for the Centennial Island reach. The amount of photic area was not affected by an increase in flow rates, except during the natural river option. A decrease in flow rate, associated with a deep drawdown, substantially increased the photic zone area at the Silcott Island Reach.

(b) Significant Relationships to Consider

Presently, data are unable to determine if chironomids, which are a significant food item for young salmonids in the Columbia River (Becker, 1973) and some fish species in the Lower Granite reservoir (Bennett *et al.*, 1988), are those organisms inhabiting riprap or soft sediments. If it is demonstrate that the main food items are from the riprap chironomids, consideration should be given to the combined effects of a loss of food base (*e.g.*, periphyton, short-term) and decimation of the invertebrate community (see following paragraphs) on salmonid survival.

(4) Secondary Production

There is only limited data available on zooplankton in lower Snake River reservoirs. Zooplankton is one potentially important food web component. The impact of drawdown on this component of the ecosystem is uncertain. Benthic invertebrates may be extremely important for some Snake River salmonid species, and may be impacted by dewatering for extended periods of time.

Depending upon the length of drawdown and the final operational surface elevation, benthic invertebrates may or may not be affected by drawdown. The drawdown scenarios presented in this report are of sufficient duration to cause adverse impacts to those populations existing in areas above the final pool elevation. Adverse impacts would be recognizable among organisms that are exposed and cannot follow the receding water levels or burrow into substrates to survive. Particularly susceptible are the riprap-inhabiting insects (*i.e.*, chironomids and caddisfly larvae), amphipods, crayfish that get trapped above the water level, and mollusks. Organisms that are to exposed should not suffer adverse impacts, except as described below, under velocity changes and the mobilization of sediments. Drawdown is unlikely to have a significant impact on benthic organisms through changes in water quality, unless toxics (*i.e.*, dioxins and furans) are liberated in the system in sufficient concentrations to be deleterious (refer to Water Quality section).

For mobile organisms like crayfish that can change position with fluctuating water levels, the greatest potential for impact would be associated with crowding and migration to areas that subsequently dry up. In addition, because the preferred location is among riprap, dewatering the shoreline and forcing survivors into less suitable habitat (*e.g.*, sandy bottoms) may affect these organisms. Numerous losses of crayfish were recorded during the experimental drawdown of the Lower Granite reservoir in March 1992 (Wik *et al*., 1993). Some molluscs may be mobile enough to follow receding water levels or burrow into moist sediments to escape desiccation. Despite this, there was a significant loss of molluscs, mainly *Corbicula*, during the experimental drawdown of the Lower Granite reservoir in March 1992. Amphipods may also have a limited ability to follow receding water levels, but many desiccated amphipods were observed on riprap stones during the experimental drawdown in March 1992.

Increased velocities and the mobilization of fine sediments can have an adverse impact on some benthic invertebrates. Increased suspended sediment loads can adversely impact filter-feeding invertebrates, such as *Brachycentrus* and Hydropsychidae larvae, which are both present in lower Snake River reservoirs and occur below the dewatered zone. Heavy losses of the filter-feeding organisms that inhabit riprap habitats, from desiccation, were observed during the experimental dewatering. Increased mobilization of sediments was documented during the experimental drawdown in March 1992 (refer to Water Quality section). This will obviously impact sediment-dwelling benthic organisms in these reservoirs by transport to new sections of the reservoirs, or by death if they cannot withstand the actual suspension, transport, or deposition on unsuitable substrata. Beckman *et al.* (1985) reported that the extensive reservoir drawdown of Lake Roosevelt greatly reduced bottom fauna habitat.

Impacts of drawdown on the soft-bottom benthos is undetermined. Surveys conducted by Battelle during the March 1992 drawdown test (Cushing *et al.*, 1993) suggested that organisms occurring within this substrate burrow to deeper depths to avoid desiccation, or else they perish. However, quantitative samples collected from the Little Goose reservoir showed o decrease in benthic populations following dewatering and subsequent filling. In fact, increases of many forms were found, although it is highly likely that these increases were not related to the experimental drawdown but, rather, to the limited sampling.

Chironomids, oligochaetes, and amphipods are significant food items in the diet of salmonids in the Columbia River (Becker, 1973), as well as of some fish species in the Lower Granite reservoir (Bennett *et al.*, 1988). However, it is not known whether these are obtained by the fish from populations inhabiting the riprap, but it is uncertain as to whether or not the soft-bottom populations will be adversely impacted. The uncertainty regarding impacts to soft-bottom populations is related to the data collected by Battelle during the experimental drawdown, which showed no impacts (Cushing *et al.*, 1993). However, these data were cursory, at best, because pre-drawdown samples were not available due to the timing of the experiments. The importance of littoral zooplankton in the diets of juvenile salmonids requires further examination.

(5) Spawning Habitat

Drawdown could impact the spawning and reproductive success of adult salmonids by reducing spawning habitat or by restricting access of fish to tributary spawning grounds. Fall Chinook are known to have spawned in the area just downstream of Lower Granite, Little Goose, and Lower Monumental Dams. These spawning areas range in depth from about 20 to 28 feet below normal minimum operating pool. No other salmonids are known to spawn in the lower Snake River reservoirs. Drawdown to near spillway crest would not directly affect the availability of spawning habitat in these areas, because the reservoirs would be back to minimum operating pool during the fall spawning and winter incubation periods. However, lowering the pool while fall Chinook fry are still in and/or near redds downstream of the dams could impact their survival. The construction of rockfill weirs would drastically alter substrate and velocity characteristics downstream of the lower Snake River dams. These changes could severely impact the present spawning habitat for fall Chinook salmon.

During the 1992 test drawdown of the Lower Granite and Little Goose reservoirs, Dauble and Geist (1992) surveyed tributary streams to determine if the access of adult steelhead was affected by lowered pool levels. Their studies indicated that severe drawdown over an extended period could cause resuspension of silt, and form migration barriers to steelhead that use small streams for spawning.

d. Quantitative Estimates of Impacts

(1) General

(a) Methods

Several fishery models have been developed within the region over the last 10 years to assess the effects of river operations and mitigation measures on salmon and steelhead. Downstream passage models estimate the effects of changed operations on downstream survival and travel time of juvenile salmonids, while life-cycle models track salmon from the gravel bed or hatchery and back as returning adults. As noted earlier, the SOR Anadromous Fish Work Group (AFWG) employed CRiSP version 1.4 and PAM as its passage models, and SLCM as its life-cycle model.

The AFWG selected three value measures and studied how they respond to two sets of flow conditions (critical and average) for determining the potential impacts of the proposed operating strategies on salmonids. These value measures are: 1) average time (in days) that it takes for smolts to migrate downstream from their point of origin to below Bonneville Dam; 2) the percentage of juveniles that survive from their point of origin to below Bonneville Dam; and 3) the number of returning adults. As noted previously, none of the models provide *actual* travel times or survival levels as outputs, but are useful tools for comparing the relative potential changes in those parameters under various proposals.

Snake River indicator stocks evaluated by the CRiSP1.4 and SLCM models included natural Snake River spring Chinook, natural Snake River summer Chinook, natural Snake River fall Chinook, and Dworshak Hatchery summer steelhead. The Snake River stocks evaluated by the NPPC, using PAM, were spring Chinook above Lower Granite Dam. Sockeye could not be modeled because measures of migrational characteristics (*i.e.*, dam passage parameters, travel time, and survival) were not available. Subyearling Chinook (*e.g.*, Snake River fall Chinook) could not be modeled using PAM, since neither system nor reservoir survival estimates are available. The AFWG did attempt to model fall Chinook using the mechanistically-based CRiSP 1.4 model, since direct estimates of reach or reservoir survival are not required.

Not all of the drawdown alternatives were modeled, nor were those that were all modeled in a consistent fashion. The SOR process was tasked to evaluate the 33-foot and natural river drawdown alternatives. The models completed some runs for the 52-foot and variable pool alternatives, but the changes in parameters identified by the TAG were not incorporated into the runs, using CRiSP. It was assumed that results for the 43-foot alternative would be somewhere between the 33- and 52-foot constant pool alternatives.

(b) Assumptions

There are many assumptions made within the models about various relationships between salmonid survival and environmental factors. Refer to Appendix G, the Biological Plan, for a review of the models. However, for use with the drawdown scenarios, even more assumptions had to be made based on professional judgment, since data regarding the many factors affecting salmonids under a drawdown are simply non-existent.

The PAM incorporates the flow, travel time, and survival data collected in the past (Sims and Ossiander) to calculate survival through the reservoirs as a function of water travel time. Juvenile survival in the CRiSP is determined more mechanistically and is a function of predator density, water temperature, dissolved gas supersaturation levels, flow, and reservoir volume. The PAM does not account for dissolved gas supersaturation effects for fish directly, although it may be implicitly accounted for in the relationship developed from the past survival data. Both models incorporate project-specific estimates of bypass efficiencies, and powerhouse, spill, and transport survivals.

The TAG provided modified inputs to the downstream passage models for several of the factors affecting juvenile fish passage at the dams. Since no data exist, a range of "best" to "worst" case values were developed for FGE, turbine survival, and spill survival for the near spillway crest alternatives (except the Lower Granite only option). Bypass system survival was not modified, assuming that systems would be designed and constructed to provide similar survival to existing (this may not be a valid assumption).

The modified input parameters were used to model the 33-foot constant pool drawdown alternatives. The original plan had been to also model the 52-foot constant pool alternative with modified parameters, but this was not completed. The variable pool and 52-foot constant pool alternatives were run in CRiSP with no changes to input parameters, which would still be considered "optimistic." The 52-foot constant pool alternative was run in PAM, using "best" and "worst" sets of input parameters. (The 52-foot alternative was run for critical water years only.) Table 6-7 shows the potential changes in dam passage parameters developed by the TAG. Justification for modifying input parameters can be found in the appropriate sections on the potential effects of drawdown.

Table 6-7
Changes to Model Input Parameters for Drawdown Scenarios

Parameter	Best Case	Worst Case
FGE (estimates for existing conditions varies by project	Increased by 25 percent	Decreased by 50 percent
Spill Survival	No change (average survival is estimated to be 2 percent)	Average survival decreased 5 percent
Turbine Survival (existing estimated at 11 percent	2 percent	24 percent
Spill Efficiency (existing is estimated 1:1 for all projects except Lower Monumental, which is 1:1.2)	1:1.5 for all except Lower Monumental (1:1.8)	1:0.5 for all except Lower Monumental (1:0.6)

The TAG agreed that the worst-case variables may, in fact, not be the worst possible, but deemed them the worst "likely." The models do not account for the effects of drafting and refill. The group also acknowledged that it was highly unlikely that turbine survival and FGE would increase (for the "best" case), but did not want to exclude the possibility.

Input parameters for the natural river option were changed to eliminate the effects of the dams (100-percent bypass with 100-percent survival). It was assumed that the river would be returned to a truly "natural" state (pre-dam conditions), which may not be a valid assumption. As noted previously, there could be impacts to fish during drafting and refill periods, as well as during the drawdown periods, and these could not be accounted for. Therefore, the modeling results do not present a range of "best" to "worst" for the natural river option, as they potentially do for the near spillway crest alternatives.

Modified input parameters were not used for the Lower Granite only option. This option will be rerun in the future, with FGE, turbine survival, and spill efficiencies modified. Spill survival estimates would not be expected to change, since this drawdown alternative would not change stilling basin conditions. On this basis, the only change in survival due to drawdown that was evaluated with the models was the change due to increased velocities in the reservoir.

(c) Parameters Not Accounted for in the Models

There are many variables that the models do not account for that may act on the fish during a drawdown, in particular for adult fish passage at the dams. The models do not account for changing flow conditions at the dams, for example, and the potential effects on adult fish passage. In addition, none of the modeling efforts included the potential impacts of the construction periods and potential adverse conditions on salmon survival. Factors affecting anadromous fish survival not accounted for in either of the juvenile passage models, or the life-cycle model, are listed below. This list also includes variables for which the models contain a method for dealing with, but about which there is no information.

- Increased turbidity.
- Potential increased contaminant exposure.
- Potential stranding.
- Bypass release point mortality.
- Potential increased juvenile delay due to gatewell changes.
- Construction impacts.
- Drafting and refill impacts on project fish passage (adult and juvenile).
- Changes in tailrace hydraulic conditions and impacts on adult passage.
- Changes in adult fish passage facilities, including transition systems.
- Effects of downstream weirs.
- Potential changes in predatory/prey relationships.
- Potential effects on food sources.
- Physical condition of fish (*i.e.*, descaling, stress, indirect effects of dissolved gas).
- Effects on fish above Lower Granite reservoir (juveniles and adults), and below Bonneville Dam (juveniles).
- Effects of increased numbers of predators in near-free flowing river (natural river option).
- Effects on fall Chinook spawners below lower Snake River dams.

(d) Uncertainties

While it has been noted that there are many "assumptions" in the models and many parameters either for which no data exist or there is no method by which to account for them in the model, there are two major areas of uncertainty in the models that need to be highlighted. The relationship between flow, travel time, and the survival of juvenile fish is not clear, nor are the benefits of transport.

The results from the CRiSP and PAM models present results based on a range of assumptions regarding the flow/survival relationship. As noted previously, CRiSP calculates survival based on several factors, while PAM uses the relationship developed from the Sims and Ossiander data gathered in the 1970's. Juvenile survival in CRiSP is based somewhat less on flow than PAM.

Current estimates of transport survival are very high, and research data show a benefit ratio for Snake River spring Chinook of approximately 2 to 1. However, if the fish models' estimates of in-river survival are approximately correct, then higher transport benefit ratios (TBR's) would be expected. Therefore, both models adjust the survival of transported fish downward to match the estimates of in-river survival. The CRiSP model shows a higher benefit for transport because it uses a higher TBR, based on an average of the most recent results, and because it estimates a higher in-river survival. The estimated benefits for transport in PAM are somewhat lower because it uses a TBR of 1.6, and adjusts transport survival according to lower estimates of in-river survival.

These two models present a range of transport benefits, but do not present a "best" case. It may be that many of the fish that survive the transport process and are counted alive at release die shortly thereafter due to stress, or are not able to home as well as adults. Many of the fish that are transported are diseased and even injured from sources prior to collection and transport, and would die enroute whether they were transported or not. However, it is also quite possible that in-river survival is substantially higher than the fish models estimate. As noted previously, these models have not been validated with actual juvenile survival data (Lower Granite to below Bonneville). If the latter were the case, the potential benefits of drawdown would be even more questionable. The third possibility is that estimates of survival to below Bonneville Dam for both transported and in-river fish are correct, but survival in the estuary and ocean for both groups of fish is much poorer than expected, possibly caused by inadequate food supplies, water quality, *etc.* It may be that reality is a combination of all three potential factors.

It is not possible to answer these questions with existing data. An attempt was made to evaluate a range of possibilities using the models. The goal of the SCS is to determine those measures that will *best* improve salmon survival through the Snake and Columbia Rivers whatever method that may be.

(2) Results

(a) General

Modeled results indicated that travel times of all salmonid stocks would be decreased during drawdown relative to current conditions, with greatest benefits (*e.g.*, faster travel time) achieved with the natural river option. Travel time predictions also varied by model, with PAM indicating faster travel times for migrating spring Chinook salmon than CRiSP 1.4. However, the relative amount of change in the predictions was consistent between the two passage models (AFWG, 1993). See the discussion on travel time in paragraph 6.03.a.(2) for specific results.

The following paragraphs discuss the predicted impacts to salmon survival for the various drawdown alternatives. A summary of the SOR results is presented in table 6-8. There is no comparison of drawdown results with all proposed methods of improving salmonid survival (*i.e.*, additional flow augmentation, improvements to existing systems, and upstream collection facilities and transport), since the model results are not available for those at this point in time.

Table 6-8
Predicted Relative Percent Juvenile Survival in Critical Water Conditions From the Head of Lower Granite Reservoir to Below Bonneville Dam

Stock	Existing Conditions (In-River)	Existing Conditions (Overall Survival, with Transport)	Four Pool, 33-Foot Drawdown "Worst" Case	Four Pool, 33-Foot Drawdown "Best" Case	Four Pool, 33-Foot Drawdown No Changes in Dam Passage Parameters	Four Pool, 52-Foot Drawdown "Worst" Case	Four Pool, 52-Foot Drawdown "Best" Case	Four Pool, 52-Foot Drawdown No Changes in Dam Passage Parameters	Four Pool, Variable Pool Drawdown No Changes in Dam Passage Parameters	Lower Granite Only, With Transport No Changes in Dam Passage Parameters
Spring Chinook (CRiSP)	19	37	12	29 to 33[2]	24.7 to 26.1[2]	Not run	28.2 to 29.2[2]	29.1 to 29.4[2]	45 to 48[2]	40
Spring Chinook (PAM)	9	18.7 to 25.2	9.5	17.7	n/a	12.7	23.7[3]	n/a	24.8	31.5[4]
Summer Chinook	24	38	13	33	26.8 to 27.1[2]	Not run	29.1 to 30.1[2]	30.1 to 30.3[2]	46 to 47[2]	40
Fall Chinook	7	43	4	12 to 14[2]	Not run	Not run	n/a	Not run	28 to 29[2]	44 to 46[2]
Dworshak Steelhead	20	44	11	26 to 27[2]	26.4 to 27.4[2]	Not run	30.8 to 32.7[2]	31.5 to 31.8[2]	43	45

Predicted Relative Percent Juvenile Survival in Critical Water Conditions From the Head of Lower Granite Reservoir to Below Bonneville Dam

Stock	Existing Conditions (In-River)	Existing Conditions (Overall Survival, with Transport)	Four Pool, 33-Foot Drawdown "Worst" Case	Four Pool, 33-Foot Drawdown "Best" Case	Four Pool, 33-Foot Drawdown No Changes in Dam Passage Parameters	Four Pool, Variable Pool Drawdown No Changes in Dam Passage Parameters	Natural River Option	Lower Granite Only, With Transport No Changes in Dam Passage Parameters
Spring Chinook (CRiSP)	25	40	15	36	29.5	31.7 to 31.9	47 to 48[2]	42
Spring Chinook (PAM)	23.7	24 to 30[2]	23.3	37.7	n/a	n/a	41.4	32.6 to 35.8
Summer Chinook	31	41	17	40	31.6 to 31.8	33.8 to 34	51	43
Fall Chinook	11	47	7	21 to 23[2]	Not run	Not run	34 to 36[2]	50 to 51[2]
Dworshak Steelhead	27	47	11	26 to 27[2]	33.2 to 33.3	36.2 to 36.3	49	49

Predicted Relative Percent Juvenile Survival in Critical Water Conditions From the Head of Lower Granite Reservoir to Below Bonneville Dam

Stock	Base Level of Spawners	Existing Conditions (In-River) Survival	Existing Conditions (Overall Survival	Four Pool, 33-Foot Drawdown "Worst" Case	Four Pool, 52-Foot Drawdown "Worst" Case	Four Pool, 33-Foot Drawdown "Best" Case	Four Pool, 52-Foot Drawdown "Best" Case	Natural River Drawdown	Lower Granite Only, With Transport No Changes in Dam Passage Parameters
Spring Chinook (CRiSP)	9,272		18,375	20	Not run	10,728	Not run	36,786	9,288
Spring Chinook (PAM)					22.1		40.8		
Summer Chinook	3,078			3	Not run	1,379	Not run	6,723	811
Fall Chinook	478		51	0	Not run	1	Not run	5	1
Dworshak Steelhead	5,730		5,660	2	Not run	960	Not run	7,529	3,001

[1] Results are in a range because of two different assumptions about transport benefits. See SOR anadromous fish technical appendix.

[2] Results are in a range representing the 2- and 4.5-month scenarios. PAM cannot model fall Chinook, therefore no 4.5-month scenarios were run.

[3] Results for PAM used "best" case parameters.

[4] PAM ran best and worst cases for the Lower Granite only alternative.

(b) Near Spillway Crest

The four-pool drawdown scenario, with optimistic assumptions, increased juvenile survival estimates for Snake River stocks over the in-river survival estimates produced for existing conditions (including current levels of flow augmentation). However, juvenile survival for all stocks was decreased when compared to existing conditions with juvenile fish transportation, except for PAM spring Chinook runs with the 50-year water average, which showed a potential increase of 6 to 12 percent (33-foot) and 10 to 16 percent (52-foot), because the assumptions regarding benefits of transport during average and higher flow years differ from the assumptions used in CRiSP. All runs using potential "worst" case assumptions showed a decline in survival, even in PAM, over the 50-year average. The drawdown concept was conceived to increase survival in low-flow years, when flow augmentation cannot provide minimum desired flow levels. These model results indicate it is highly unlikely that it will not likely accomplish this purpose.

The four-pool, 33-foot drawdown, with the optimistic assumptions of dam passage parameters for spring Chinook, was able to maintain a level of spawners equivalent to, or slightly above, those observed during the base period. This drawdown alternative resulted in decreased returns of adults for all other Snake River stocks. Using worst case assumptions, all near spillway crest alternatives resulted in stocks being reduced to extremely low numbers due to substantially reduced juvenile survival.

Lower Granite drawdown, including transportation at Lower Granite, showed a slight potential benefit in all flow years in CRiSP and over the 50-year average in PAM. However, if likely range of potential impacts to juvenile fish dam passage parameters were included, the survival would decrease when compared to existing conditions.

(c) Natural River Option

For all stocks except fall Chinook, survival estimates for the natural river option were greater than for all other drawdown alternatives. The model results for natural river option estimated increasing adult returns for all Snake River stocks except fall Chinook.

6.04. Resident Fish

a. General

The effects of various drawdown alternatives on resident fish will be dependent on species habitat preference, period and length of spawning, and location of rearing areas. The resident fish species most likely to be affected by drawdown include species that use nearshore habitats for spawning, rearing, and adult feeding. Certain species utilize both nearshore and deep water zones for rearing. Resident game fish currently utilizing this nearshore habitat include bluegill, pumpkinseed, black and white crappie, smallmouth and largemouth bass, bullheads, and channel catfish.

The dewatering of shoreline areas during the spawning periods could have a substantial negative impact on many resident fish species that rely to a large extent on these areas as critical habitat for survival. The existing impoundments, characterized by large, deep, slow-moving bodies of water, favor many of the introduced resident game fish that are now increasing and becoming firmly established in the four reservoirs. The resident fish least likely to be impacted by drawdown include those species that prefer high flow rates and tend to inhabit mid-channel zones. These fish include the white sturgeon, mountain whitefish, bull trout, rainbow trout, northern squawfish, and redside shiner.

b. Stranding

The 1992 test drawdown of the Lower Granite reservoir provided an indication of impacts on resident fish populations from lowered water levels. Resident fish mortality associated with the test was estimated to be in excess of 35,000 game and non-game species. Most fish were stranded within the first 10 days of drawdown, when the pool was drawn down about 23 feet (Wik *et al.*, 1993). Fish were typically found in embankment ponds or shallow-water embayments, and were unable to follow receding water levels. The majority of these stranded fish were juveniles.

Although these mortality figures from the test drawdown appear high, they may have been insignificant in relation to the total population of resident fish in the reservoir, and did not appear to impact the size structure and composition of the populations during studies continued after the drawdown test was completed (Wik *et al.*, 1993). However, impacts to the prey base and other potential ecosystem-level effects were not determined. Thus, the cumulative effects of stranding from annual drawdowns could be more severe than the one-time test event would indicate.

c. Effects of Drawdown Alternatives on Spawning and Rearing

Because most resident fish inhabiting the lower Snake River rely on nearshore habitat for spawning, rearing, and feeding; the impact associated with these factors will depend on the period and extent of drawdown. However, species could spawn during the stable low-flow period, because shallow-water habitat may still be present. The most severe impact pertaining to resident fish would occur under the extended (*e.g.*, 4½-month) near spillway crest drawdown alternative. Under this alternative, nearly all of the shallow-water habitat would be dewatered from April 15 to August 15 at all four reservoirs. Most resident fish spawning takes place during this time period. The Little Goose reservoir, which has the most backwater and embankment habitats, would lose a greater percentage of these areas under the minimum operating pool alternative (Bennett *et al.*, 1992).

The major sport fish established in the lower Snake River include the smallmouth bass, black and white crappies, channel catfish, yellow perch, and sunfish (Bennett *et al.*, 1983). Members of the Centrarchidae family have become fairly well established in the lower Snake River (Bennett *et al.*, 1983). These species have similar spawning periods and habitat requirements. Smallmouth bass are especially vulnerable to water-level fluctuations because they spawn in relatively shallow water (3 to 15 feet). Spawning is known to occur from June to July on low-gradient shorelines with sand or gravel substrate. Much of the preferred spawning habitat would be unavailable for utilization under the natural river option. Although suitable spawning habitat may be available, the amount (in terms of area) would be less.

Crappies and sunfish prefer to spawn in the littoral zone near submerged vegetation, from April to June. If spawning is initiated before drawdown, nests will become dewatered and dry up. Male sunfish and crappies that guard the nest during this period would be vulnerable to stranding in pools and embayment areas. Sunfish can spawn more than once per season.

Juvenile smallmouth bass utilize the nearshore riprap areas for rearing and protection from predators. Feeding on benthic invertebrates and phytoplankton. Juvenile crappies and sunfish rear near shoreline habitats, feeding on insects and crustaceans (Bennett *et al.*, 1979). Drawdown would impact the rearing of these species by dewatering these important rearing areas. In addition, prey items could be less abundant at lower elevations, which would reduce predation success. Predation on fry and yearling smallmouth bass could increase due to reduced cover and shelter.

Channel catfish, brown bullhead, and yellow bullhead occur throughout the lower Snake River. Spawning for channel catfish has been reported from June through August in the lower Snake River. Suitable spawning habitat includes sheltered areas near undercut banks, as well as near tree roots. This type of spawning habitat occurs, for the most part, near the shoreline in the littoral region of the reservoirs.

Channel catfish would probably not be impacted by drawdown if spawning occurs after refill. In contrast, if the spawning period is near the end of the drawdown, refill would place nests in deep water and could reduce the viability of eggs. If spawning begins during drawdown, spawning habitat would be reduced and hatching success would be affected by increased velocities and sedimentation.

Brown bullhead spawn over an extended period, usually from May to September. Their spawning habitat is similar to that of channel catfish. Rearing habitat includes the shallow-water zone for a short period, followed by dispersal to deeper water zones. Brown bullheads utilize embayment and shallow shoal habitats, feeding on plankton and midge larvae. These areas are the first to warm in the spring and begin to be productive. The potential negative impacts to channel catfish and bullheads would be less severe than for channel catfish if drawdown lasted only 2 months, because they spawn later in the year, probably after reservoir refill. In addition, brown bullheads have the capacity to spawn again if their first attempt is unsuccessful (Bennett *et al.*, 1983). Potential negative impacts during the drawdown alternatives include the loss of spawning habitat, loss of forage areas, and loss of prey items. Channel catfish are known to migrate to the base of dams in the spring to feed on outmigrating salmon. Deep drawdowns could expose channel catfish to prolonged elevated levels of supersaturated water as a result of increased spill.

Yellow perch have become well established throughout the lower Snake River. The species is one of the most popular game fish in the Little Goose reservoir (Bennett *et al.*, 1983). Spawning occurs near rooted vegetation or near sand and gravel, from mid-April to early May. Rearing takes place in the littoral zone, with fry feeding on zooplankton and insect larvae. If spawning is completed prior to drawdown, there would be significant negative impacts to this species. Preferred habitat for fingerling yellow perch is clear water, near modest amounts of vegetation. Juvenile perch feed primarily on zooplankton in the shallow backwater regions of the reservoirs. These areas would be reduced under all drawdown alternatives. the reduction of zooplankton production, resulting from increased velocities and turbidity, could severely impact the survivorship of juvenile yellow perch and decrease the feeding success of adult perch (Corps, 1992b). During the March 1992 drawdown test, the Washington Department of Wildlife counted 260 dead perch (Wik *et al.*, 1993).

Tadpole madtom and sculpins are believed to be most numerous in the Little Goose reservoir. During the March 1992 drawdown test, adult sculpin and egg nests were found in recently dewatered shoreline areas of the reservoir (Dauble and Geist, 1992). Most sculpin prefer cool, clear water, with moderate-to-rapid currents. They spawn in March and April in gravel and rocky bottoms. The male guards the nests until the eggs hatch. Sculpins are considered an important food item for salmonids and other warmwater fishes (Bennett *et al.*, 1983). The impact to these species will depend on the period and extent of drawdown.

Species that could benefit from drawdown include white sturgeon and mountain whitefish. Both species prefer swifter river sections, and inhabit deep water zones as well as shallow riffle areas. Increased water velocities could benefit sturgeon by providing more spawning habitat and helping to disperse their eggs. Both species have a wide and diverse forage base (Bennett *et al.*, 1983). During the experimental drawdown in March 1992 many mollusks (especially *Corbicula*), were found dead and drying out along mud, cobble, and riprap shoreline areas (Dauble and Geist, 1992). Potential negative impacts to sturgeon would occur if there was a reduction in these important food items. Drawdown would not affect mountain whitefish spawning, since this species spawns in late fall and early winter (Bennett *et al.*, 1979). Late-attaching juvenile whitefish would be susceptible to dewatering since they would be utilizing the shallow areas for feeding in early spring. Feeding success may be enhanced for sturgeon by increasing the availability of prey during the natural river option or spillway crest alternative.

Other resident fish that may benefit from deep drawdown are members of the cyprinid family, including northern squawfish and redside shiner. Both species spawn in free-flowing waters, and tend to prefer higher water velocities (Bennett *et al.*, 1979). Northern squawfish and redside shiners are very numerous throughout the lower Snake River system. Northern squawfish could benefit from decreased competition for food items, as well as from having food items confined to a smaller volume of water. Bennett *et al.* (1983) reported species having a high correlation to increased water velocity, including white sturgeon, chiselmouth, northern squawfish, and reside shiner. Hjort *et al.* (1981) found bridgelip sucker, largescale sucker, and sculpin to be positively correlated to current in Lake Umatilla.

Largescale and bridgelip sucker are the most abundant fish species throughout the entire Snake system, accounting for approximately 34 percent of the relative abundance (Bennett *et al.*, 1983). The impacts of drawdown on adult largescale suckers are expected to be less adverse than on other fish species, because of the high adaptability of the largescale suckers. Adult largescale suckers have a diverse food base that changes throughout the year. Larval suckers have bee observed utilizing the shallow-water nearshore areas, and are susceptible to becoming stranded during water-level fluctuations (Hjort *et al.*, 1981). Dauble and Geist (1992) found that, of the resident fish observed during the 1992 drawdown test, juvenile catostomids were by far the most susceptible to becoming stranded in shallow bays and nearshore habitats. Larval bridgelip suckers are less vulnerable than many resident species to becoming stranded because they tend to utilize tributary streams away from the reservoir's influence (Hjort *et al.*, 1981). Adult bridgelip suckers feed mainly on periphyton and detritus during the summer. Reduced areas of suitable substrate and increased turbidities would reduce periphyton communities and, thus, provide fewer food items for bridgelip suckers.

d. Changes in Habitat Caused by Flow, Velocity, Temperature, and Dissolved Gas

Increased water velocities as a result of drawdown may cause entrainment of juvenile resident fish, especially members of the centrarchid family, which prefer more lake-like environments (Corps, 1992b). Fish studied in the Little Goose reservoir that prefer more lentic environments include largemouth bass, black crappie, warmouth, and tadpole madtom (Bennett *et al.*, 1983).

Increased erosion and sloughing of the shoreline could adversely affect resident fish by depleting macrophyte beds, increasing sediment transport, depleting spawning areas, reducing benthic invertebrate populations, and increasing turbidities. Increased sedimentation associated with lowering the reservoirs would severely impact the egg survival of some species. Sediment transport has been shown to have an adverse effect on the spawning success of smallmouth bass, white crappie, and pumpkinseed, all of which are susceptible to the sedimentation of embayment areas (Bennett *et al.*, 1983). Species that are able to tolerate increased turbidities include channel catfish and carp.

Important food sources for juvenile centrarchids, including zooplankton, are vulnerable to entrainment associated with reservoir drawdowns. Because most of the overall productivity originates from the primary producers, especially phytoplankton, extended drawdown periods may result in fewer food items being available to juvenile fish during and after reservoir refill. Studies have found that zooplankton densities are reduced following the drawdown and refill of reservoirs. The overall impacts to juvenile centrarchid growth rates will depend both on the periods when fish will be utilizing this important food group, and on the extent of the drawdown.

The impact of increased velocity on spawning success will depend on the type of spawning habitat. Fish that tend to spawn in the upper reaches of the reservoirs will be more prone to adverse impacts of sediment transport and higher velocities. Velocities above 3 fps are considered unsuitable for successful Percidae reproduction (McMahon *et al.*, 1984). Other species that would be affected by increasing water velocities during spawning include black and white crappie, pumpkinseed, bluegill, and brown bullhead (Bennett *et al.*, 1983). During the March 1992 drawdown test near Clarkston, Washington, the average velocity profiles increased from less than 1 fps at full pool to more than 5 fps during the drawdown. Velocities were generally greatest at mid-channel (Wik *et al.*, 1993).

During the March 1992 drawdown test, approximately 1600 fish were examined for symptoms of gas bubble trauma following the spill tests. The majority of these fish were largescale sucker, smallmouth bass, and squawfish. Gas saturation values during the tests ranged from 104 to 135 percent. No symptoms of gas bubble trauma were observed, although fish most susceptible to gas trauma were not sampled, durations of exposure were extremely limited, and it is unknown if sampling locations were adequate to ensure complete coverage of exposed fish.

e. Summary of Potential Drawdown Impacts on Resident Fish

Resident fish species that use shallow-water habitat for spawning, rearing, and adult feeding will be affected by reservoir drawdown. Smallmouth bass and channel catfish are introduced resident game fish of concern. Native species (*i.e.*, white sturgeon and northern squawfish) prefer more lotic environments, and could benefit from a drawdown. Northern squawfish utilize shallow nearshore habitat for rearing. However, the increase in lotic habitat, preferred for spawning and adult habitat needs, that will occur as a result of drawdown could mitigate for the loss of juvenile rearing habitat.

An analysis of the Lower Granite reservoir, using GIS, indicated a potential increase in the amount of shallow habitat. However, the substrate quality will be the limiting factor as to whether juvenile fish will utilize the "new" shallow habitat uncovered by a drawdown. The possibility exists that most of this shallow habitat is covered with sediment because of habitat degradation associated with reservoir aging. Thus, its value as spawning and/or rearing habitat is unknown.

Two-month drawdowns could adversely affect smallmouth bass populations. The spawning success of smallmouth bass and channel catfish could be adversely affected if they were flooded off their nests during the spawning period. Depending on water temperatures, spawning could occur after drawdown refill with little or no adverse effect. For resident fish that have already spawned, the stranding of fry and/or adults may occur because some species (*i.e.*, channel catfish and smallmouth bass) remain with their fry for a period of time after hatching.

Under a 4½-month drawdown, most species could still spawn during the stable low-flow period because suitable shallow-water habitat would still be present. This scenario would provide stable pool levels for spawning in an environment of increased riverine conditions, and this should be favorable to smallmouth bass. However, an extended drawdown may result in reducing the food items available to juvenile fish during, and after, reservoir refill. Zookplankton will likely decrease during an extended drawdown because less lentic areas will be available during the productive season.

Constant pool drawdown would be more beneficial to smallmouth bass than variable pool drawdowns, because spawning habitat will be kept submerged over a longer period of time. There may an increase, compared to normal pool elevations, in the amount of production to the early life-history stage if elevations prior to, and following, spawning were held constant. The amount of deep-water habitat is reduced under the near spillway crest alternatives from those found with current operations. A good compromise for white sturgeon may be provided by limiting the depth of the drawdown and maintaining some deep holes for rearing, while still providing some high-velocity habitat for spawning. Since drawdown in these alternatives is not as deep as the natural river operation, severe impacts to the benthos and other food production components may not occur.

Under the variable pool alternatives (near spillway crest), egg incubation success for smallmouth bass and channel catfish will be reduced substantially if the pool is fluctuated more than 2 to 3 feet during the months of June and July. Variable pool elevations would likely increase stranding events.

If the natural river option were implemented, northern squawfish might benefit by having prey concentrated in a more confined water channel. The extreme (>115 feet) fluctuations, on an annual basis, would generally result in negative impacts to introduced resident fish in the Lower Granite reservoir. A 2-month, natural river drawdown would have deleterious impacts to smallmouth bass because of the rapid rise in pool elevations during the spawning period. The flooding of bass spawning nests would place already-spawned eggs in over 100 feet of water, with little chance of successful egg incubation; or would force adult fish off the nests and prohibit spawning from taking place. This assessment also assumes that the substrate that exists at the lower elevation is suitable for spawning.

In the 4½-month natural river drawdown scenario, when the reservoir is refilled in September, a substantial change in the rearing environment will occur. This may strand young-of-the-year fry in deep, open water for a short period of time. If the young-of-the-year do not reorient to the rising water level, they will have difficulty finding food. They might also be subjected to increased predation. Increased water velocities and riverine habitat should benefit the spawning of sturgeon and northern squawfish. Food production would be expected to decrease, primarily because of the loss of benthic production and crayfish under reduced reservoir conditions. If the reservoir level were kept down, more riverine, lotic-type invertebrates may colonize and provide forage for the lost production from the dewatered benthos.

The reproduction success of the white sturgeon may actually be higher during a drawdown than under current conditions, because of increased lotic habitat. Crayfish, which are a major food source for white sturgeon, smallmouth bass, and northern squawfish, will decrease due to stranding. Plankton will be entrained downstream, thus reducing the food supply for juvenile centrarchids. Less suitable habitat might be available because of the siltation effects of the reservoir. Predation on fry and yearling smallmouth bass could increase because of a lack of cover. All residential fish young-of-the-year and juveniles would be vulnerable to the rapid lowering of water levels. Drawdown will alter availability and complexity of specific habitat types for all resident fish young-of-the-year and juveniles. The physical flushing of young-of-the-year out of the reservoirs could be a serious problem with drawdown. Nest-building species that guard their nests (*i.e.*, channel catfish, sculpin, and smallmouth bass) will be vulnerable to stranding and desiccation if thy spawn prior to a drawdown. Resident catostomids and cyprinids (including northern squawfish) may benefit from an increase in potential spawning habitat formed by additional high velocity habitat. This may result in additional recruitment of subyearlings, and offset the loss of rearing habitat.

6.05. Terrestrial

a. Habitat

In the early seral development of riparian vegetation, flooding occurs annually. Plants develop, and are tolerant of variations in the flow regime. Although vegetation along the lower Snake River projects has developed in areas subject to daily fluctuations in surface-water elevation (*e.g.*, 3 to 5 feet), a drawdown would be expected to affect both riparian and emergent vegetation production.

Riparian vegetation impacted by the initial inundation of the lower Snake River projects is not yet restored to the shorelines of the reservoir margins (Mudd, 1980). This may be due, in part, to unsuitable substrate, low moisture conditions, lack of an adequate seed source, or competition. Responses of vegetation to the effects of inundation and drawdown include dormancy, destruction of the root system (Hosner and Boyce, 1962; Burrows and Carr, 1969; and Broadfoot and Williston, 1973), including decreased stem elongation, wilting, and chlorisis; or reduced capillary action of vegetation. It is speculated that reduced capillary action can hinder the colonization potential of vegetation.

The Lower Monumental reservoir supports the most extensive wetland community of any of the lower Snake River projects. Therefore, the effects of a drawdown to spillway crest would have the most significant impact along this reach of the river.

Although fluctuating water levels tend to favor the regeneration of emergent wetland species, species success is dependent on the frequency and intensity of the water level change. The primary effect of drawdown on emergent vegetation would likely result from the interruption of the hydrologic connection to the main channel. Groundwater flows that maintain suitable growing conditions outside the main river channel would be interrupted, and would result in reduced system function (Kadlec, 1962). The rate of groundwater loss would further be affected by soil permeability that would dictate the rate at which standing and near surface water was lost in wetland habitats.

b. Waterfowl

Potential impacts to water fowl nesting in the lower Snake River include: 1) a reduction in testing habitat or inundation of nests during the breeding season; 2) increased rates of predation due to land bridging; and 3) decreased forage (*e.g.*, benthic invertebrates) in shallow-water areas (Cooke, 1980). In addition, water-level fluctuations can affect brood success through decreases in food availability or increases in energy demand caused by increased travel between feeding areas and cover. In the northern Flathead Valley, where reservoir drawdown coincided with nesting and brook rearing (late March through May), many habitats that were suitable for duck nesting were replaced by seasonally-flooded mudflats and cattail stands that provide poor-quality duck nesting habitat (BPA, 1987). During the March 1992 experimental drawdown on the lower Snake River, the loss of goose-nesting habitat as a result of drawdown resulted in the displacement of individuals to open-water areas distant from the drawdown zone. Displacement subsequently delayed nesting for individuals from both of these populations (BPA, 1987; and Corps, 1992).

A loss of habitat is also realized when drawdown renders goose-nesting structures ineffective. During the March 1992 experimental drawdown on the lower Snake River, goose-nesting structures were dewatered and rendered useless to geese. In the northern Flathead Valley, the loss of island and marsh-nesting habitat increased the importance of these elevated nest structures. Many of the elevated nests that were occupied by displaced individuals were formerly occupied by osprey, bald eagles, or great blue herons (BPA, 1987).

Fluctuating water levels, and the resultant land bridging in the lower Snake River (Corps, 1992), are the primary causes of increased predation and nest failure. Although land bridging occurred at both the Little Goose and Lower Granite pools during the March 1992 experimental drawdown, increased predation was not observed (Corps, 1992). It should be noted, however, that areas historically used by waterfowl during normal operations were used less frequently (Corps, 1992), and land bridges were exposed.

A drawdown that increases the distance of shoreline vegetation to water may subsequently impact waterfowl foraging habitat. Effects to wintering Canada geese on the lower Snake River should be negligible, since geese forage primarily with agricultural fields adjoining the project reservoirs (Corps, 176). In addition to increased distance of shoreline vegetation to water, the desiccation of backwater ponds as a result of drawdown will affect the production of emergent vegetation and limit the distribution of benthic invertebrates in exposed sediments. A reduction in invertebrate availability can lead to termination of renesting, no nesting, reduced clutch size, or can affect the timing of sexual maturation. Renesting species are reliant on high protein diets and, if invertebrate populations are affected by drawdown in areas where predation or nest destruction is high, duck nest attempts and/or success likely will be reduced.

In studies of areas characterized as deficient in moisture with unstable water levels, Swanson and Meyer (1977) concluded that the aquatic biota continually adjusted to the changing water levels. During spring and early summer, wetlands were characterized by low water, and seasonal wetlands dried. Although the amount of available surface water within the wetland was reduced and the species of invertebrates present varied, the proportion of animal food in the diet remained similar to that found during wetter years. Water conditions do, however, reflect major changes in the abundance and availability of species within temporary wetlands (Swanson and Meyer, 1977), and can be used as an indicator of waterfowl diet composition.

Although waterfowl adapt their diets to changes in invertebrate composition, temporary losses of invertebrates in shallow feeding zones affect waterfowl ecology to a greater extent than an overall loss of seasonal water and associated invertebrate fauna. When complete drawdown occurs, aquatic invertebrates are eliminated, or greatly reduced, and feeding conditions for breeding waterfowl deteriorate rapidly. As stated previously, most invertebrates associated with permanent water cannot adjust to short-term drawdowns that expose and inundate their habitat (Swanson and Meyer, 1977). This situation is remedied, to some extent, by sustained drawdown. Invertebrate fauna do not increase directly as a result of pioneering new habitats within the drawdown zone. However, species increase indirectly by thriving on decaying plant material that degrades as rising water levels inundate vegetation that has pioneered the drawdown zone. Invertebrates (*e.g.*, gastropods) may also respond to rising water levels by depositing large numbers of egg masses in flooded vegetation.

Vegetation that develops in the drawdown zone, and benefits waterfowl indirectly through invertebrate production, may also benefit waterfowl directly by facilitating the production of new species in foraging areas where succession has reduced species composition (Kadlec, 1962).

c. Raptors

Negative effects to raptors as a result of drawdown will depend on the loss of riparian habitat and reduction in prey density resulting from upland and riparian habitat loss. Impacts to raptors are not anticipated to be severe, because raptor species living in the lower Snake River (*i.e.*, red-tailed hawk, Swainson's hawk, and rough-legged hawk) generally use cliff and riparian habitat for nesting and perching, and forage in upland fields. The timing and duration of drawdown would have a greater impact on raptors due to lost production of prey species that inhabit embayments, shallow-water areas, and riparian and wetland habitats during raptor breeding and nesting season (February through August).

The overall goal, which is to increase smolt survival and the number of adults returning to the lower Snake River system, should provide the long-term benefit of increasing anadromous fish stocks for bald eagle foraging. Negative long-term effects on wintering bald eagles may result from decreased production of waterfowl, associated with reduced nesting habitat and reduced numbers of upland game birds (Corps, 1992). However, because eagles tend to use the lower Snake River only minimally and only during winter (bald eagles usually disperse from wintering areas by late March), impacts are not anticipated to be significant.

d. Upland Game Birds

Based on initial recommendations of the Lower Snake River Fish and Wildlife Compensation Plan (Corps, 1987), it is anticipated that upland game bird habitat may be impacted by a drawdown. Enhancement measures within the original plan provided for, and established, contractual agreements with private land owners to retain irrigated alfalfa strips, dryland alfalfa, grass hay meadows, and/or unirrigated corners in circle-irrigated fields for buffer, roost, nest, and forage areas for upland game birds (Corps, 1987). Effects to upland game bird habitat would be largely related to changes in riparian vegetation or changes in current land use on uplands adjoining the projects.

California quail, ring-necked pheasant, and mourning dove that commonly occur in the riparian corridor (Corps, 1976) may be more severely impacted by direct effects of a drawdown. Gray partridge, which are locally abundant above Lower Monumental Dam are more reliant on agricultural uplands beyond the ordinary high-water mark (Corps, 1976), and should not be affected by a drawdown. Although chukar are reliant on moist areas for forage, the species generally occurs in association with rocklands, grasslands, and steep terrain. They are capable of shift in habitat use from riparian areas to higher altitudes during wet years (Corps, 1976). Chukar rely on springs and palustrine forested habitat located in the draws of the Snake River. These birds can fly to the river's edge if additional moisture is needed. Common snipe, associated with mudflats or similar habitat from Lower Monumental through the Lower Granite reservoirs (Corps, 1976), may benefit from drawdown and increased exposures of sandbar, embayment, mudflat, and wetland sediments that have been observed during periods of power peaking (Corps, 1976).

e. Colonial Nesting Birds

Species of colonial nesting birds may compensate, if disruption occurs early enough in the season, by renesting immediately following disruption or renesting later in the nest cycle. They must be adaptable, and will be influenced to the degree that site tenacity is decreased or system stability is restored. Other species may pioneer new habitats (Prince and D'Itri, 1985), as was evidenced in a case of extreme drawdown in the Flathead Valley where terns and gulls, displaced from historic sites, nested on elevated stumps (BPA, 1987).

f. Threatened and Endangered Species

Each of the listed species typically occur in moist areas that have been established as a result of reservoir recharge. Drawdown may temporarily impact many of the plants along the lower Snake River. Drawdown elevations vary considerably from those of normal operations, and drawdown during the breeding season would result in extensive impact to these plant species. Impacts, however, are expected to be minimal. The critical period for many of the plant species will be from April to June.

Insects, reptiles, and amphibians that are reliant on moist soils or waters of riparian and wetland habitats may be impacted by drawdown. Because many of these species rely on microsites, impacts could be manifested in the loss or permanent displacement of the species.

During the March 1992 test drawdown of the Lower Granite reservoir, two mollusk species were exposed: the shortface lanx (*Fisherola nuttalli*) and the California floater (*Anodonta californiensis*) (Frest and Johannes, 1992). Further evaluation of habitat suitability and the potential effects of drawdown will be necessary to determine the extent of impact to the species.

g. Small Mammals

Small mammals would be impacted by a sustained drawdown that exceeds 10 to 14 days (Corps, 1992). Although a majority of microtines are able to relocate temporarily, the continued fluctuation of water levels would likely displace species permanently or result in reduced overall production potential.

Impacts to furbearers as a result of drawdown will include the exposure of muskrat, beaver, and river otter dens during breeding seasons; a reduction in riparian and wetland habitat; and the exposure of riprap den sites. Species diversity of aquatic furbearers along the lower Snake River was drastically reduced as a result of original construction and inundation of riparian habitat (Corps, 1976). During the March 1992 experimental drawdown, beavers were displaced from their lodges (Wik *et al.*, 1993). Aquatic furbearers exhibit a preference for non-fluctuating river reaches, subimpoundments, or tributaries not affected by water-level fluctuation. It has been postulated that, on run-of-river reservoirs, aquatic furbearers compensate for the effects of a drawdown by extending their den entrances in to the active channel (Mudd, 1980). The extent of drawdown below elevations that expose den entrances within natural and manmade habitats, and predispose furbearers to predation during the breeding season, may determine the extent of impact to the species.

In addition to the exposure of furbearers (*e.g.*, beaver) along project shorelines, the change in spatial distribution of vegetation within riparian habitat may influence species-specific foraging efficiency. Both stem density and stand homogeneity could be affected by a drawdown. Although stem density and distance from the beaver den site to forage are not correlated, vegetative homogeneity and distance from the den site to forage have been established. In riparian areas where disturbance has altered vegetative species composition [*e.g.*, increased species diversity (Corps, 1992b)], beaver foraging efficiency may decline due to a lack of dominance of one or two selected forage species.

h. Big Game

Based on the initial recommendations of the Lower Snake River Fish and Wildlife Compensation Plan, it is anticipated that mule deer habitat may be impacted by a drawdown. The original compensation plan recognized that an estimated 1800 deer wintered in the area of the four lower Snake River projects prior to initial inundation. Subsequent to the original study, estimates of 1900 to 3200 deer have been observed on or near the four lower Snake River projects (Corps, 1987). Upland grass and shrub communities, as well as riparian tree, shrub, and marsh habitat, are significant to mule deer in the lower Snake River area (Corps, 1976). The primary effects to mule deer would be associated with a reduction in riparian habitat and increased distance from forage to cover.

Section 7 - Economic Analysis

7.01. National Economic Evaluation Concepts

a. National Economic Development

The National Environmental Policy Act (NEPA) of 1969 requires analysis of all significant effects of any proposed action on the human environment. Four accounts are established to facilitate evaluation and display of the effects of alternative plans. These accounts are national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE). This section will discuss the economic effects of SCS drawdown plans.

The NED account identifies beneficial and adverse effects on the national economy. Beneficial effects in the NED account are increases in the economic value of the national output of goods and services from a plan, the value of output resulting from external economies caused by a plan, and the value associated with the use of otherwise unemployed or under-employed labor reservoirs.

The filing of formal petitions with the National Marine Fisheries Service in 1990 for the Endangered Species Act (ESA) listing of three salmon stocks as threatened or endangered focused regional attention on the need for more aggressive action addressing the precarious status of specific wild salmon stocks. The formal listings in December 1991 and May 1992 triggered the initiation of the National Marine Fisheries Service recovery plan and Federal agency consultation on the effects of actions, including the operations of the coordinated Columbia River system, on listed salmon. Under the ESA, the Corps and the cooperating agencies have a responsibility to ensure that their actions do not jeopardize the continued existence of the listed species. Consequently, a traditional NED analysis was not completed for anadromous fish because it was felt to be inappropriate in light of the ESA.

b. Regional Economic Development

Regional economic activity is measured using input-output analysis, which is a method used to estimate the size of economic impacts to regions and communities. Many of the alternatives would affect local economies. For example, alternatives that decrease opportunities for recreation (through lowering reservoir elevations) may result in less recreation money being spent in that region. The input-output model (IMPLAN was used to conduct the regional economic analysis, but the results will not be available for the SCS Phase I.

c. Scarcity

The notions of scarcity, choice, and opportunity cost underlie the economist's concept of costs. Price can be interpreted as a measure of the relative scarcity of goods. Determined by the interaction of supply and demand, price reflects the relative balance between the desire for a good and its availability. Commodities with low prices are usually less scarce than goods and services with high prices.

The scarcity of any resource dictates that choices be made. Choosing to use a resource one way means choosing not to use it in another way. Therefore, every choice costs something. It costs us an opportunity. It is signification that the definition of opportunity costs does not refer to, or depend on, dollars.

Opportunity cost is comprised of social and resource cost. Social cost is the cost imposed on the rest of society by the actions of an individual or some other agent of economic activity. Resource costs is the cost of the depleted resource. The opportunity cost of resources changes over time, as supply and the demand for goods and services change. The more the alternative opportunity is valued, the higher the cost of the opportunity.

The process of developing a plan to improve migration conditions for anadromous fish is an exercise in the fundamental economic problem of scarcity.

d. Optimal Use of Scarce Resources

The question faced by the region is whether or not the nation would be better off if the Columbia River system were operated differently to improve anadromous fish migration. Using economics to make this decision is complicated by the fact that the effects on anadromous fish cannot be measured in dollar terms or economic terms. In addition, other biological impacts to resident fish and wildlife are also difficult to accurately measure in economic terms.

e. Expected and Equivalent Annual Values

Economic impacts are expressed as average annual dollars. The annual estimates generally represent either an expected value or equivalent value, or a combination of the two.

Expected annual values are stochastically determined from observations made over many years. Expected annual value is the average damage that can be expected to result from many years of flow experiences with conditions remaining unchanged. It is computed by weighing each damage value according to its probability of exceedance. Graphically, it represents the area under the damage-frequency curve.

Equivalent annual values take into account conditions that change over time. Economic impacts are estimated for future years over the period of analysis. The estimates are then discounted to a base year and amortized over the life of the project. Amortization is equivalent to calculating a loan payment that repays both principal and interest. This process takes into account the social discount rate, and allows impacts that occur at different pints in time to be directly compared.

f. Discounting and Discount Rates

The process of equating money values across time is to equate future sums of money with their equivalent in today's market. This process is known as discounting. The discount rate is society's opportunity cost of current consumption. That is, it is the rate society uses to equate amounts of money at different points in time.

Economic theory suggests that the social rate of discounting should reflect the return that can be earned on resources employed in alternative private use. To avoid losses of well-being, resources should not be transferred from the private sector to the public sector if those resources can earn a higher return to the private sector. Setting the discount rate equal to the social opportunity cost of funds ensures an efficient allocation of resources across time.

The Federal discount rate, effective October 1, 1993, is 8.00 percent. However, the SCS Phase I utilized analysis provided by SOR (which calculated the benefit analysis at the then current interest rate of 8.25 percent). It is recognized that a conflict exists between the benefits (presented at 8.25-percent interest) and costs (calculated at 8.00-percent interest). However this small variance is acceptable for the SCS Phase I (reconnaissance-level report).

The analysis did not take into account the different implementation dates of the various alternatives. Therefore, although the benefits and costs were amortize (using 8.25 and 8.0 percent, respectively) over 100 years, the values were not brought back to present value. These undiscounted values include all lower Snake River projects, as well as John Day to MOP.

g. Price Level and Inflation

Constant prices expressed at a mid-1992 price level are assumed in the SCS economic analysis. Under this frequently used and simplifying assumption, prices do not change relative to one another, and inflation has no bearing on the results.

h. Period of Analysis

The NED impacts were evaluated over a 100-year planning horizon.

i. Farm Income Analysis

The impact on commercial irrigators affected by drawdown alternatives was measured by estimating the net farm income for each alternative. Net farm income is the gross income less the costs (either variable or variable and fixed costs). Comparison of net farm income between alternatives and the base case yield the incremental net farm income loss attributable to the drawdown alternative.

7.02. Alternatives and Conditions Evaluated

a. The Base Case, No Action, or Without Project Alternative

This alternative reflects the current operation of the Snake River, with interim flow improvement measures made in response to the Endangered Species Act listing of Snake River salmon.

It includes 3.0 MAF of flow augmentation water on the Columbia, additional water volumes from Dworshak in the spring and summer, flood control shifts from Dworshak and Brownlee to Grand Coulee, and up to 42,000 AF of additional upper Snake River water.

This alternative is very similar to the way the system operated in 1992, and reflects the results of Endangered Species Act Section 7 consultation with the National Marine Fisheries Service in 1992. The strategy is consistent with the 1992 to 1993 operations described in the Corps' *Interim Columbia and Snake River Flow Measures Supplemental EIS (SEIS)*, dated 1993.

The base year, or beginning of the analysis period, for the SCS Phase I is 1995. This is the first year an alternative could be implemented. However, most of the alternatives studied under SS cannot be implemented until the year 2000. To be consistent with the SOR analysis, it was assumed that the base case will exist until a new project is implemented.

National Economic Development benefit estimation in the Corps' planning process proceeds by comparing forecasts of economic conditions with the project to forecasts of economic conditions with the project. Therefore, all alternatives presented in the SCS Phase I report are compared against the base case to obtain the incremental change.

Table 18 presents the net change between each alternative, by economic impact.

b. Natural River Alternative (4A)

This alternative is designed to aid anadromous fish by increasing river velocity through mainstem reservoir drawdown at the four lower Snake River projects. It provides for the installation of new outlets in the lower Snake River dams that permit the lowering of the reservoirs to near original river bed levels. Drawdown elevations would be 623 feet at Lower Granite, 524 feet at Little Goose, 432 feet at Lower Monumental, and 343 feet at Ice Harbor. Drafting would be at the rate of 2 feet per day, beginning on February 18 each year. The reservoirs would refill again with natural inflows and storage releases from upriver projects, if needed. System flood control will shift from Brownlee and Dworshak to the lower Snake projects, but Dworshak would operate for local flood control. This alternative has 2 options:

- Alternative 4A, Natural River, 2-Month Duration: Provides for a 2-month drawdown beginning on April 16 and ending on June 15.

- Alternative 4A, Natural River, 4½-Month Duration: Provides for a drawdown lasting 4½ months, beginning on April 16 and ending on August 31.

c. Constant Pool Alternative (13, 13A, 14, 15, 17, 18, and 19)

The objective of this alternative is to increase river velocity by drawing down the four lower Snake projects to fixed elevations below minimum operating pool. This is done in an effort to aid anadromous fish. Drafting of the reservoirs under all suboptions would be at the rate of 2 feet per day, beginning on April 1. Elevations would be 705 feet at Lower Granite, 605 feet at Little Goose, 507 feet at Lower Monumental, and 407 feet at Ice Harbor. System flood control shifts from Brownlee and Dworshak to lower Snake project, but Dworshak would continue to operate for local flood control. This alternative has 11 options:

- Alternative 13, Constant Pool, 33-Foot Drawdown, 2-Month Duration: Drawdown of all four reservoirs, beginning on April 16 and ending on June 16.

- Alternative 13, Constant Pool, 33-Foot Drawdown, 4½-Month Duration: Drawdown all four reservoirs, beginning on April 16 and ending on August 31.

- Alternative 13A, Constant Pool, 33-Foot Drawdown, 2-Month Duration: Drawdown only the Lower Granite Reservoir, beginning April 16 and ending on June 16.

- Alternative 13A, Constant Pool, 33-Foot Drawdown, 4½-Month Duration: Drawdown only the Lower Granite Reservoir, beginning April 16 and ending on August 31.

- Alternative 14, Constant Pool, 43-Foot Drawdown (35 to 48 feet) of All Four Reservoirs, 2-Month Duration: The pools would be operated at a near constant pool at the drawdown level during the juvenile fish outmigration, from April 15 through June 15. The powerhouses would be operated to their hydraulic capacity, with excess water passing over modified existing spillways.

- Alternative 14, Constant Pool, 43-Foot Drawdown (35 to 48 feet) of All Four Reservoirs, 4½-Month Duration: The pools would be operated at a near constant pool at the drawdown level during the juvenile fish outmigration, from April 15 through Labor Day. The powerhouses would be operated to their hydraulic capacity, with excess water passing over modified existing spillways.

- Alternative 15, Constant Pool, 52-Foot Drawdown (43 to 57 feet) of All Four Reservoirs, 2-Month Duration: The pools would be operated at a near constant pool at the drawdown level during the juvenile fish outmigration, from April 15 through June 15. The powerhouses would be operated to their hydraulic capacity, with excess water passing over modified existing spillways.

- Alternative 15, Constant Pool, 52-Foot Drawdown (43 to 57 feet) of All Four Reservoirs, 4½-Month Duration: The pools would be operated at a near constant pool at the drawdown level during the juvenile fish outmigration, from April 15 through Labor Day. The powerhouses would be operated to their hydraulic capacity, with excess water passing over modified existing spillways.

- Alternative 17, Constant Pool: Same as alternative 13, except for powerhouse modifications (necessary to maintain the operating efficiency of the base case).

- Alternative 18, Constant Pool: Same as alternative 14, except for powerhouse modifications (necessary to maintain the operating efficiency of the base case).

- Alternative 19, Constant Pool: Same as alternative 15, except for powerhouse modifications (necessary to maintain the operating efficiency of the base case).

d. Variable Pool Alternatives (5 and 9)

- Alternative 5, Variable Pool, 49- to 57-Foot Drawdown of All Four Reservoirs, 2-Month Duration: The pools would be operated at a near constant pool at the drawdown level from April 15 through June 15. The powerhouses would be operated to their hydraulic capacity, with excess water passing over existing spillways.

- Alternative 5, Variable Pool, 49- to 57-Foot Drawdown of All Four Reservoirs, 4½-Month Duration: The pools would be operated at a near constant pool at the drawdown level from April 15 through Labor Day. The powerhouses would be operated to their hydraulic capacity, with excess water passing over existing spillways.

- Alternative 9, Variable Pool, 49- to 57-Foot Drawdown: Same as alternative 5, except for powerhouse modifications (necessary to maintain the operating efficiency of the base case).

e. Socioeconomic Effects

The socioeconomic effects of system operations are felt primarily within the communities along the river system, in nearby upland areas that draw water from the rivers, and in the commodity production areas that rely on the rivers for transportation. Quantified geographically, the area most likely to feel the socioeconomic effects would be a zone extending up to 30 or 40 miles on either side of the river. The largest population area is along the Lower Granite reservoir, comprising the "Quad Cities" of Lewiston and Moscow, Idaho; and Clarkston and Pullman, Washington.

Over the past 10 years, the economy of the Pacific Northwest has evolved from being resource-based to more diverse, with growing trade and service sectors. The lumber and wood products industry still plays an important role in the region's economy, but this sector has declined from a decade ago.

For the forecast period, 1990 to 2010, overall growth for major sectors of the regional economy in each state (Washington, Oregon, and Idaho) is expected to be moderate. The economies of some parts of the region are thriving, while others are not. Job-producing businesses are moving into or expanding in some areas, while other areas are losing jobs. While it might appear that the Columbia River Basin as a whole is doing well economically, much of the region east of the Cascade Mountains has been lagging behind. A primary reason for this economic difference is that employment in extractive industries (*i.e.*, mining, fishing, logging, and farming) has been declining, and many of these jobs have not been replaced by growth in other industries.

f. Economic Effects

The economic impact of various alternatives was determine for six elements: flood control, irrigation, municipal and industrial (M&I) water use, navigation and transportation, power, and recreation. Construction activity and the effects o cultural resources associated with implementing each alternative were also analyzed.

After identifying the annual economic activity in each of the above categories, the information had to be associated with an alternative to allow for a comparison of all alternatives. Data compiled for the SOR was utilized as input for SCS Phase I. However, there are alternatives that were analyzed under SCS Phase I, but not analyzed for the SOR. In the cases where data was not available for SCS from SOR analysis, the figures were interpolated from the SOR data, where practicable.

For ease of comparison, table 16 enumerates SOR and SCS alternative numbers, implementation dates, and descriptions.

Table 17 is a summary table of all economic costs for each alternative, by economic impact category. Note that the economic analysis is complete only for alternatives 4A, 13, and 13A.

g. Mitigation Opportunities

All reservoir drawdown alternatives will impact natural resources, cultural resources, and commerce. The NPPC, in amendments to the Columbia River Basin Fish and Wildlife Program (Phase 2), calls for the development of a mitigation plan consisting of measures to mitigate the impact of the reservoir drawdown strategy to the greatest extent practicable.

Analysis completed under Phase I of the SCS has identified opportunities to mitigate navigation, hydropower, irrigation, recreation, and cultural resource impacts associated with reservoir drawdown alternatives. However, these opportunities were not included in the benefit and cost calculations that are presented in the SCS Phase I. The mitigation costs are offered for consideration, as well as to show the possible scope of mitigation required.

Where it is not possible to develop impacts and/or mitigation measures, they will be identified as future study requirements in section 11.

7.03. Recreation

a. General

The diverse landscape of the region provides a wide range of recreational opportunities. The reservoirs and adjacent lands of the Columbia River system are important elements of these recreational resources. Various agencies have developed hundreds of recreation sites that offer opportunities for boating, swimming, fishing, water-skiing, wind surfing, camping, and picnicking. The projects are heavily used for recreation, with a total of 14 million recreation days reported on the 14 study area pools. These activities have significant economic and non-economic value to the users. In addition, recreationists using the projects spend money for a variety of recreation-related goods and services. The recreation resources of the Columbia River system, and the expenditures that they generate, are important components of the regional tourism industry.

Generally, recreation parks along the lower Snake River are opened around April 1 and closed around October 1 each year. These dates fluctuate depending on annual climate conditions and the physical layout of each park facility. Boat launching ramps, however, are open all year. All ramps are usable throughout normal pool fluctuations between normal full pool and minimum operating pool elevations.

Recreation activities affected by system operations include boating, wind surfing, sport fishing, swimming, hunting, wildlife viewing, camping, and picnicking. Direct economic impacts include changes in visitor use, consumer surplus associated with this use, and the expenditures made by visitors. The indirect impacts stem from changes in expenditures made by visitors.

b. Effects and Impacts of the Drawdown Alternatives

Reservoir fluctuations can adversely affect both water- and land-based recreational facilities. Fixed water-based facilities (*i.e.*, boat ramps, swimming beaches, and moorage facilities) have very specific ranges of elevations where they can operate effectively. Some floating facilities (*i.e.*, docks, log boos, and swimming area markers) can be relocated as pool elevations drop. However, it is often not practical to move them, because pool elevations fluctuate frequently, or rapidly, and moving facilities can be difficult. Floating facilities can also be damaged by drawdowns, and can be difficult to refloat.

Land-based facilities at recreational sites can also be affected by drawdowns. Many of the developed recreational sites in the study area have extensive lawns and numerous shade trees that require irrigation. If pool elevations drop below irrigation intakes, irrigation systems would either have to be shut down or possibly modified. Without irrigation during the summer, vegetation could be damaged or killed.

Recreational facilities at the four lower Snake River projects are designed to function within 5 feet of the full pool elevation. Changes in visitation associated with changes in reservoir levels tend to be concentrated among activities that are most dependent on facilities with specific operating ranges. These activities include boating, fishing, water-skiing, swimming, and wind surfing. When the use of developed facilities is limited by changes in water levels, there are often corresponding effects on related uses at different locations. Boat-in camping, for example, is a popular activity throughout the study area, and it would be indirectly affected by limitations on the ability to launch boats at developed ramps due to lower water levels. The potential increase in fishing due to the possible availability of more fish (as a long-term result of drawdown alternatives) was not studied at this time.

The drawdown alternatives would all result in drawdowns at the lower Snake River projects that would lower pool elevations to well below the minimum required for the use of existing recreation facilities. The natural river alternative would reduce pool elevations 94 to 104 feet below full pool from mid-April to mid-June. The constant pool alternative would lower pool elevations from 28 to 57 feet below full pool. With the variable pool alternatives, the pools would be refilled starting in the middle of June, and would rise to within 5 feet of full pool by the end of July. During most of the refill period, the pool elevations would be too low for most existing recreational facilities to be used.

c. Mitigation Opportunities

Two options were considered to mitigate the impact to recreation facilities from reservoir drawdowns. The first option would be to build new facilities and/or reconstruct the existing recreation facilities so that they will function both during drawdown and normal operations. The second option would be to construct only additional boat-handling facilities for use during a drawdown condition. Each alternative action was developed assuming a drawdown to spillway crest at each project. Because the location and arrangement of the proposed facilities of each option is more dependent on the shoreline topography than differences in water surface between drawdown alternatives, each mitigation option is assumed applicable to all drawdown alternatives.

The first option would require, in some cases, relocating the entire facility to a more suitable location, since the existing site cannot be adapted to provide total visitor access to the river during drawdown. In other cases, the facility would require extensive redesign and reconstruction to maintain the existing facility at its current day-use levels.

The second option would retain all existing recreation sites as they are, and construct only additional boat-handling facilities for use during drawdowns. New boat-handling facilities would be inundated when each lake is at its normal pool level. Additional facilities would consist of a series of boat ramps, portable floating boat docks, additional parking areas, and access roads at different elevations. These facilities would allow continuous access to the river as the water surface elevation changes during drawdown or refill. Swimming would be the only activity that may not be available at the existing recreation sites during a drawdown.

d. Mitigation Construction Cost

The actual construction of mitigation measures at each park will depend on the need and use of each site. The total cost of mitigation measures will vary between minimal boat-handling facilities (about $23 million) and reconstruction of recreation sites (about $46 million). The extent of new and reconstructed facilities will be determined during Phase II studies. The potential cost ranges to mitigate for reservoir drawdowns are summarized below. Average costs are used for the summary of project mitigation costs at the end of this report.

	New Boat Launch Facilities Only	**Average**	**New and Reconstructed Facilities**
Ice Harbor	$5,200,000	$8,400,000	$11,600,000
Lower Monumental	10,100,000	14,300,000	18,400,000
Little Goose	1,900,000	3,700,000	5,400,000
Lower Granite	6,100,000	8,300,000	10,500,000
Totals	**$23,300,000**	**$34,700,000**	**$45,900,000**

e. Mitigation, Operation, and Maintenance Cost

In addition to construction of the facilities described above, certain actions are necessary during any drawdown in order to control public access and safety. Requirements common to all alternatives include:

- Removing or preparing existing floating docks to prevent structural damage.

- Implementing security and safety programs, including barricading water access locations and monitoring the entire shoreline for health and safety.

- Disconnecting utility systems.

- Restoring all water-related facilities following each drawdown.

- Implementing a preventive maintenance program to protect the existing structures from damage.

- Implementing an information program to alert the public about the recreational facilities that would be usable on each lake, or directing them to alternate locations within driving distances.

Although pumping facilities may be modified as part of mitigating irrigation systems, additional operation and maintenance by project personnel is anticipated.

Reservoir drawdowns will certainly add more responsibility to the recreation staff at all operating projects on the Snake River.

The estimated operation and maintenance cost is the additional incremental operation and maintenance cost related to drawdown activities. The annual cost for losses due to fishing and water sports; or financial losses to concessionaires, operating marinas, or restaurants is not identified. The estimated annual operation and maintenance cost, by project, is summarized below:

Ice Harbor Project	$270,000
Lower Monumental Project	280,000
Little Goose Project	270,000
Lower Granite Project	290,000
Annual Operation and Maintenance Cost	**$1,110,000**

f. Annual Recreation Cost

Economic values associated with recreation can be separated into direct and indirect economic values. Direct values represent the recreator's willingness to pay (WTP) for the recreation activity. The WTP includes two components: 1) the costs to participate (*e.g.*, the entrance fee); and 2) the dollar amount the recreator is willing to pay over the out-of-pocket costs (entitled the consumer surplus). Indirect impacts are associated with the expenditures that recreators make, and the individuals who will receive income and jobs from these expenditures. The annual cost for losses due to fishing, water sports, or financial losses to concessionaires, operating marinas, or restaurants is not identified in the cost presented. These indirect impacts will be analyzed in the SCS Phase II.

Recreation participation was estimated at each of the reservoirs within the region. Utilizing a recreation impact assessment model, the number of annual recreation days for major activities (camping, picnicking, swimming, boating, and fishing) was estimated for each of the alternatives. The future population and recreation participation rate was also estimated for the Pacific Northwest.

A recent survey estimates the current (1993) recreation use, consumer surplus values, expenditure patterns of the recreators, and the expected impacts to recreation with each alternative. Because this information was not available for Phase I, values developed in earlier studies were used here. It is recognized that there are shortcomings to applying recreation values developed for a specific recreation site, geographic area, or for specific recreation activities to different sites, geographic areas, and activities. The recreation benefits were computed by multiplying the total recreation days by the recommended consumer surplus value.

The base case presented in tables 17 and 18 includes the recreation usage of the entire Columbia/Snake River system (as opposed to the recreation usage of only the four Snake River projects) because it was assumed that the entire system acts as a whole, whereby recreation usage would be transferred to other projects. The Absolute Economic Costs, presented in table 17, are the total costs associated with each alternative. The Net Economic Costs, found in table 18, indicate the increase in costs over the base case. The constant pool alternatives (both the 43- and 52-foot drawdowns) were not specifically analyzed for the SCS Phase I, but would fall within this range. These same recreation costs associated with each alternative are presented in the following table.

Comparison of Total Annual Recreation Cost

Alternative Description	Absolute Economic Costs	Net Economic Costs (Change From the Base Case)
Base Case (No action)	$189,143,500	$0
4A, Natural River, 2 Months	$176,993,000	$12,150,500
4A', Natural River, 4.5 Months	$171,960,500	$17,183,000
5, Variable Pool with Existing Powerhouse/Existing Spillway, 2 Months	Not evaluated	Not evaluated
5', Variable Pool with Existing Powerhouse/Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
9, Variable Pool, Modified Powerhouse with Existing Spillway, 2 Months	Not evaluated	Not evaluated
9', Variable Pool, Modified Powerhouse with Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
13, Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 2 Months	$178,297,000	$10,846,500
13', Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 4.5 Months	$174,263,000	$14,880,500
13A, Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	$181,706,500	$7,437,000
13A', Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	$179,387,000	$9,756,500
14, Constant Pool, 43-Foot Drawdown with Modified Spillway, 2 Months	Not evaluated	Not evaluated
14', Constant Pool, 43-Foot Drawdown with Modified Spillway, 4.5 Months	Not evaluated	Not evaluated
15, Constant Pool, 52-Foot Drawdown with New Spillways, 2 Months	Not evaluated	Not evaluated
15', Constant Pool, 52-Foot Drawdown with New Spillways, 4.5 Months	Not evaluated	Not evaluated
17, Same as Alternative 13, with Modified Powerhouse	$178,297,000	$10,846,500
17', Same as Alternative 13', with Modified Powerhouse	$179,263,000	$14,880,500
18, Same as Alternative 14, with Modified Powerhouse	Not evaluated	Not evaluated
18', Same as Alternative 14', with Modified Powerhouse	Not evaluated	Not evaluated
19, Same as Alternative 15, with Modified Powerhouse	Not evaluated	Not evaluated
19', Same as Alternative 15', with Modified Powerhouse	Not evaluated	Not evaluated

Any drawdown of Snake River reservoirs below minimum operating pool would eliminate the use of existing boat ramps, boat docks and mooring facilities, and swimming beaches. A reservoir drawdown would not directly affect day-use at the parks, but the quality of the experience would definitely change as the lowering water exposes mud flats, stumps, and debris. It is generally assumed that the use of park facilities without access to the water would diminish below historic visitation levels. The most dramatic lessening of use would be at Chief Timothy State Park (Lower Granite Lake), where the island would no longer be an island, and would be surrounded by mud flats.

All moored boats at marinas would either be removed from the water or relocated to other marinas (Lake Wallula) during each annual drawdown. If a drawdown became an annual occurrence, the operation of existing marinas may cease because of the desire to moor boats year-round. The steamboat "Jean," near Hells Gate State Park, would be moved into the river channel or shored in place. Also, the city of Lewiston fireboat moored at the O&M ramp at Clarkston, Washington, would have to be relocated.

7.04. Flood Control

a. General

Land forms in the area are comprised of high mountain ridges, steep slopes, narrow canyons and valleys, and a few sloping plateaus. Sites suitable for building are usually limited to the narrow valley bottoms that comprise the floodplain. The area of potential flood damage along the Clearwater River between Dworshak Dam and the Lower Granite reservoir is a relatively narrow, long (approximately 40 miles in length) floodplain. Structure development is centered on either end of the floodplain, with agricultural and undeveloped land in between. The city of Lewiston, Idaho, is on the downstream end of the floodplain. A system of roads, railroads, and bridges runs throughout the study area.

The city of Lewiston, at the confluence of the Clearwater and Snake Rivers, is protected by levees up to about RM 5 on the Clearwater River. These levees were built as part of the Lower Granite Project, in order to allow slackwater navigation to Lewiston. As no alternative results in a discharge that exceeds the safe carrying capacity of the levees at Lewiston, all flood damages associated with the various alternatives within the study area are located upriver from Dworshak Dam to Lewiston.

b. Impacts

The impacts each of the alternatives have on flood control is based on the risk of flooding that would result from each alternative. The operation of the system of upstream storage projects provides flood protection via control of excess river discharges during the spring/summer freshet. Alternatives that require the drawdown of Snake River projects, or those designed to simulate natural river conditions, would not be expected to negatively impact the system flood control objective.

Under both the natural river and constant pool alternatives, Dworshak would be operated for local flood control. The four lower Snake projects would be drawn down to near the original river elevation for part of the year and would take over the system flood control duties shifted from Brownlee and Dworshak. The space made available by drawing down the lower Snake projects in the spring would not have a significant effect on mainstem flood control, but could slightly decrease the likelihood of flooding on the lower Columbia.

Impacts of the various alternatives on flood control are measured in terms of average annual damages. These are based on July 1992 prices and 1995 (base year) conditions. Future growth in damages were not considered significant for this study and were, therefore, not considered in the analysis. The implementation of the various alternatives varies in timing.

To obtain an accurate assessment of property valuation and damage, each damage category was studied independently. The value and damage of each category was determined by the best method available (assessor's data, depreciated replacement value, or values assigned by category experts).

Damage to structures and content was estimated by combining water depths and depth damage functions for various structure types to estimate damages. Data for structures was entered into a computer program created by the Corps, Walla Walla District, that calculates depreciated structure value. The program also calculates damage in 0.10-foot increments, based on depth damage relationships for structures and contents for building type.

The Absolute Economic Costs, presented in table 17, are the total costs associated with each alternative. The Net Economic Costs, found in table 18, indicate the increase in costs over the base case. The constant pool alternatives (both the 43- and 52-foot drawdowns) were not specifically analyzed for the SCS Phase I, but would fall within this range. These same costs associated with each alternative are presented in the following table.

Comparison of Annual Flood Control Damages		
Alternative Description	**Absolute Economic Costs**	**Net Economic Costs (Change From the Base Case)**
Base Case (No action)	$10,275	$0
4A, Natural River, 2 Months	$19,360	$9,085
4A', Natural River, 4.5 Months	$21,125	($10,850)
5, Variable Pool with Existing Powerhouse/Existing Spillway, 2 Months	Not evaluated	Not evaluated
5', Variable Pool with Existing Powerhouse/Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
9, Variable Pool, Modified Powerhouse with Existing Spillway, 2 Months	Not evaluated	Not evaluated
9', Variable Pool, Modified Powerhouse with Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
13, Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 2 Months	$19,360	$9,085
13', Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 4.5 Months	$19,360	$9,085
13A, Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	$19,360	$9,085
13A', Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	$19,360	$9,085
14, Constant Pool, 43-Foot Drawdown with Modified Spillway, 2 Months	Not evaluated	Not evaluated
14', Constant Pool, 43-Foot Drawdown with Modified Spillway, 4.5 Months	Not evaluated	Not evaluated
15, Constant Pool, 52-Foot Drawdown with New Spillways, 2 Months	Not evaluated	Not evaluated
15', Constant Pool, 52-Foot Drawdown with New Spillways, 4.5 Months	Not evaluated	Not evaluated
17, Same as Alternative 13, with Modified Powerhouse	$19,360	$9,085
17', Same as Alternative 13', with Modified Powerhouse	$19,360	$9,085
18, Same as Alternative 14, with Modified Powerhouse	Not evaluated	Not evaluated
18', Same as Alternative 14', with Modified Powerhouse	Not evaluated	Not evaluated
19, Same as Alternative 15, with Modified Powerhouse	Not evaluated	Not evaluated
19', Same as Alternative 15', with Modified Powerhouse	Not evaluated	Not evaluated

7.05. Irrigation and Municipal and Industrial Water Use

a. General

Pumping facilities on the Snake River system serve agriculture, wildlife areas, recreational areas, and municipal and industrial uses. The inventory of pumping facilities compiled by Anderson Perry and Associates is extensive, but it is possible that one or more users may not be represented. The inventory will need to be verified for the Phase II study.

Each dam is operated to allow a fluctuation of only 3 to 5 feet in water surface elevation. The majority of pumps are the vertical turbine-type, designed to operate within this relatively constant water surface elevation. They will not operate with any significant drawdown below these levels. Each analysis assumes that every pumping station will remain in service, and each station must be modified to allow it to provide the same quantity of water that it now provides. Twenty-nine of the thirty-one stations identified will require some revisions to allow them to operate under the proposed drawdown alternatives.

The impact of a reservoir drawdown on each pumping facility is dependent on the distance from each dam (lower end of the reservoir that is deep, or the upper shallower end), the profile (pumping head) from pump to river, and the configuration of the river bank. Pumping plants along the lower (deeper) end of each reservoir will be heavily impacted by any drawdown.

As an example, impacts to the 11 pumping stations located on the Lower Granite pool vary greatly depending on reservoir location. Impacts vary from no impact to 108 feet of added pumping head for the near natural river alternative.

b. Direct Economic Impacts

The impacts on reservoir pumpers who might be impacted by the drawdown alternatives are presented in two parts: 1)irrigation pumping associated with commercial agriculture, termed "commercial irrigation;" and 2) municipal and industrial (M&I) users, which includes pumpers who utilize reservoir water for M&I purposes, fish hatcheries, Corps pumping for recreation areas and wildlife habitat, and other uses.

An analysis was completed to assess the impacts to commercial irrigators and M&I users. The Ice Harbor reservoir is the only pool with commercial irrigators that would be impacted under the SCS drawdown alternatives. Impacts on M&I users have been identified for the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite pools.

Direct economic impacts to irrigators and M&I water users include two components: 1) pump or other facility modification costs; and 2) energy and other operating costs.

Pump modifications paid for by private owners will have a direct impact on the net income available to the operation for which the pumps are required. In other cases of irrigated agriculture, producers will be required to withhold or delay investment in other farm activities in order to meet the modification expenses. The lower net income may also reduce returns to the farm household.

c. Indirect Economic Impacts

The indirect economic impact associated with annualized costs of the pump modifications would depend in large part on whether costs are paid for by the public or whether they are paid for by the pump owners. If the costs are paid by the public sector, in the form of regional rate payers, the modification costs are likely to be translated into higher electricity rates and subsequent decline in regional household incomes. If the costs are paid by the public sector, in the form of taxpayers, any associated secondary impacts are not likely to be measurable because of the much broader base over which the costs are distributed.

If modification costs are paid by the pump owners, the magnitude of the secondary impacts would depend on whether the pumps are under public or private ownership. To evaluate the impacts linked to pumps owned by Federal, state, or local governments; it is first necessary to know whether the modification cost will be funded through diversion of existing expenditures or whether new funds will be required and what the likely source will be for these funds. From this, it can be determined whether existing regional activities will be displaced in order to fund the pump modifications. The displaced activity becomes the measure of secondary impact.

d. Impacts on Commercial Irrigators

The waters of the Columbia/Snake River system irrigate more than 7.3 million acres (2.95 million hectares) of land in the Columbia River Basin, including British Columbia. This irrigation water makes possible the production of crops, ranging from relatively low-valued hay and pasture to very specialized fruit and vegetable crops that provide a high return per acre. Because of the importance of agricultural irrigation to the economy of the Columbia River Basin, the irrigation analysis focused on determining the cost to irrigators of maintaining the status quo with regard to water deliveries. Thus, most of the analysis is based on cropping patterns that remain the same as current conditions, and an assumption that non e of the land would go out of production due to implementation of any of the alternatives.

Analysis of the alternatives indicates that, while all four reservoirs (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) would experience lowered reservoir pools under drawdown alternatives, only Ice Harbor has commercial irrigators that would be impacted by those alternatives that propose a drawdown of the pool during the pumping season. It is estimated that 13 pumpers on the Ice Harbor pool irrigate approximately 36,389 acres (14,726.16 hectares). Many of these entities are large corporate operations.

Irrigation pumpers utilize pumping plants or collection systems located on the reservoir bank to pump water to lands lying essentially adjacent to the reservoir. Irrigation entities pumping from reservoir pool utilize natural flow rights permitted, or granted, by the Washington department of Ecology, as well as easements and permits issued by the Corps.

The impact on commercial agriculture irrigators directly affected by reservoir drawdowns was analyzed in terms of the cost to modify pumping plants and the associated increased operating and power cost. These costs allow the entities to continue pumping from the pools under reservoir drawdown conditions, as identified in the hydroregs. (The HYDREG is a seasonal regulation program that sets the regulation for the coordinated operation of the region's hydroelectric system.)

Pump modification costs were prepared by private engineering consultants. Modification costs are necessary, in general, to lower the intake structure, extend the intake lines further into the reservoir pool, dredge a channel to the intake line, or some combination of all three remedies.

In addition to pump modification, additional operating and power costs are incurred. The pump modification costs, along with the increased operating and pumping cost, were included in the farm income analysis as a farm expense. Consequently, net farm income is reduced for those SCS alternatives with drawdowns.

It is recognized that, in the long-run, the variables affecting irrigation are dynamic. The economic viability of irrigation in the region, like any enterprise, depends on its ability to respond to various internal and external variables. The farm income analysis provides an estimate of the income lost to the pumpers and, in turn, to the region as a result of any drawdown proposal. The increased costs are considered mitigation costs, in that they are necessary to continue irrigation from the reservoir pools. Although they are included in the farm income analysis, what entity will bear these costs is unknown, and is beyond the scope of this study.

Under the base case (*e.g.*, without project condition), annual equivalent net farm income is approximately $71.1 million for Ice Harbor pumpers (or $453 per acre). Under reservoir drawdown, annual net farm income is reduced. The greatest impact occurs under the natural river, 4½-month duration option, where annual equivalent net farm income is approximately $62.6 million, or a reduction of $8.6 million annually.

The Absolute Economic Costs, presented in table 17, are the total costs associated with each alternative. The Net Economic Costs, in table 18, indicate the increase in net farm income over the base case. Costs for the variable pool alternatives were not analyzed at this time. These same costs associated with each alternative are presented in the following table.

Comparison of Annual Net Farm Income*

Alternative Description	Absolute Economic Costs	Net Economic Costs (Change From the Base Case)
Base Case (No action)	$17,073,000	$0
4A, Natural River, 2 Months	$62,610,000	$8,463,000
4A', Natural River, 4.5 Months	$62,502,000	$8,571,000
5, Variable Pool with Existing Powerhouse/Existing Spillway, 2 Months	Not evaluated	Not evaluated
5', Variable Pool with Existing Powerhouse/Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
9, Variable Pool, Modified Powerhouse with Existing Spillway, 2 Months	Not evaluated	Not evaluated
9', Variable Pool, Modified Powerhouse with Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
13, Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 2 Months	$64,495,000	$6,578,000
13', Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 4.5 Months	$64,452,000	$6,621,000
13A, Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	$67,127,000	$3,946,000
13A', Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	$67,127,000	$3,946,000
14, Constant Pool, 43-Foot Drawdown with Modified Spillway, 2 Months	$64,030,636	$7,042,384
14', Constant Pool, 43-Foot Drawdown with Modified Spillway, 4.5 Months	$63,970,544	$7,102,456
15, Constant Pool, 52-Foot Drawdown with New Spillways, 2 Months	$68,189,620	$2,883,380
15', Constant Pool, 52-Foot Drawdown with New Spillways, 4.5 Months	$64,186,264	$2,886,736
17, Same as Alternative 13, with Modified Powerhouse	$64,495,000	$6,578,000
17', Same as Alternative 13', with Modified Powerhouse	$64,452,000	$6,621,000
18, Same as Alternative 14, with Modified Powerhouse	$64,030,636	$7,042,364
18', Same as Alternative 14', with Modified Powerhouse	$63,970,544	$7,102,456
19, Same as Alternative 15, with Modified Powerhouse	$68,189,620	$2,883,380
19', Same as Alternative 15', with Modified Powerhouse	$68,186,264	$2,886,735

*Includes pump modifications to commercial navigation.

e. Impacts on M&I

Impacts on M&I pumpers were identified at the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite reservoir pools. Municipalities draw water from the reservoir pools for their water supplies. Recreation-related users, such as country clubs, use water to irrigate golf courses; and various state and county parks use water for irrigation and water supply. Wildlife management areas also draw water from the system to irrigate vegetation provided for wildlife. In various ways, these water uses support local jobs and contribute to the regional economy.

The impact on M&I water users directly affected by reservoir drawdowns was analyzed in terms of the cost to modify pumping plants and the associated increased operating and power cost. These costs allow the entities to continue pumping from the pools under reservoir drawdown conditions, as identified in the hydroregs.

Table 22 shows the modification cost, the annual increase in pumping cost, and the increased annual equivalent pumping cost at 8.25 percent. The greatest increase in annual equivalent pumping cost is approximately $1.4 million for the natural river, 4½-month duration alternative.

The Absolute Economic Costs, presented in table 17, are the total costs associated with each alternative. The Net Economic Costs, found in table 18, indicate the increase in M&I costs over the base case. These same costs associated with each alternative are presented in the following table.

Comparison of Annual Increased M&I Water Cost*

Alternative Description	Absolute Economic Costs	Net Economic Costs (Change From the Base Case)
Base Case (No action)	$0	$0
4A, Natural River, 2 Months	$4,177,990	$4,177,990
4A', Natural River, 4.5 Months	$254,000	$254,000
5, Variable Pool with Existing Powerhouse/Existing Spillway, 2 Months	Not evaluated	Not evaluated
5', Variable Pool with Existing Powerhouse/Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
9, Variable Pool, Modified Powerhouse with Existing Spillway, 2 Months	Not evaluated	Not evaluated
9', Variable Pool, Modified Powerhouse with Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
13, Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 2 Months	$3,891,600	$3,891,600
13', Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 4.5 Months	$3,893,100	$3,893,100
13A, Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	$3,695,400	$3,695,400
13A', Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	$3,695,800	$3,695,800
14, Constant Pool, 43-Foot Drawdown with Modified Spillway, 2 Months	$4,381,860	$4,381,860
14', Constant Pool, 43-Foot Drawdown with Modified Spillway, 4.5 Months	$4,383,550	$4,383,550
15, Constant Pool, 52-Foot Drawdown with New Spillways, 2 Months	$3,324,710	$3,324,710
15', Constant Pool, 52-Foot Drawdown with New Spillways, 4.5 Months	$3,325,990	$3,325,990
17, Same as Alternative 13, with Modified Powerhouse	$3,891,600	$3,891,600
17', Same as Alternative 13', with Modified Powerhouse	$3,893,100	$3,893,100
18, Same as Alternative 14, with Modified Powerhouse	$4,381,800	$4,381,800
18', Same as Alternative 14', with Modified Powerhouse	$4,383,550	$4,383,550
19, Same as Alternative 15, with Modified Powerhouse	$3,324,710	$3,324,710
19', Same as Alternative 15', with Modified Powerhouse	$3,325,990	$3,325,990

*Includes amortization of M&I pump modifications, plus increased operation and maintenance pumping costs for M&I and commercial irrigation.

7.06. Navigation/Transportation

a. General

Columbia River Basin economic growth is closely associated with water transportation. The 465-mile Columbia/Snake Inland waterway represents a key link to the eastern interior region by providing barge transport from the Pacific Ocean to Lewiston, Idaho (the most inland port).

The navigation channel, from the confluence of the Snake River with the Columbia to Lewiston, Idaho, is authorized to depths of 14 feet and a width of 250 feet. Historical records show continuing improvements to the water system. The Corps maintains the channels at authorized dimensions, and locks on the mainstem dams provide hydraulic lifts for barge access.

b. Navigation

Six barge companies operate approximately 40 towboats and 175 barges on the Columbia-Snake River system. Fifty-four port facilities and associated shipping operations provide transport for the various agricultural and timber products produced in the region. In addition to barging, other types of commercial transportation activities in the system include log rafting on Dworshak Reservoir, passenger and mail bo9at service on the Snake River upstream of Lewiston, and tour boat excursions from Portland to Lewiston.

c. Port Facilities

There are 20 port facilities on the lower Snake River. The geographic distribution of port facilities reflects the concentration of shipping activity on the Lower Granite pool. Grain terminals are the most common facilities, and account for nearly half of all terminals within the study area.

Port facilities at Clarkston, Washington, and Lewiston, Idaho, have histories of siltation. Siltation occurs because of the change in river flow as the Snake River enters the pool formed behind Lower Granite Dam. River current velocity decreases as it enters the pool, and drops large amounts of sediment. Maintaining water depths has been most critical on the south side of the river (at Clarkston) and, to a lesser extent, at Lewiston. Facilities on the north bank, downstream of the Clearwater/Snake confluence have reported few problems.

d. Other Transportation Modes

Other modes of transportation that exist in the region are truck and rail.

e. Impacts

Alternatives that require drawdown of the lower Snake River pools all have the same result: commercial barge transportation will cease. Although there is a limited ability to light load barges, none of the drawdown alternatives analyzed dropped water levels within the range where light-loading could occur, nor are the refill or drawdown processes slow enough to take advantage of an intermediate water level.

The only difference in the impacts of the various drawdown scenarios is the length of time that the pools are below minimum operating pool. Goods normally carried by barge would have to be either stored for the duration of the drawdown, or shipped by alternate modes of transportation. The more significant impacts are those related to the financial losses of the shipping dependent businesses.

If the Snake River pools were drawn down over an extended period, the refill of the projects during the summer and fall months could potentially affect river stages of the deep-draft channel from Portland/Vancouver to the mouth of the Columbia River. This would be a concern, particularly if refill coincided with the low point of the Snake and Columbia Rivers' natural hydrograph, generally from August into September or October. Depending upon the lower Columbia River could be impaired during refill. Again, this could represent an increase in travel time and costs.

Physical impacts to navigation and the associated facilities on the lower Snake River are substantial for the natural river alternative. In order to achieve natural river elevations, the lower Snake River dams would begin drawdown in February of each year. The locks would become unusable for commercial navigation very soon after the process began, and would not be usable until the following July. Under a 2-month drawdown alternative (including lowering the reservoir at a rate of 2 feet per day and refilling), this amounts to a 5-month lock closure on the lower Snake River. The 4½-month constant pool alternative would not have navigation back online until the following September. This amounts to a 7-month lock closure, including drawdown and refill time.

The physical impacts to navigation and associated facilities under the constant pool alternative are similar to those described for the natural river alternative. The differences among the alternatives are basically in the duration of the drawdown and the number of reservoirs involved.

The ports and facilities on the Lower Granite pool, between RM's 432 and 471, would be greatly impacted during the same timeframe. Damage to the foundations of structures along the pools is likely because of the extended loss of the normal hydraulic destabilizing effects (having the foundation soils dryout and be rehydrated on an annual basis).

Severe rains and wave action will cause the erosion of unprotected banks, which could then fail and further impact facilities.

Some facilities that depend on barges for cargo shipments of raw materials or finished products, and cannot ship by an alternate mode of transportation, will simply halt all operations.

Boat marinas may become fully, or partially, unusable. Damage to the floating docks from resting on the river bottom during low water is likely, as experienced during the 1992 test drawdown at Lower Granite.

A related transportation impact of restricting commercial barge traffic is the increased wear on the region's rail and highway infrastructure as barged commodities are shipped by truck and rail. The magnitude of the impact would be proportional to the amount of the commercial tonnage going by alternate carriers.

f. Impacts

The erosion of sediment deposits will present an uneven surface for floating docks and boats to rest on in one, or more, of the small boat basins.

A drawdown during the peak of the runoff season should remove most of the accumulated sediment adjacent to the Port of Lewiston, as well as significantly reduce the amount of sediment that would have been deposited adjacent to the Port of Clarkston. An annual drawdown to elevation 710 or below, would probably eliminate or greatly reduce navigation dredging requirements at the Port of Lewiston, as well as reduce the frequency of dredging at the Port of Clarkston.

Sediment deposition during a drawdown is unlikely to create an immediate problem for any of the ports since nearly all deposition will occur below the authorized navigation depth (elevation 719). Should limited navigation capabilities somehow be restored during future drawdowns, sediment deposition would likely interfere with navigation at the upper end of the drawdown pool (possibly at the Port of Wilma).

Port facilities and navigation channels would have to be evaluated individually for projects downstream of Lower Granite Dam. However, dredging requirements would generally be reduced for facilities in the zone that is converted to a free-flowing river by the drawdown.

It is unlikely that the reduction in navigation dredging would result in overall cost savings for the Lower Granite Project, since the eroded material would simply move downstream where it would eventually have to be dredged to maintain the hydraulic capacity of the reservoir. Dredging to maintain hydraulic capacity of the river channel between the Corps' levees would still be required in the long-term, since sediment is not moved far enough downstream to eliminate the backwater effects on the levees.

g. Change in Mode of Shipment

Any change in river conditions that affects tow speed, size, maximum vessel draft, or transit through the system locks will impact costs related to waterborne transportation on the Columbia/Snake River system. Therefore, the overall costs of transporting commodities and other products to and from the region will also be impacted. Increased transportation costs will have different effects on agricultural commodities and other shipments, depending on the costs and capacity of transportation and storage alternatives relative to the magnitude and duration of river impairment. Under the base condition, the transportation cost savings between water transportation and alternative modes (*e.g.*, savings between water transportation and alternative modes (*e.g.*, rail) are translated into the capitalized values of agricultural investments in the economic region served by the waterway.

As drawdown affects transportation, commodities may be rerouted by alternate transportation modes to river elevators located on the McNary pool, and/or railed direct to export elevators on the lower Columbia River or Puget Sound. Increased transportation costs will have different effects on agricultural commodities and other shipments, depending on the costs and capacity of transportation and storage alternatives relative to the magnitude and duration of river impairment. The impact on producers of any alternative that affects navigation will be a function of producer location, capacity and storage alternatives, and transportation costs.

A drawdown of one or more lower Snake River projects would prevent access to the locks at Ice Harbor, Lower Monumental, Little Goose, and/or Lower Granite Dams, making them unusable at certain times of the year. Drawdown actions could interrupt navigation during the spring or summer. Therefore, they could overlap with much of the current navigation activity, as 90 percent of the tonnage is shipped in the months of June, July, and August.

Normal seasonal flows of grain and other commodities would be altered if barge service were interrupted in this manner. Shippers would have to reschedule shipments, store commodities, and/or use trucks or railways to avoid major disruptions in the delivery of products to their final destinations. In addition, existing activities at affected lower Snake River ports would shift to other ports in response to the interruption of service and changes in commodity movements.

h. Transportation Model

Impacts to shallow draft commercial navigation were analyzed using a system transportation model that was developed to simulate transportation responses under varying alternatives, as well as measure the costs of commodity transportation under each scenario. The model simulated the economic impacts of impairments to navigation, and captured the changes in cost of storage, handling, or transport potentially incurred by present users of the system.

For the base condition and each alternative, the transportation model simulates the following conditions: 1) an unoptimized base case that reflects historical commodity flows under existing conditions; 2) an unconstrained drawdown, where system-wide transportation costs are computed under the assumption that handling or storage capacity is not a limiting factor; and 3) a constrained drawdown, wherein handling and/or storage capacity are limiting factors.

The unconstrained drawdown event captures the total costs of responses to drawdown (cessation of barge transport), assuming that none of the responses (alternative mode or node) are limited by capacity (transportation, handling, or storage) through the duration of the drawdown period. This applies to non-grain commodities where the volume of products shipped on the waterway is such that handling and storage would not serve as constraints during a river drawdown. The constrained drawdown is an extension of the unconstrained drawdown, which allows the model to incorporate the capacity limitations of existing transportation, storage, or handling facilities for grain. The constrained drawdown scenarios reflect the change in system transportation costs. They also affect storage capacity within the system, and would alter handling and throughput at various country and river elevators. This latter scenario reflects options that would likely be exercised given the limitations of transport, handling, or storage capabilities.

As grain or other commodity transport is impacted by drawdown, the model considers the rerouting of commodities and use of alternative transport modes (*i.e.*, truck to river elevators located on McNary pool; and/or rail direct to export elevators on the lower Columbia or at Puget Sound). A determination is thus made of the minimum cost combination for handling and transport of commodities, given the duration and magnitude of river impairments.

The model allows for shifts in transport patterns and the use of alternative modes during drawdown periods. However, it does not assume permanent changes from existing patterns. Therefore, for that portion of the year when pools are operated within their normal ranges, commodity movements would follow their normal patterns. If additional information concerning the transportation model is needed, please refer to the SOR Environmental Impact Statement.

i. Impacts

The added transportation costs and shifts from barge to truck and/or rail that are measured as direct impacts become the linkages to the indirect impact analysis. For those plans scheduled for implementation after 1995, costs have been adjusted to reflect 1995 conditions and, along with the other alternatives, are presented as average annual amounts over the period of analysis, 1995 to 2095. Average annual amounts, computed at 8.25 percent and expressed in 1992 dollars, are displayed in table 23.

Cost impacts to navigation would generally be approximately $416 million (for both the 2- and 4½-month drawdown alternatives). The reasons there is not much difference in the costs between the 2-month alternative and the 4½-month alternative may be because of truck rates. (Once the grain is placed on a truck, it is not much more expensive to truck grain to the Tri-Cities than it is to take it to Lewiston, Idaho.) This cost includes the economic impacts of impairments to navigation, as well as the changes in the cost of storage, handling, or transport that present users of the system would incur.

The Absolute Economic Costs, presented in table 17, are the total costs associated with each alternative. The Net Economic Costs, found in table 18, indicate the increase in costs over the base case. The constant pool alternatives (both the 43- and 52-foot drawdowns) were not specifically analyzed for the SCS Phase I, but would fall within this range. These same costs associated with each alternative are presented in the table below.

Comparison of Annual Shallow Draft Transportation Cost

Alternative Description	Absolute Economic Costs	Net Economic Costs (Change From the Base Case)
Base Case (No action)	$413,350,000	$0
4A, Natural River, 2 Months	$415,755,653	$2,405,653
4A', Natural River, 4.5 Months	$416,935,300	$3,585,300
5, Variable Pool with Existing Powerhouse/Existing Spillway, 2 Months	Not evaluated	Not evaluated
5', Variable Pool with Existing Powerhouse/Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
9, Variable Pool, Modified Powerhouse with Existing Spillway, 2 Months	Not evaluated	Not evaluated
9', Variable Pool, Modified Powerhouse with Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
13, Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 2 Months	$414,876,866	$1,526,866
13', Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 4.5 Months	$416,056,514	$2,706,514
13A, Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	$413,754,531	$404,531
13A', Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	$413,787,613	$437,613
14, Constant Pool, 43-Foot Drawdown with Modified Spillway, 2 Months	Not evaluated	Not evaluated
14', Constant Pool, 43-Foot Drawdown with Modified Spillway, 4.5 Months	Not evaluated	Not evaluated
15, Constant Pool, 52-Foot Drawdown with New Spillways, 2 Months	Not evaluated	Not evaluated
15', Constant Pool, 52-Foot Drawdown with New Spillways, 4.5 Months	Not evaluated	Not evaluated
17, Same as Alternative 13, with Modified Powerhouse	$414,876,866	$1,526,866
17', Same as Alternative 13', with Modified Powerhouse	$416,056,514	$2,706,514
18, Same as Alternative 14, with Modified Powerhouse	Not evaluated	Not evaluated
18', Same as Alternative 14', with Modified Powerhouse	Not evaluated	Not evaluated
19, Same as Alternative 15, with Modified Powerhouse	Not evaluated	Not evaluated
19', Same as Alternative 15', with Modified Powerhouse	Not evaluated	Not evaluated

j. Reservoir Navigation--Log Rafting Operations on Dworshak

(1) General

On the Snake River, commercial traffic uses the waterway from its confluence with the Columbia River to Lewiston, Idaho. An authorized use of the Dworshak pool is made by the logging industry, where rafts of timber cut from the North Fork of the Clearwater River drainage are towed to transfer areas near the dam. Private and recreational craft also operate throughout the system.

Logs cut along the drainage of the North Fork of the Clearwater River are hauled to a number of staging areas near the dam and, from there, hauled by truck to mills. Staging areas have been developed for use at various pool elevations so that timber drops and hauling can be maintained during periods of normal drawdown. However, at certain minimum pool elevations, this activity must be replaced by trucking when the timber has to roll too far to the pool and becomes susceptible to damage. There are no maintenance activities associated with log rafting on the Dworshak pool, although during periods of significant drawdown, the pool becomes unusable for log rafting.

(2) Impacts

Relative to the base case, all of the drawdown alternatives are beneficial to this use of Dworshak Lake. With the exception of the natural river alternatives, the longer the drawdown period, the greater the benefit to the log rafting. The use of Dworshak Lake for moving logs is economical and assists in sustaining a viable timber industry in the region. The long-term outlook for timber harvest in the region served by the log dumps is good, whether it is increased or sustained at present levels.

The alternatives include late summer drafting of Dworshak reservoir for refill of the lower Snake River dams. This drafting would leave Dworshak log dumps dry in nearly all years. Particularly dry water years cause dumps to be inoperable earlier, and they would never be usable during some years.

The Absolute Economic Costs, presented in table 17, are the total costs associated with each alternative. The Net Economic Costs, found in table 18, indicate the increase in costs over the base case. The constant pool alternatives (both the 43- and 52-foot drawdowns) were not specifically analyzed for the SCS Phase I, but would fall within this range. These same costs associated with each alternative are presented in the table below.

Dworshak Reservoir Log Trucking Annual Cost		
Alternative Description	**Absolute Economic Costs**	**Net Economic Costs (Change From the Base Case)**
Base Case (No action)	$0	$0
4A, Natural River, 2 Months	($106,093)	($106,093)
4A', Natural River, 4.5 Months	($82,044)	($82,044)
5, Variable Pool with Existing Powerhouse/Existing Spillway, 2 Months	Not evaluated	Not evaluated
5', Variable Pool with Existing Powerhouse/Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
9, Variable Pool, Modified Powerhouse with Existing Spillway, 2 Months	Not evaluated	Not evaluated
9', Variable Pool, Modified Powerhouse with Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
13, Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 2 Months	($139,000)	($139,000)
13', Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 4.5 Months	($165,000)	($165,000)
13A, Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	($139,000)	($139,000)
13A', Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	($165,000)	($165,000)
14, Constant Pool, 43-Foot Drawdown with Modified Spillway, 2 Months	Not evaluated	Not evaluated
14', Constant Pool, 43-Foot Drawdown with Modified Spillway, 4.5 Months	Not evaluated	Not evaluated
15, Constant Pool, 52-Foot Drawdown with New Spillways, 2 Months	Not evaluated	Not evaluated
15', Constant Pool, 52-Foot Drawdown with New Spillways, 4.5 Months	Not evaluated	Not evaluated
17, Same as Alternative 13, with Modified Powerhouse	($139,000)	($139,000)
17', Same as Alternative 13', with Modified Powerhouse	($165,000)	($165,000)
18, Same as Alternative 14, with Modified Powerhouse	Not evaluated	Not evaluated
18', Same as Alternative 14', with Modified Powerhouse	Not evaluated	Not evaluated
19, Same as Alternative 15, with Modified Powerhouse	Not evaluated	Not evaluated
19', Same as Alternative 15', with Modified Powerhouse	Not evaluated	Not evaluated

7.07. Hydropower

a. General

The Columbia and Snake Rivers are heavily developed for hydroelectric power generation, and are currently supplying approximately 76 percent of the electricity in the Northwest. The remainder of the region's electricity comes from thermal resources, including nuclear, gas-fired, and coal-fired plants.

Federal and non-Federal dams comprise this highly coordinated hydropower system. These economical power resources serve residential, commercial, agricultural, and industrial loads. The hydropower system currently provides many products, including firm and non-firm energy, capacity (both peak and sustained), and daily load-following capacity, system reliability, and other attributes that contribute to the efficiency of the regional power system.

b. Drawdown Impacts and Hydropower Losses

Drawdown of the lower Snake River reservoirs to natural river levels would eliminate hydroelectric generation at the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite hydropower plants.

The impact for each drawdown alternative is based on information from SOR studies. Alternatives are compared in terms of their effects on average annual generation, measured in average megawatts (aMW) and their effects on the cost of satisfying the region's energy demands. All alternatives are compared to the without-project condition in terms of reduced average annual generation.

Alternative A4, the natural river option, would have the greatest negative effect on generation, reducing average annual generation by 678 aMW for a 2-month drawdown. A 4½-month drawdown would reduce average annual generation by 828 aMW.

Alternative 13 (constant pool, 33-foot drawdown) would reduce average annual generation by 277 aMW for a drawdown duration of 2 months. Data for a 4.5-month drawdown is unavailable.

Intermediate drawdowns of 43 feet and 52 feet, of a 2-month duration, would reduce average annual generation by 330 aMW and 378 aMW, respectively.

c. Economic Analysis of Generation Losses

There are several options for replacing or offsetting hydropower losses, and all have their own economic and environmental consequences. In some cases, increase generation efficiency at existing facilities, or increased energy conservation, can offset hydropower generating losses. Alternatively, other resource types (*i.e.*, cogeneration, wind, solar or nuclear power) can be used to replace hydropower losses. However, specifying exactly how losses will be replaced is not within the scope of the SCS Phase I.

The approach and methodology used to measure and compare the economic impact to power resulting from the drawdown alternatives is based on work performed for the SOR. The analysis of hydrosystem power generation and total regional system power costs are described in the *Preliminary Draft Environmental Impact Statement (PDEIS)*, Draft #2, dated December 1993. The methodology employed, and the results for drawdown of 33 feet and a near natural river condition, are presented in appendix I and appendix O of the PDEIS.

The analysis presented in appendix I of the PDEIS has three major purposes: 1) to determine the effects of each alternative on power generation from Northwest regional hydro/thermal system; 2) given these effects, to determine what, if any, actions would be required to meet forecasted regional energy consumption; and 3) to estimate the cost for serving the forecasted regional energy demand. The analysis was based on the regional electrical energy load forecast for the 1993 to 1994 operating year. The analysis estimated both the capacity and energy (system generation) costs for meeting regional load while operating the hydrosystem under each alternative.

The analysis presented in appendix I of the PDEIS is based on costs associated with an assumption that losses in hydrosystem generation for each alternative would be replaced in total, without regard to the effect that higher cost replacement power would have on the demand for power. Appendix O of the PDEIS expands the analysis to determine how BPA's rates paid by consumers would change given each of the alternatives. The estimated rates were then used to recompute electrical demand. Using the recomputed demand, net system generation and capacity, costs were computed using the same methodology that was used to calculate gross system generation and capacity costs. The only difference between gross and net is that the regional load forecast for 1993 and 1994 is reduced to reflect the effects of rate increases.

The SOR studies analyzed two resource acquisition philosophies to determine the net system costs associated with each alternative. In the combustion turbine case, a resource with characteristics similar to a combustion turbine is acquired to meet load in months where there is a deficit. The important characteristics of this resource are that it has a low fixed cost, with a higher variable operating cost. In the purchase case, no resources are acquired. All deficits are covered by purchasing energy on the short-term sport market. Short-term purchases cannot be guaranteed, and it is possible that energy would not be available on the market at any price. Nonetheless, the risk of not being able to make sufficient purchases on the spot market is not so great as to be unacceptable.

The SOR studies calculated the cost of each alternative for both the combustion turbine and the purchase case. The purchase case represents the low end of power system costs that could result from the adoption of these alternatives, whereas the costs from the combustion turbine case are likely to be on the high end of power costs that could result. Thus, these two options provide a range of costs and system reliability.

d. Costs

Combustion turbine resources are assumed to be the most likely strategy to replace lost hydropower generation. Therefore, only net system generation costs for the combustion turbine case are presented in this SCS Phase I report.

The SOR studies identified equivalent annual net system generation costs for the following:

Equivalent Annual Net Costs*
Combustion Turbine Resources
($,000,000)

SOR Number	Alternative Description	SCS No.	Cost
SOS2c	Without Project Condition		$996
SOS5a	Natural River, 2 Months	4a	$1,344
SOS5b	Natural River, 4.5 Months	4a	$1,395
SOS6a	Constant Pool, 33-Foot Drawdown, Four Reservoirs, 2 Months	13	$1,199
SOS6b	Constant Pool, 33-Foot Drawdown, Four Reservoirs, 4.5 Months	13	$1,198
SOS6c	Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	n/a	$1,111
SOS6d	Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	n/a	$1,121

*Net costs include adjustments made for increased consumer rates and subsequent reduced system demand. Costs are discounted and levelized to account for differences in implementation timing of the alternatives.

Other constant pool drawdown alternative costs were calculated by interpolation between the 33-foot drawdown and the near natural river drawdown. The hydropower cost of the variable pool alternatives were not evaluated. The change in system power costs (net economic costs) associated with each alternative are presented in the table below, and are shown on table 18. Equivalent annual net generation costs developed in the SOR studies are shown as Absolute Economic Costs.

Comparison of Annual Power System Generation Cost		
Alternative Description	**Absolute Economic Costs**	**Net Economic Costs (Change From the Base Case)**
Base Case (No action)	$996,000,000	$0
4A, Natural River, 2 Months	$1,394,000,000	$398,000,000
4A', Natural River, 4.5 Months	$1,395,000,000	$399,000,000
5, Variable Pool with Existing Powerhouse/Existing Spillway, 2 Months	Not evaluated	Not evaluated
5', Variable Pool with Existing Powerhouse/Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
9, Variable Pool, Modified Powerhouse with Existing Spillway, 2 Months	Not evaluated	Not evaluated
9', Variable Pool, Modified Powerhouse with Existing Spillway, 4.5 Months	Not evaluated	Not evaluated
13, Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 2 Months	$1,199,000,000	$203,000,000
13', Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 4.5 Months	$1,198,000,000	$202,000,000
13A, Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	$1,111,000,000	$115,000,000
13A', Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	$1,121,000,000	$125,000,000
14, Constant Pool, 43-Foot Drawdown with Modified Spillway, 2 Months	$1,181,990,220	$185,950,220
14', Constant Pool, 43-Foot Drawdown with Modified Spillway, 4.5 Months	$1,180,964,440	$184,964,440
15, Constant Pool, 52-Foot Drawdown with New Spillways, 2 Months	$1,075,192,470	$79,192,470
15', Constant Pool, 52-Foot Drawdown with New Spillways, 4.5 Months	$1,084,487,170	$88,870,170
17, Same as Alternative 13, with Modified Powerhouse	Not evaluated	Not evaluated
17', Same as Alternative 13', with Modified Powerhouse	Not evaluated	Not evaluated
18, Same as Alternative 14, with Modified Powerhouse	Not evaluated	Not evaluated
18', Same as Alternative 14', with Modified Powerhouse	Not evaluated	Not evaluated
19, Same as Alternative 15, with Modified Powerhouse	Not evaluated	Not evaluated
19', Same as Alternative 15', with Modified Powerhouse	Not evaluated	Not evaluated

7.08. Construction Activities

Some of the alternatives include construction activities to modify projects and/or mitigate for the effects of the operations strategies on the direct river users. Construction activities may include the modification of irrigation pumping stations, additions to on-farm grain storage, improvements to boat ramps and moorages, dam modifications, and the development of new power stations. Expenditures for the construction activities will generate positive short-term indirect impacts on the regional economy. These effects are differentiated from the secondary linkages to the direct economic impacts in that they can be expected to last only through the duration of the construction activity, perhaps a few months to a few years. The indirect effects associated with the alternatives will continue throughout the length of the direct impact, in many cases reflecting permanent changes in regional economic activity. See section 10 for analysis that has been identified for future considerations.

7.09. Cultural Resources

Although an analysis of cultural resources was not intended to be placed in this section, it could be argued that the costs associated with the destruction of such resources should be measured by the same measurement used for anadromous fish (*e.g.*, an important resource, the loss of which cannot be measured in dollar terms.)

a. Mitigation

The proposed drawdown of the lower Snake River projects will have negative impacts on significant or potentially significant cultural resources located in the drawdown zone and along the shoreline of each reservoir. The most critical impact zone is the area subjected to shoreline fluctuation of the water level and wet/dry cycling. The most complete destruction can be expected here, where the mechanical forces of wave action and nearshore currents can drastically alter shoreline topography and any cultural resources occurring on that topography.

Research and experience during the 1992 drawdown test demonstrated that the problem of human vandalism is extremely severe in this expanded fluctuation zone, which normally would be inundated below minimum operating pool.

b. Mitigation Alternatives

Various options are available in terms of managing cultural resources threatened by reservoir drawdown. These options range from complete archaeological excavation to site protection and preservation.

Site burial or covering is one of several alternatives that might be employed in the protection of cultural resources.

The fencing of archaeological sites is effective in deterring access, as well as in restricting and routing movement around sites open to the public view.

A combination of law enforcement and education may hold the greatest possibility for the future curtailment of vandalism. An intensive education program about vandalism that stresses cultural value and uses various media as well as professional archaeologists and historians, may help to involve the public in preservation and protection programs.

c. Costs

Historically, the mitigation process for prehistoric and historic cultural resources has been equated with excavation or avoidance. However, archaeological site stabilization and preservation is being investigated as a means of protecting cultural resource sites.

Cultural resources (archaeological site) mitigation measures for the proposed drawdown alternatives can potentially be treated in three different ways: 1) testing or data recovery excavations; 2) complete avoidance of the site by project-generated activities; and 3) *in situ* preservation of the site, using some form of protection method. Each site is a unique entity in terms of size, content, and complexity.

d. Protection-In-Place Cost Estimates

None of the protection methods considered guarantee that the site will be protected for an indefinite period. Site protection, even on a short-term basis, may also require a combination of techniques. None of the protection methods, other than complete site burial, are adequate to protect significant or potentially significant cultural deposits in the drawdown zone. Even complete site burial as a protective measure remains an uncertain alternative.

Protection-in-place for known sites at the lower Snake River projects could range from a total of $273 million to $328 million should the reservoirs be lowered to the near natural river condition. This range is based on the lowest cost method for each site, and the highest cost method at each site.

Testing and Data Cost Recovery Excavations
Estimated Total Costs
(1992 Price Level)

Drawdown to Near Natural River Condition	
Ice Harbor/Lower Monumental (57 sites)	
Testing	$3,200,000
Data Recovery	61,900,000
Lower Granite/Little Goose (88 sites)	
Testing	$2,700,000
Data Recovery	42,900,000
Total	**$110,700,000**
Drawdown to Constant and Variable Pool Elevations	
Ice Harbor/Lower Monumental (47 sites)	
Testing	$2,200,000
Data Recovery	41,700,000
Lower Granite/Little Goose (62 sites)	
Testing	$1,600,000
Data Recovery	36,700,000
Total	**$82,200,000**

Protection-In-Place Estimated Total Costs (1992 Price Level)	
Drawdown to Near Natural River Condition	
Ice Harbor/Lower Monumental (57 sites)	
Testing	$3,200,000
Data Recovery	126,700,000
Lower Granite/Little Goose (88 sites)	
Testing	$2,700,000
Data Recovery	201,400,000
Total	**$334,000,000**
Drawdown to Constant and Variable Pool Elevations	
Ice Harbor/Lower Monumental (47 sites)	
Testing	$2,200,000
Data Recovery	87,500,000
Lower Granite/Little Goose (62 sites)	
Testing	$1,600,000
Data Recovery	96,000,000
Total	**$187,300,000**

7.10. Overall Effects of Alternatives

An economic analysis for each of the drawdown alternatives was completed for the SOR. The analysis examined both a 2- and a 4½-month drawdown period for each of the alternatives. The net economic annual costs of the drawdown alternatives range from $140 to $956 million. The following table is a summary of incremental economic costs by alternative. The incremental costs (net economic cost) is the additional cost of the drawdown alternative as compared to existing conditions (base case). The base case reflects the current operation of the Snake River with the interim flow improvement measures made in response to the ESA listing of Snake River salmon.

These costs include an analysis of each alternative by recreation, flood control, net farm income, increased M&I water use, shallow draft transportation, Dworshak log-trucking transportation, and system generation.

These costs do not include the entire costs associated with alternatives 5, 9, 14, 15, 18, and 19, since the above economic category analysis was not conducted. Additionally, no attempt was made to place monetary values on the endangered anadromous fish or their habitat. Mitigation costs for recreation and cultural resources also must be examined in the overall evaluation of the true cost of an alternative. The mitigation costs presented in this report are offered for consideration, and to show the possible scope of mitigation required. These subject areas all warrant additional detailed study.

The analysis did not take into account the different implementation dates of the various alternatives. Therefore, although the benefits and costs were amortized (using 8.25 and 8.0 percent, respectively) over 100 years, the values were not brought back to present value. These undiscounted values include all lower Snake River projects, as well as John Day to MOP.

Comparison of Total Annual Economic Cost*

Alternative Description	Net Economic Costs (Change From the Base Case)
Base Case (No action)	$0
4A, Natural River, 2 Months	$949,038,048*
4A', Natural River, 4.5 Months	$956,387,609
5, Variable Pool with Existing Powerhouse/Existing Spillway, 2 Months	[1]
5', Variable Pool with Existing Powerhouse/Existing Spillway, 4.5 Months	[1]
9, Variable Pool, Modified Powerhouse with Existing Spillway, 2 Months	[1]
9', Variable Pool, Modified Powerhouse with Existing Spillway, 4.5 Months	[1]
13, Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 2 Months	$356,116,566
13', Constant Pool, 33-Foot Drawdown, 4 Reservoirs, 4.5 Months	$360,347,712
13A, Constant Pool, 33-Foot Drawdown, Lower Granite Only, 2 Months	$140,298,975
13A', Constant Pool, 33-Foot Drawdown, Lower Granite Only, 4.5 Months	$152,625,957
14, Constant Pool, 43-Foot Drawdown with Modified Spillway, 2 Months	[2]
14', Constant Pool, 43-Foot Drawdown with Modified Spillway, 4.5 Months	[2]
15, Constant Pool, 52-Foot Drawdown with New Spillways, 2 Months	[2]
15', Constant Pool, 52-Foot Drawdown with New Spillways, 4.5 Months	[2]
17, Same as Alternative 13, with Modified Powerhouse	[3]
17', Same as Alternative 13', with Modified Powerhouse	[3]
18, Same as Alternative 14, with Modified Powerhouse	[4]
18', Same as Alternative 14', with Modified Powerhouse	[4]
19, Same as Alternative 15, with Modified Powerhouse	[4]
19', Same as Alternative 15', with Modified Powerhouse	[4]

[1] Costs were not analyzed for recreation flood damages, net farm income, increased M&I water cost, shallow draft transportation, Dworshak log-trucking, or the system generation. Therefore, net total economic cost is unavailable.

[2] Costs were not analyzed for recreation, flood damages, shallow draft transportation, or Dworshak log trucking. Therefore, net total economic cost is unavailable.

[3] Costs were not analyzed for system generation. Therefore, net total economic cost is unavailable.

[4] Costs were not analyzed for recreation, flood damages, shallow draft transportation, Dworshak log trucking, or system generation. Therefore, net total economic cost is unavailable.

*Undiscounted.

Section 8 - Mitigation Opportunities

8.01. General

All reservoir drawdown alternatives will impact natural resources, cultural resources, and commerce. Mitigation measures described in this section identify measures to mitigate navigation, hydropower, irrigation, recreation, and cultural resource impacts associated with reservoir drawdown alternatives. Where it is not possible to develop impacts and/or mitigation measures, they will e identified as future study requirements. It is not the intent of this report to provide an in-depth impact assessment of each drawdown alternative.

a. The NPPC

The NPPC, in amendments to the Columbia River Basin Fish and Wildlife Program (Phase II), calls for development of a mitigation plan consisting of measures to mitigate the impact of the reservoir drawdown strategy to the greatest extent practicable.

b. The U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service prepared a draft Fish and Wildlife Planning Aid Report for the Columbia River Salmon Mitigation Analysis System Configuration Study, dated May 1993. The U.S. Fish and Wildlife Service identified a wide variety of mitigation and enhancement opportunities for further study. Drawdown impacts to native fish and wildlife populations and their habitat, as well as to existing wildlife mitigation sites, would require mitigation. Fish and wildlife impacts and mitigation measures are not addressed in this report section.

However, mitigation measures to maintain irrigation of Habitat Management Units (HMU's) are presented in this section.

8.02. Impacts of Reservoir Drawdowns

The SCS Phase I utilized the extensive analysis of impacts that was the result of the SOR. The analysis will be refined in SCS Phase II.

a. Navigation

Without physical modification to existing navigation locks, river channels below each lock and dam, modification to existing port facilities, and the creation of a fleet of small barges, all navigation on the Snake River would cease.

b. Hydropower

Reservoir drawdowns at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Locks and Dams would reduce the power output of each powerhouse. Turbines would operate at less than optimum efficiency at this reduced head, and further impact hydroelectric production.

c. Irrigation

Anderson Perry and Associates, Inc., under contract to the Corps, investigated the impact to pumping facilities of lowering the pools behind the four dams on the lower Snake River. The impacts of two specific drawdown conditions were evaluated in this investigation: 1) a drawdown of spillway elevations at each of the dams; and 2) the run-of-river condition that would draw the water level down to a near natural elevation of the river without any dams.

Each dam on the lower Snake River is operated to allow a fluctuation of only 3 to 5 feet in water surface elevation. The existing pumping facilities along this section of the river are designed to operate within this relatively constant water surface elevation, and will not operate below these levels.

The investigation revealed 31 active water users along this nearly 150-mile section of the lower Snake River: 16 on the Ice Harbor pool, 2 on Lower Monumental, 2 on Little Goose, and 11 on Lower Granite. The maximum capacity of all of these pumping stations together is approximately 750 cfs. Of this total, approximately 645 cfs is for agricultural irrigation, 10 cfs is for wildlife areas, 5 cfs is for recreational areas, and 90 cfs is for municipal and industrial uses.

Approximately 7,750 acres of land are designated as HMU's on the Snake River. These HMU's were developed as part of the mitigation measures for the Snake River dams. They range in size from ¼-acreislands to 832 acres at the Big Flat HMU. Most units are managed as dryland, but 764 acres are under irrigation and are intensely managed to provide a diversity of wildlife habitats. Irrigation is provided by surface pumps (Snake River) or by wells. Surface pumps would be directly affected by a drawdown of the Snake River.

Wells used for irrigation are typically installed in gravel benches along the river. The rate of withdrawal, depth of the well, proximity to the river, and duration of drawdown would affect the output of these wells. An analysis of this potential impact is beyond the scope of this reconnaissance study.

Acquisition and development of additional HMU's under the Lower Snake River Fish and Wildlife Compensation Plan is progressing. Development will include additional irrigation facilities not presently installed. Anticipated irrigation developments potentially affected include 164 additional acres at Central Ferry HU, and 162 additional acres potentially irrigated by well at Heneley HMU.

d. Recreation

Proposed reservoir drawdowns can be divided into the following three categories: 1) near natural river conditions; 2) variable pool; and 3) constant pool.

The near natural river condition would produce the most extreme impact to recreation activities. At low river flows, the drawdown would be about 115 feet at Lower Granite Dam, 114 feet at Little Goose Dam, 108 feet at Lower Monumental Dam, and about 97 feet at Ice Harbor Dam.

A variable pool is the most uncertain condition, because water surface levels would vary from 28 to 57 feet below normal full pool levels. Water surfaces would rise and fall between the following elevations:

Variable Drawdown Lake Elevations

Lake	Variance Elevation
Lake Sacajawea (maximum elevation 440)	410 to 391
Lake Herbert G. West (maximum elevation 540)	503 to 483
Lake Bryan (maximum elevation 638)	601 to 581
Lower Granite Lake (maximum elevation 738)	701 to 681

Recreation sites near the upper end of each lake would experience free-flowing river conditions at all times during a variable pool drawdown. Sites affected by the variable pool elevation range would experience free-flowing river conditions at 57 feet below normal pool to semi-slackwater conditions at 28 feet below normal pool.

Constant pool alternatives are: 1) a 33-foot drawdown; 2) a 43-foot drawdown; and 3) a 52-foot drawdown from maximum pool levels. All recreation sites located in the upper reaches of each lake, above the following elevations, would have free-flowing river conditions. The following is a list of water surfaces at each lake under the various drawdown conditions:

Constant Drawdown Lake Elevations

Lake	33 Feet	43 Feet	52 Feet
Lake Sacajawea	415	405	396
Lake Herbert G. West	507	497	488
Lake Bryan	605	595	586
Lower Granite Lake	705	695	686

Any drawdown of Snake River reservoirs below minimum operating pool would impact all recreation facilities. Drawdown below minimum operating pool would eliminate the use of existing boat ramps, boat docks and mooring facilities, and swimming beaches. A reservoir drawdown would not directly affect day-use at the parks, but the quality of experience would definitely change as the lowering water exposes mud flats, stumps, and debris. It is generally assumed that the use of park facilities without access to the water would diminish below historic visitation levels. The most dramatic lessening of use would be at Chief Timothy State Park (Lower Granite Lake), where the island would no longer be an island and would be surrounded by mud flats.

All moored boats at marinas would either be removed from the water or relocated to other marinas (Lake Wallula) during each annual drawdown. If a drawdown became an annual occurrence, operation of existing marinas may cease because of the desire to moor boats year-round. The steamboat "Jean," near Hells Gate State Park, would be moved into the river channel or shored in place. Also, the City of Lewiston fireboat moored at the O&M ramp at Clarkston, Washington, would have to be relocated.

The impact to recreation is directly related to the numbers of visitors that frequent and use the parks and boat ramps. The analysis evaluated expected visitation levels for a number of operation alternatives. These studies compare expected visitation for Snake River drawdown alternatives to visitation experienced during system operations as they existed from 1983 through the 1990 to 1991 operating year, prior to management actions undertaken in response to ESA listings. The recreational impacts of alternatives compared against historic visitation (August 1987 to 1991), by project, are summarized below. The data suggests that overall visitation on the Snake River recreation sites will be less than half of historic visitation.

Percent Change in Total Visitation
(Greater Than or Equal To)

	Ice Harbor	**Lower Monumental**	**Little Goose**	**Lower Granite**
Natural River Option				
2 Month	-25 to -50%	-25 to -50%	-50%	-25 to -50%
4.5 Month	-50%	-50%	-50%	-25 to -50%
Fixed Drawdown				
2 Month	-25 to -50%	-25 to -50%	-50%	-25 to -50%
4.5 Month	-50%	-50%	-50%	-25 to -50%

e. Cultural Resources

The proposed drawdown of the lower Snake River projects will have negative impacts on significant or potentially significant cultural resources located in the drawdown zone and along the shoreline of each reservoir. The most critical impact zone is the area subjected to shoreline fluctuation of the water level and wet/dry cycling. The most complete destruction can be expected here where the mechanical forces of wave action and nearshore currents can drastically alter shoreline topography and any cultural resources occurring on that topography.

Research and experience during the 1992 Drawdown Test demonstrated that the problem of human vandalism is extremely severe in this expanded fluctuation zone, which normally would be inundated below minimum operating pool.

The National Reservoir Inundation Study defined several inundation-related processes that affect the preservation of cultural resources in reservoirs and waterways. The three broad categories of impact are mechanical, biochemical, and human and other processes. Mechanical processes include the physical erosion and deposition processes associated with large bodies of water such as wave and water motion, siltation, and saturation and slumping of shoreline and submerged geological deposits. Biochemical processes include the chemical and biological environment associated with a reservoir and its effect on the differential preservation and destruction of cultural materials in sites. The final category, human and other processes, includes the various consequences of human activities.

Most all categories of cultural resource impacts are magnified within the shoreline fluctuation zone. In this zone, wave action poses the most serious threat. A reservoir drawdown will enlarge the area of destructive wave action by increasing the fluctuation zone of the reservoir. During pool level drawdowns, waves will strike the saturated and unconsolidated sediments in the basin already denuded of protective vegetation, thereby disrupting archaeological sites. Frequent wetting and drying episodes of cultural deposits during drawdowns also pose a negative impact to sites in the reservoir fluctuation zone.

Another mechanical impact that needs consideration is the wind. Sandy or unconsolidated cultural deposits exposed in sand dunes or in the drawdown zone can be severely disturbed, and the contextual relationships of artifacts and features can be destroyed.

Shorelines of reservoirs are subject to greater human impacts than any other reservoir zone. Recreational activities are concentrated along the shoreline, increasing the access to sites. This, in turn, may lead to both intentional and unintentional vandalism. Vandalism to cultural resource properties has a long history of occurrence, and continues to be a major cause of the loss of information concerning our heritage. Based on observations during the 1992 Drawdown Test, vandalism would be common in all of the concerned projects. The lack of vegetation along the periodically exposed shoreline will make cultural resources more visible and susceptible to human impact. Reservoir drawdown and subsequent erosion of the fluctuation zone will provide opportunity for all forms of vandalism.

8.03. Navigation Mitigation Measures

The movement of barges is an either/or situation: either water elevations are high enough for barge traffic or there is not sufficient water depth over the navigation lock sills to float barges. Also, during any drawdown, river channels downstream of each lock and dam would be at or near natural river conditions, with shallow depths and high flows. These conditions would prevent safe and effective navigation.

Limited opportunities exist for mitigating the physical effects of a drawdown on navigation. Locks and dams, as well as river channels below each dam, could be modified only at great cost to allow the movement of barges. However, the near natural river conditions throughout the upper reaches of each reservoir preclude using barges of the size and dimension of those that comprise the present fleet. A second fleet of smaller barges could be created and maintained for use during drawdown periods, and the modification of existing port facilities would also be necessary.

Based on the magnitude of physical modifications required to mitigate the impact to navigation, as well as the potential for a second fleet of smaller barges, physical modifications necessary to maintain barge traffic during reservoir drawdowns are not considered. It is assumed that commodities would be shipped by an alternate method (*i.e.*, truck, rail, or no shipping at all) during reservoir drawdowns. The option of no shipments at all assumes that barge shipments would be seasonal. Commodities would be stored during reservoir drawdowns, and shipped only when reservoirs are returned to normal operating levels. The costs of alternative modes of transportation are summarized in the economic appendix of this report.

8.04. Hydropower Mitigation Measures

There are several options for replacing or offsetting hydropower losses, and all have their own economic and environmental consequences. Physical modifications to turbines and generators to improve efficiency and output are under consideration. Such modifications will not mitigate the loss. Rather, they will only reduce hydropower generation losses.

To identify hydropower losses, two resource acquisition philosophies were used to analyze the cost of alternatives. The first is the combustion turbine case, a resource with characteristics similar to a combustion turbine. It would be acquired to meet electrical loads in months when system hydropower generation is decreased. This type of resource has low fixe cost, but a higher variable operating cost.

The second case is described as purchases. This case assumes that no resources are acquired. All system generating deficits are covered by purchasing energy on the short-term spot market.

Specifying exactly how hydropower losses will be replace was not addressed, and does not fall within the scope of this Phase I report. The magnitude of costs, reflected in the combustion turbine case, to mitigate for lost hydropower generation are presented in the economics sections of this report.

8.05. Irrigation Mitigation Measures

a. General

Parts of this section are a summary of the report and analysis conducted by Anderson Perry and Associates, dated 1991.

Pumping facilities serve agriculture, wildlife areas, recreational areas, and municipal and industrial uses. The inventory compiled by Anderson Perry and Associates is extensive, but it is possible that one or more users may not be represented. The inventory will need to be verified for the Phase II study.

Each dam is operated to allow a fluctuation of only 3 to 5 feet in water surface elevation. The majority of pumps are the vertical turbine type, designed to operate within this relatively constant water surface elevation, and will not operate with any significant drawdown below these levels. Each analysis assumes that each pumping station will remain in service, and each station must be modified to allow it to provide the same quantity of water it now provides. Twenty-nine of the thirty-one stations identified will require some revisions to allow them to operate under the proposed drawdown alternatives.

The impact of a reservoir drawdown on each pumping facility is dependent on the distance from each dam (the lower, deeper end of the reservoir or the upper, shallower end), the profile (pumping head) from pump to river, and the configuration of the river bank. Most pumping plants located along each reservoir will be heavily impacted by any drawdown.

As an example, impacts to the 11 pumping stations located on the Lower Granite pool vary greatly depending on reservoir location. Impacts vary from no impact to 108 feet of added pumping head for the near natural run-of-river alternative. Conversely, none of the stations located along the Ice Harbor, Little Goose, and Lower Monumental pools can function under any drawdown alternative without some revisions.

b. Existing Pumping Station Types

There is little variation in the type of pumping station used on the lower Snake River. A typical station is constructed over the water, either along the undisturbed shoreline or in an excavated or natural inlet. A location away from the natural shore makes the station more accessible for maintenance, and makes it less visible to river users. The typical station has a reinforced concrete platform supported by piling, a metal framework, and concrete walls or sheet piling. The pumps are suspended from the platform, with the motors above the platform for easy access.

Electrical panels and controls are typically installed on, or in, structures located on the shore near the platform.

Each pumping station typically has one pump platform that supports all of the pumps needed to supply the required flow quantity. Smaller pump stations may have one or two pumps, while larger stations may have ten or more. Pump sizes vary from 10 horsepower to over 1,000 horsepower each.

Below the platform is a pumping gallery into which the vertical turbine pumps are suspended. Most of these pumps are multi-staged to achieve the required pumping head. The required pumping head varies from 40 feet to over 550 feet. Most stations are lifting 300 to 400 feet.

The intake of each pump must be carefully screened to prevent debris from entering and damaging the pump. Debris is also unacceptable in the water being pumped, as it will foul the irrigation facilities where most of the water is delivered. In addition to the needs of the irrigator, screening is also a requirement of both state and Federal governments as part of their efforts to protect fish populations. The method of screening varies in design due to the approach of the station designer and the specific needs of the site.

For the purpose of this study, it is assumed that all pumps stations are the vertical turbine platform stations described above. This assumption is reasonable because the data collected by Anderson Perry and Associates shows that only two of the smaller stations vary from this design.

c. Standard Pumping Station Modifications

Key factors in the design of the pumping station modifications are the type of existing station, the vertical drawdown to be overcome, and the horizontal distance between the existing station and the lowered water surface. Standard modifications considered include deepening the existing pumping station, extending the existing pump platform, installing slant turbine pumps, and installing low-head submersible pumps. The predominant modification recommended is to install low-head submersible pumps. The second most recommended modification is deepening the existing pumping stations.

(1) Submersible Pumps

Most pumping stations are at locations where there would be more than 75 feet between the existing station and the edge of the water for all drawdown alternatives. Because submersible pumps are applicable for most pumping stations, this is the primary option used in determining the cost of pumping plant mitigation measures.

Submersible pumps would lift water from the lowered pool level to the existing pumping station. Wedge-wire fish screens would be installed on each new submersible pump intake. Pumps and screens would be installed on the reservoir bottom approximately 10 feet below the lowest pool level. Pumps would be manifolded into a single-force main that would discharge into the exiting station (modified to receive the water). An enlarged pump gallery to receive water from the force main, with gates to allow operation during normal water levels, is considered the most feasible option. A predesign study considering other modification possibilities for each pumping station would be appropriate prior to actual modification.

(2) Deepen Existing Pumping Stations

The second most common standard option used in this study is to deepen the existing pumping stations. This method may be possible if only a small reduction in pool level is experienced at the station and if the station is pile- or sheetpile-supported. Pumping stations can be deepened by excavation under the station, or a new deeper pumping platform may be constructed adjacent to the existing station with a trench excavated between the two platforms.

d. Drawdown Elevations

Drawdown alternatives can be divided into three groups: 1) constant pool; 2) variable pool; and 3) natural river. Anderson Perry and Associates conducted their analysis of pumping facilities along the Snake River for a drawdown to spillway crest (constant pool option) and for a run-of-river condition (natural river option) at each reservoir. Other drawdown options that fall between spillway crest and natural river were, in this study, evaluated based on their relative difference from spillway crest. Those differences are indicated in the following:

Reservoir Drawdown Elevations						
Project Max/Min Pool	**Spillway Crest**	**33-Foot Drawdown**	**43-Foot Drawdown**	**52-Foot Drawdown**	**28- to 57-Foot Drawdown**	**Natural River at Dam**
Ice Harbor						
440/437 Feet from Crest	391.0	415 +24	405 +14	396 +5	410 to 391 +19/0	339
Lower Monumental						
540/537 Feet from Crest	483.0	507 +24	497 +14	488 +5	503 to 483 +20/0	429
Little Goose						
638/633 Feet from Crest	581.0	605 +24	595 +14	586 +5	601 to 581 +20/0	518
Lower Granite						
738/733 Feet from Crest	681.0	705 +24	695 +14	686 +5	701 to 681 +20/0	618

g. Costs

Estimated construction costs are based on a general application of unit designs to site conditions developed from available records and maps. Costs are considered to be reconnaissance-level preliminary estimates.

Typical construction at existing pumping stations would include new fish screens, new submersible pump(s), power cable, force main, and modification of the existing station to receive water from the new pump(s). The above construction items would be the same for any constant pool drawdown except for the length of power cable and force main. The cost difference between each constant and variable pool drawdown is based on the elevation differences and the estimated variations in shoreline conditions.

The high volume pumps used by the Snake River pumping stations are typically designed to operate within a narrow range of pumping head. It is very difficult to have a single pump operating efficiently at heads that would vary by 28 feet, as called for by alternatives 5 and 9. This is particularly true of the submersible pumps that would be the same for any constant pool drawdown except for the length of power cable and force main. The cost difference between each constant and variable pool drawdown is based on the elevation differences and the estimated variations in shoreline conditions.

The high volume pumps used by the Snake River pumping stations are typically designed to operate within a narrow range of pumping head. It is very difficult to have a single pump operating efficiently at heads that would vary by 28 feet, as called for by alternatives 5 and 9. This is particularly true of the submersible pumps that would supply the existing stations. The use of variable speed drive controls may be able to effectively meet this need. The additional cost difference between the 52-foot drawdown and the variable pool drawdown reflects the cost of providing variable speed controls for pumps to function throughout the head range. It is assumed that variable speed drive controls would be able to effectively meet the pumping needs for the 28- to 52-foot variable head range. A unit cost of variable controls, based on horsepower, was provided by equipment suppliers.

The cost estimates assume that construction would occur when the pools are filled with water. Drawdowns for construction could create a window of opportunity for lower construction costs, providing that the window occurs during good weather and is of sufficient time for construction activities to be completed.

The cost to maintain existing irrigation pumping stations along the lower Snake River is tabulated in the following:

Summary of Irrigation Pump Modification Construction Costs
1 October 1992 Price Levels

Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Totals
Alternative 13/17: 33-Foot Drawdown				
$23,217,000	$627,000	$498,000	$5,220,000	$29,562,000
Alternative 15/18: 43-Foot Drawdown				
$23,668,000	$617,000	$505,000	$5,367,000	$30,211,000
Alternative 16/19: 52-Foot Drawdown				
$24,069,000	$707,000	$511,000	$5,501,000	$30,788,000
Alternative 5/9: 28- to 57-Foot Drawdown				
$26,209,000	$751,000	$535,000	$5,590,000	$33,085,000
Near Natural River Condition				
$29,259,000	$838,000	$693,000	$6,982,000	$37,772,000

h. Implementation

The schedule for implementing pumping station modifications assumes that resources are available. Considering that other major construction will be necessary to implement a drawdown, it is assumed that resources would be mobilized within the region to accomplish all work under consideration. Also, it is assumed that pump modifications would be done prior to the initiation of permanent drawdowns.

The estimated schedule for modification of pumping facilities is from 2 to 4 years. This schedule includes preliminary engineering, permits, design, advertisement and award, lead time for manufacture and delivery of equipment, and construction and installation. Therefore, the design and permitting process would begin 2 to 4 years prior to the completion of dam modifications.

i. Operation and Maintenance

Modification to the existing pumping stations on the lower Snake River will involve either the addition of pumps or the conversion of existing pumps to operate at higher heads. The resulting added pumping horsepower will increase the cost of power to the water user. It will also add equipment to the facilities that will require additional maintenance.

Power (pumping cost) is not included in the analysis presented here. The SOR studies have identified pumping costs, and include the incremental labor and materials for the operation, maintenance, and replacements tabulated below.

Additional operation and maintenance costs presented here do not include interest and amortization of the added modifications. The annual replacement cost for the additional equipment is based on a percentage of construction costs. Estimated operation, maintenance, and replacement costs for each alternative are shown below.

Additional Annual Operation, Maintenance, and Replacement Costs[1,2]
1 October 1992 Price Levels

Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Totals
33-Foot Drawdown				
$1,576,400	$37,800	$32,100	$259,100	$1,905,400
43-Foot Drawdown				
$2,054,100	$49,200	$41,800	$337,700	$2,482,800
52-Foot Drawdown				
$2,484,100	$59,400	$50,600	$408,300	$3,002,400
28- to 57-Foot Drawdown				
$2,772,900	$65,200	$55,500	$447,600	$3,291,200
Near Natural River Condition				
$9,340,700	$67,000	$55,400	447,600	$2,910,700

[1] Costs include the incremental increase of labor and materials to operate, maintain, and replace additional facilities.

[2] Estimated Annual Operation and Maintenance costs do not include additional electrical power costs.

j. Future Considerations

Acquisition and development of additional HMU's under the Lower Snake River Fish and Wildlife Compensation Plan is progressing. Development will include additional irrigation facilities not presently installed. Future irrigation developments potentially affected include 164 additional acres at Central Ferry HMU, and 162 additional acres potentially irrigated by well at Heneley HMU.

8.06. Recreation Mitigation Measures

a. General

Generally, recreation parks along the lower Snake River are opened around April 1 and closed around October 1 each year. These dates fluctuate depending on annual climate conditions and the physical layout of each park facility. Boat launching ramps, however, are open all year. All ramps are usable throughout normal pool fluctuations between normal full pool and minimum operating pool elevations.

b. Existing Recreation Sites

(1) Lake Sacajawea (Ice Harbor Dam)

Major recreation areas along Lake Sacajawea include Ice Harbor Dam Park, Charbonneau Park and Marina, Levey Park, Fishhook Park, Windust Park, and Matthews Park. Other recreation sites are available for use, but do not have water access for boating.

Charbonneau Park, with 148 acres, is the largest and most developed park on Lake Sacajawea. Charbonneau Park, Levey Park, Fishhook Park, and Windust Park are developed parks with boat ramps, paved vehicle parking, sanitary dump stations, comfort stations, beaches, and picnic areas.

Matthews Park has been developed primarily for boat launching. The facility has a single-lane boat ramp, parking, and two vault toilets.

Ice Harbor Dam Park is situated just north of Ice Harbor Dam. The site consists of a two-lane boat launching ramp, paved parking, and portable chemical toilets.

(2) Lake Herbert G. West (Lower Monumental Dam)

Recreation development on Lake Herbert G. West has been limited by the extreme length and narrowness of the lake; and the rugged, high, basalt bluffs that flank it.

Devils Bench Park is located just upstream of Lower Monumental Dam, on the north shore. The facilities there include a two-lane boat launching ramp, vault toilets, and parking.

Lyons Ferry Park is leased to the State of Washington, and is the most highly developed and highly used park on the lake. The park's 105 acres include day-use areas, a well-developed swimming beach, picnic shelters, a two-lane boat launching ramp, boat-handling docks, and camping facilities with a sanitary dump station.

Across the river from Lyons Ferry Park is Lyons Ferry Marina, which is leased to the Port of Columbia County. This is the only marina on the lake. Site development includes both open and covered boat moorage, a marine gas dock, a restaurant/grocery store, a two-lane boat launching ramp, a boat hoist, handling docks, and a campground.

Texas Rapids is primarily a boat launching facility and fishing access site with minimal improvements.

Ayer Boat Basin is located on the south shore behind the railroad right-of-way. Access to the river is through a tunnel under the railroad tracks. Visitor facilities are minimal.

Riparia is a primitive site, and is used primarily as a fishing access point. The boat launching ramp has a gravel surface.

(3) Lake Bryan (Little Goose Dam)

The Lake Bryan shoreline is predominantly talus slopes and basalt cliffs, which limits the opportunity for recreational development. Recreation facilities are developed in six locations: two intensive areas (Central Ferry State Park and Boyer Park and Marina), and four boat launching areas (Little Goose Landing, Willows Landing, Port of Garfield, and Illia Landing). Penawawa Landing is primitive and not as well developed as the others.

Central Ferry State Park is leased to the State of Washington, and provides both day-use and camping facilities. A four-lane boat launching ramp is located in a protected boat basin with a marine dump station. The park is highly developed and maintained, and has a permanent maintenance staff.

Boyer Park and Marina is leased to the Port of Whitman County, and is operated by a concessionaire. It includes a public marina with moorage, marine dump station, public fuel docks, a three-lane boat launching ramp, a restaurant with two motel rooms, a campground, a sanitary dump station, and a developed swimming beach. There are also day-use areas with picnic shelters.

Little Goose Landing, Willow Landing, Illia Landing, and Garfield Landing are boat ramp locations with minimal day-use facilities.

Penawawa Landing is very primitive, and is not generally used for boating activities.

(4) Lower Granite Lake (Lower Granite Dam)

Recreational developments on Lower Granite Lake are numerous, and vary between major state parks and primitive boat launching areas. There are two state parks (Chief Timothy and Hells Gate), one county park (Wawawai Bay), two city parks (Chief Looking Glass and Clearwater Parks), a private marina (Red Wolf), and seven boat launching sites (Clearwater Ramp, Southway Ramp, Wawawai Landing, Offield Landing, Blyton Landing, Nisqually John Landing, and the O&M Ramp). There are also three parks developed on the levees or shoreline (Swallows Park, Greenbelt Park, and Lewiston Levee Parkway).

Offield Landing is located just upstream of Lower Granite Lock and Dam. It is primarily a boat launching ramp for project use.

Wawawai Bay is leased to Whitman County Parks. It has camping and day-use facilities located on the north shore, near the lower end of the lake. Park access to the lake is through a small embayment that connects with the lake. Boat launching is at the adjacent Wawawai Landing. Facilities include a small boat basin, a single-lane boat launching ramp, a picnic area, and a primitive swimming beach. A portion of Wawawai Landing is leased to the University of Washington for use by their rowing teams. They have constructed a storage building and special docks for their sculls.

Blyton Landing and Nisqually John Landing are boat access ramps, and each as limited day-use facilities. Parking and picnic areas are also available.

Chief Timothy State Park is located about 10 miles downstream from Clarkston, and is located on a large island created by the lake. The park is leased to the State of Washington. All of the park facilities are located on the island except for the park maintenance headquarters, which is located landward of U.S. Highway 12. Approximately 30 acres are developed, including a campground, boat courtesy docks, boat launching ramps, a visitor center, day-use areas with a developed beach, comfort stations with showers, a food concessionaire, a sanitary dump station, and a marine pumpout station.

Red Wolf Marina is a public marina, and is leased to the Port of Clarkston. It is located in a protected bend of the shoreline, at the base of Red Wolf Bridge. A boat launching ramp, store, restaurant, showers and restrooms, and marine services are available there.

The O&M Ramp is located next to the Clarkston Resource Office, at the confluence of the Snake and Clearwater Rivers. The boat basin is also used as a base for the Clarkston Resource Office ranger boats, and the Port of Lewiston fireboat "Karl Prehn" is moored here.

Greenbelt Park consists of a 50-foot strip of land that runs from the Clarkston Resource Office upstream to Swallows Park. Pedestrians and cyclists can use a paved pathway to the old city beach area. The city beach site has been developed as a small picnic area and riverside park.

Swallows Park is located along the left bank of the Snake River, upstream from Clarkston. A swimming beach, playground, picnic shelters, and comfort station and changehouse are available. A four-lane oat launching ramp with handling docks can also be found at this site.

Chief Looking Glass is a small marina developed to support boat access in the upper Snake River reach of the lake. It is leased to the town of Asotin. Facilities include a boat launching ramp, paved parking, baseball and football fields, a concession area, and two playgrounds.

The Lewiston Levee Parkway, built on the levee protecting the city of Lewiston, is a 3-mile parkway that provides a landscaped greenbelt along the city of Lewiston waterfront. It has paved walkways, exercise trails, bike trails, fishing access points, paved parking, day-use facilities, a comfort station, two interpretive centers, and tie-up docks for boat access.

Southway Ramp is leased to Nez Perce County. This ramp provides boat access to the right bank of the river between Lewiston and Hells Gate State Park.

Hells Gate State Park is leased to the State of Idaho, and is the largest park on the reservoir. Located just upstream of the city of Lewiston, development includes a campground, developed day-use areas, a swimming beach, picnic shelters, a group shelter, and a visitor center. A public marina and commercial boat moorage are also available. The boat launching ramp has six lanes. The historic steamboat, "Jean," is moored nearby, and is open to the public.

Clearwater Park is located in North Lewiston. It is developed as a community park, and has baseball fields and a small picnic area.

Clearwater Ramp is leased to Nez Perce County. This ramp provides boat access to the Clearwater River. A gravel parking area serves the two-lane boat launching ramp.

c. Mitigation Measures

Two options were considered to mitigate the impact to recreation facilities from reservoir drawdowns. The first option would be to build new facilities and/or reconstruct the existing recreation facilities so that they will function both during drawdown and normal operations. The second option would be to construct only additional boat-handling facilities for use during a drawdown condition. Each alternative action was developed assuming a drawdown to spillway crest at each project. This is equivalent to a drawdown of about 57 feet (maximum drawdown for the variable pool alternative). Because the location and arrangement of the proposed facilities for each option is more dependent on the shoreline topography than differences in water surface between drawdown alternatives, each alternative option is assumed applicable to all drawdown alternatives.

The first option would require, in some cases, relocating the entire facility to a suitable location since the existing site cannot be adapted to provide total visitor access to the river during a drawdown. In other cases, the facility would require extensive redesign and reconstruction to maintain the existing facility at its current day-use levels.

The second option would retain all existing recreation sites as they are, and construct only additional boat-handling facilities for use during drawdowns. New boat-handling facilities would be inundated when each lake is at its normal pool level. Additional facilities would consist of a series of boat ramps, portable floating boat docks, additional parking areas, and access roads at different elevations. In some cases, a long boat launching ramp would be appropriate, whereas other parks might require multiple ramps at different elevations. These facilities would allow continuous access to the river as the water surface elevation changes during drawdown or refill. The only activity not available under this option during a drawdown would be swimming. The work at each park could include several of the following items:

- Abandon existing boating facilities.
- Construct boat ramps, including portable boat docks.
- Construct replacement commercial marinas.
- Construct rock breakwaters, where appropriate, to protect boat launching facilities from high water velocity.
- Install fencing and gates for security and safety.
- Extend existing boat launching ramps to the original run-of-river elevation. This may require dredging or excavating small inlets to provide protection during boat launching.
- Close primitive and little-used recreation sites at appropriate drawdown elevations, and direct water-related activities to other nearby parks.
- Construct multiple-level parking areas near each boat launching ramp.
- Dredge existing channels to allow boat access to existing facilities.
- Replace existing boat docking facilities that are not suitable for repeated handling during annual drawdowns.

d. Costs

(1) General

The cost to mitigate for recreation losses is assumed to be the same for all drawdown alternatives because the location of water recreation facilities may be more dependent on site conditions and shoreline contours than water surface elevations. New recreation facilities would be constructed for drawdowns of 57 feet (variable pool), 52 feet, 43 feet, or 33 feet. There would be no cost difference between the 57- or 52-foot drawdown alternatives. The cost to mitigate recreation losses for a 43- or 33-foot drawdown could be slightly less than the cots presented.

(2) Alternative Option 1--Costs

The total cost would include constructing new facilities to provide a continuously usable facility without any interruption to the activity, including the construction of swimming beaches. Included in the cost estimate is the cost for temporary facilities until the new recreation facilities are completed. The cost of restoring abandoned areas is also included.

New and Reconstructed Recreation Facilities Construction Cost 1 October 1992 Price Levels	
Lake Sacajawea	$11,600,000
Lake Herbert G. West	18,400,000
Lake Bryan	5,400,000
Lower Granite Lake	10,500,000
Total	**$45,900,000**

(3) Alternative Option 2--Estimated Costs

Costs for constructing boating facilities tailored to meet minimal water-related activities at each recreational site are summarized in the following:

Additional Boat-Handling Facilities Construction Cost 1 October 1992 Price Levels	
Lake Sacajawea	
Ice Harbor Dam Park	$2,620,000
Levey Park	817,000
Charbonneau Park	1,075,000
Fishhook Park	635,000
Windust Park	310,000
Matthew Park	4,000
Subtotal Construction Cost (Use)	**$5,200,000**
Lake Herbert G. West	
Devils Bench Park	$498,000
Ayer Boat Basin Park	471,000
Lyons Ferry Park	541,500
Lyons Ferry Marina	8,200,000
Texas Rapids Park	335,000
Riparia Park	92,000
Subtotal Construction Cost (Use)	**$10,100,000**
Lake Bryan	
Central Ferry State Park	$536,500
Boyer Park	797,200
Little Goose Landing	$42,100
Willow Landing	576,540
Illia Landing	42,100
Garfield Ramp[1]	0
Subtotal Construction Cost (Use)	**$1,900,000**

Lower Granite Lake	
Chief Timothy State Park	$594,000
Hells Gate State Park	1,374,000
Chief Looking Glass Park	25,000
Red Wolf Marina	2,780,000
Clearwater Ramp	22,000
Southway Ramp	22,000
Wawawai Landing	628,000
Offield Landing[1]	0
Blyton Landing	300,500
Nisqually John Landing[1]	0
O&M Ramp[1]	0
Greenbelt Park[1]	0
Swallows Park[1]	327,000
Subtotal Construction Cost (Use)	**$6,100,000**
Total Construction Cost	**$23,300,000**

[1]These sites were not considered in the study during drawdown because of low visitor use, location, cost, or the proximity of other sites and their ability to absorb the activity.

e. Implementation

The implementation of these actions assumes that resources are available. Considering that other major construction will b necessary to implement a drawdown, it is assumed that resources would be mobilized within the region to accomplish all work under consideration.

The scope and magnitude of modifications at each park site will be determined during Phase II studies. Construction at sites selected for relocation and/or major reconstruction can begin prior to commencement of reservoir drawdowns. However, construction below normal water surface elevations can only be done once drawdowns begin. Assuming a combination of park reconstruction and construction of boat-handling facilities, the following implementation schedule is estimated:

Estimated Construction Time			
	Prior to the Beginning of Drawdown	**After Drawdown Begins**	**Total Construction Time**
Lake Sacajawea	2 years	2 years	4 years
Lake Herbert G. West	2 years	3 years	5 years
Lake Bryan	1 year	3 years	4 years
Lower Granite Lake	1 year	4 years	5 years

f. Operation and Maintenance

In addition to construction of the facilities described above, the following actions are necessary during any drawdown to control public access and safety. Requirements common to all alternatives include:

- Removing or preparing existing floating docks to prevent structural damage.
- Implementing security and safety programs, including barricading water access locations and monitoring the entire shoreline for health and safety.
- Restoring all water-related facilities following each drawdown.
- Implementing a preventive maintenance program to protect the existing structures from damage.
- Implementing an information program to alert the public about which recreational facilities would be usable on each lake, or directing them to alternate locations within driving distances.

Although pumping facilities may be modified as part of mitigating irrigation systems, additional operation and maintenance by project personnel is anticipated.

Reservoir drawdowns will certainly add more responsibility to the recreation staff at all operating projects on the Snake River. New items to contend with would include closing off areas as the water elevation changes, installing portable chemical toilet stations, changing the various types of floating boat docks to accommodate different conditions, and implementing extensive security and safety requirements to ensure a safe environment for the recreation user. Operation and maintenance work would be performed by additional project personnel or by annual contracts.

The estimated operation and maintenance cost is the additional incremental operation and maintenance cost related to drawdown activities. The annual cost for losses due to fishing, water sports, or financial losses to concessionaires operating marinas or restaurants is not identified. The estimated annual operation and maintenance cost, by project, is summarized below:

Lake Sacajawea, Ice Harbor Project	$270,000
Lake Herbert G. West, Lower Monumental Project	280,000
Lake Bryant, Little Goose Project	270,000
Lower Granite Lake, Lower Granite Project	290,000
Annual Operation and Maintenance Cost	**$1,110,000**

8.07. Cultural Resources Mitigation

a. General

Much of the information and data presented in this section was prepared by the Center for Northwest Anthropology at Washington State University, and by David Evans and Associates, Inc., under contract to the Corps.

b. The 1992 Drawdown Test Observations

Results of the monitoring project during the 1992 Drawdown Test of Lower Granite and Little Goose reservoirs has provided some insights into the effects of reservoir operation and drawdowns on archaeological sites not previously accessible, since they were inundated in Lower Granite and Little Goose reservoirs.

During the drawdown of both reservoirs, erosion was enhanced by wind-induced wave action that resulted in the terracing of steeper slopes and/or undercutting of bank deposits that lead to slumping. None of the recorded rockshelters selected for monitoring could be located during the drawdown. Either the rockshelters have been buried by post-inundation scree, or they have been lost as a result of slumpage.

Exposed sandy flats were also subject to wind deflation when exposed long enough to dry.

In the event that future drawdowns are conducted to enhance salmon runs, it is clear that additional personnel will be needed to monitor and identify illegal acts of site vandalism and relic collecting. Sites such as Hells Gate (10NP151) and Wilma Bar (45WT78/79), which attracted relic collectors on a daily basis, will require surveillance on a continuous bases as long as they are exposed during the drawdown.

c. Mitigation Measures

Various options are available in terms of managing cultural resources threatened by reservoir drawdown. These options range from complete archaeological excavation to site protection and preservation. The underlying premise of the Reservoir Salvage Act is that inundation of archaeological resources by freshwater is a destructive process, and associated adverse impacts can only be effectively mitigated through a program of intensive survey and excavation.

Site burial or covering is one of several alternatives that might be employed in the protection of cultural resources. Field and laboratory research associated with the National Reservoir Inundation Study (NRIS) led to the conclusion that *in situ* protection is a viable mitigation alternative to excavation only in limited circumstances. The benefits of site burial include the complete, or nearly complete, elimination of vandalism to the cultural deposits. Natural erosion processes may in part be alleviated by site burial, but the long-term effects of site burial are not yet fully understood. A variety of methods are available, utilizing both natural and manmade materials.

Unfortunately, some sites in the project area will need more protection from human access than from the negative forces of erosion and other natural causes of site destruction. Vandalism cannot be ignored as a major cause of site destruction. Although many such acts are not intended to be malicious and destructive, the cumulative effects of people collecting occasional artifacts or walking across a site ultimately have a negative impact on the cultural resource. The effects of intentional site looting, however, are clearly a negative impact. The most direct solution to this problem is limiting access to the sites.

A combination of law enforcement and education may hold the greatest possibility for the future curtailment of vandalism. An intensive education program about vandalism that stresses cultural value and uses various media as well as professional archaeologists and historians, may help to involve the public in preservation and protection programs.

Although many cultural resource managers are dismayed at the possibility of posting signs to make the public aware of the presence of cultural resources, enforcement of 18 United States Code, Section 1361, is sometimes impossible if signs are not in place during acts of intentional site vandalism. Two general signing techniques are most frequently used. The first appeals to the general public by indicating the importance of cultural resources and directs that they be left intact for future generations and research. The second approach is more direct, indicating that the property is posted and protected by Federal laws, and violators will be prosecuted. Signs placed to limit access to a site are often, however, more effective if used in conjunction with fences, patrolling, or other deterrents. Site signing is one of the least expensive techniques that can be applied to a site for preservation purposes.

Fencing of archaeological sites is effective in deterring access and in restricting and routing movement around sites open to public view. Fencing, combined with signs and/or patrolling, provides better protection than fencing alone. The major advantage of fencing is the essentially low cost of installation compared to other protection techniques. The major drawback to fencing archaeological properties is that the fence will usually only keep out those individuals not intent on destroying or vandalizing the site. Additionally, the need for maintenance will increase the long-term cost of this preservation technique. Costs should include the fencing material, the clearance of vegetation along the fence alignment, and installation.

Often it is desirable to protect and preserve the site as a whole by various means, rather than conducting archaeological excavations that recover only a portion of the site data. Protection or preservation techniques can retard the loss of site integrity associated with both natural and cultural processes. Efforts must be made between the archaeologist and engineer in the design and implementation of any protection-in-place method. Specifically, the archaeologist should define what must be protected and preserved, and the engineer must design a protection project that produces the best possible environmental conditions in which to protect the artifactual assemblages.

In 1981, NRIS concluded that the detailed documentation and excavation of cultural resources within the conservation pool and shoreline fluctuation zone is, in most cases, the most effective and often the least expensive method of mitigating adverse impacts. In some instances, however, *in situ* protection measures in these zones have been attempted with varying degrees of success. The long-term cost of protection and maintenance are sometimes prohibitive, and the potential impacts to the sites from such protective methods are not yet fully understood.

d. Costs

(1) General

Historically, the mitigation process for prehistoric and historic cultural resources has been equated with excavation or avoidance. However, archaeological site stabilization and preservation is being investigated as a means of protecting cultural resource sites.

Cultural resource (archaeological site) mitigation measures for the proposed drawdown alternatives can potentially be treated in three different ways: 1) testing or data recovery excavations; 2) complete avoidance of the site by project-generated activities; and 3) *in situ* preservation of the site using some form of protection method. Each site is a unique entity in terms of size, content, and complexity.

(2) Testing and Data Recovery Cost Estimate

Archaeological testing and/or data recovery would include field work, laboratory analysis, report preparation, and curation of project collections. The cost for archaeological testing is also directly related to the size, content, and complexity of each site; the types of equipment needed to accomplish the tasks; the amount of site matrix to be excavated; and so forth.

Because many of the sites considered significant or potentially significant are known only from surface indicators documented when the site was recorded, a site-by-site cost estimate for testing or data recovery excavations cannot be realistically calculated for each separate site at this time. Using information known about certain types of sites in the projects that have been excavated, it is possible to calculate reconnaissance-level cost estimates for various site types.

Cost estimates for excavating an open camp, a housepit site, and a rockshelter or cave were used as the basis for reconnaissance cost estimates. All potential cost factors and variables were considered and included during this computation. In short, all possible contingency needs, in terms of laboratory and special technical assistance, that might be needed were included. Costs presented for each project do not include any new sites that might be exposed.

Testing and data recovery estimates for the sites of concern in the Ice Harbor/Lower Monumental and Lower Granite/Little Goose projects were determined in part by site size, depth of the cultural deposits (if known), site type, and potential content and/or complexity. Using assumed sample fractions, a cost per volume was used to calculate testing and data recovery excavation costs.

Should the pool levels for each of these projects be lowered to the near natural river condition, all known sites will be exposed. These known sites include 57 sites at Ice Harbor/Lower Monumental, and 88 sites at the Lower Granite/Little Goose projects.

Should the pool levels for each project on the lower Snake River be lowered to constant pool elevations at or near spillway crest elevation, about 109 sites would be exposed. These exposed sites would include 47 sites at Ice Harbor/Lower Monumental, and 62 sites at the Lower Granite/Little Goose projects.

Testing/Data Recovery Excavations Estimated Total Costs (1992 Price Level)	
Drawdown to Near Natural River Condition	
Ice Harbor/Lower Monumental (57 sites)	
Testing	$3,200,000
Data Recovery	61,900,000
Lower Granite/Little Goose (88 sites)	
Testing	$2,700,000
Data Recovery	42,900,000
Total	**$110,700,000**
Drawdown to Constant and Variable Pool Elevations	
Ice Harbor/Lower Monumental (47 sites)	
Testing	$2,200,000
Data Recovery	41,700,000
Lower Granite/Little Goose (62 sites)	
Testing	$1,600,000
Data Recovery	36,700,000
Total	**$82,200,000**

(3) Testing and Data Recovery--Discussion of Risk

It should also be noted that the total costs for testing and data recovery may vary considerably from the figures presented here. For sites known only from survey data, for example, it was assumed that cultural deposits averaged 1 meter in depth. In all likelihood, however, it is likely that artifact and feature densities will vary considerably from site to site, and that depth will vary as well. Monitoring and/or testing will no doubt eliminate some sites from data recovery considerations. Likewise, newly discovered sites or sites not included in this study may prove to contain significant information about the region's prehistory.

Data recovery estimates might be considered a worst case scenario should all the project pool levels be lowered to the near natural river condition. A 10-percent reduction in the number of sites, for example, would reduce the total cost figure from about $120 million to $108 million, while a 20- or 50-percent reduction in the number of significant sites would likewise reduce costs. These same factors will no doubt affect the cost estimates calculated for testing and in-place protection measures.

(4) Protection-in-Place Cost Estimates

Stabilization techniques appropriate for halting erosion and other natural destructive processes may also have some utility in the protection of archaeological sites. The stabilization of an archaeological site, however, entails the consideration of cultural residues that must be evaluated in the design and construction of a stabilization technique for specific sites. In short, the stabilization technique must not be more destructive than the problem itself. It is necessary, therefore, to understand each site and its contents before any stabilizing measures are undertaken. Potential impacts must also be understood (*i.e.*, changes in soil chemistry, weight, runoff patterns, and erosion patterns).

It must also be remembered that, while many sites may appear similar or share common features, each is uniquely different. This uniqueness must be considered in the design and implementation of a stabilization project. The tendency to group together sites that seem similar must be avoided so that a solution to one site is not perceived to be suitable to the protection of other "similar" sites. Not all cultural resources are significant, or require or merit preservation and the expenditure of tine and money.

There are several requirements for computing the various alternative costs for *in situ* protection and stabilization of an archaeological site. The information requirements for sites located within the reservoir fluctuation zone include: 1) the length and height of bank to be stabilized; 2) the method of stabilization to be employed; and 3) the cost per linear foot for the stabilization technique selected. Information requirements for sites located in the backshore zone of each reservoir include, but are not limited to: 1) the horizontal area encompassed by each site of concern; 2) the type of vegetation present; 3) site topography; 4) the method of stabilization or protection selected for employment; and 5) the cost per square foot for the selected stabilization technique. Other factors to be considered that affect the overall cost include access to the site, the availability or proximity of construction materials (*e.g.*, riprap), equipment and labor needs, and design and engineering costs.

Estimated construction and design costs, as well as project schedules for stabilization and/or preservation of selected archaeological sites on the lower Snake River were prepared under contract by the Center for Northwest Anthropology at Washington State University, and by David Evans and Associates, Inc. Twelve sites of various types (village, open camp, rockshelter, *etc.*), located in different environmental/topographic settings, were selected as "prototypes" for which the design and construction costs of various stabilization methods were calculated. For some sites, alternative stabilization methods and cost were formulated to provide a broader perspective on analysis and design costs. The design and construction cost estimates were based on standard engineering methods for determining design fees.

Based on these "prototype" costs, estimates were prepared for a variety of protection methods for those sites located in the fluctuation zone. Protection methods included riprap and filter fabric, riprap in conjunction with earthen mounding, Gabion mattress, geomatrix, traditional riprapping of banks and shorelines, bulkhead/riprap (with sheet pile), gunite/riprap protection, timber bulkhead, and vegetation.

Protection-In-Place Estimated Total Costs (1992 Price Level)	
Drawdown to Near Natural River Condition	
Ice Harbor/Lower Monumental (57 sites)	
Testing	$3,200,000
Data Recovery	126,700,000
Lower Granite/Little Goose (88 sites)	
Testing	$2,700,000
Data Recovery	201,400,000
Total	**$334,000,000**
Drawdown to Constant and Variable Pool Elevations	
Ice Harbor/Lower Monumental (47 sites)	
Testing	$2,200,000
Data Recovery	87,500,000
Lower Granite/Little Goose (62 sites)	
Testing	$1,600,000
Data Recovery	96,000,000
Total	**$187,300,000**

(5) Site Protection--Discussion of Risk

None of the protection methods considered guarantee that the site will be protected for an indefinite period. Site protection, even on a short-term basis, may also require a combination of techniques. None of the protection methods, other than complete site burial, are adequate to protect significant or potentially significant cultural deposits in the drawdown zone. Even complete site burial as a protective measure remains an uncertain alternative. Although this method has been employed on sites before inundation, the long-term benefits and/or impacts remain unknown. Analysis and prototype testing will be needed to develop appropriate techniques for normally inundated sites that might be exposed during the annual drawdown.

Protection-in-place for known sites at the lower Snake River projects could range from a total of $273 million to $328 million should the reservoirs be lowered to the near natural river condition. This range is based on the lowest cost method for each site, and the highest cost method at each site.

Estimates for each project do not include any new sites that might be exposed, or any previously recorded sites that might be determined eligible for inclusion in the National Register of Historic Places.

e. Implementation and Estimated Annual Costs

(1) General

Time periods of 2 and 4½ months are being considered for annual drawdowns. Each is a relatively short period of time for archaeological site investigations. Assuming the lower Snake River drawdowns to be a significant action in the region, it is reasonable to assume that archaeologists and assisting personnel would be available to conduct timely site investigations. Given a 4½-month timeframe, it is assumed that 10 to 12 sites could be tested during each drawdown. The shorter period (2 months) may allow testing of 6 to 8 sites.

Because almost all sites are inundated by the existing reservoirs, site testing and protection cannot begin until the first drawdown occurs. Testing in the Lower Granite and Little Goose reservoirs could begin 8 years following authorization and appropriation for modifications to the dams for drawdowns. Testing in the Ice Harbor and Lower Monumental reservoirs would begin 14 years following authorization and appropriations.

(2) Near Natural River Conditions

A total of 145 exposed archaeological sites are known to exist for this condition. Therefore, archaeological testing, recovery, or in-place site protection for this condition would take about 14 years, assuming a 4½-month annual drawdown. Shorter drawdown periods could extend this time to 24 or more years with an associated lower annual cost.

Assuming there are limited annual resources that would be distributed somewhat equally over the period of analysis, the magnitude of the annual expenditure can be estimated by dividing the cost by the number of analysis years. The following table shows the estimated annual cost for a 14-year period, for the option of testing and data recovery, as well as for the option of testing and protection-in-place.

Estimated Annual Cost Range for a 14-Year Period Year 8 Through Year 17 (1992 Price Level)		
Drawdown to Near Natural River Condition		
Testing	$420,000	$420,000
Data Recovery	7,500,000	n/a
Protection-in-Place	n/a	23,400,000
Annual Cost Range	**$7,920,000 to $23,820,000**	

(3) Constant Pool Elevation Conditions

A total of 109 exposed archaeological sites are known to exist for these conditions. Therefore, archaeological testing, recovery, or protection for these conditions would take about 9 years, assuming a 4½-month annual drawdown. Shorter drawdown periods could extend this time to about 14 years.

Estimated Annual Cost Range for a 9-Year Period Year 8 Through Year 17 (1992 Price Level)		
Drawdown to Constant Pool Elevations		
Testing	$400,000	$400,000
Data Recovery	8,700,000	n/a
Protection-in-Place	n/a	20,400,000
Annual Cost Range	**$9,100,000 to $20,800,000**	

Actual costs are estimated between $9 million and $21 million. Using a simple average of the cost range, the average annual expenditure for a period of 9 years is computed to be about $15,000,000.

8.08. Summary of Mitigation Costs

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation. Recreation and cultural resource mitigation costs are the simple average of the estimated high and low cost range.

Operation and maintenance costs are the estimated incremental increases due to reservoir drawdowns.

Lower Snake River Mitigation
Estimated Total Construction Costs By Project
1 October 1992 Price Levels

	Reservoir Drawdown Alternatives				
	33-Foot Drawdown	**43-Foot Drawdown**	**52-Foot Drawdown**	**28- to 57-Foot Drawdown**	**Natural River**
Ice Harbor, Lake Sacajawea					
Irrigation	23,200,000	23,700,000	24,100,000	26,200,000	29,300,000
Recreation	8,400,000	8,400,000	8,400,000	8,400,000	8,400,000
Cultural Resources	33,400,000	33,400,000	33,400,000	33,400,000	48,800,000
Subtotal	$65,000,000	$65,500,000	$65,900,000	$68,000,000	$86,500,000
Lower Monumental, Lake Herbert G. West					
Irrigation	600,000	700,000	700,000	800,000	800,000
Recreation	14,300,000	14,300,000	14,300,000	14,300,000	14,300,000
Cultural Resources	33,400,000	33,400,000	33,400,000	33,400,000	48,800,000
Subtotal	$48,400,000	$48,300,000	$48,300,000	$48,300,000	$63,900,000
Little Goose, Lake Bryan					
Irrigation	500,000	500,000	500,000	500,000	700,000
Recreation	3,700,000	3,700,000	3,700,000	3,700,000	3,700,000
Cultural Resources	33,800,000	33,800,000	33,800,000	33,800,000	62,500,000
Subtotal	$38,000,000	$38,000,000	$38,000,000	$38,000,000	$66,900,000
Lower Granite, Lower Granite Lake					
Irrigation	5,200,000	5,400,000	5,500,000	5,600,000	7,000,000
Recreation	8,300,000	8,300,000	8,300,000	8,300,000	8,300,000
Cultural Resources	33,800,000	33,800,000	33,800,000	33,800,000	62,500,000
Subtotal	$47,300,000	$47,500,000	$47,600,000	$47,700,000	$77,800,000
Totals	**$198,600,000**	**$199,400,000**	**$199,900,000**	**$202,200,000**	**$295,100,000**

Lower Snake River Mitigation
Estimated Annual Operation and Maintenance Costs[1],[2]
1 October 1992 Price Levels

	Reservoir Drawdown Alternatives				
	33-Foot Drawdown	**43-Foot Drawdown**	**52-Foot Drawdown**	**28- to 57-Foot Drawdown**	**Natural River**
Ice Harbor, Lake Sacajawea					
Irrigation	1,580,000	2,100,000	2,480,000	2,720,000	9,340,000
Recreation	270,000	270,000	270,000	270,000	270,000
Cultural Resources	n/a	n/a	n/a	n/a	n/a
Subtotal	$1,850,000	$2,370,000	$2,750,000	$2,990,000	$9,610,000
Lower Monumental, Lake Herbert G. West					
Irrigation	38,000	49,000	59,000	65,000	67,000
Recreation	280,000	280,000	280,000	280,000	280,000
Cultural Resources	n/a	n/a	n/a	n/a	n/a
Subtotal	$318,000	$329,000	$339,000	$345,000	$347,000
Little Goose, Lake Bryan					
Irrigation	32,000	42,000	51,000	56,000	55,000
Recreation	270,000	270,000	270,000	270,000	270,000
Cultural Resources	n/a	n/a	n/a	n/a	n/a
Subtotal	$302,000	$312,000	$321,000	$326,000	$325,000
Lower Granite, Lower Granite Lake					
Irrigation	259,000	338,000	408,000	448,000	448,000
Recreation	290,000	290,000	290,000	290,000	290,000
Cultural Resources	n/a	n/a	n/a	n/a	n/a
Subtotal	$549,000	$628,000	$698,000	$738,000	$738,000
Totals	**$198,600,000**	**$199,400,000**	**$199,900,000**	**$202,200,000**	**$295,100,000**

Section 9 - Coordination

9.01. Columbia/Snake River Drawdown Committee

The Drawdown Committee was established by NPPC, as identified in their *Strategy for Salmon,* and serves in an advisory capacity to NPPC. This committee is charged with coordinating analysis conducted by the Federal agencies, and oversees the development of plans for drawdown on the Columbia and Snake Rivers. The committee, chaired by NPPC, consists of representatives from each of the following groups and agencies: the Corps; BPA; the Bureau of Reclamation; the states of Idaho, Oregon, Washington, and Montana; the Columbia River Inter-Tribal Fish Commission; and the Shoshone-Bannock tribes. The committee facilitates regional involvement in ongoing Federal processes related to drawdown, and helps prevent the duplication of efforts between Federal and NPPC-sponsored efforts.

The BPA, in coordination with the committee, funded an independent contractor to review the adequacy of technical analyses conducted by the Federal agencies, as well as to conduct their own analyses when the committee or the chair deem appropriate.

9.02. The TAG

A group of technical experts representing regional fish agencies and tribes, river operating agencies and user groups, conservation groups, and other interested parties, was formed in the spring of 1991 to develop plans for the 1992 Lower Snake reservoir drawdown test. This group has continued to meet since the completion of the March drawdown test, and has been designated as the CRSMA TAG.

The TAG is responsible for the following: 1) developing and reviewing criteria for each alternative being considered by the Corps in the System Configuration Study; 2) reviewing technical reports produced under this study; 3) developing and evaluating recommendations for methods of obtaining additional information regarding alternatives proposed for study under the NPPC's Fish and Wildlife Program Amendments; 4) development of the scope of the Biological Plan for the Lower Snake reservoir drawdown; and 5) the Biological Plan. Input from the TAG is provided to NPPC's Drawdown Committee, as well as the Corps.

Preparation of this document was coordinated with the TAG, who provided guidance in the development and screening of alternatives and fishway design criteria. The TAG also reviewed and commended on various drafts of this document. (Refer to appendix D for pertinent correspondence.)

9.03. Public Involvement

A description of the Public Information Program for the System Configuration Study is included in the Summary Report.

Section 10 - Phase II Study Requirements

10.01. General

This section identifies some of the study requirements that must be completed if any of the drawdown alternatives are considered further during the feasibility study phase (SCS Phase II). Engineering, environmental, economic, and system operational studies will be required. Additionally, mitigative opportunities will be further investigated.

10.02. Engineering

a. Geotechnical Studies

Geotechnical investigations will be necessary to determine the suitability of foundations for proposed hydraulic structures. Current embankment information is not adequate for determining the true quantities needed for embankment riprap. Therefore, hydrographic surveys of existing embankments will be necessary. Several of the proposed drawdown alternatives require the relocation of railroads, highways, or other facilities. Relocation site data will be required for design, and will be obtained during Phase II studies.

b. Hydraulic Model Studies

Extensive hydraulic modeling of each of the four lower Snake River dams will be necessary to obtain design data for the major structural changes required by the various drawdown alternatives. As many as three separate hydraulic models of each dam may be required. Sectional models of spillways and powerhouses, in addition to general models of the projects, will be necessary.

c. Specific Engineering Studies

A partial list of studies that should be conducted if any drawdown alternatives are considered further includes the following:

- Evaluate tailrace flow patterns with lowered tailwaters.
- Evaluate specific adult fish passage facility entrance conditions under the lowered tailwater.
- Evaluate modified adult chute system design.
- Evaluate effects of tailrace flow patterns as a result of drumgate installation.

- Determine the number of years/probability that cofferdam would cause spill and the extent of the spill.

- Evaluate the effect of powerhouse cofferdams on tailrace hydraulic patterns.

- Evaluate VBS (existing and modified) flow conditions during drafting, the drawdown period, and refill.

- Evaluate standard, and extended-length screening device flow conditions during drafting, the drawdown period, and refill.

- Evaluate flow conditions and velocities within deepened adult fish passage channels under lowered tailwater and normal pool conditions.

- Evaluate the surface flow collector concept, including dye traces, effects on submerged screening devices, forebay hydraulics, and turbine intake hydraulics.

- Evaluate turbine conditions specific to drawdown projects.
- Evaluate gatewell conditions during drafting, the drawdown period, and refill, with both existing and proposed VBS's.

- Determine potential bypass release sites and evaluate conditions under full and lowered tailwaters under a large range of flow conditions (particularly low flows), and with and without downstream weirs.

- Evaluate tailrace hydraulic conditions and flow patterns as a result of downstream weir installation.

- Evaluate velocities associated with downstream weir configuration for adult fish passage conditions, salmonid predator potential, *etc.*

- Evaluate the effect of sediment transfer downstream past the projects and into the Snake River delta and the McNary pool.

- If alternative 4A is carried into the Phase II feasibility studies, additional work will be done to examine the possibility of providing some type of ladder for adult fish during the transitional period when pool levels are between spillway crest and near-natural river elevations.

- Additional studies will also be done to identify the impact of lowered pool elevations on all components of the turbine intake screening systems, including VBS and STS performance. Additionally, impacts to OPE will need to be quantified.

- If alternatives recommending new turbine runners are carried into Phase II, studies and research should be done to determine any benefits to juvenile fish. Likewise, additional studies should be done to confirm that the turbine-runner replacement option is the option of choice.

- For alternatives 15 and 19, future studies will be needed to determine a method for collecting and bypassing adults that are attracted into the new spillway area when the new low-level spillway is operating.

10.03. Environmental

a. Fish and Wildlife Planning Aid Report

A draft Fish and Wildlife Planning Aid Report (DPAR), prepared by the U.S. Fish and Wildlife Service, is included as an appendix to the System Configuration Summary Report. The DPAR summary report recommends that the following actions be taken:

- A sediment and bedload study be conducted to evaluate the effect of sediment transfer downstream past the projects and into the Snake River delta and McNary pool.

- An evaluation of the impacts to adult and juvenile resident and anadromous fish during drafting and refilling of the reservoir to normal operating elevation should be conducted. This should include an analysis of effects to population size and age structure of resident fish and an evaluation of the value of rearing habitat on the lower Snake River for juvenile salmonids.

- Hydraulic model testing and prototype testing to determine changes in forebay and turbine intake water velocity patterns should be conducted to provide information on possible changes to FGE's. Biological evaluations should also be conducted.

- Model testing and prototype testing is needed to evaluate the conditions within the modified adult fish facilities under the various drawdown alternatives. This should include an evaluation of fishway exit and entrance conditions, as well as attraction flows. Biological evaluations should also be conducted.

- An analysis of the effects of gas supersaturation on anadromous and resident fish species should be completed. The U.S. Fish and Wildlife Service has proposed laboratory research, funded by BPA, that may be adequate for this analysis. The 1993 smolt monitoring program is collecting biological data from fish at various sampling sites.

A number of studies would be needed to fully evaluate the impacts of drawdown alternatives, as well as the mitigation needs of resident fish and wildlife. These include the following:

- Quantify potential impacts to riparian and wetland vegetation, based on an evaluation of soil characteristics, soil moisture, and species-specific water requirements for different plants. The potential of seed germination and plant growth within the drawdown zone should also be evaluated. Habitat losses and changes can then be predicted. Existing habitat quantity and quality should be evaluated through the use of HEP, although the HEP done for the Lower Snake River Fish and Wildlife Compensation Plan may provide adequate information. The quality and type of terrestrial habitat that would be lost as a result of construction should also be quantified using HEP. Mitigation sites, and their potential for enhancement, should be identified and evaluated.

- Evaluate what type of irrigation system would be required to continue irrigation of HMU's.

- Identify sites where artificial watering points for game birds would be needed.

- Where data are not available, detailed bathymetric studies should be conducted to provide the basis for the analysis of impacts to spawning and rearing habitats of resident fish, riparian and wetland vegetation, establishment of vegetation in the drawdown zone, and predator access to islands.

- An intensive mollusk survey should be carried out at sites that may still harbor components of the native mollusk community. These sites are most likely to occur in tailraces and tributaries. Based on the survey, a plan should be developed to identify sites where native species might be maintained under the drawdown alternatives.

- A systematic plant survey should be conducted within the affected area to identify locations of rare, threatened, and endangered plants, as well as potential sites for maintenance and enhancement, if possible, of these plant populations.

- Raptor surveys, including winter bald eagle surveys, should be conducted to characterize raptor use of riparian zones.

- An evaluation of aquatic furbearer use of the reservoir is needed to evaluate the effects of reservoir drawdown.

- Sites with the potential for fish stranding should be identified and the means to provide an outlet for fish should be addressed. This is particularly needed for culverted subimpoundments.

- A post-implementation study of effects to resident fish, including an evaluation of food resources, is needed. A mitigation program to maintain sport fisheries compatible with the anadromous fishery should be developed, based on the results of the study.

b. Other Environmental Studies

There are many uncertainties presented in the discussion of potential impacts of reservoir drawdown to the environment. The Pacific Northwest has not reached a consensus on the appropriate plan of action. The following paragraphs discuss some of the potential means to resolve the question of whether or not to implement drawdown, as well as some of the potential advantages and disadvantages associated with each.

(1) Recommendations for Further Analysis, Research, and Evaluation

There are many elements of the Columbia River Basin anadromous fish cycle about which we know a lot, and many about which very little is known. Some elements have been studied for decades, but the results under past or existing conditions do not allow extrapolation to proposed operating scenarios. There are risk associated with any proposed measure to improve salmon survival, but decisions must still be made and the risk must be carefully weighed.

Specific areas where little data exists and further research and evaluation are necessary are presented below. Studies described include those presented by the U.S. Fish and Wildlife Service in their Planning Aid Report. The first section describes information required prior to a decision to implement drawdown. These types of information fall into three major categories: 1) necessary to understand what is occurring in the system under current operating conditions; 2) necessary baseline for comparison should a drawdown be implemented and need evaluation; and

3) critical information pertaining to survival necessary to determine risks associated with potential conditions under a drawdown and develop appropriate action plans.
If drawdown alternatives are considered further in the SCS Phase II, a field study of drawdown may be necessary to obtain better information for further evaluation. The second section describes information that possibly could be collected during a test.

(a) Prior to Any Field Drawdown Tests

- Determine survival and travel time through the system of reservoirs and at dams under full-pool conditions for subsequent decision-making and comparison.

- Determine travel time and survival of smolts through proposed test reaches under project operating scenarios equivalent to those proposed for test conditions.

- Complete estimates of survival under existing and proposed drawdown conditions using the FLUSH/ELCM, and compare to CRiSP/SLCM and PAM/SPM. Evaluate differences in results.

- Use fish models to estimate survival with all planned modifications to fish passage systems, and compare to drawdown estimates.

- Incorporate data obtained from studies in first bulleted item, and rerun all three sets of models. Evaluate the differences in results.

- Evaluate use, timing, and duration of juvenile salmonids' use of staging habitat in the lower Snake River.

- Evaluate the extent that subyearling fall Chinook use shoreline habitats for rearing in the lower Snake River.

- Evaluate the effects of turbine cavitation, shear flow, and draft tube vortices on smolt survival.

- Determine spatial (*i.e.*, vertical, horizontal, and lateral) distribution of migrating smolts at various flow regimes and subsequent effects of drawdown.

- Determine to what extent soft bottom benthic organisms and littoral zooplankton will be impacted by dewatering. This should include the potential for downstream entrainment of food sources used by resident and anadromous fish species.

- Determine whether salmonids obtain their food primarily from benthos inhabiting the riprap or soft-bottom habitat.

- Determine the importance of littoral zooplankton as food items.

- Develop the means to safely pass anadromous fish at proposed test project, and collect information that allows evaluation of the efficacy of drawdown.

- Develop a plan to evaluate both short- and long-term impacts of drawdown and the effects to water quality.

- Evaluate the factors contributing to the mortality of smolts during migrations from various tributaries to Lower Granite Dam.

- Evaluate estuarine conditions and dynamics with regards to smolt survival. Determine timing and survival to estuary of Columbia River Basin salmon stocks, lower Snake River stocks, and others.

- Evaluate chronic and sub-lethal effects of dissolved gas supersaturation on anadromous fish, including disorientation and reduced predator avoidance.

- Determine the relative importance of various food sources in salmonid predator avoidance.

- Quantify potential impacts to riparian and wetland vegetation, as well as the potential of seed germination and plant growth within the drawdown zone. Use this information to predict habitat losses and changes. Identify and evaluate potential mitigation sites.

- Evaluate bird species diversity and densities in habitats to be affected by drawdown.

- Survey wetland habitats for amphibians.

- Evaluate irrigation systems for continued irrigation of wildlife HMU's during drawdown.

- Survey native mollusk populations, including candidate species.

- Identify locations of rare, threatened, and endangered plants within the potentially affected area, and locate potential sites for the maintenance of plants.

- Evaluate aquatic furbearer use of lower Snake River reservoirs.

- Evaluate the potential of various strategies to minimize resident fish strandings.

(b) During a Drawdown Test

- Determine travel time and survival through reservoirs and at projects, and compare to full pool conditions.

- Assess the effects of dam modifications on adult and juvenile migration behavior, including adult fallback.

- Determine spatial (*i.e.*, vertical, horizontal, and lateral) distribution of migrating smolts at various flow regimes under drawdown, and compare to full pool conditions.

- Evaluate impacts of lowered pool elevations on smolt injury and descaling at VBS's and STS's.

- Monitor water velocity throughout the system during drawdown, and study the effects of velocity changes on migrating fish.

- Use computer modeling and additional data from field analysis to document relationships between storage volume, flow, and temperature. This should be integrated with the GIS database.

- Evaluate FGE.

- Determine distribution and food sources of salmonid predators. Evaluate the effects of crowding on predator and prey species during a drawdown.

- Monitor the effects of drawdown on wildlife habitat use, predation rates, and affected food webs.

- Evaluate to what extent the loss of riprap habitat will impact food sources and the habitat of resident fish species.

- Study how drawdown may disrupt or alter fish behavior, including migratory pathways, spawning habitat, and feeding areas of important fish species.

- Determine the relationships among nutrients, algal production, pelagic zooplankton production, and smolt bioenergetics. This may include modeling of the aquatic food chain under different operational conditions.

- Monitor changes in sedimentation rates during drawdown.

- Characterize the type and amount of substrate in the reservoirs and determine relationships to habitat requirements of important aquatic species.

- Evaluate the effects of construction on resident fish, food webs, and migrating fish.

(2) Biological Reservoir Drawdown Testing

If drawdown alternatives are further evaluated in Phase II, some testing, without full modifications of dams, could be prudent to guide subsequent decisions regarding the potential of various alternatives for improving salmon survival, including drawdown. The foremost uncertainties associated with reservoir drawdown are: 1) whether juvenile fish will respond to increases in average reservoir velocities and move through the system faster; and 2) if the cumulative changes in reservoir and dam passage survival for both juveniles and adults result in increased overall survival.

(a) Types

A one-pool drawdown may answer some of the questions regarding reservoir drawdown (*e.g.*, the response of juvenile fish, both in the reservoir environment and at the dams), but it does not allow evaluation of some potentially serious concerns that should be addressed. The primary area a one-pool drawdown does not cover is the change in tailwater elevations and the subsequent effects on juvenile and adult passage and survival. Lowering the tailwater, following modifications to the adult fish passage facilities, and the installation of drumgates in the stilling basin will change tailwater flow patterns, turbine environment conditions, and stilling basin flows and survival. To evaluate these conditions, a two-reservoir drawdown test, with noted dam modifications, would be necessary.

(b) Test Measurements

Because of the uncertainty surrounding the mechanisms by which reservoir drawdown may benefit salmon survival, there may be a lack of consensus about the appropriate variables to measure during a test drawdown and how to subsequently use the results. Any test results would have to be evaluated in light of the different hypotheses regarding the potential mechanisms for survival benefits. However, since baseline data for some of the hypotheses do not exist, and comparable data during a drawdown test would be difficult (if not impossible) to collect, it may not be possible to prove or disprove some of the hypotheses. For example, if an improvement in travel time can be measured in a one-reservoir drawdown test but survival through the reservoir does not change, it cannot be concluded that reservoir drawdown does not have some benefits. It could be that the benefit is gained in the estuary, and current technology does not allow the evaluation of this hypothesis.

Implementation of a test itself changes conditions from baseline, making it difficult to obtain even comparable travel data. The elimination of current sources of delay may mask results during a test. While some information regarding reservoir drawdown can be gained from a one-reservoir drawdown test, the ability to gain adequate information on which to base a decision about implementation from a test or series of tests is highly questionable. The potential risks to survival must be weighed in light of all information gained prior to any tests.

10.04. Economic Studies

Future study requirements that must be completed for any of the drawdown alternatives are considered for SCS Phase II.

a. Recreation

Reservoir fluctuations can adversely affect both water and land-based recreational facilities. Fixed water-based facilities (*i.e.*, boat ramps, swimming beaches, and moorage facilities) have very specific ranges of elevations where they can operate effectively. Any drawdown of Snake River reservoirs below minimum operating pool would eliminate the use of these facilities. In addition, changes in visitation associated with changes in reservoir levels tend to be concentrated among activities that are most dependent on facilities with specific operating ranges.

Site-specific information will need to be gathered for each recreation site. Visitation, the importance of each park site, and detailed topography (above and under water) in the vicinity of the park will be used to evaluate the level of mitigation suitable for each site.

Neither the variable pool alternatives nor the constant pool alternatives (both the 43- and the 52-foot drawdown) were specifically analyzed for the SCS Phase I.

b. Flood Control

Dworshak would be operated for local flood control under alternatives that require the drawdown of Snake River projects, and those designed to simulate natural river conditions. Under the natural river and constant pool, 33-foot drawdown alternatives, analysis revealed no damage to the city of Lewiston by a levee-overtopping event. Damages presented are associated with the reach located between the upstream end of the Lewiston Levees and Dworshak Dam.

Neither the variable pool alternatives nor the constant pool alternatives (both the 43- and the 52-foot drawdown) were specifically analyzed for the SCS Phase I.

c. Irrigation and M&I Water Use

The inventory of pump facilities, compiled by Anderson Perry and Associates, is extensive. However, they recommended that this inventory be verified for future detailed studies. An investigation of drawdown impact to existing wells in the vicinity of the Snake River will also be needed.

A predesign study considering other modification possibilities at each pumping station would be appropriate prior to actual modification.

It is possible that the increased power requirements may affect the power supply to the pumping station. If the high voltage supply and electrical substation at the pumping station size has been sized to fit only the existing requirements, the increase may also cause capital expenditures to the power utility supplying the station. Ownership and power service locations are unknown at this time, and will need to be identified when inventories are verified for future detailed studies.

If the variable pool option is considered further, a detailed investigation and engineering analysis of variable pump controls will be needed.

Acquisition and development of additional HMU's, under the Lower Snake River Fish and Wildlife Compensation Plan, is progressing. Development will include additional irrigation facilities not presently installed. Future irrigation developments potentially affected include 164 additional acres at Central Ferry HMU, and 162 additional acres potentially irrigated by well at Heneley HMU.

The variable pool alternatives were not specifically analyzed for the SCS Phase I.

d. Transportation/Navigation

Without physical modification to existing navigation locks, all navigation on the Snake River will cease.

Mitigation of navigation impacts includes the possibility of temporal shifts in the shipment of commodities, as well as alternative means of transportation. Additions to grain storage (both on-farm or offsite) may need to be built.

Neither the variable pool alternatives nor the constant pool alternatives (both the 43- and the 52-foot drawdown) were specifically analyzed for the SCS Phase I.

e. Power

Reservoir drawdowns at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Locks and Dams would reduce the operating head on the hydroelectric turbines, and reduce the power output of each powerhouse. Turbines would operate at less than optimum efficiency at this reduced head, further impacting hydroelectric production.

There are several options for replacing or offsetting hydropower losses, and all have their own economic and environmental consequences. In some cases, increased generating efficiency at existing facilities or increased energy conservation can offset hydropower generating losses. Alternatively, other resource types (*i.e.*, cogeneration, wind, solar, or nuclear power) can be used to replace hydropower losses. However, specifying exactly how losses will be replaced is not within the scope of this study.

Neither the variable pool alternatives nor the constant pool alternatives (both the 43- and the 52-foot drawdown) were specifically analyzed for the SCS Phase I.

Analysis will also be required on each of the following alternatives that did not receive the same degree of study afforded to alternatives 4A, 13, and 13A. Specifically, economic costs will need to be developed for recreation, flood damages, changes in net farm income, transportation costs, reservoir log-trucking, system generation, and implementation.

Alternative	**Description**
5	Variable Pool, existing powerhouse, existing spillway, 2- or 4.5-month duration
9	Variable Pool, modified powerhouse, existing spillway, 2- or 4.5-month duration
14	Constant Pool, 43 feet, modified spillways, 2- or 4.5-month duration
15	Constant Pool, 52 feet, new spillways, 2- or 4.5-month duration
18	Same as Alternative 14, but with modified powerhouse
19	Same as Alternative 15, but with modified powerhouse

A major source of concern is the subject of mitigation. If an alternative is implemented, what needs to be done to alleviate the losses caused by project construction, operation, maintenance, and replacement?

According to the Institute of Water Resources' Report 93-R-12, *National Economic Development Procedures Manual - National Economic Development,* "this cost category should now be expanded to include the costs of protecting, restoring, and enhancing fish and wildlife habitat as well as the costs of mitigating environmental losses. The costs of environmental resources planning, the collective name given to protection, restoration, enhancement, and mitigation measures, are as all inclusive as are the costs of any project. Mitigation/environmental resource costs consist of all the same cost elements (*e.g.*, construction and contingency?) as installation costs in general, and are NED project costs."

Per Engineer Regulation 1105-2-100, page 7-39, "mitigation includes:

1. Avoiding the impact altogether by not taking a certain action or part of an action;
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation;
3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;
5. Compensating for the impact by replacing or providing substitute resources or environments."

Environmental impacts do not include only impacts to fish, wildlife, water quality, or habitat, *etc.* Environmental impacts also include effects to recreation, flood control, irrigation, transportation, power, and cultural resources.

The subject of mitigation needs to be revisited for those categories that have been studied in Phase I, as well as for those categories that have not been addressed in Phase I (*i.e.*, recreation and cultural resource needs).

10.05. Mitigation

Detailed economic studies will be necessary to show that proposed mitigation measures are incrementally justified.

a. Navigation

Phase II studies will further address reservoir drawdown impacts to navigation.

b. Hydropower

Phase II studies will further address how hydropower generation losses will be replaced, as well as all associated costs.

c. Irrigation

Phase II studies will verify the Phase I assumption to install typical submersible pumps at each pumping station. A detailed survey of pumping facilities, including wells adjacent to the river, will be conducted to detail impacts and design.

The inventory of pumping facilities along the river prepared for the Phase I studies is extensive. However, this inventory needs to be verified for future detailed studies. Detailed investigations of drawdown impact to existing wells in the vicinity of the Snake River will also be needed.

It is possible that the increased power requirement may affect the power supply to the pumping station. If the high voltage supply and electrical substation at the pumping station site has been sized to fit only the existing requirements, the increase may also cause capital expenditures to the power utility supplying the station. Ownerships and power service locations are unknown at this time, and will need to be identified when inventories are verified for future detailed studies.

A predesign study considering other modification possibilities at each pumping station would be appropriate prior to actual modification.

d. Recreation

Studies and analysis of visitation will be required to determine the importance and value of each recreation site. Phase II visitation and economic analysis will play an important role in determining the level of modifications to existing recreation sites. Shoreline topography, above an below water, will be a major factor in siting relocated recreation facilities. Hydrographic surveys and topographic surveys will be required to locate and design facilities.

Visitation and topography will be used to evaluate the level of mitigation suitable for each recreation site.

e. Cultural Resources

Cultural resource studies for all alternatives will be conducted during Phase II studies.

Based on the results of the 1992 drawdown test, selected land forms for which no sites have been recorded, or at least a sample of such land forms, should be selected for resurvey during any future drawdowns. Such a strategy is necessary to ensure that any cultural resources missed during previous surveys can be located, properly recorded, and evaluated as necessary. There can be no doubt that many unrecorded sites are present in each reservoir that wen undetected prior to filling of the reservoirs. Some of these may prove significant and worth of additional work. If future monitoring efforts are directed solely on known cultural resources, many unrecorded sites will eventually be lost to erosion.

Coordination during the Phase II studies will continue up to, and during, all site testing, recovery, or in-place site protection. Major agencies and native American Indian tribes include the Washington State Historic Preservation Office, the Idaho State Historic Preservation Office, the Advisory Council on Historic Preservation, the Nez Perce Indian Tribe, the Confederated Tribes of the Umatilla Indian Reservation, and the Yakima Indian Nation.

10.06. System Operations

To be added.

Section 11 - Summary/Conclusions

11.01. General

Twenty drawdown alternatives were identified and screened for feasibility. The alternatives identified included drawdowns ranging from 33 feet below maximum normal operating pool levels to alternatives that attempt to restore near-natural flow conditions. During initial screening, twelve alternatives were found to be unsuitable, as determined by the TAG, and were eliminated. One additional alternative, the Natural River Option, was added. Another alternative, involving a single reservoir drawdown (Lower Granite), was later added by NPPC's Drawdown Committee.

Alternatives that propose spillway-only operations were found to be not feasible because of the adverse impact on adult fish passage and associated high dissolved gas levels. These alternatives were eliminated from further consideration. Additionally, variable pool alternatives that require turbine operation below existing spillway crest elevations were eliminated due to unacceptable impacts to turbines, as well as the high potential for unacceptable impacts to fish bypass system components.

Ten alternatives were evaluated in additional detail, and were discussed throughout this Technical Report.

11.02. Structural Modifications

Each of the drawdown alternatives require significant modifications to various features at each of the four lower Snake River dams. Features requiring modification to accommodate drawdown operations include adult fish passage facilities, juvenile fish bypass facilities, spillways, and turbines. For some alternatives, new structures must be added. Additionally, features such as navigation lock guide walls and debris shear booms will require modification. Earth embankments, railroad fills, highway fills, and culvert outfalls will require additional riprap protection to accommodate drawdown operations.

11.03. Implementation Costs and Schedules

a. Costs

The reconnaissance-level, fully-funded project costs, including real estate, for the drawdown alternatives range from an estimated $87.2 million to $4.9 billion. The construction costs are based on an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, model studies, DM's, and engineering and design are included at an estimated 28 percent of construction costs. Construction management is estimated at 11 percent of construction costs. Contingencies used reflect the anticipated level of construction risk, unknowns, and the level of design detail available for this study.

Estimated annual costs range from $3.6 million to $142.2 million. These costs include interest and amortization of the project costs at8-percent interest rate (current Federal Discount rate), and a project life of 100 years. In addition, increased operation, maintenance, and replacement costs are included.

These costs do not include required modifications to irrigation plants, recreation facilities, port facilities, costs of measures to project cultural resources exposed during drawdown operations, or hydropower losses.

The costs do not include modifications required to allow the four Lower Snake River dams to operate under the proposed drawdown levels, while still providing effective fish bypass. The costs also include modifications to protect structures, levees, railroads, highways, and drainage systems while the projects are operating under drawdown conditions.

These costs are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation.

b. Implementation

The implementation of drawdown will vary depending on the alternative selected. Modifications to the four lower Snake River dams to accommodate a four-reservoir drawdown are anticipated to take from 14 to 17 years to fully implement, assuming unlimited resources. Modifications to accommodate drawdown operations of the Lower Granite reservoir only (alternative 13A) are anticipated to take about 4 years. Resource limitations such as manpower, money, or materials may extend these time periods.

11.04. Economic Effects

An economic analysis for each of the drawdown alternatives was completed. The analysis examined both a 2- and a 4½-month drawdown period for each of the alternatives. The net economic costs of the alternatives range from $76 million to $193 million annually. The incremental costs (net economic costs) are the additional cost of the drawdown alternative as compared to existing conditions.

However, it should be noted that these are not the entire costs associated with each alternative. No attempt was made to place monetary values on the endangered anadromous fish or their habitat. Mitigation costs for recreation and cultural resources also must be examined in the overall evaluation of the true cost of an alternative. The mitigation costs that are offered in this report are offered for consideration, and to show the possible scope of mitigation required. These subject areas all warrant additional detailed study.

11.05. Environmental Effects

a. Anadromous Fish

Reservoir drawdown has potential positive and negative impacts to anadromous fish. Lowering pool elevations will result in substantially changed conditions throughout the reservoir system, including water quality, velocity, and at dam passage facilities. Changes will occur during construction as well as operation. Some water quality conditions may be poorer during the first few years after implementation, while others would potentially be poorer than existing every year, depending upon the reservoir drawdown alternative.

The increase in average reservoir velocity resulting from drawdown has the potential to reduce juvenile fish travel time through the lower Snake reservoirs. However, whether or not the fish will respond to the change in average velocity and, if so, how much, is uncertain. Mathematical models were used to predict the change in travel times, which were greatest for spring Chinook. For the near spillway crest alternatives, reductions of 14 to 32 percent were predicted for spring Chinook salmon, depending upon the assumptions used in the model, and the flow (critical water year and the 50-year average were modeled). Reductions in travel time for summer and fall Chinook were predicted, but were less substantial. There are many uncertainties with the assumptions and data used in the models, since there are many factors affecting fish travel time. In addition, the models do not take into account potential increased delay at the dams, or the effects of refill operations. The natural river option has the greatest potential for reducing juvenile fish travel time through the lower Snake reservoirs. Overall travel time from above Lower Granite to below Bonneville was estimated to be reduced as much as 48 percent (using the PAM model).

All near spillway crest alternatives are likely to increase adult travel time. The net effect of the natural river option on adults is uncertain. Increases in average velocity through the reservoir stretch will increase the amount of time it takes adults to pass through what was formerly a pool area, but the elimination of time required to find and pass through adult fish passage facilities at the dams may result in a net decrease in travel time.

The relationship between juvenile travel time and survival is not clear. While there is a potential to increase juvenile salmon survival through a reduction in travel time resulting from lowered pool elevations, there are many factors that affect survival, and many of these may also be affected by drawdown. Negative impacts to juvenile and adult salmonids can occur during both construction of the modifications required to implement drawdown and during operation of the various drawdown scenarios. Dam passage facilities would be designed with state-of-the-art knowledge, but this is based on current operating conditions. Drawdown will result in substantial changes to project operating conditions. The effects of these changes on adult and juvenile travel time and survival are uncertain but are, based on initial evaluation, likely to have negative impacts.

Mathematical models were used to try to predict relative potential benefits of the proposed drawdown scenarios. The primary purpose of the salmon survival models is not to predict actual numbers of surviving juveniles, but to compare the results of different alternatives and options. The models used represent a range in interpretation of the existing flow, juvenile travel time, and survival data. However, there are many factors that these models do not take into account, or for which no data applicable to a drawdown scenario is available.

Increased migration rate (*e.g.*, decreased travel time) is expected to potentially increase the survival of smolts through the reservoir environment mainly because of the potential for decreased contact with predators. However, if overall smolt survival is to be increased, passage mortality must not be increased from current levels. Thus, smolt mortality during each route of dam passage (*i.e.*, bypass, turbine, and spill mortality) must not increase markedly during drawdown. Intuitively, the natural river option would decrease travel time, and decrease mortality from dam passage. No other alternatives would satisfy these assumptions, and expected benefits (if any) from implementation are debatable. The model results verify these conclusions. Based on existing mathematical models, only the natural river option shows a potential benefit, and then only to spring and summer Chinook stocks. Survival under any of the drawdown alternatives has not been compared with survival once all currently planned adult and juvenile fish facility improvements are complete.

b. Resident Fish

Some resident fish species could benefit by the increased riverine habitat resulting from reservoir drawdown, while others could be impacted by the substantial water surface elevation changes during or following spawning activities. The extent of effects, both positive and negative, depend on the depth of the drawdown and the duration, which includes the flow conditions at the time of refill. Constant pool alternatives would have less negative impact than the variable pool alternatives. The natural river option would be more beneficial for native species than for introduced game species.

c. Wildlife

Wildlife habitat would be affected by the loss of hydrologic connection to the main river channel. The water supply for vegetation would be interrupted due to changes in the river channel and the water table.

Potential impacts to waterfowl nesting in the lower Snake River include: 1) reduction in nesting habitat or inundation of nests during the breeding season; 2) increased rates of predation due to land bridging; and 3) decreased forage (*e.g.*, benthic invertebrates) in shallow-water areas. In addition, water-level fluctuations can affect brood success through decreases in food availability or increases in energy demand caused by increased travel between feeding areas and cover. When complete drawdown occurs, aquatic invertebrates are eliminated or greatly reduced, and feeding conditions for breeding waterfowl deteriorate rapidly.

Impacts to raptors are not anticipated to be severe because raptor species occurring in the lower Snake River generally use cliff and riparian habitat for nesting and perching, and forage in upland fields. The timing and duration of drawdown would have a greater impact on raptors due to the lost production of prey species that inhabit embayments, shallow-water areas, and riparian and wetland habitats during raptor breeding and nesting season. The overall goal, which is to increase smolt survival and the number of adults returning to the lower Snake River system, should provide the long-term benefit of increasing anadromous fish stocks for bald eagle foraging. Negative long-term effects on wintering bald eagles may result from the decreased production of waterfowl associated with reduced nesting habitat and reduced numbers of upland game birds.

It is anticipated that upland game bird habitat may be impacted by a drawdown. Effects to upland game bird habitat would be largely related to changes in riparian vegetation or changes in current land use on uplands adjoining the projects.

Insects, reptiles, and amphibians that are reliant on moist soils or waters of riparian and wetland habitats may be impacted by a drawdown. Because many of these species rely on microsites, impacts could be manifested in the loss or permanent displacement of the species.

Although a majority of small mammals are able to relocate temporarily, continued fluctuation of water levels would likely displace species permanently or result in reduced overall production potential. Impacts to furbearers as a result of drawdown will include the exposure of muskrat, beaver, and river otter dens during breeding season, a reduction in riparian and wetland habitat, and the exposure of riprap den sites. In addition to the exposure of furbearers along project shorelines, the change in spatial distribution of vegetation within riparian habitat may influence species-specific foraging efficiency (*e.g.*, beavers). The primary effects to mule deer would be associated with a reduction in riparian habitat and increased distance from forage to cover.

11.06. Mitigation Opportunities

All reservoir drawdown alternatives will impact natural resources, cultural resources, and commerce. The mitigation measures described in this report identify the means of dealing with the impacts associated with the reservoir drawdown alternatives. It is not the intent of this report to provide an in-depth impact assessment of each drawdown alternative or to present detailed mitigation measures. Where it is not possible to develop specific mitigation measures, sufficient data was collected to identify the magnitude of potential implementation or alternative action and cost.

The NPPC, in amendments to the Columbia River Basin Fish and Wildlife Program (Phase Two), calls for development of a mitigation plan consisting of measures to mitigate the impact of the reservoir drawdown strategy to the greatest extent practicable. This report addresses those measures and identifies the magnitude of mitigation actions. Mitigation and/or enhancement opportunities identified in the Fish and Wildlife Planning Aid Report, prepared by the U.S. Fish and Wildlife Service, were also taken into consideration.

All navigation on the Snake River would case during reservoir drawdowns unless physical modifications are made to existing navigation locks, the river channels below each lock and dam, and the existing port facilities; as well as creating a fleet of small barges. Based on limited opportunities, the magnitude of physical modifications to mitigate the impact to navigation, and the potential need for a second fleet of smaller barges; physical modifications to maintain barge traffic during reservoir drawdowns are not considered. It is assumed that commodities would be shipped by an alternative method (either truck or rail), or not shipped at all during reservoir drawdowns.

Reservoir drawdowns would reduce the operating head on the turbines, thus impacting hydroelectric production. Physical modifications to turbines and generators to improve efficiency and output are under consideration. However, such modifications will not mitigate the loss; they will only reduce hydropower generation losses. This report identifies the hydropower losses in terms of combustion turbines as a resource that would be acquired to meet system electrical load in months when system hydropower generation is decreased. Specifying exactly how losses will be replaced was not addressed by the SOR, and is not within the scope of this Phase I report.

Investigations revealed 31 active pumping facilities along this nearly 150-mile section of the lower Snake River. Twenty-nine of these stations will require some revisions to allow them to operate under the proposed drawdown alternatives. For the purpose of this study, it is assumed that all pump stations are vertical turbine platform stations, because the data collected shows that only two of the smaller stations vary from this design. The predominant modification recommended is to install low-head, submersible pumps to pump water from drawdown elevations to the existing pumping facilities. Construction costs range from $29 to $33 million for constant and variable pool drawdowns. The construction cost for a near natural river drawdown is about $38 million.

In addition to direct pumping from the river, a limited amount of irrigation comes from wells that pump from gravel benches along the river. The rate of withdrawal, depth of the well, proximity to the river, and duration of drawdown would affect the output of these wells. The analysis of this potential impact and mitigation is beyond the scope of this reconnaissance-level study.

Data collection suggests that overall recreation activity at the Snake River recreation sites during drawdowns will be less than half of historic visitation. Mitigation for this effect ranges from complete rebuilding of park sites to providing only boat launching facilities for drawdown elevations. The choice between rebuilding a site or installing only boat launching facilities will depend on the recreation value of each site and the topography of the shoreline. Estimated construction costs may range from $23 million to about $46 million.

Mitigation of potential cultural resource damage would include testing each identified site, and choosing between recovery of artifacts and data or *in situ* protection of the site. The choice of recovery or protection can only be determined following testing of each site after reservoir drawdown is completed. A total of 109 sites are known to exist under constant pool conditions, and 145 known sites would be exposed at near natural river conditions. Based on the number of sites, limited drawdown time, and availability of archaeologists, mitigation activities could take about 9 years for constant pool conditions and about 14 years for the near natural river conditions. The cost of mitigating cultural resources by testing and data recovery is about $82 million. Testing and protection-in-place is about $187 million for constant pool conditions. Mitigation costs for near natural river conditions are about $111 million for testing and recovery, and about $334 million for testing and *in situ* protection.

Generally, the construction of mitigation measures would be completed during the same time period that other modifications are made to the Snake River projects. However, portions of mitigation work for pumping facilities, recreation facilities, and cultural resources can only be accomplished once the reservoirs are in a drawdown condition.

11.07. System Operation Studies

System operation studies were conducted using BPA's computer program, HYDROSIM, which is a program for computing power production. A number of alternatives were evaluated to show the effects on reservoir elevations and power production in the Columbia River system. There are two drawdown periods: 15 April through 15 June; and 15 April through Labor Day. The Columbia River system was modeled using a continuous operation (the results at the end of one year would be the starting condition for the next year). The computational period for each condition is from water year 1929 through water year 1978.

11.08. Additional Required Studies

If lower Snake reservoir drawdown is selected as an alternative to be further evaluated in the feasibility phase of the SCS, additional work will be necessary to provide more data to evaluate the concept. Engineering, environmental, system operation, economic, and mitigative studies will be initiated to further define and quantify unknown parameters.

11.09. Conclusions

All drawdown alternatives will require substantial modifications to each of the four lower Snake River dams, except for alternative 13A, which requires modifications to Lower Granite Dam only. Construction cost estimates for the four reservoir drawdown alternatives range between $1.3 billion to $4.9 billion. The construction cost estimates for alternative 13A is $87.2 million. These costs are based on the October 1992 price level adjusted for inflation to midpoint of construction (using OMB inflation factors).

For the four reservoir drawdown alternatives, implementation timeframes are long, ranging from 14 to 17 years from the date authorization is enacted and construction funds are appropriated to construction completion. For the Lower Granite only alternative, implementation is anticipated at 4 years.

Economic effects of the four reservoir drawdown alternatives are substantial. The net economic costs of the drawdown alternatives range from $3.6 million (alternative 13A) to $142.2 million (alternative 4A) annually. These economic costs include both the cost of construction, as well as direct and indirect economic impacts to other system users. The economic costs include modification costs, recreation impacts, flood damage reduction charges, losses to farm income, impacts to M&I water supply, increases in transportation, and hydropower costs. These costs do not include potential mitigation opportunities for recreation, cultural resources, and fish and wildlife.

There are many negative environmental impacts that would result from implementation of all reservoir drawdown alternatives. Impacts to resident fish and wildlife could potentially be mitigated by year-round drawdowns. However, using modeling results and currently-limited biological information and judgement, only the natural river option shows a consistent potential benefit for anadromous fish, with the exception of fall Chinook. Percent relative change from the base case for each of the alternatives is summarized in tables 11-1 (critical water years) and 11-2 (50-year average).

Table 11-1
Predicted Change in Relative Survival From Base Case for Drawdown Alternatives in Critical Water Conditions From the Head of Lower Granite Reservoir to Below Bonneville Dam

Stock	Four-Pool 33-Foot Drawdown "Worst Case"	Four-Pool 33-Foot Drawdown "Best Case"	Four-Pool 33-Foot Drawdown No Changes in Dam Passage Parameters	Four-Pool 52-Foot Drawdown "Worst Case" (PAM Only)	Four-Pool 52-Foot Drawdown "Best Case" (PAM), or No Change in Dam Passage Parameters (CRiSP)	Four-Pool Variable Pool Drawdown No Changes in Dam Passage Parameters	Natural River Option	Lower Granite Only, With No Changes in Dam Passage Parameters (CRiSP) or "Best" and "Worst" Case (PAM)
Spring Chinook (CRiSP)	-25	-4 to 8[2]	-10.9 to -12.3[2]	Not run	-7.8 to -8.8[2]	-7.6 to -7.9[2]	+8 to +11[2]	+3
Spring Chinook (PAM)[1]	-9.2 to -15.7	-1 to -7.5	Not run	-6 to -12.5	+5 to -1.5	Not run	-0.4 to +6.1	-0.7 to +6.3
Summer Chinook (CRiSP)	-25	-5	-10.9 to -11.2[2]	Not run	-7.9 to -8.9[2]	-7.7 to -7.9[2]	+8 to +9[2]	+2
Fall Chinook (CRiSP)	-29	-19 to -21[2]	Not run	Not run	Not run	Not run	-14 to -15[2]	+1 to +3[2]
Dworshak Steelhead (CRiSP)	-33	-17 to -18[2]	-16.6 to -17.6[2]	Not run	-11.3 to -13.2[2]	-2.2 to -12.5[2]	-1	+1

[1] Results are in a range because of two different assumptions about transport benefits. See SOR anadromous fish technical appendix.

[2] Results are in a range representing the 2- and 4.5-month scenarios. The PAM cannot model fall Chinook, therefore no 4.5-month scenarios were run.

Table 11-2
Predicted Change in Relative Survival
From Base Case for Drawdown Alternatives Over 50-Year Average Conditions
From the Head of Lower Granite Reservoir to Below Bonneville Dam

Stock	Four-Pool 33-Foot Drawdown "Worst Case"	Four-Pool 33-Foot Drawdown "Best Case"	Four-Pool 33-Foot Drawdown No Changes in Dam Passage Parameters	Four-Pool 52-Foot Drawdown "Worst Case" (PAM Only)	Four-Pool 52-Foot Drawdown "Best Case" (PAM), or No Change in Dam Passage Parameters (CRiSP)	Four-Pool Variable Pool Drawdown No Changes in Dam Passage Parameters	Natural River Option	Lower Granite Only, With No Changes in Dam Passage Parameters (CRiSP) or "Best" and "Worst" Case (PAM)
Spring Chinook (CRiSP)	-25	-4	-10.5	Not run	Not run	-8.1 to -8.3[2]	+7 to +8[2]	+2
Spring Chinook (PAM)[1]	-3.7 to -9.7	+7.7 to +13.7	Not run	-1.9 to -7.9	+10.8 to +16.8	Not run	+11.4 to +17.4	=1.4 to +5.8
Summer Chinook (CRiSP)	-24	-1	-9.2 to -9.4[2]	Not run	Not run	-7 to -7.2[2]	+10	+2
Fall Chinook (CRiSP)	-40	-24 to -26[2]	Not run	Not run	Not run	Not run	-11 to -13[2]	+3 to +4[2]
Dworshak Steelhead (CRiSP)	-36	-20 to -21[2]	-13.7 to -13.8[2]	Not run	Not run	-10.7 to -10.8[2]	+2	+2

[1] Results are in a range because of two different assumptions about transport benefits. See SOR anadromous fish technical appendix.

[2] Results are in a range representing the 2- and 4.5-month scenarios. The PAM cannot model fall Chinook, therefore no 4.5-month scenarios were run.

Two mathematical models were used to attempt to quantify the potential relative benefits of reservoir drawdown alternatives. The models were run with a range of assumptions about the survival benefits of reduced juvenile travel time. Both were run with sets of optimistic and pessimistic reservoir mortality and dam passage parameters as a sensitivity analysis. Model results from the Passage Analysis Model (PAM) for Snake River spring Chinook indicated a potential benefit resulting from a maximum increase in juvenile fish survival of 14 percent for the four pool, 33-foot drawdown, and 16 percent for the 52-foot drawdown over the 50-year average water conditions, assuming dam passage conditions that are substantially better than those currently existing (which is unlikely, given current information). However, in low-water years, PAM showed no measurable benefits and a potential decline in survival, even with optimistic dam passage conditions assumed (a maximum of 5-percent increase in juvenile survival for the 52-foot drawdown, and as much as a 15-percent decrease in juvenile survival for the 33-foot drawdown). The CRiSP model results did not indicate any potential benefits for the four-pool, near spillway crest alternatives. They also indicated substantial losses for fall Chinook, even with optimistic dam passage and reservoir mortality assumptions. The models do not account for many of the variables [see section 6.03.d.(1)(c)] that could have additional substantial negative impacts on anadromous fish survival as a result of drawdown.

The only near spillway crest drawdown alternative to show possible marginal benefits for all stocks was the Lower Granite only option, with transport. The CRiSP model showed only a 1- to 5-percent increase in juvenile survival for this alternative, but these results could change with dam passage parameters adjusted to reflect worsened conditions for collection and bypass hydraulics during a drawdown. Survival could be substantially worse with these hydraulic changes associated with drawdown than under existing conditions, especially for spring Chinook. The PAM showed a maximum gain of 6 percent under best case assumptions, and a potential loss of approximately 1 percent under worst case assumptions. With those results considered, the Lower Granite only alternative does seem to have some potential as an upstream collector for transportation, and should be compared to the other collector options in the SCS summary report.

Both CRiSP and PAM showed potential benefits for spring and summer Chinook juveniles under the natural river option, for both the critical water period and the 50-year average. The CRiSP showed higher potential benefits in the critical water year (11 percent for spring Chinook and 10 percent for summer). The PAM modeling resulted in extremes of no change for spring Chinook to a gain of 6 percent, depending on assumptions regarding transport. The CRiSP estimated at 11- to 15-percent reduction in survival for fall Chinook, and no substantial change for steelhead (-1 to +2 percent).

While there are many uncertainties regarding the model parameters and results that could be tested and further refined, it is highly unlikely that these refinements would produce substantial additional benefits for drawdowns below minimum operating pool to spillway crest. The PAM model utilizes a strong positive relationship between flow and survival, and ascribes relatively low benefits to transportation. These are the two main variables where changes would drive higher benefits for drawdown alternatives. It is very unlikely that further studies would modify these relationships to an extent that would result in higher potential benefits for minimum operating pool to spillway crest reservoir drawdowns. Tests of drawdown could only affirm the flow/travel time/survival relationship used in the PAM model, but this would not increase the potential benefit that PAM modeling would show for drawdown. Potential detrimental effects on survival not accounted for by the models, including construction, drafting, refill, adult fish passage changes, and other areas of impact all could adjust both model results (PAM and CRiSP) substantially downward. In addition, the base case (for both PAM and CRiSP) used for comparison did not incorporate the potential benefits of ongoing improvements to existing fish passage facilities, including new juvenile fish bypass systems at Ice Harbor and The Dalles Dams, and extended length screening devices at Lower Granite, Little Goose, and McNary Dams, *etc.* Adjusting dam passage parameters to reflect these improvements would result in higher survival for the base case, and a reduced potential improvement for reservoir drawdown alternatives.

Based on the identified potential impacts, as presented in the qualitative discussions contained in this report, the results of the fish models (with current limitations and assumptions) as a means for comparing potential relative benefits, and the limited utility of a test drawdown to obtain definitive information that would enhance the potential benefit that would reasonably be expected from minimum operating pool to near spillway crest drawdowns.

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Tables

Table 1
Proposed Alternatives

Number	Description	Drawdown Level (Feet)
Variable Pool--No Powerhouse Operation[1]		
1	Existing Spillway Only	28 to 57
2	Modified Spillway Only	38 to 67
3	New Low-Level Spillway Only	52 to 76
4	Auxiliary Regulating Outlet (ARO) Only	>76
Variable Pool With Existing Powerhouse		
5	Existing Powerhouse With Existing Spillway	28 to 57
6	Existing Powerhouse With Modified Existing Spillway	38 to 67
7	Existing Powerhouse With New Low-Level Spillway	52 to 76
8	Existing Powerhouse With ARO	>76
Variable Pool With Modified Powerhouse		
9	Modified Powerhouse With Existing Spillway	28 to 57
10	Modified Powerhouse With Modified Existing Spillway	38 to 67
11	Modified Powerhouse With New Low-Level Spillway	52 to 76
12	Modified Powerhouse With ARO	>76
Constant Pool With Existing Powerhouse		
13	Existing Powerhouse With Existing Spillway	33
14	Existing Powerhouse With Modified Existing Spillway	43
15	Existing Powerhouse With New Low-Level Spillway	52
16	Existing Powerhouse With ARO	52
Constant Pool With Modified Powerhouse		
17	Modified Powerhouse With Existing Spillway	33
18	Modified Powerhouse With Modified Existing Spillway	43
19	Modified Powerhouse With New Low-Level Spillway	52
20	Modified Powerhouse With ARO	52

[1] For reference, a 57-foot drawdown represents an upstream pool at a level equal to the existing spillway crest at Lower Granite Dam.

Table 2
Initial Screening

No.	Description	Drawdown Level (Feet)	Recommended For Further Study
Variable Pool--No Powerhouse Operation[1]			
1	Existing Spillway Only	28 to 57	Eliminated
2	Modified Spillway Only	38 to 67	Eliminated
3	New Low-Level Spillway Only	52 to 76	Eliminated
4	Auxiliary Regulating Outlet (ARO) Only	>76	Eliminated
4A	Natural River Option	Near Freeflow	Added
Variable Pool With Existing Powerhouse			
5	Existing Powerhouse With Existing Spillway	28 to 57	Yes
6	Existing Powerhouse With Modified Existing Spillway	38 to 67	Eliminated
7	Existing Powerhouse With New Low-Level Spillway	52 to 76	Eliminated
8	Existing Powerhouse With ARO	>76	Eliminated
Variable Pool With Modified Powerhouse			
9	Modified Powerhouse With Existing Spillway	28 to 57	Yes
10	Modified Powerhouse With Modified Existing Spillway	38 to 67	Eliminated
11	Modified Powerhouse With New Low-Level Spillway	52 to 76	Eliminated
12	Modified Powerhouse With ARO	>76	Eliminated
Constant Pool With Existing Powerhouse			
13	Existing Powerhouse With Existing Spillway	33	Yes
13A	Existing Powerhouse With Existing Spillway--Lower Granite Only	33	Yes
14	Existing Powerhouse With Modified Existing Spillway	43	Yes
15	Existing Powerhouse With New Low-Level Spillway	52	Yes
16	Existing Powerhouse With ARO	52	Eliminated
Constant Pool With Modified Powerhouse			
17	Modified Powerhouse With Existing Spillway	33	Yes
18	Modified Powerhouse With Modified Existing Spillway	43	Yes
19	Modified Powerhouse With New Low-Level Spillway	52	Yes
20	Modified Powerhouse With ARO	52	Eliminated

[1] For reference, a 57-foot drawdown represents an upstream pool at a level equal to the existing spillway crest at Lower Granite Dam.

Table 3
Project Modifications

Modifications	Alternative								
	4A	5	9	13	14	15	17	18	19
Lower Granite Dam									
Existing Spillway									
Lower Crest[1]					X			X	
Drum Gate[2]					X			X	
Stilling Basin[2]	X	X	X	X		X	X		X
Gates/Hoists					X			X	
Adult Fish Passage									
New Adult Ladder	X	X	X	X	X	X	X	X	X
Secondary Ladder Exit		X	X	X	X	X	X	X	X
Auxiliary Exit	X	X	X	X	X	X	X	X	X
Entrance and Collection System[2]	X	X	X	X	X	X	X	X	X
Powerhouse									
New Turbine Runners			X				X	X	X
New Spillway[1]									
Six New Bays with Gates						X			X
Juvenile Fish Passage									
Collection Channel		X	X	X	X	X	X	X	X
Vertical Barrier Screens		X	X	X	X	X	X	X	X
Transportation Channel		X	X	X	X	X	X	X	X
River Bypass									
Bypass Structure[1]	X								
Channel Extension	X								
Embankment Protection									
Dam Embankments Railroad, Highway Fills Levees	X	X	X	X	X	X	X	X	X
Miscellaneous Modifications									
Nav Lock Guide Wall Debris Shear Boom Culvert Outfalls	X	X	X	X	X	X	X	X	X
Real Estate Acquisition and Relocations									
Roads/Railroads Visitor Facilities	X					X			X

Little Goose Dam

Existing Spillway									
Lower Crest[1] Drum Gate[2] Stilling Basin[2] Gates/Hoists	X X	X X	X X	X X	X X X X	X X	X X	X X X X	X X
Adult Fish Passage									
New Adult Ladder	X	X	X	X	X	X	X	X	X
Secondary Ladder Exit		X	X	X	X	X	X	X	X
Auxiliary Exit	X	X	X	X	X	X	X	X	X
Entrance and Collection System[2]	X	X	X	X	X	X	X	X	X
Powerhouse									
New Turbine Runners			X				X	X	X
New Spillway[1]									
Six New Bays with Gates						X			X
Juvenile Fish Passage									
Collection Channel		X	X	X	X	X	X	X	X
Vertical Barrier Screens		X	X	X	X	X	X	X	X
Transportation Channel		X	X	X	X	X	X	X	X
River Bypass									
Bypass Structure[1]	X								
Channel Extension	X								
Embankment Protection									
Dam Embankments Railroad, Highway Fills Levees	X	X	X	X	X	X	X	X	X
Miscellaneous Modifications									
Nav Lock Guide Wall Debris Shear Boom Culvert Outfalls	X	X	X	X	X	X	X	X	X
Real Estate Acquisition and Relocations									
Roads/Railroads Visitor Facilities	X					X			X

Lower Monumental Dam

Existing Spillway									
Lower Crest[1]					X			X	
Drum Gate[2]					X			X	
Stilling Basin[2]	X	X	X	X		X	X		X
Gates/Hoists					X			X	
Adult Fish Passage									
New Adult Ladder									
Secondary Ladder Exit		X	X	X	X	X	X	X	X
Auxiliary Exit	X	X	X	X	X	X	X	X	X
Entrance and Collection System[2]	X	X	X	X	X	X	X	X	X
Powerhouse									
New Turbine Runners			X				X	X	X
New Spillway[1]									
Six New Bays with Gates						X			X
Juvenile Fish Passage									
Collection Channel		X	X	X	X	X	X	X	X
Vertical Barrier Screens		X	X	X	X	X	X	X	X
Transportation Channel		X	X	X	X	X	X	X	X
River Bypass									
Bypass Structure[1]	X								
Channel Extension	X								
Embankment Protection									
Dam Embankments									
Railroad, Highway Fills	X	X	X	X	X	X	X	X	X
Levees									
Miscellaneous Modifications									
Nav Lock Guide Wall									
Debris Shear Boom	X	X	X	X	X	X	X	X	X
Culvert Outfalls									
Real Estate Acquisition and Relocations									
Roads/Railroads									
Visitor Facilities	X					X			X

Ice Harbor Dam

Existing Spillway									
Lower Crest[1]					X			X	
Drum Gate[2]									
Stilling Basin[2]									
Gates/Hoists					X			X	
Adult Fish Passage									
New Adult Ladder Secondary Ladder Exit Auxiliary Exit Entrance and Collection System[2]	X	X X	X X	X X	X X	X X	X X	X X	X X
Powerhouse									
New Turbine Runners			X				X	X	X
New Spillway[1]									
Six New Bays with Gates						X			X
Juvenile Fish Passage									
Collection Channel		X	X	X	X	X	X	X	X
Vertical Barrier Screens		X	X	X	X	X	X	X	X
Transportation Channel		X	X	X	X	X	X	X	X
River Bypass									
Bypass Structure[1]	X								
Channel Extension	X								
Embankment Protection									
Dam Embankments Railroad, Highway Fills Levees	X	X	X	X	X	X	X	X	X
Miscellaneous Modifications									
Nav Lock Guide Wall Debris Shear Boom Culvert Outfalls	X	X	X	X	X	X	X	X	X
Real Estate Acquisition and Relocations									
Roads/Railroads Visitor Facilities	X					X			X

[1] Requires both upstream and downstream cofferdams.

[2] Requires downstream cofferdams only.

Table 4
Existing Conditions Without Weirs - Little Goose in Drawdown Mode

Discharge (In cfs)	Water Surface Elevation At RM 06.63 (Feet msl)	Lower Granite Tailwater	Maximum Velocity In Reach (fps)	Minimum Velocity In Reach (fps)	Minimum Navigation Clearance (In feet)
20000	614.6	617.9	9.0	2.6	*
46000	618.6	621.5	9.9	3.9	*
80000	622.4	625.1	0.3	5.1	*
120000	625.8	628.6	11.3	6.1	*
160000	628.6	631.6	12.2	7.0	*
240000	633.2	636.6	13.9	8.4	*

*No navigation in Drawdown Mode

Table 5
Existing Conditions Without Weirs - Little Goose at Minimum Operating Pool Level
(Forebay Elevation = 633)

Discharge (In cfs)	Water Surface Elevation At RM 06.63 (Feet msl)	Lower Granite Tailwater	Maximum Velocity In Reach (fps)	Minimum Velocity In Reach (fps)	Minimum Navigation Clearance (In feet)
20000	633.0	633.1	1.2	0.8	22.0
46000	633.2	633.4	2.7	.7	22.2
80000	633.7	634.1	4.5	2.9	22.7
120000	634.5	635.3	6.5	4.1	23.5
160000	635.5	636.7	8.2	5.1	24.6
240000	638.0	639.9	11.1	6.7	27.0

Table 6
Existing Conditions Without Weirs - Little Goose at Maximum Operating Pool Level
(Forebay Elevation = 638)

Discharge (In cfs)	Water Surface Elevation At RM 06.63 (Feet msl)	Lower Granite Tailwater	Maximum Velocity In Reach (fps)	Minimum Velocity In Reach (fps)	Minimum Navigation Clearance (In feet)
20000	638.0	638.0	0.9	0.6	27.0
46000	638.1	638.2	2.1	1.4	27.1
80000	638.4	638.6	3.6	2.4	27.4
120000	638.9	639.4	5.3	3.4	27.9
160000	639.6	640.3	6.9	4.4	28.6
240000	641.3	642.7	9.6	6.0	30.3

Table 7
Two-Weir System - Little Goose Reservoir in Drawdown Mode

Discharge (In cfs)	Weir Number	Downstream Elevation (Feet msl)	Upstream Elevation (Feet msl)	Difference Between U/S and D/S Elevation (Feet)	Velocity (fps)	Minimum Navigation Clearance (In feet)
20000	2	617.0	624.6	7.6	8.8	*
	1	624.7	630.3	5.6	8.3	*
46000	2	620.5	627.2	6.7	11.5	*
	1	627.4	632.8	5.4	11.0	*
80000	2	624.0	629.8	5.8	13.7	*
	1	630.1	635.3	5.2	13.2	*
120000	2	627.4	632.3	4.9	15.6	*
	1	632.8	637.7	4.9	15.1	*
160000	2	630.3	634.5	4.2	17.2	*
	1	635.2	639.9	4.7	16.6	*
240000	2	635.1	638.3	3.2	19.6	*
	1	639.3	643.7	4.4	19.0	*

*No navigation in downstream mode.

Table 8
Two-Weir System - Little Goose Reservoir at Minimum Operating Pool Level

Discharge (In cfs)	Weir Number	Downstream Elevation (Feet msl)	Upstream Elevation (Feet msl)	Difference Between U/S and D/S Elevation (Feet)	Velocity (fps)	Minimum Navigation Clearance (In feet)
20000	2	633.1	633.1	0.0	1.7	12.0
	1	633.1	633.1	0.0	3.0	**
46000	2	633.3	633.4	0.1	3.8	12.2
	1	633.4	633.7	0.3	6.9	**
80000	2	633.9	634.1	0.2	6.3	12.6
	1	634.2	635.2	1.0	13.1	**
120000	2	634.9	635.2	0.3	9.0	13.3
	1	635.6	637.8	2.2	15.3	**
160000	2	636.1	636.6	0.5	11.1	14.3
	1	637.2	639.9	2.7	16.7	**
240000	2	639.0	639.8	0.8	14.1	16.7
	1	640.7	643.7	3.0	18.8	**

**Weir 1 is not in navigation channel.

Table 9
Two-Weir System - Little Goose Reservoir at Maximum Operating Pool Level

Discharge (In cfs)	Weir Number	Downstream Elevation (Feet msl)	Upstream Elevation (Feet msl)	Difference Between U/S and D/S Elevation (Feet)	Velocity (fps)	Minimum Navigation Clearance (In feet)
20000	2	638.0	638.0	0.0	1.2	17.0
	1	638.1	638.1	0.0	1.6	**
46000	2	638.2	638.2	0.0	2.6	17.1
	1	638.2	638.3	0.1	3.7	**
80000	2	638.5	638.6	0.1	4.5	17.4
	1	638.7	638.9	0.2	6.3	**
120000	2	639.1	639.3	0.2	6.6	17.9
	1	639.5	639.9	0.4	9.1	**
160000	2	640.0	640.2	0.2	8.5	18.5
	1	640.6	641.3	0.7	11.6	**
240000	2	642.0	642.5	0.5	11.6	20.2
	1	643.1	644.3	0.2	15.2	**

**Weir 1 is not in navigation channel.

Table 10
Three-Weir System - Little Goose Reservoir in Drawdown Mode

Discharge (In cfs)	Weir Number	Downstream Elevation (Feet msl)	Upstream Elevation (Feet msl)	Difference Between U/S and D/S Elevation (Feet)	Velocity (fps)	Minimum Navigation Clearance (In feet)
20000	3	616.9	621.8	4.9	8.9	*
	2	621.8	626.3	4.5	8.2	*
	1	626.3	630.3	4.0	8.3	*
46000	3	620.4	624.4	4.0	11.7	*
	2	624.5	628.6	4.1	10.8	*
	1	628.7	632.8	4.1	11.0	*
80000	3	623.9	627.1	3.2	14.1	*
	2	627.3	630.9	3.6	12.9	*
	1	631.1	635.3	4.2	13.2	*
120000	3	627.2	629.7	2.5	16.0	*
	2	630.0	633.2	3.2	14.8	*
	1	633.5	637.8	4.3	15.1	*
160000	3	630.1	631.9	1.8	17.2	*
	2	632.4	635.2	2.8	16.2	*
	1	635.6	640.0	4.4	16.6	*
240000	3	634.9	636.2	1.3	16.8	*
	2	637.0	638.7	1.7	17.8	*
	1	639.1	643.7	4.6	19.0	*

*No navigation in Drawdown Mode.

Table 11
Three-Weir System - Little Goose Reservoir at Minimum Operating Pool Level

Discharge (In cfs)	Weir Number	Downstream Elevation (Feet msl)	Upstream Elevation (Feet msl)	Difference Between U/S and D/S Elevation (Feet)	Velocity (fps)	Minimum Navigation Clearance (In feet)
20000	3	633.1	633.1	0.0	1.4	15.0
	2	633.1	633.1	0.0	1.7	10.0
	1	633.1	633.1	0.0	3.0	"**
46000	3	633.3	633.3	0.0	3.2	15.2
	2	633.3	633.4	0.1	3.8	10.2
	1	633.4	633.7	0.3	6.9	**
80000	3	633.9	634.0	0.1	5.4	15.7
	2	634.0	634.2	0.2	6.2	10.6
	1	634.4	635.3	0.9	12.5	**
120000	3	634.8	635.0	0.2	7.6	16.5
	2	635.2	635.6	0.4	8.6	111.6
	1	635.8	637.8	2.0	15.4	**
160000	3	636.1	636.4	0.3	9.5	17.6
	2	636.7	637.2	0.5	10.4	12.8
	1	637.4	639.9	2.5	16.7	**
240000	3	638.9	639.4	0.5	12.4	20.1
	2	639.9	640.6	0.7	12.5	15.8
	1	641.0	643.7	2.7	18.8	**

**Weir 1 is not in navigation channel.

Table 12
Three-Weir System - Little Goose Reservoir at Maximum Operating Pool Level

Discharge (In cfs)	Weir Number	Downstream Elevation (Feet msl)	Upstream Elevation (Feet msl)	Difference Between U/S and D/S Elevation (Feet)	Velocity (fps)	Minimum Navigation Clearance (In feet)
20000	3	638.0	638.0	0.0	1.0	20.0
	2	638.0	638.0	0.0	1.1	14.9
	1	638.1	638.1	0.0	1.6	**
46000	3	638.2	638.2	0.0	2.4	20.1
	2	638.2	683.2	0.0	2.5	15.1
	1	638.2	638.3	0.1	3.7	**
80000	3	638.5	638.6	0.1	4.1	20.4
	2	638.6	638.7	0.1	4.3	15.4
	1	638.7	638.9	0.2	6.3	**
120000	3	639.1	639.2	0.1	5.9	20.9
	2	639.3	639.5	0.2	6.2	16.0
	1	639.6	640.0	0.4	9.0	**
160000	3	639.9	640.1	0.2	7.6	21.6
	2	640.3	640.5	0.3	7.8	16.8
	1	640.7	641.4	0.7	11.4	**
240000	3	641.9	642.2	0.3	10.6	23.4
	2	642.6	643.0	0.4	10.4	18.9
	1	643.3	644.5	1.2	14.8	**

**Weir 1 is not in the navigation channel.

Table 13
Five-Weir System - Little Goose Reservoir in Drawdown Mode

Discharge (In cfs)	Weir Number	Downstream Elevation (Feet msl)	Upstream Elevation (Feet msl)	Difference Between U/S and D/S Elevation (Feet)	Velocity (fps)	Minimum Navigation Clearance (In feet)
20000	5	614.6	618.7	4.1	9.6	*
	4	619.0	621.9	2.9	8.9	*
	3	621.9	624.7	2.8	8.7	*
	2	624.7	627.9	3.2	7.8	*
	1	627.9	630.3	2.4	8.3	*
46000	5	618.6	621.3	2.7	12.1	*
	4	621.8	624.5	2.7	11.7	*
	3	624.6	627.3	2.7	11.5	*
	2	627.4	630.0	2.6	10.3	*
	1	630.1	632.8	2.7	11.0	*
80000	5	622.4	623.8	1.4	14.6	*
	4	624.7	627.2	2.5	14.1	*
	3	627.3	629.9	2.6	13.7	*
	2	630.1	632.2	2.1	12.4	*
	1	632.3	635.3	3.0	13.2	*
120000	5	625.7	626.5	0.8	14.2	*
	4	627.6	629.8	2.2	16.0	*
	3	629.9	632.4	2.5	15.6	*
	2	632.8	634.4	1.6	14.2	*
	1	634.5	637.7	3.2	15.1	*
160000	5	628.6	629.2	0.6	14.5	*
	4	630.4	632.0	1.6	17.0	*
	3	632.2	634.6	2.4	17.1	*
	2	635.1	636.3	1.2	14.4	*
	1	636.4	639.9	3.5	16.6	*
240000	5	633.1	633.7	0.6	15.8	*
	4	635.1	636.3	1.2	16.6	*
	3	636.6	638.4	1.8	18.4	*
	2	639.2	640.2	1.0	13.9	*
	1	640.3	643.7	3.4	19.0	*

*No navigation in Drawdown Mode.

Table 14
Five-Weir System - Little Goose Reservoir at Minimum Operating Pool Level

Discharge (In cfs)	Weir Number	Downstream Elevation (Feet msl)	Upstream Elevation (Feet msl)	Difference Between U/S and D/S Elevation (Feet)	Velocity (fps)	Minimum Navigation Clearance (In feet)
20000	5	633.1	633.1	0.0	1.3	19.1
	4	633.1	633.1	0.0	1.4	15.0
	3	633.1	633.1	0.0	1.7	12.0
	2	633.1	633.1	0.0	1.8	8.1
	1	633.1	633.2	0.1	3.0	**
46000	5	633.2	633.2	0.0	2.9	19.3
	4	633.3	633.3	0.0	3.2	15.1
	3	633.3	633.4	0.1	3.8	12.1
	2	633.4	633.5	0.1	4.1	8.3
	1	633.5	633.6	0.3	6.8	**
80000	5	633.7	633.7	0.0	5.0	19.8
	4	633.9	634.0	0.1	5.4	15.6
	3	634.0	634.2	0.2	6.3	12.6
	2	634.3	634.5	0.2	6.6	8.9
	1	634.6	635.4	0.8	11.5	**
120000	5	634.5	634.6	0.1	7.1	20.5
	4	634.8	635.0	0.2	7.7	6.4
	3	635.1	635.4	0.3	8.8	13.5
	2	635.7	636.1	0.4	8.7	10.1
	1	636.2	637.8	1.6	15.3	**
160000	5	635.5	635.6	0.1	9.0	21.5
	4	636.1	636.4	0.3	9.6	17.5
	3	636.5	637.0	0.5	10.8	14.6
	2	637.4	637.9	0.5	10.1	11.6
	1	638.0	639.9	1.9	16.7	**
240000	5	638.0	638.2	0.2	12.0	23.8
	4	638.9	639.4	0.5	12.5	20.1
	3	639.6	640.4	0.8	13.6	17.4
	2	641.0	641.6	0.6	11.6	15.0
	1	641.8	643.7	1.9	18.4	**

*Weir 1 is not in navigation channel.

Table 15
Five-Weir System - Little Goose Reservoir at Maximum Operating Pool Level

Discharge (In cfs)	Weir Number	Downstream Elevation (Feet msl)	Upstream Elevation (Feet msl)	Difference Between U/S and D/S Elevation (Feet)	Velocity (fps)	Minimum Navigation Clearance (In feet)
20000	5	638.0	638.0	0.0	1.0	24.1
	4	638.0	638.0	0.0	1.0	19.9
	3	638.0	638.0	0.0	1.2	16.9
	2	638.0	638.0	0.0	1.1	13.0
	1	638.1	638.1	0.0	1.6	**
46000	5	638.1	638.1	0.0	2.3	24.2
	4	638.2	638.2	0.0	2.4	20.0
	3	638.2	638.2	0.0	2.7	17.0
	2	638.3	638.3	0.0	2.6	13.2
	1	638.4	638.4	0.1	3.7	**
80000	5	638.4	638.4	0.0	3.9	24.5
	4	638.5	638.5	0.0	4.1	20.3
	3	638.5	638.6	0.1	4.5	17.4
	2	638.7	638.8	0.1	4.3	13.6
	1	638.8	639.0	0.2	6.2	**
120000	5	638.9	638.9	0.0	5.7	25.0
	4	639.1	639.2	0.1	6.0	20.8
	3	639.2	639.4	0.2	6.6	17.9
	2	639.6	639.8	0.2	6.1	14.3
	1	639.8	640.2	0.4	8.9	**
160000	5	639.6	639.7	0.1	7.4	25.6
	4	639.9	640.1	0.2	7.7	21.5
	3	640.1	640.4	0.3	8.4	18.6
	2	640.6	640.9	0.3	7.6	15.3
	1	641.0	641.6	0.6	11.0	**
240000	5	641.3	641.4	0.1	10.3	27.2
	4	641.9	642.2	0.3	10.6	23.3
	3	642.3	642.8	0.5	11.4	20.5
	2	643.3	643.7	0.4	9.8	17.7
	1	643.9	644.9	1.0	14.1	**

*Weir 1 is not in navigation channel.

Table 16
Comparison of SOR Alternatives to SCS

SOR Alternative	SCS Alternative		Implementation Date	Description
SOS 5A	NR2	4A	2010	Natural River, 2-Month Duration
SOS 5B	NR4.5	4A	2010	Natural River, 4.5-Month Duration
SOS 6A	CP33-2	13	2005	Constant Pool, 33 Feet, 2-Month Duration
SOS 6B	CP33-4.5	13	2005	Constant Pool, 33 Feet, 4.5-Month Duration
SOS 6C	NEW	13A	2000	Constant Pool, Lower Granite Only, 33 Feet, 2-Month Duration
SOS 6D	NEW	13A	2000	Constant Pool, Lower Granite Only, 33 Feet, 4.5-Month Duration
NA	CP43	14	2005	Constant Pool, 43 Feet, 2-Month Duration With Modified Spillways
NA	CP43	14	2005	Constant Pool, 43 Feet, 4.5-Month Duration With Modified Spillways
NA	CP52	15	2010	Constant Pool, 52 Feet, 2-Month Duration, With New Spillways
NA	CP52	15	2010	Constant Pool, 52 Feet, 4.5-Month Duration, With New Spillways
NA	CP33PH	17	2005	Constant Pool, 33 Feet, With Modified Powerhouse
NA	CP43PH	18	2005	Constant Pool, 43 Feet, With Modified Powerhouse
NA	CP52PH	19	2010	Constant Pool, 52 Feet, With Modified Powerhouse

Table 17
Absolute Economic Costs Associated with Lower Snake River Drawdown**

Alt	(1) Annual Rec Costs	(2) Average Annual Flood Damage Costs[6]	(3) Annual Net Farm Income Benefits[2]	(4) Annual Increased M&I Water Cost*[1]	(5) Annual Shallow Draft Transportation Cost	(6) Dworshak Reservoir Log Trucking Annual Cost	(7) Annual System Generation Cost[4]	(8) Annualized Implementation Cost*[5]
BC	$189,143,500	$10,275	$71,0763,000	$0	$413,350,000	$0	$996,000,000	$0
4A	176,993,000	19,360	62,610,000	4,177,900	415,755,653	(106,093)	1,394,000,000	523,938,003
4A'	171,960,500	21,125	62,502,000	4,181,500	416,935,300	(82,044)	1,395,000,000	523,938,003
5	*3	*3	*3	*3	*3	*3	*3	133,405,016
5'	*3	*3	*3	*3	*3	*3	*3	133,405,016
9	*3	*3	*3	*3	*3	*3	*3	174,002,246
9'	*3	*3	*3	*3	*3	*3	*3	174,002,246
13	178,297,000	19,360	64,495,000	3,891,600	414,876,866	(139,000)	1,199,000,000	130,403,515
13'	174,263,000	19,360	64,452,000	3,893,100	416,056,514	(165,000)	1,198,000,000	130,403,513
13A	181,706,500	19,360	67,127,000	3,695,400	413,754,531	(139,000)	1,111,000,000	9,945,959
13A'	179,387,000	19,360	67,127,000	3,695,800	413,787,613	(165,000)	1,121,000,000	9,945,959
14	*3	*3	64,030,636	4,381,860	*3	*3	1,181,925,220	242,500,315
14'	*3	*3	63,970,544	4,383,550	*3	*3	1,180,964,440	242,500,215
15	*3	*3	68,189,620	3,324,710	*3	*3	1,075,192,470	363,562,378
15'	*3	*3	68,186,264	3,925,900	*3	*3	1,084,870,170	363,562,378
17	178,297,000	19,360	64,495,000	3,891,600	414,876,866	(139,000)	*3	171,000,664
17'	174,263,000	19,360	64,452,000	3,893,100	416,056,514	(165,000)	*3	171,000,664
18	*3	*3	64,030,636	4,381,860	*3	*3	*3	282,900,468
18'	*3	*3	63,970,544	4,383,550	*3	*3	*3	282,900,468
19	*3	*3	68,189,620	3,324,710	*3	*3	*3	410,160,496
19'	*3	*3	68,186,264	3,325,990	*3	*3	*3	410,160,496

*1 - Includes amortization of M&I pump modifications plus increased O&M pumping costs for M&I commercial irrigation (Lower Snake River projects only)
*2 - Includes pump modifications to commercial irrigation (Lower Snake River projects only)
*3 - Not estimated at this time
*4 - Based on most likely long-term strategy
*5 - Implementation costs discounted at 8 percent. All other costs at 8.25 percent (see Table 24)
*6 - Includes Clearwater River only
**Undiscounted values for lower Snake River sites.
*Definitions of Alternatives
BC = Base Case
4A = Natural River, 2-Month Duration
4A' = Natural River, 4.5-Month Duration
5 = Variable Pool, Existing Powerhouse With Existing Spillway, 2-Month Duration
5' = Variable Pool, Existing Powerhouse With Existing Spillway, 4.5-Month Duration
9 = Variable Pool, Modified Powerhouse With Existing Spillway, 2-Month Duration
9' = Variable Pool, Modified Powerhouse With Existing Spillway, 4.5-Month Duration
13 = Constant Pool, 33 Feet, Four Reservoirs, 2-Month Duration
13' = Constant Pool, 33 Feet, Four Reservoirs, 4.5-Month Duration
13A = Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration
13A' = Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration
14 = Constant Pool, 2-Month Duration With Modified Spillways
14' = Constant Pool, 4.5-Month Duration With Modified Spillways
15 = Constant Pool, 2-Month Duration, With New Spillways
15' = Constant Pool, 4.5-Month Duration, With New Spillways
17 = Same as Alternative 13 With Modified Powerhouse
17' = Same as Alternative 13' With Modified Powerhouse
18 = Same as Alternative 14 With Modified Powerhouse
18' = Same as Alternative 14' With Modified Powerhouse
19 = Same as Alternative 15 With Modified Powerhouse
19' = Same as Alternative 15' With Modified Powerhouse

Table 18
Net Economic Costs Associated With Lower Snake River Drawdown**

Alt	Annual Recreation Costs	Average Annual Flood Damage Costs	Annual Net Farm Income Benefits[2]	Annual Increased M&I Water Cost[1]	Annual Shallow Draft Transport Cost	Dworshak Reservoir Log Trucking Annual Cost	Annual System Generation Cost[4]	Annualized Implement Cost[5]	Net Total Annual Economic Cost[6]
BC									
4A	12,150,500	9,085	8,463,000	4,177,900	2,405,653	(106,093)	399,000,000	523,938,003	$949,038,048
4A'	17,183,000	10,850	8,571,000	4,181,500	3,585,300	(82,044)	339,000,000	523,938,003	$956,387,609
5	*3	*3	*3	*3	*3	*3	*3	133,405,016	*3
5'	*3	*3	*3	*3	*3	*3	*3	133,405,016	*3
9	*3	*3	*3	*3	*3	*3	*3	174,002,246	*3
9'	*3	*3	*3	*3	*3	*3	*3	174,002,246	*3
13	10,846,500	9,085	6,578,000	3,891,600	1,526,866	(139,000)	203,000,000	130,403,515	356,116,566
13'	14,880,500	9,085	6,621,000	3,893,100	2,706,514	(165,000)	202,000,000	130,403,513	360,348,712
13A	7,437,000	9,085	3,946,000	3,695,400	404,531	(139,000)	115,000,000	9,945,959	140,298,975
13A'	9,756,500	9,085	3,946,000	3,695,800	437,613	(165,000)	125,000,000	9,945,959	152,625,957
14	*3	*3	7,042,364	4,381,860	*3	*3	185,950,220	242,500,315	*3
14'	*3	*3	7,102,456	4,383,550	*3	*3	184,964,440	242,500,315	*3
15	*3	*3	2,883,380	3,324,710	*3	*3	79,192,470	363,562,378	*3
15'	*3	*3	2,886,736	3,325,990	*3	*3	88,870,170	363,562,378	*3
17	10,846,500	9,085	6,578,000	3,891,600	1,526,866	(139,000)	*3	171,000,664	*3
17'	14,880,500	9,085	6,621,000	3,893,100	2,706,514	(165,000)	*3	171,000,664	*3
18	*3	*3	7,042,364	4,381,860	*3	*3	*3	282,900,468	*3
18'	*3	*3	7,102,456	4,383,550	*3	*3	*3	282,900,468	*3
19	*3	*3	2,883,380	3,324,710	*3	*3	*3	410,160,496	*3
19'	*3	*3	2,886,736	3,325,990	*3	*3	*3	410,160,496	*3

*1 - Includes amortization of M&I pump modifications plus increased O&M pumping costs for M&I commercial irrigation (Lower Snake River projects only)
*2 - Includes pump modifications to commercial irrigation (Lower Snake River projects only)
*3 - Not estimated at this time
*4 - Based on most likely long-term strategy
*5 - Implementation costs discounted at 8 percent. All other costs at 8.25 percent (see Table 24)
*6 - Includes Clearwater River only
**Undiscounted values for lower Snake River sites.
*Definitions of Alternatives
BC = Base Case
4A = Natural River, 2-Month Duration
4A' = Natural River, 4.5-Month Duration
5 = Variable Pool, Existing Powerhouse With Existing Spillway, 2-Month Duration
5' = Variable Pool, Existing Powerhouse With Existing Spillway, 4.5-Month Duration
9 = Variable Pool, Modified Powerhouse With Existing Spillway, 2-Month Duration
9' = Variable Pool, Modified Powerhouse With Existing Spillway, 4.5-Month Duration
13 = Constant Pool, 33 Feet, Four Reservoirs, 2-Month Duration
13' = Constant Pool, 33 Feet, Four Reservoirs, 4.5-Month Duration
13A = Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration
13A' = Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration
14 = Constant Pool, 2-Month Duration With Modified Spillways
14' = Constant Pool, 4.5-Month Duration With Modified Spillways
15 = Constant Pool, 2-Month Duration, With New Spillways
15' = Constant Pool, 4.5-Month Duration, With New Spillways
17 = Same as Alternative 13 With Modified Powerhouse
17' = Same as Alternative 13' With Modified Powerhouse
18 = Same as Alternative 14 With Modified Powerhouse
18' = Same as Alternative 14' With Modified Powerhouse
19 = Same as Alternative 15 With Modified Powerhouse
19' = Same as Alternative 15' With Modified Powerhouse

Table 19
Recreation Benefits Computation of Annual Equivalent Consumer Surplus Using "Low" Values ($) and Expected Value Water Year

SCS Alt	Description	Implement Date	Annual Recreation Benefits
4A	Natural River, 2-Month Duration	2010	$176,993,000
4A	Natural River, 4.5-Month Duration	2010	$171,960,500
13	Constant Pool, 33 Feet, 2-Month Duration	2005	$178,297,000
13	Constant Pool, 33 Feet, 4.5-Month Duration	2005	$174,263,000
13A	Constant Pool, Lower Granite Only, 33 Feet, 2-Month Duration	2000	$181,706,500
13A	Constant Pool, Lower Granite Only, 33 Feet, 4.5-Month Duration	2000	$179,387,000
14	Constant Pool, 43 Feet, 2-Month Duration With Modified Spillways	2005	*
14	Constant Pool, 43 Feet, 4.5-Month Duration With Modified Spillways	2005	*
15	Constant Pool, 52 Feet, 2-Month Duration With New Spillways	2010	*
15	Constant Pool, 52 Feet, 4.5-Month Duration With New Spillways	2010	*
17	Same as Alternative 13 With Modified Powerhouse	2005	*
18	Same as Alternative 14 With Modified Powerhouse	2005	*
19	Same as Alternative 15 With Modified Powerhouse	2010	*

*These alternatives may be analyzed in Phase 2
These figures include John Day.
Source: Table E4-1.3.1, SOR, Economics Appendix

Table 20
Analysis of Equivalent Annual Flood Damages Dworshak to Lewiston Reach Calculated at 8.25 Percent

SCS Alt	Description	Year Online	Initial Expected Annual Drawdown	Duration Of Initial Damage	Ultimate Expected Annual Damage	Duration Of Ultimate Damage
4A	Natural River, 2-Month Duration	2010	$10,275	15	$19,360	85
4A	Natural River, 4.5-Month Duration	2010	$10,275	15	$21,125	85
13	Constant Pool, 33 Feet, 2-Month Duration	2005	$10,275	10	$19,360	90
13	Constant Pool, 33 Feet, 4.5-Month Duration	2005	$10,275	10	$19,360	90
13A	Constant Pool, Lower Granite Only, 33 Feet, 2-Month	2000	$10,275	5	$19,360	95
13A	Constant Pool, Lower Granite Only, 33 Feet, 4.5-Month	2000	$10,275	5	$19,360	95
14	Constant Pool, 43 Feet, 2-Month W/Modified Spillways	2005	*	*	*	*
14	Constant Pool, 43 Feet, 4.5-Month W/Modified Spillways	2005	*	*	*	*
15	Constant Pool, 52 Feet, 2-Month With New Spillways	2010	*	*	*	*
15	Constant Pool, 52 Feet, 4.5-Month With New Spillways	2010	*	*	*	*
17	Same as Alternative 13 With Modified Powerhouse	2005	*	*	*	*
18	Same as Alternative 14 With Modified Powerhouse	2005	*	*	*	*
19	Same as Alternative 15 With Modified Powerhouse	2010	*	*	*	*

*These alternatives may be analyzed in Phase II.

Table 21
Estimate of the Change in Annual Net Farm Income
For Commercial Agriculture Irrigators
Ice Harbor Pool
Calculated at 8.25-Percent Interest

SCS Alt	Description	Irrigated Acres	Pump Mod Req	Change In Income Amount ($1,000)	Change In Net Farm Income $/A	Imp. Date
	Base Case	36,389				
4A	Natural River, 2-Month Duration	36,389	Yes	$11,958	$329	2010
4A	Natural River, 4.5-Month Duration	36,389	Yes	$11,850	$326	2010
13	Constant Pool, 33 Feet, 2-Month Duration	36,389	Yes	$13,842	$380	2005
13	Constant Pool, 33 Feet, 4.5-Month Duration	36,389	Yes	$13,800	$379	2005
13A	Constant Pool, Lower Granite Only, 33 Feet, 2-Month	36,389	No	$16,475	$453	2000
13A	Constant Pool, Lower Granite Only, 33 Feet, 4.5-Month	36,389	No	$16,475	$453	2000
14	Constant Pool, 43 Feet, 2-Month With Modified Spillways	36,389	Yes	$13,600	$374	2005
14	Constant Pool, 43 Feet, 4.5-Month With Modified Spillways	36,389	Yes	$13,550	$372	2005
15	Constant Pool, 52 Feet, 2-Month With New Spillways	36,389	Yes	$13,100	$360	2010
15	Constant Pool, 52 Feet, 4.5-Month With New Spillways	36,389	Yes	$13,025	$358	2010
17	Same as Alternative 13 With Modified Powerhouse	*	*	*	*	2005
18	Same as Alternative 14 With Modified Powerhouse	*	*	*	*	2005
19	Same as Alternative 15 With Modified Powerhouse	*	*	*	*	2010

*These alternatives may be analyzed in Phase II.
**Net farm income includes pump modification plus increased O&M and power costs.
Source: SOR Economics Appendix, Tables 4.4.1.2.2

Table 22
Modification and Increased O&M Cost
For M&I and Agricultural Irrigators
Calculated at 8.25-Percent Interest

SCS Alt	Description	Modification Cost	Increased O&M and Power Cost
Ice Harbor Pool			
4A	Natural River, 2-Month Duration	$4,405,353	$1,168,690
4A	Natural River, 4.5-Month Duration	$4,405,353	$1,281,668
13	Constant Pool, 33 Feet, 2-Month Duration	$2,323,523	$669,104
13	Constant Pool, 33 Feet, 4.5-Month Duration	$2,323,523	$614,120
13A	Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration	$0	$0
13A	Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration	$0	$0
14	Constant Pool, 43 Feet, 2-Month Duration With Modified Spillways	$16,839,684	$607,456
14	Constant Pool, 43 Feet, 4.5-Month Duration With Modified Spillways	$16,839,684	$655,794
15	Constant Pool, 52 Feet, 2-Month Duration With New Spillways	$21,132,304	$760,866
115	Constant Pool, 52 Feet, 4.5-Month Duration With New Spillways	$21,132,304	$821,004
17	Same as Alternative 13 With Modified Powerhouse		
18	Same as Alternative 14 With Modified Powerhouse		
19	Same as Alternative 15 With Modified Powerhouse		

Lower Monumental			
4A	Natural River, 2-Month Duration	$852,000	$26,470
4A	Natural River, 4.5-Month Duration	$852,000	$27,068
13	Constant Pool, 33 Feet, 2-Month Duration	$401,000	$12,231
13	Constant Pool, 33 Feet, 4.5-Month Duration	$401,000	$12,539
13A	Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration	$0	$0
13A	Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration	$0	$0
14	Constant Pool, 43 Feet, 2-Month Duration With Modified Spillways	$534,936	$16,427
14	Constant Pool, 43 Feet, 4.5-Month Duration With Modified Spillways	$534,936	$16,721
15	Constant Pool, 52 Feet, 2-Month Duration With New Spillways	$655,288	$20,122
115	Constant Pool, 52 Feet, 4.5-Month Duration With New Spillways	$655,288	$20,482
17	Same as Alternative 13 With Modified Powerhouse		
18	Same as Alternative 14 With Modified Powerhouse		
19	Same as Alternative 15 With Modified Powerhouse		
Little Goose			
4A	Natural River, 2-Month Duration	$705,000	$23,169
4A	Natural River, 4.5-Month Duration	$705,000	$24,505
13	Constant Pool, 33 Feet, 2-Month Duration	$287,000	$8,914
13	Constant Pool, 33 Feet, 4.5-Month Duration	$287,000	$9,211
13A	Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration	$0	$0
13A	Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration	$0	$0
14	Constant Pool, 43 Feet, 2-Month Duration With Modified Spillways	$385,266	$11,985
14	Constant Pool, 43 Feet, 4.5-Month Duration With Modified Spillways	$385,266	$12,397
15	Constant Pool, 52 Feet, 2-Month Duration With New Spillways	$474,178	$14,745
115	Constant Pool, 52 Feet, 4.5-Month Duration With New Spillways	$474,178	$15,256
17	Same as Alternative 13 With Modified Powerhouse		
18	Same as Alternative 14 With Modified Powerhouse		
19	Same as Alternative 15 With Modified Powerhouse		
Lower Granite			
4A	Natural River, 2-Month Duration	$3,524,000	$106,457
4A	Natural River, 4.5-Month Duration	$3,524,000	$107,037
13	Constant Pool, 33 Feet, 2-Month Duration	$2,983,319	$89,970
13	Constant Pool, 33 Feet, 4.5-Month Duration	$2,983,319	$90,373
13A	Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration	$2,983,319	$89,970
13A	Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration	$2,983,319	$90,373
14	Constant Pool, 43 Feet, 2-Month Duration With Modified Spillways	$3,257,704	$98,269
14	Constant Pool, 43 Feet, 4.5-Month Duration With Modified Spillways	$3,257,704	$98,721
15	Constant Pool, 52 Feet, 2-Month Duration With New Spillways	$3,479,169	$104,944
115	Constant Pool, 52 Feet, 4.5-Month Duration With New Spillways	$3,479,169	$105,419
17	Same as Alternative 13 With Modified Powerhouse		
18	Same as Alternative 14 With Modified Powerhouse		
19	Same as Alternative 15 With Modified Powerhouse		

Total of All Projects			
4A	Natural River, 2-Month Duration	$9,486,353	$1,324,786
4A	Natural River, 4.5-Month Duration	$9,486,353	$1,440,278
13	Constant Pool, 33 Feet, 2-Month Duration	$5,994,842	$780,219
13	Constant Pool, 33 Feet, 4.5-Month Duration	$5,994,842	$726,243
13A	Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration	$2,983,319	$89,970
13A	Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration	$2,983,319	$90,373
14	Constant Pool, 43 Feet, 2-Month Duration With Modified Spillways	$21,017,590	$734,137
14	Constant Pool, 43 Feet, 4.5-Month Duration With Modified Spillways	$21,017,590	$783,633
15	Constant Pool, 52 Feet, 2-Month Duration With New Spillways	$25,740,939	$900,688
115	Constant Pool, 52 Feet, 4.5-Month Duration With New Spillways	$25,740,939	$952,161
17	Same as Alternative 13 With Modified Powerhouse	*	*
18	Same as Alternative 14 With Modified Powerhouse	*	*
19	Same as Alternative 15 With Modified Powerhouse	*	*
Total Annual Cost of All Projects			
4A	Natural River, 2-Month Duration	$10,811,139	
4A	Natural River, 4.5-Month Duration	$10,926,631	
13	Constant Pool, 33 Feet, 2-Month Duration	$6,775,061	
13	Constant Pool, 33 Feet, 4.5-Month Duration	$6,721,085	
13A	Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration	$3,073,289	
13A	Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration	$3,073,692	
14	Constant Pool, 43 Feet, 2-Month Duration With Modified Spillways	$21,751,727	
14	Constant Pool, 43 Feet, 4.5-Month Duration With Modified Spillways	$21,801,223	
15	Constant Pool, 52 Feet, 2-Month Duration With New Spillways	$26,641,616	
115	Constant Pool, 52 Feet, 4.5-Month Duration With New Spillways	$26,703,100	
17	Same as Alternative 13 With Modified Powerhouse		
18	Same as Alternative 14 With Modified Powerhouse		
19	Same as Alternative 15 With Modified Powerhouse		

*These alternatives will be analyzed in Phase II.

**Annual cost includes amortization of modification cost, increased O&M and increased pumping cost.

***Modification of facilities on Ice Harbor (3), Lower Monumental (2), Little Goose (2), and Lower Granite (8)

Source: SOR Economics Appendix, Tables 4.4.2.1 and 4.4.2.2

Table 23
Average Annual Transportation Costs Calculated at 8.25-Percent Interest

SCS Alt	Description	Date	Annual Transportation Cost
4A	Natural River, 2-Month Duration	2010	$415,755,653
4A	Natural River, 4.5-Month Duration	2010	$416,935,301
13	Constant Pool, 33 Feet, 2-Month Duration	2005	$414,876,866
13	Constant Pool, 33 Feet, 4.5-Month Duration	2005	$416,056,514
13A	Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration	2000	$413,754,531
13A	Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration	2000	$413,787,613
14	Constant Pool, 43 Feet, 2-Month Duration With Modified Spillways	2005	*
14	Constant Pool, 43 Feet, 4.5-Month Duration With Modified Spillways	2005	*
15	Constant Pool, 52 Feet, 2-Month Duration With New Spillways	2010	*
115	Constant Pool, 52 Feet, 4.5-Month Duration With New Spillways	2010	*
17	Same as Alternative 13 With Modified Powerhouse	2005	*
18	Same as Alternative 14 With Modified Powerhouse	2005	*
19	Same as Alternative 15 With Modified Powerhouse	2010	*

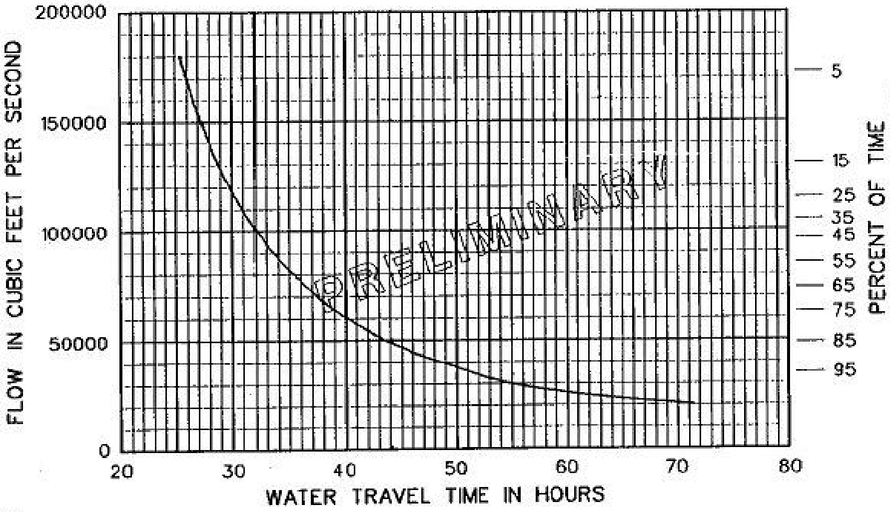
*These alternatives may be analyzed in Phase 2.

Table 24
SCS Phase I Alternatives
Construction Categories

SCS Alt*	Construction Costs**	Engineering And Design	Construction Management	Total Project Costs	Interest During Construction	Total Investment Costs	Annualized Investment Costs***	Annualized OM&R Costs	Total Annual Costs
4A	$2,397,972,787	$566,391,055	$203,968,207	$3,168,332,049	$3,368,545,000	$6,536,877,049	$523,188,003	$750,000	$523,938,003
4A'	$2,397,972,787	$566,391,055	$203,968,207	$3,168,332,049	$3,368,545,000	$6,536,877,049	$523,188,003	$750,000	$523,938,003
5	$705,618,326	$160,070,274	$57,644,355	$923,332,955	$736,350,000	$1,659,682,955	$132,835,016	$570,000	$133,405,016
5'	$705,618,326	$160,070,274	$57,644,355	$923,332,955	$736,350,000	$1,659,682,955	$132,835,016	$570,000	$133,405,016
9	$918,362,326	$211,128,834	$76,031,515	$1,205,522,675	$961,395,000	$2,166,917,675	$173,432,246	$570,000	$174,002,246
9'	$918,362,326	$211,128,834	$76,031,515	$1,205,522,675	$961,395,000	$2,166,917,675	$173,432,246	$570,000	$174,002,246
13	$689,889,074	$156,295,254	$56,284,898	$902,469,226	$719,712,000	$1,622,181,226	$129,833,513	$570,000	$130,403,513
13'	$689,889,074	$156,295,254	$56,284,898	$902,469,226	$719,712,000	$1,622,181,226	$129,833,513	$570,000	$130,403,513
13A	$50,719,106	$12,082,758	$4,351,231	$67,153,095	$53,554,000	$120,707,095	$9,660,959	$285,000	$9,945,959
13A'	$50,719,106	$12,082,758	$4,351,231	$67,153,095	$53,554,000	$120,707,095	$9,660,959	$285,000	$9,945,959
14	$1,276,285,339	$297,030,357	$108,335,643	$1,681,651,339	$1,341,103,000	$3,022,754,339	$241,930,315	$570,000	$242,500,315
14'	$1,276,285,339	$297,030,357	$108,335,643	$1,681,651,339	$1,341,103,000	$3,022,754,339	$241,930,315	$570,000	$242,500,315
15	$1,666,164,626	$390,601,386	$140,662,999	$2,197,429,011	$2,336,289,000	$4,533,718,011	$362,862,378	$700,000	$363,562,378
15'	$1,666,164,626	$390,601,386	$140,662,999	$2,197,429,011	$2,336,289,000	$4,533,718,011	$362,862,378	$700,000	$363,562,378
17	$902,633,074	$207,353,814	$74,672,058	$1,184,658,946	$944,756,000	$2,129,414,946	$170,430,664	$570,000	$171,000,664
17'	$902,633,074	$207,353,814	$74,672,058	$1,184,658,946	$944,756,000	$2,129,414,946	$170,430,664	$570,000	$171,000,664
18	$1,489,029,339	$348,088,917	$125,353,449	$1,962,471,705	$1,565,055,000	$3,527,526,705	$282,330,468	$570,000	$282,900,468
18'	$1,489,029,339	$348,088,917	$125,353,449	$1,962,471,705	$1,565,055,000	$3,527,526,705	$282,330,468	$570,000	$282,900,468
19	$1,878,908,630	$441,659,947	$159,050,160	$2,479,618,737	$2,636,311,000	$5,115,929,737	$409,460,496	$700,000	$410,160,496
19'	$1,878,908,630	$441,659,947	$159,050,160	$2,479,618,737	$2,636,311,000	$5,115,929,737	$409,460,496	$700,000	$410,160,496

*Definitions of Alternatives
4A = Natural River, 2-Month Duration
4A' = Natural River, 4.5-Month Duration
5 = Variable Pool, Existing Powerhouse With Existing Spillway, 2-Month Duration
5' = Variable Pool, Existing Powerhouse With Existing Spillway, 4.5-Month Duration
9 = Variable Pool, Modified Powerhouse With Existing Spillway, 2-Month Duration
9' = Variable Pool, Modified Powerhouse With Existing Spillway, 4.5-Month Duration
13 = Constant Pool, 33 Feet, Four Reservoirs, 2-Month Duration
13' = Constant Pool, 33 Feet, Four Reservoirs, 4.5-Month Duration
13A = Constant Pool, Lower Granite Only, 33-Feet, 2-Month Duration
13A' = Constant Pool, Lower Granite Only, 33-Feet, 4.5-Month Duration
14 = Constant Pool, 2-Month Duration With Modified Spillways
14' = Constant Pool, 4.5-Month Duration With Modified Spillways
15 = Constant Pool, 2-Month Duration, With New Spillways
15' = Constant Pool, 4.5-Month Duration, With New Spillways
17 = Same as Alternative 13 With Modified Powerhouse
17' = Same as Alternative 13' With Modified Powerhouse
18 = Same as Alternative 14 With Modified Powerhouse
18' = Same as Alternative 14' With Modified Powerhouse
19 = Same as Alternative 15 With Modified Powerhouse
19' = Same as Alternative 15' With Modified Powerhouse
**Includes real estate and contingencies
***Based on PV of total investment costs annualized at the current Federal interest rate of 8 percent, for 100 years.

Charts



NOTES:

1. TRAVEL TIMES ON THIS CURVE WERE COMPUTED USING THE HYDROLOGIC ENGINEERING CENTER PROGRAM "WATER SURFACE PROFILES." (HEC-2). CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: 1) SEDIMENT RANGE DATA FROM RIVER MILE 107.4 (LOWER GRANITE DAM) TO THE SNAKE-CLEARWATER RIVER CONFLUENCE AND 2) 1934 SOUNDING DATA AND TOPOGRAPHIC MAPPING FOR THE REACH BETWEEN COLUMBIA-SNAKE RIVER CONFLUENCE TO LOWER GRANITE DAM.

2. THIS ALTERNATIVE IS FOR ACHIEVING NEAR FREE FLOW CONDITIONS.

3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 15 APRIL TO 15 JUNE FOR THE PERIOD 1976 THROUGH 1992.

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
SNAKE RIVER FROM COLUMBIA RIVER CONFLUENCE
TO CLEARWATER RIVER CONFLUENCE

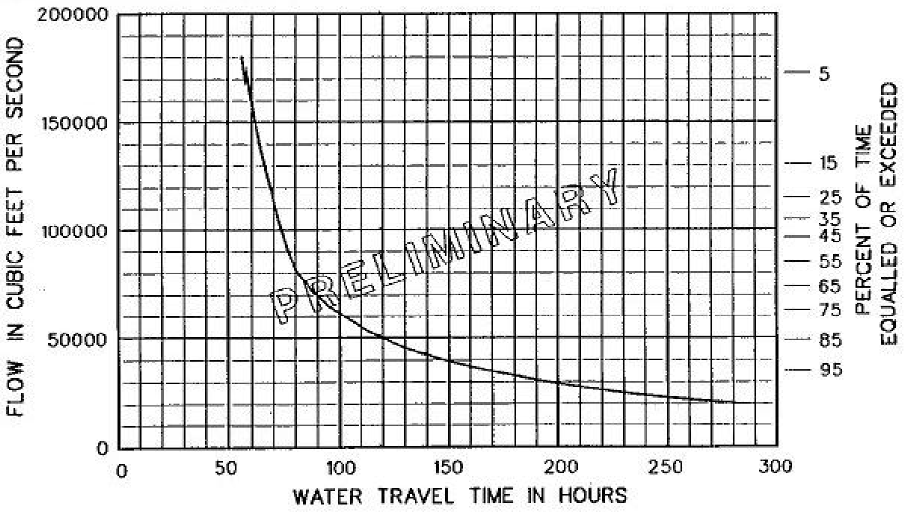
WATER TRAVEL TIME
NEAR FREE FLOW

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

A00183

DESIGNED	DRAWN	
MAXSON	SCHUSTER	21 AUG 19

Chart 1. Water Travel Time Near Free Flow



NOTES:

1. TRAVEL TIMES ON THIS CURVE WERE COMPUTED USING THE HYDROLOGIC ENGINEERING CENTER PROGRAM "WATER SURFACE PROFILES." (HEC-2). CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: 1) SEDIMENT RANGE DATA FROM RIVER MILE 107.4 (LOWER GRANITE DAM) TO THE SNAKE-CLEARWATER RIVER CONFLUENCE AND 2) 1934 SOUNDING DATA AND TOPOGRAPHIC MAPPING FOR THE REACH BETWEEN COLUMBIA-SNAKE RIVER CONFLUENCE TO LOWER GRANITE DAM.

2. WATER SURFACE ELEVATIONS ARE TO REMAIN AT THE EXISTING SPILLWAY CRESTS WHICH ARE 391, 483, 581, AND 681 FEET MSL FOR ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE AND LOWER GRANITE, RESPECTIVELY.

3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 15 APRIL TO 15 JUNE FOR THE PERIOD 1976 THROUGH 1992.

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
SHAKE RIVER FROM COLUMBIA RIVER CONFLUENCE
TO CLEARWATER RIVER CONFLUENCE

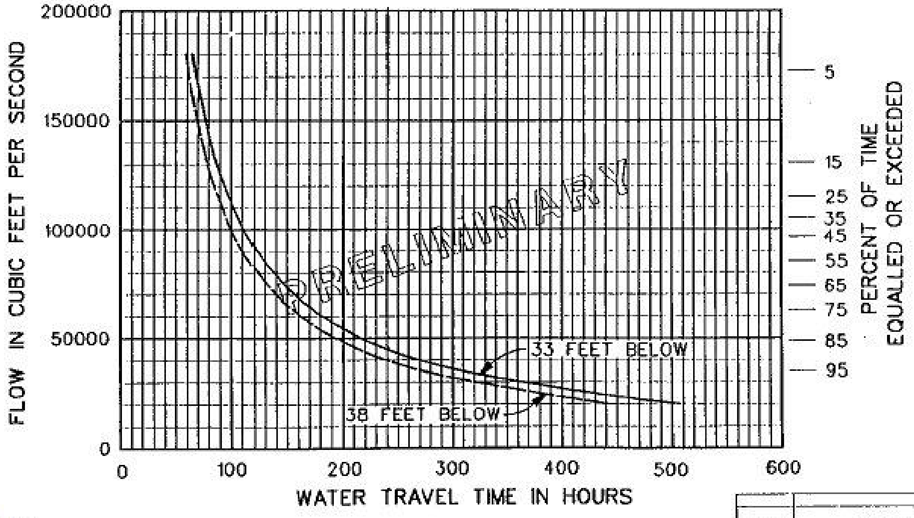
WATER TRAVEL TIME
SPILLWAY

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

A00184

DESIGNED	DRAWN	DATE
MAXSON	SCHUSTER	21 AUG 1

Chart 2. Water Travel Time Spillway



NOTES:

1. THESE CURVES WERE COMPUTED USING THE HYDROLOGIC ENGINEERING CENTER PROGRAM "WATER SURFACE PROFILES." (HEC-2). CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: 1) SEDIMENT RANGE DATA FROM RIVER MILE 107.4 (LOWER GRANITE DAM) TO THE SNAKE-CLEARWATER RIVER CONFLUENCE AND 2) 1934 SOUNDING DATA AND TOPOGRAPHIC MAPPING FOR THE REACH BETWEEN THE COLUMBIA-SNAKE RIVER CONFLUENCE AND LOWER GRANITE DAM.

2. THIS ALTERNATIVE DRAWS DOWN LOWER MONUMENTAL, LITTLE GOOSE AND LOWER GRANITE RESERVOIRS 33 (38) FEET TO ELEVATIONS 507 (502), 605 (600), AND 705 (700) FEET MSL, RESPECTIVELY, AND ICE HARBOR RESERVOIR 25 FEET TO ELEVATION 415 FEET MSL.

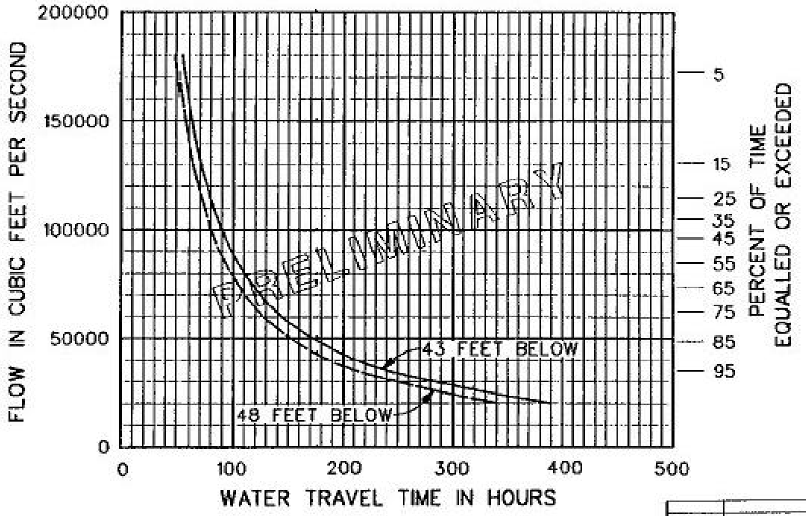
3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 15 APRIL TO 15 JUNE FOR THE PERIOD 1976 THROUGH 1992.

DATE	REVISION	BY

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
SNAKE RIVER FROM COLUMBIA RIVER CONFLUENCE
TO CLEARWATER RIVER CONFLUENCE
WATER TRAVEL TIME
33 & 38 FEET BELOW
NORMAL FULL POOL
ELEVATION
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

DESIGNED	DRAWN	DATE
WATSON	SCHUSTER	21 AUG 1992

Chart 3. Travel Time 33 and 38 Feet Below Normal Full Pool Elevation



NOTES:

1. THESE CURVES WERE COMPUTED USING THE HYDROLOGIC ENGINEERING CENTER PROGRAM "WATER SURFACE PROFILES." (HEC-2). CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: 1) SEDIMENT RANGE DATA FROM RIVER MILE 107.4 (LOWER GRANITE DAM) TO THE SNAKE-CLEARWATER RIVER CONFLUENCE AND 2) 1934 SOUNDING DATA AND TOPOGRAPHIC MAPPING FOR THE REACH BETWEEN THE COLUMBIA-SNAKE RIVER CONFLUENCE AND LOWER GRANITE DAM.

2. THIS ALTERNATIVE DRAWS DOWN LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE RESERVOIRS 43 (48) FEET TO ELEVATIONS 497 (492), 595 (590), AND 695 (690) FEET MSL, RESPECTIVELY, AND ICE HARBOR RESERVOIR 35 FEET TO ELEVATION 405 FEET MSL.

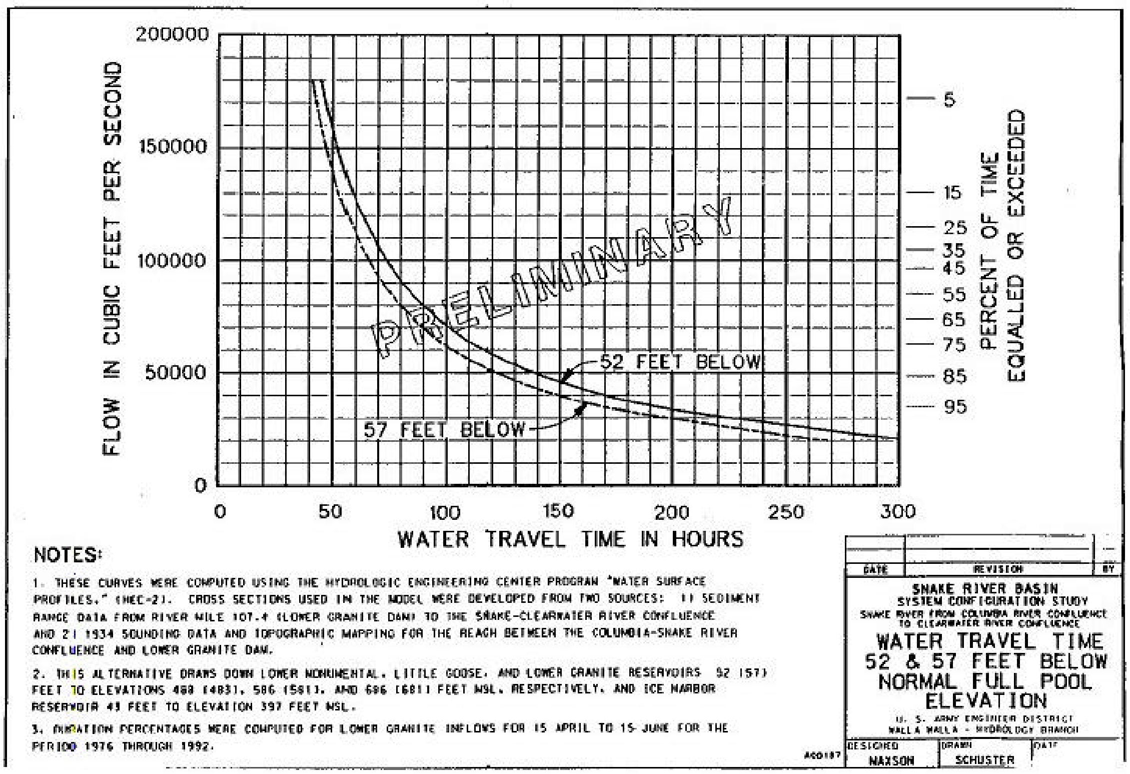
3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 15 APRIL TO 15 JUNE FOR THE PERIOD 1976 THROUGH 1992.

DATE	REVISION	BY

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
SNAKE RIVER FROM COLUMBIA RIVER CONFLUENCE
TO CLEARWATER RIVER CONFLUENCE
WATER TRAVEL TIME
43 & 48 FEET BELOW
NORMAL FULL POOL
ELEVATION
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY

DESIGNED	DRAWN

Chart 4. Travel Time 43 and 48 Feet Below Normal Full Pool Elevation



NOTES:

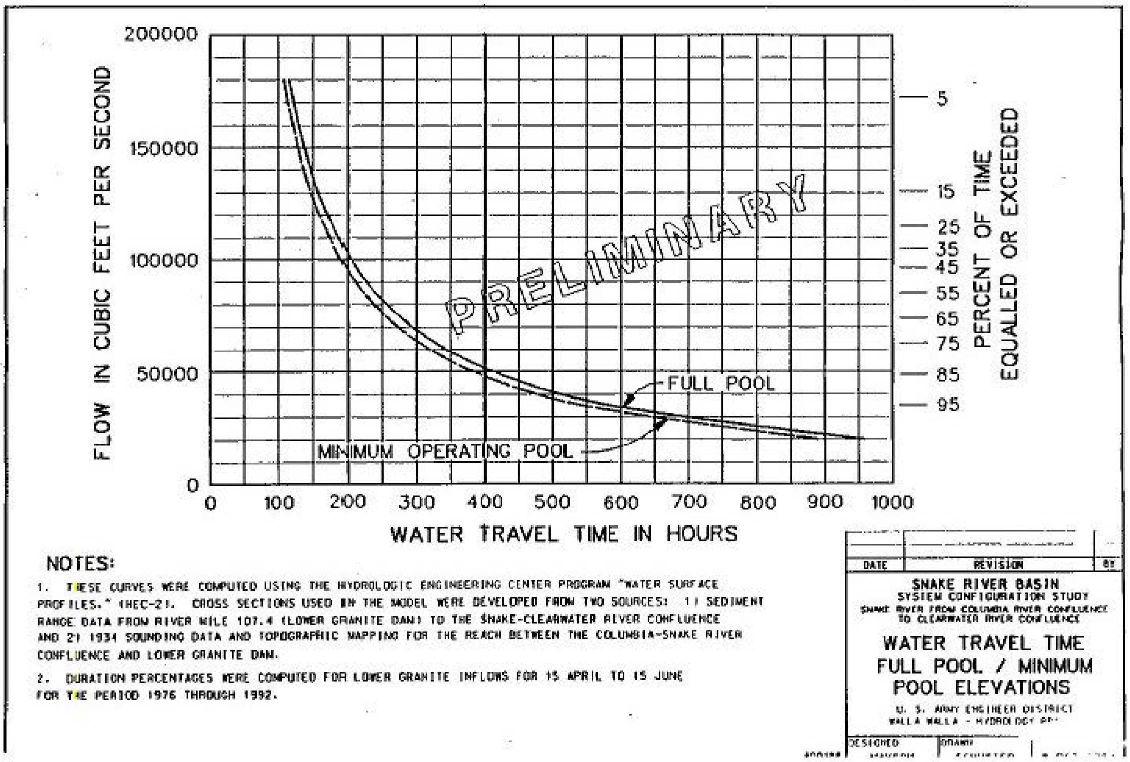
1. THESE CURVES WERE COMPUTED USING THE HYDROLOGIC ENGINEERING CENTER PROGRAM "WATER SURFACE PROFILES." (HEC-2). CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: 1) SEDIMENT RANGE DATA FROM RIVER MILE 107.4 (LOWER GRANITE DAM) TO THE SNAKE-CLEARWATER RIVER CONFLUENCE AND 2) 1934 SOUNDING DATA AND TOPOGRAPHIC MAPPING FOR THE REACH BETWEEN THE COLUMBIA-SNAKE RIVER CONFLUENCE AND LOWER GRANITE DAM.

2. THIS ALTERNATIVE DRAWS DOWN LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE RESERVOIRS 52 (57) FEET TO ELEVATIONS 488 (483), 586 (581), AND 686 (681) FEET MSL, RESPECTIVELY, AND ICE HARBOR RESERVOIR 43 FEET TO ELEVATION 397 FEET MSL.

3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 15 APRIL TO 15 JUNE FOR THE PERIOD 1976 THROUGH 1992.

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
SNAKE RIVER FROM COLUMBIA RIVER CONFLUENCE
TO CLEARWATER RIVER CONFLUENCE
WATER TRAVEL TIME
52 & 57 FEET BELOW
NORMAL FULL POOL
ELEVATION
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

Chart 5. Travel Time 52 and 57 Feet Below Normal Full Pool Elevation



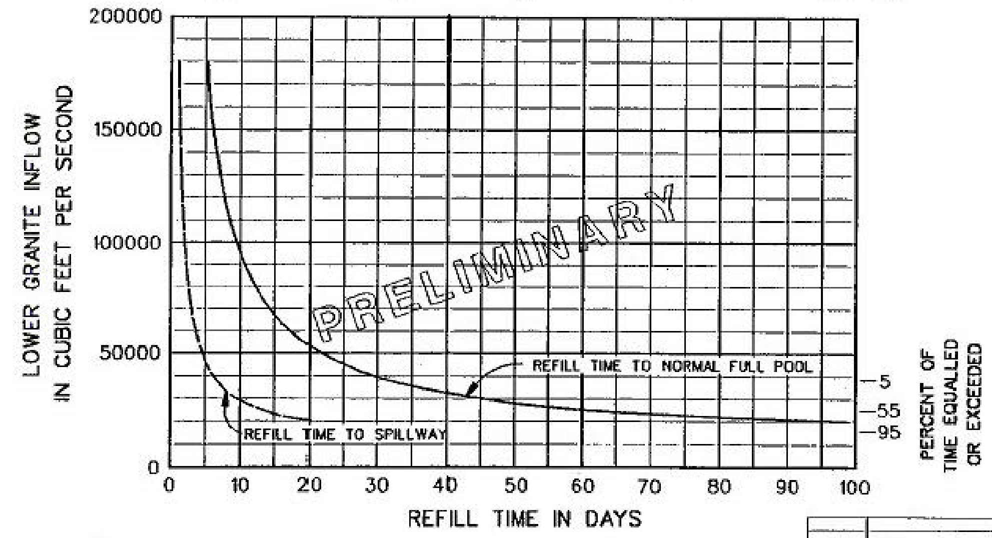
NOTES:

1. THESE CURVES WERE COMPUTED USING THE HYDROLOGIC ENGINEERING CENTER PROGRAM "WATER SURFACE PROFILES." (HEC-2). CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: 1) SEDIMENT RANGE DATA FROM RIVER MILE 107.4 (LOWER GRANITE DAM) TO THE SNAKE-CLEARWATER RIVER CONFLUENCE AND 2) 1934 SOUNDING DATA AND TOPOGRAPHIC MAPPING FOR THE REACH BETWEEN THE COLUMBIA-SNAKE RIVER CONFLUENCE AND LOWER GRANITE DAM.

2. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 15 APRIL TO 15 JUNE FOR THE PERIOD 1976 THROUGH 1992.

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
SNAKE RIVER FROM COLUMBIA RIVER CONFLUENCE
TO CLEARWATER RIVER CONFLUENCE
WATER TRAVEL TIME
FULL POOL / MINIMUM
POOL ELEVATIONS
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BR

Chart 6. Water Travel Time Full Pool/Minimum Pool Elevations



NOTES:

1. THIS CURVE DEPICTS THE TIME TO REFILL THE FOUR LOWER SNAKE RIVER PROJECTS FROM EXISTING SPILLWAY CRESTS OF 391, 438, 581, AND 681 FEET MSL FOR ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE, RESPECTIVELY TO NORMAL FULL POOL. THE ORDER OF REFILL IS NOT CONSIDERED.
2. A MINIMUM PROJECT RELEASE OF 11,000 CUBIC FEET PER SECOND IS CONSIDERED IN THE REFILL TIMES.
3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 1 SEPTEMBER THROUGH 31 OCTOBER FOR THE PERIOD 1976 THROUGH 1992.

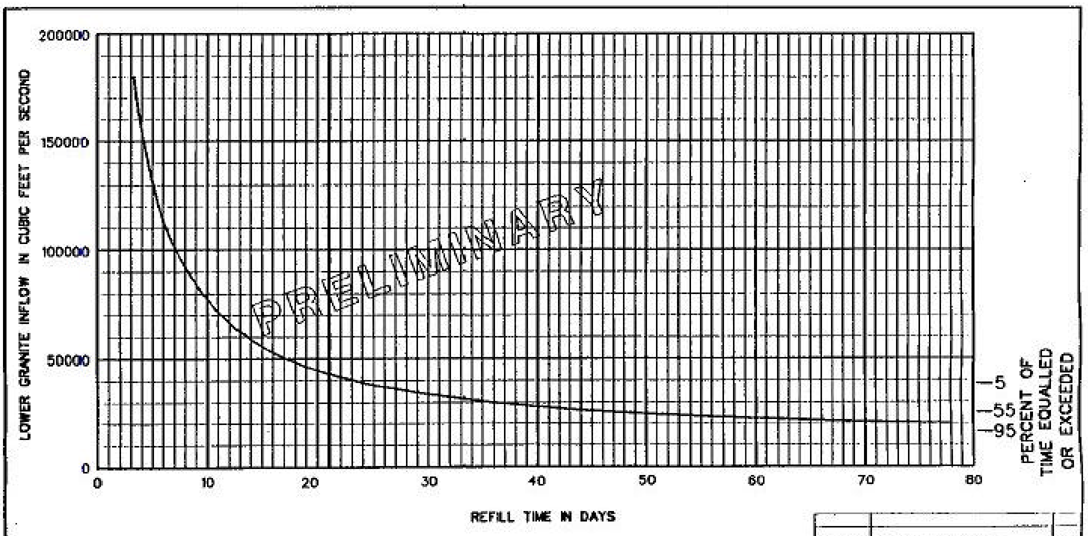
DATE	REVISION	BY

SHAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE RESERVOIRS
REFILL TIME
FROM NEAR NATURAL
CONDITION TO NORMAL
FULL POOL ELEVATION
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

DESIGNED	DRAWN	
MAXSON	SCHUSTER	

A00193

Chart 7. Refill Time from Near Natural Conditions to Normal Full Pool Elevation



NOTES:

1. THIS CURVE DEPICTS THE TIME TO REFILL THE FOUR LOWER SNAKE RIVER PROJECTS FROM EXISTING SPILLWAY CRESTS OF 391, 438, 581, AND 681 FEET MSL FOR ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE, RESPECTIVELY TO NORMAL FULL POOL. THE ORDER OF REFILL IS NOT CONSIDERED.
2. A MINIMUM PROJECT RELEASE OF 11,000 CUBIC FEET PER SECOND IS CONSIDERED IN THE REFILL TIMES.
3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 1 SEPTEMBER THROUGH 31 OCTOBER FOR THE PERIOD 1976 THROUGH 1992.

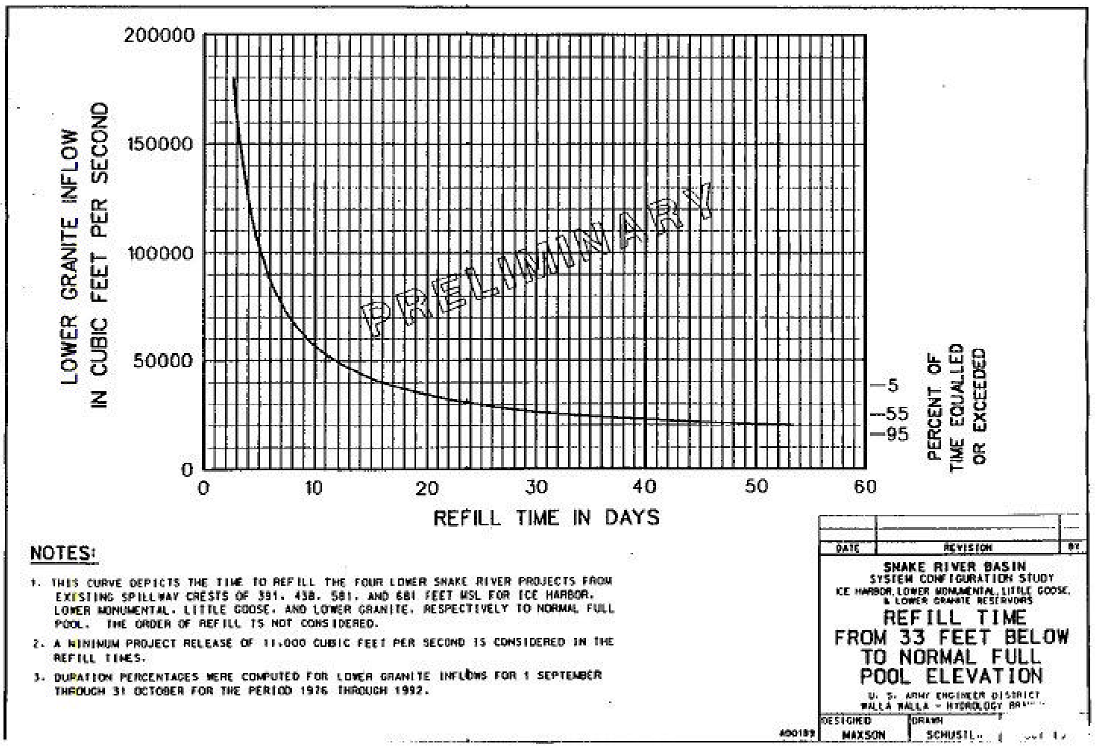
DATE	REVISION	BY

SHAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE RESERVOIRS
REFILL TIME
FROM SPILLWAY CREST
TO NORMAL FULL POOL
ELEVATION
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

DESIGNED	DRAWN	DATE
MAXSON	SCHUSTER	

A00192

Chart 8. Refill Time From Spillway Crest to Normal Full Pool Elevation

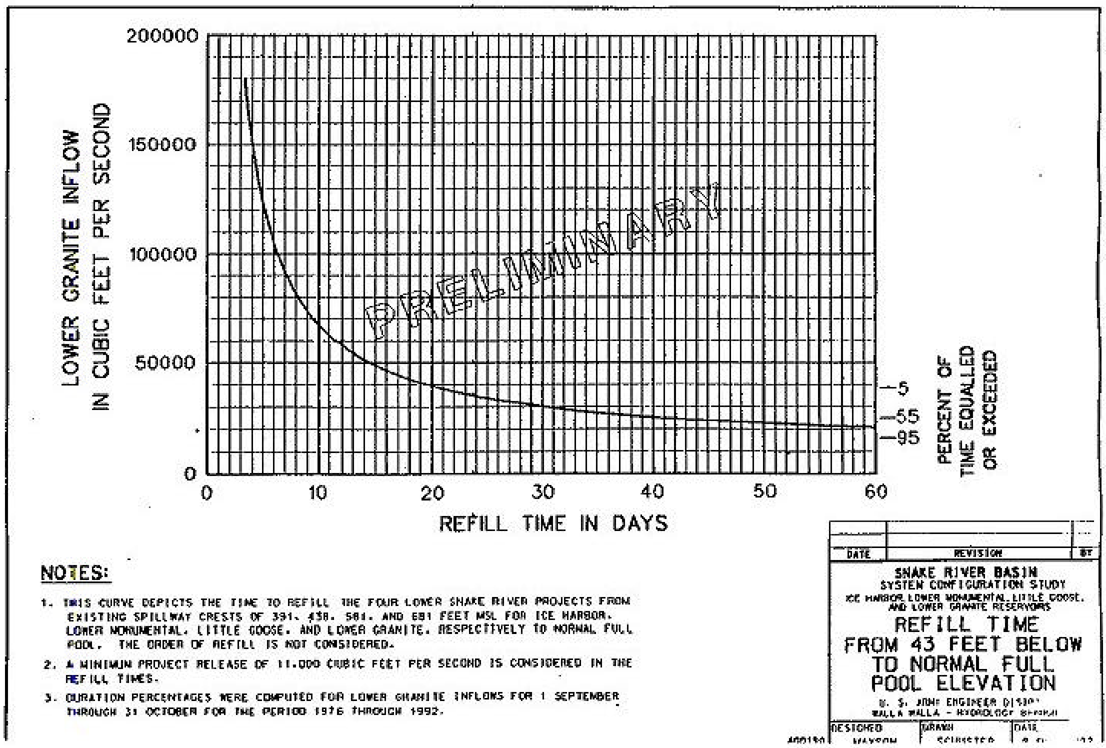


NOTES:

1. THIS CURVE DEPICTS THE TIME TO REFILL THE FOUR LOWER SNAKE RIVER PROJECTS FROM EXISTING SPILLWAY CRESTS OF 391, 438, 581, AND 681 FEET MSL FOR ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE, RESPECTIVELY TO NORMAL FULL POOL. THE ORDER OF REFILL IS NOT CONSIDERED.
2. A MINIMUM PROJECT RELEASE OF 11,000 CUBIC FEET PER SECOND IS CONSIDERED IN THE REFILL TIMES.
3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 1 SEPTEMBER THROUGH 31 OCTOBER FOR THE PERIOD 1976 THROUGH 1992.

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE, & LOWER GRANITE RESERVOIRS
REFILL TIME
FROM 33 FEET BELOW
TO NORMAL FULL
POOL ELEVATION
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BR

Chart 9. Refill Time From 33 Feet Below to Normal Full Pool Elevation

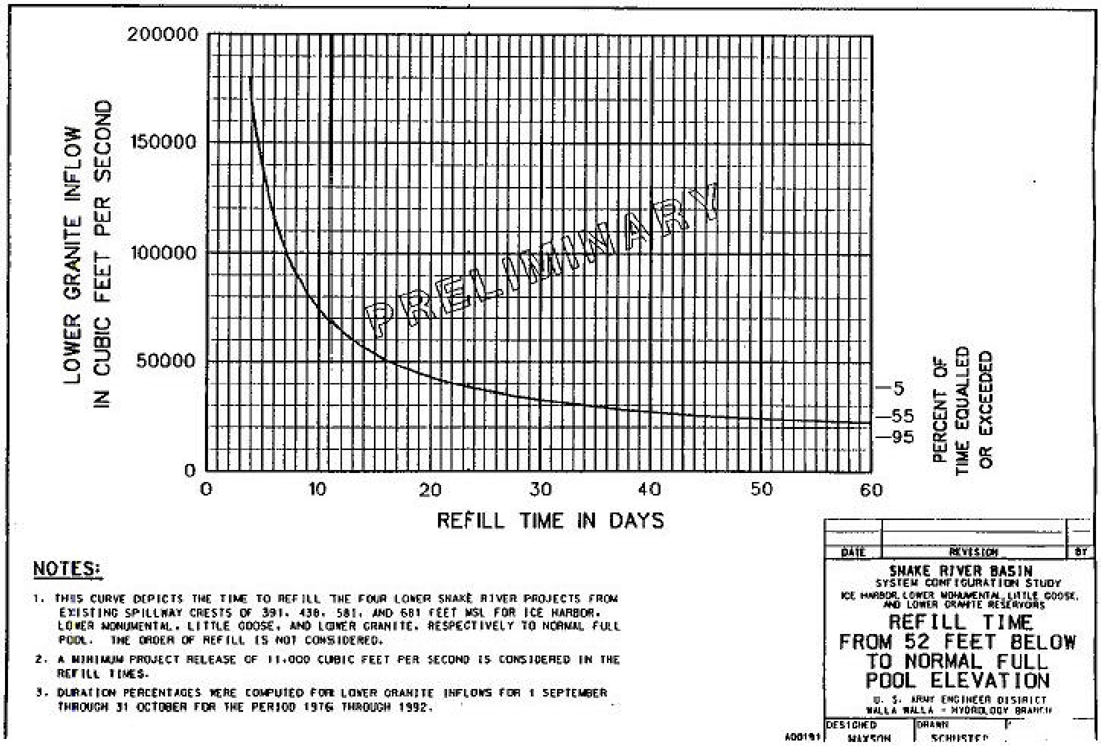


NOTES:

1. THIS CURVE DEPICTS THE TIME TO REFILL THE FOUR LOWER SNAKE RIVER PROJECTS FROM EXISTING SPILLWAY CRESTS OF 391, 438, 581, AND 681 FEET MSL FOR ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE, RESPECTIVELY TO NORMAL FULL POOL. THE ORDER OF REFILL IS NOT CONSIDERED.
2. A MINIMUM PROJECT RELEASE OF 11,000 CUBIC FEET PER SECOND IS CONSIDERED IN THE REFILL TIMES.
3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 1 SEPTEMBER THROUGH 31 OCTOBER FOR THE PERIOD 1976 THROUGH 1992.

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE RESERVOIRS
REFILL TIME
FROM 43 FEET BELOW
TO NORMAL FULL
POOL ELEVATION
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

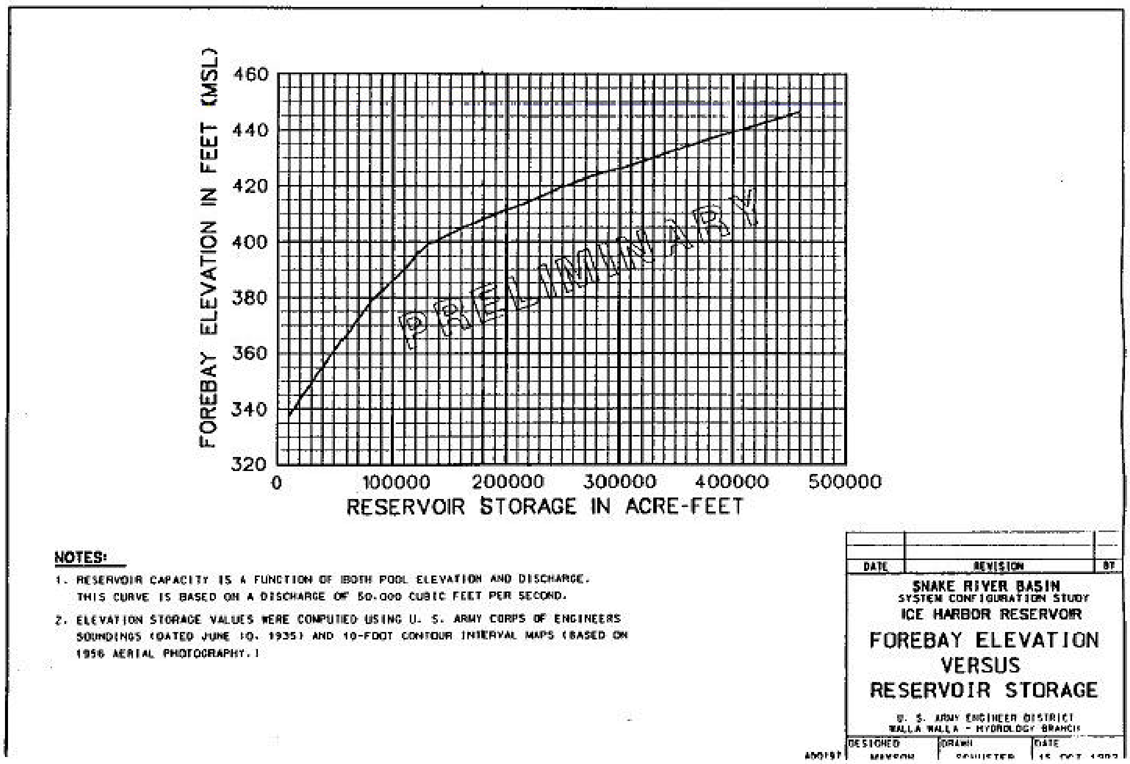
Chart 10. Refill Time From 43 Feet Below to Normal Full Pool Elevation



NOTES:

1. THIS CURVE DEPICTS THE TIME TO REFILL THE FOUR LOWER SNAKE RIVER PROJECTS FROM EXISTING SPILLWAY CRESTS OF 391, 438, 581, AND 681 FEET MSL FOR ICE HARBOR, LOWER MONUMENTAL, LITTLE GOOSE, AND LOWER GRANITE, RESPECTIVELY TO NORMAL FULL POOL. THE ORDER OF REFILL IS NOT CONSIDERED.
2. A MINIMUM PROJECT RELEASE OF 11,000 CUBIC FEET PER SECOND IS CONSIDERED IN THE REFILL TIMES.
3. DURATION PERCENTAGES WERE COMPUTED FOR LOWER GRANITE INFLOWS FOR 1 SEPTEMBER THROUGH 31 OCTOBER FOR THE PERIOD 1976 THROUGH 1992.

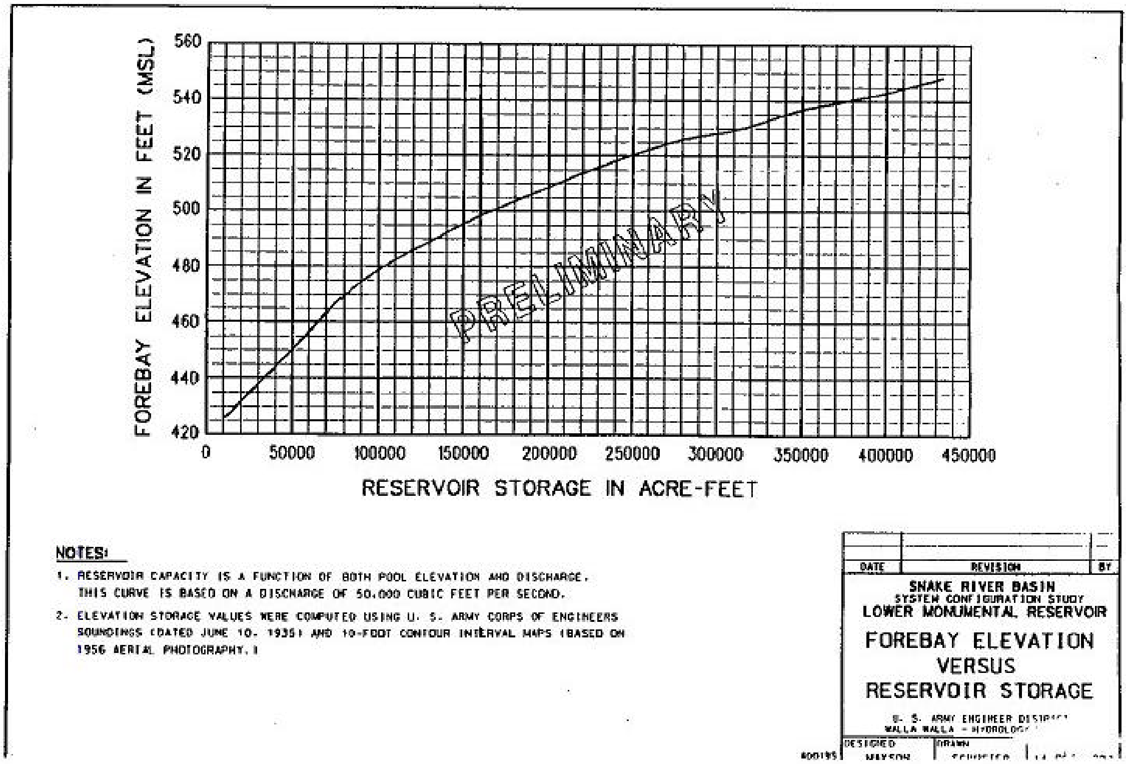
Chart 11. Refill Time From 52 Feet Below to Normal Full Pool Elevation



NOTES:

1. RESERVOIR CAPACITY IS A FUNCTION OF BOTH POOL ELEVATION AND DISCHARGE. THIS CURVE IS BASED ON A DISCHARGE OF 50,000 CUBIC FEET PER SECOND.
2. ELEVATION STORAGE VALUES WERE COMPUTED USING U. S. ARMY CORPS OF ENGINEERS SOUNDINGS (DATED JUNE 10, 1935) AND 10-FOOT CONTOUR INTERVAL MAPS (BASED ON 1956 AERIAL PHOTOGRAPHY.)

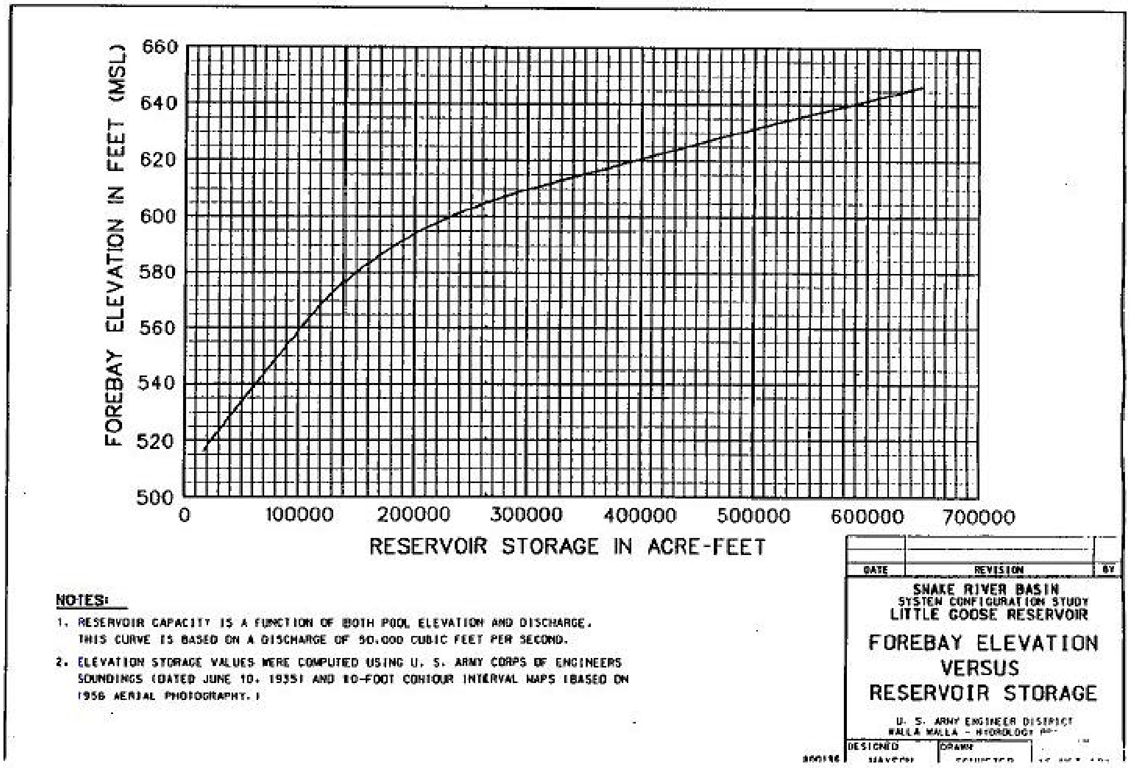
Chart 12. Ice Harbor Forebay Elevation Versus Reservoir Storage



NOTES:

1. RESERVOIR CAPACITY IS A FUNCTION OF BOTH POOL ELEVATION AND DISCHARGE. THIS CURVE IS BASED ON A DISCHARGE OF 50,000 CUBIC FEET PER SECOND.
2. ELEVATION STORAGE VALUES WERE COMPUTED USING U. S. ARMY CORPS OF ENGINEERS SOUNDINGS (DATED JUNE 10, 1935) AND 10-FOOT CONTOUR INTERVAL MAPS (BASED ON 1956 AERIAL PHOTOGRAPHY.)

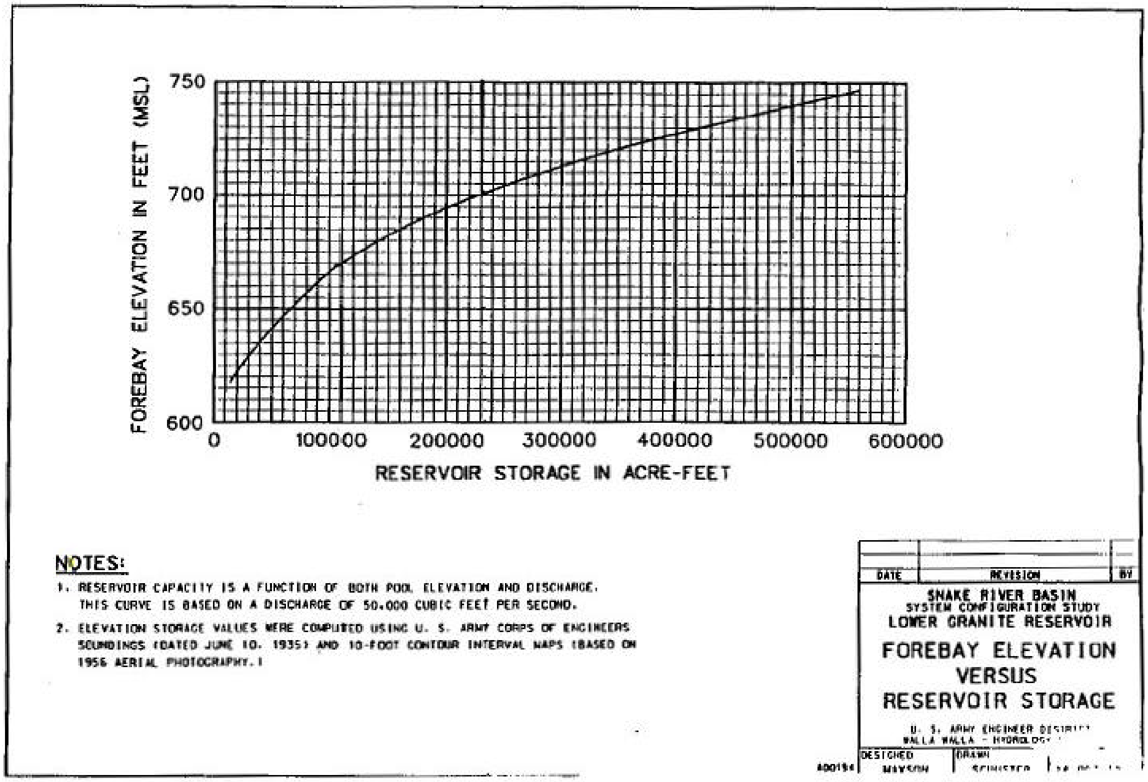
Chart 13. Lower Monumental Forebay Elevation Versus Reservoir Storage



NOTES:

1. RESERVOIR CAPACITY IS A FUNCTION OF BOTH POOL ELEVATION AND DISCHARGE. THIS CURVE IS BASED ON A DISCHARGE OF 50,000 CUBIC FEET PER SECOND.
2. ELEVATION STORAGE VALUES WERE COMPUTED USING U. S. ARMY CORPS OF ENGINEERS SOUNDINGS (DATED JUNE 10, 1935) AND 10-FOOT CONTOUR INTERVAL MAPS (BASED ON 1956 AERIAL PHOTOGRAPHY.)

Chart 14. Little Goose Forebay Elevation Versus Reservoir Storage

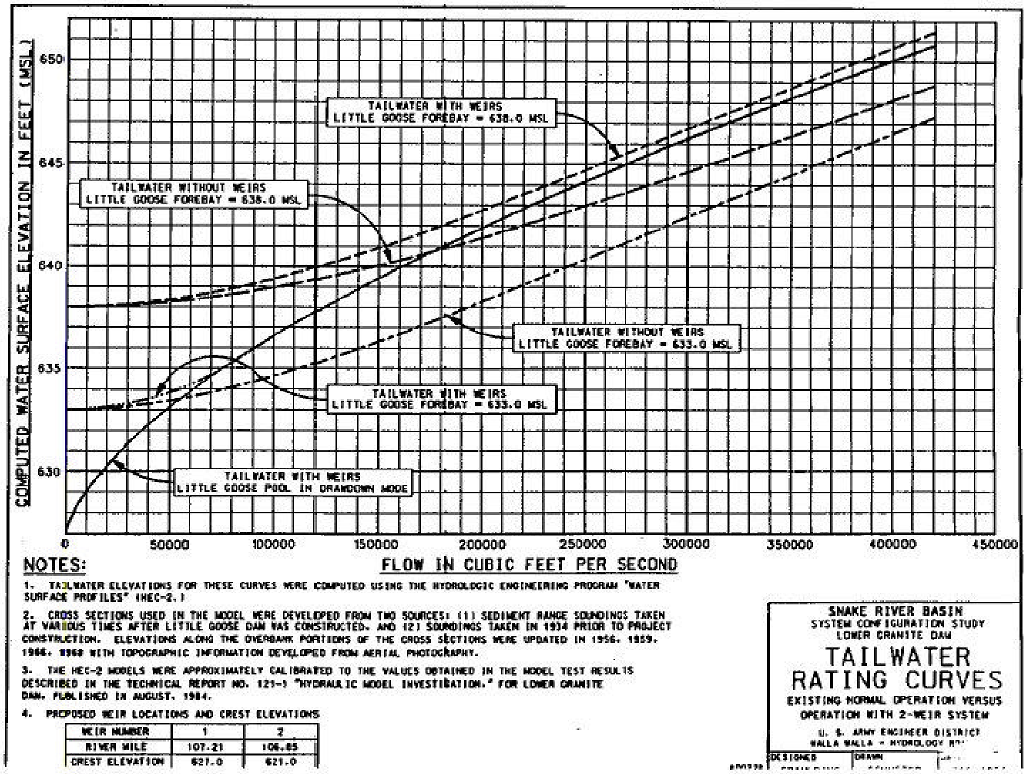


NOTES:

1. RESERVOIR CAPACITY IS A FUNCTION OF BOTH POOL ELEVATION AND DISCHARGE. THIS CURVE IS BASED ON A DISCHARGE OF 50,000 CUBIC FEET PER SECOND.

2. ELEVATION STORAGE VALUES WERE COMPUTED USING U. S. ARMY CORPS OF ENGINEERS SOUNDINGS (DATED JUNE 10, 1935) AND 10-FOOT CONTOUR INTERVAL MAPS (BASED ON 1956 AERIAL PHOTOGRAPHY.)

Chart 15. Lower Granite Forebay Elevation Versus Reservoir Storage



NOTES:

1. TAILWATER ELEVATIONS FOR THESE CURVES WERE COMPUTED USING THE HYDROLOGIC ENGINEERING PROGRAM "WATER SURFACE PROFILES" (HEC-2.)

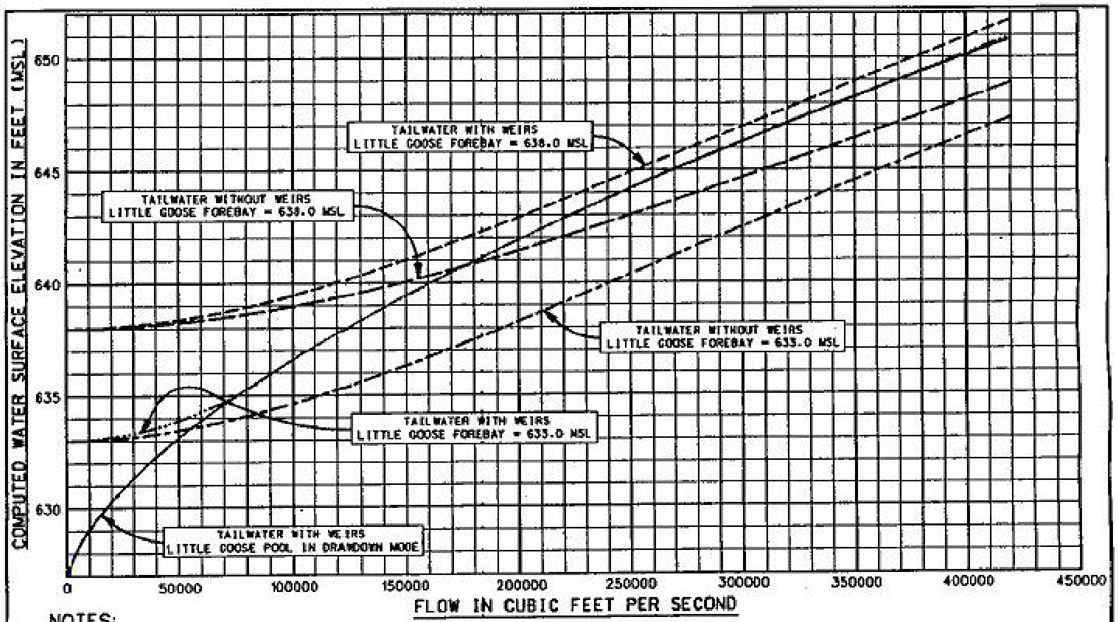
2. CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: (1) SEDIMENT RANGE SOUNDINGS TAKEN AT VARIOUS TIMES AFTER LITTLE GOOSE DAM WAS CONSTRUCTED, AND (2) SOUNDINGS TAKEN IN 1934 PRIOR TO PROJECT CONSTRUCTION. ELEVATIONS ALONG THE OVERBANK PORTIONS OF THE CROSS SECTIONS WERE UPDATED IN 1956, 1959, 1966, 1968 WITH TOPOGRAPHIC INFORMATION DEVELOPED FROM AERIAL PHOTOGRAPHY.

3. THE HEC-2 MODELS WERE APPROXIMATELY CALIBRATED TO THE VALUES OBTAINED IN THE MODEL TEST RESULTS DESCRIBED IN THE TECHNICAL REPORT NO. 121-1 "HYDRAULIC MODEL INVESTIGATION," FOR LOWER GRANITE DAM, PUBLISHED IN AUGUST, 1984.

4. PROPOSED WEIR LOCATIONS AND CREST ELEVATIONS

WEIR NUMBER	1	2
RIVER MILE	107.21	106.85
CREST ELEVATION	627.0	621.0

Chart 16. Lower Granite Dam Tailwater Rating Curves--
Existing Normal Operation Versus Operation With Two-Weir System



NOTES:

1. TAILWATER ELEVATIONS FOR THESE CURVES WERE COMPUTED USING THE HYDROLOGIC ENGINEERING PROGRAM "WATER SURFACE PROFILES" (HEC-2.)

2. CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: (1) SEDIMENT RANGE SOUNDINGS TAKEN AT VARIOUS TIMES AFTER LITTLE GOOSE DAM WAS CONSTRUCTED, AND (2) SOUNDINGS TAKEN IN 1934 PRIOR TO PROJECT CONSTRUCTION. ELEVATIONS ALONG THE OVERBANK PORTIONS OF THE CROSS SECTIONS WERE UPDATED IN 1956, 1959, 1964, 1968 WITH TOPOGRAPHIC INFORMATION DEVELOPED FROM AERIAL PHOTOGRAPHY.

3. THE HEC-2 MODELS WERE APPROXIMATELY CALIBRATED TO THE VALUES OBTAINED IN THE MODEL TEST RESULTS DESCRIBED IN THE TECHNICAL REPORT NO. 121-1 "HYDRAULIC MODEL INVESTIGATION," FOR LOWER GRANITE DAM, PUBLISHED IN AUGUST, 1984.

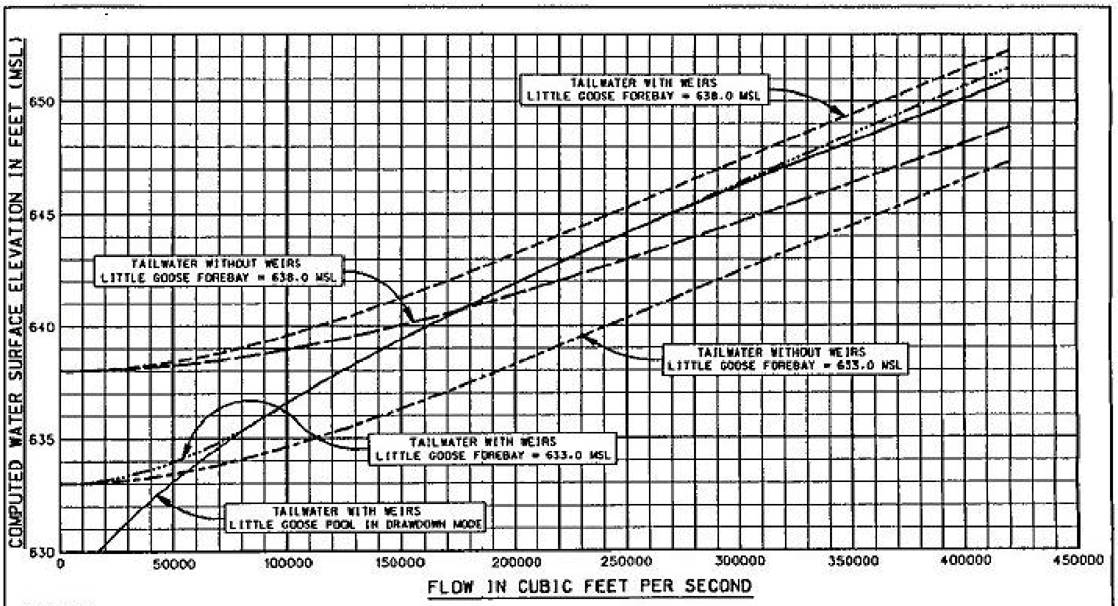
4. PROPOSED WEIR LOCATIONS AND CREST ELEVATIONS

WEIR NUMBER	1	2	3
RIVER MILE	107.21	106.92	106.77
CREST ELEVATION	627.0	623.1	618.0

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
LOWER GRANITE DAM
TAILWATER
RATING CURVES
EXISTING NORMAL OPERATION VERSUS
OPERATION WITH 3-WEIR SYSTEM
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

A00229	DESIGNED	DRAWN	DATE
	SPAULDING	SCHUSTER	[illegible]

Chart 17. Lower Granite Dam Tailwater Rating Curves--
Existing Normal Operation Versus Operation With Three-Weir System



NOTES:

1. TAILWATER ELEVATIONS FOR THESE CURVES WERE COMPUTED USING THE HYDROLOGIC ENGINEERING PROGRAM "WATER SURFACE PROFILES" (HEC-2.)

2. CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: (1) SEDIMENT RANGE SOUNDINGS TAKEN AT VARIOUS TIMES AFTER LITTLE GOOSE DAM WAS CONSTRUCTED, AND (2) SOUNDINGS TAKEN IN 1934 PRIOR TO PROJECT CONSTRUCTION. ELEVATIONS ALONG THE OVERBANK PORTIONS OF THE CROSS SECTIONS WERE UPDATED IN 1956, 1959, 1966, 1968 WITH TOPOGRAPHIC INFORMATION DEVELOPED FROM AERIAL PHOTOGRAPHY.

3. THE HEC-2 MODELS WERE APPROXIMATELY CALIBRATED TO THE VALUES OBTAINED IN THE MODEL TEST RESULTS DESCRIBED IN THE TECHNICAL REPORT NO. 121-1 "HYDRAULIC MODEL INVESTIGATION," FOR LOWER GRANITE DAM, PUBLISHED IN AUGUST, 1984.

4. PROPOSED WEIR LOCATIONS AND CREST ELEVATIONS

WEIR NUMBER	1	2	3	4	5
RIVER MILE	107.21	106.97	106.85	106.75	106.64
CREST ELEVATION	627.0	625.0	621.1	618.1	613.9

A00230

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
LOWER GRANITE DAM

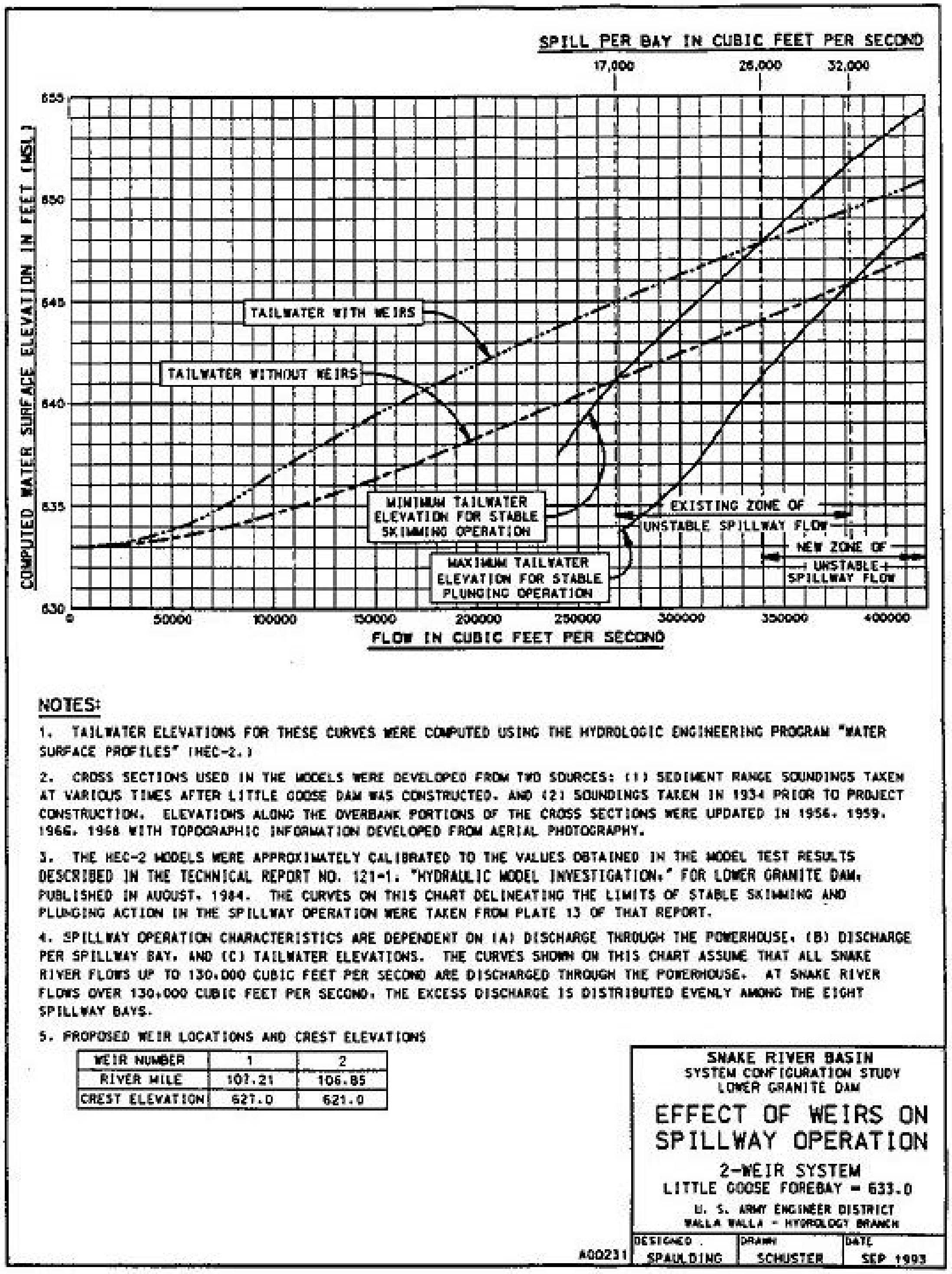
TAILWATER
RATING CURVES

EXISTING NORMAL OPERATION VERSUS
OPERATION WITH 5-WEIR SYSTEM

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

DESIGNED	DRAWN	DATE
SPAULDING	SCHUSTER	SEP 1993

Chart 18. Lower Granite Dam Tailwater Rating Curves--
Existing Normal Operation Versus Operation With Five-Weir System



NOTES:

1. TAILWATER ELEVATIONS FOR THESE CURVES WERE COMPUTED USING THE HYDROLOGIC ENGINEERING PROGRAM "WATER SURFACE PROFILES" (HEC-2.)

2. CROSS SECTIONS USED IN THE MODELS WERE DEVELOPED FROM TWO SOURCES: (1) SEDIMENT RANGE SOUNDINGS TAKEN AT VARIOUS TIMES AFTER LITTLE GOOSE DAM WAS CONSTRUCTED, AND (2) SOUNDINGS TAKEN IN 1934 PRIOR TO PROJECT CONSTRUCTION. ELEVATIONS ALONG THE OVERBANK PORTIONS OF THE CROSS SECTIONS WERE UPDATED IN 1956, 1959, 1966, 1968 WITH TOPOGRAPHIC INFORMATION DEVELOPED FROM AERIAL PHOTOGRAPHY.

3. THE HEC-2 MODELS WERE APPROXIMATELY CALIBRATED TO THE VALUES OBTAINED IN THE MODEL TEST RESULTS DESCRIBED IN THE TECHNICAL REPORT NO. 121-1, "HYDRAULIC MODEL INVESTIGATION," FOR LOWER GRANITE DAM, PUBLISHED IN AUGUST, 1984. THE CURVES ON THIS CHART DELINEATING THE LIMITS OF STABLE SKIMMING AND PLUNGING ACTION IN THE SPILLWAY OPERATION WERE TAKEN FROM PLATE 13 OF THAT REPORT.

4. SPILLWAY OPERATION CHARACTERISTICS ARE DEPENDENT ON (A) DISCHARGE THROUGH THE POWERHOUSE, (B) DISCHARGE PER SPILLWAY BAY, AND (C) TAILWATER ELEVATIONS. THE CURVES SHOWN ON THIS CHART ASSUME THAT ALL SNAKE RIVER FLOWS UP TO 130,000 CUBIC FEET PER SECOND ARE DISCHARGED THROUGH THE POWERHOUSE. AT SNAKE RIVER FLOWS OVER 130,000 CUBIC FEET PER SECOND, THE EXCESS DISCHARGE IS DISTRIBUTED EVENLY AMONG THE EIGHT SPILLWAY BAYS.

5. PROPOSED WEIR LOCATIONS AND CREST ELEVATIONS

WEIR NUMBER	1	2
RIVER MILE	107.21	106.85
CREST ELEVATION	627.0	621.0

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
LOWER GRANITE DAM

EFFECT OF WEIRS ON
SPILLWAY OPERATION

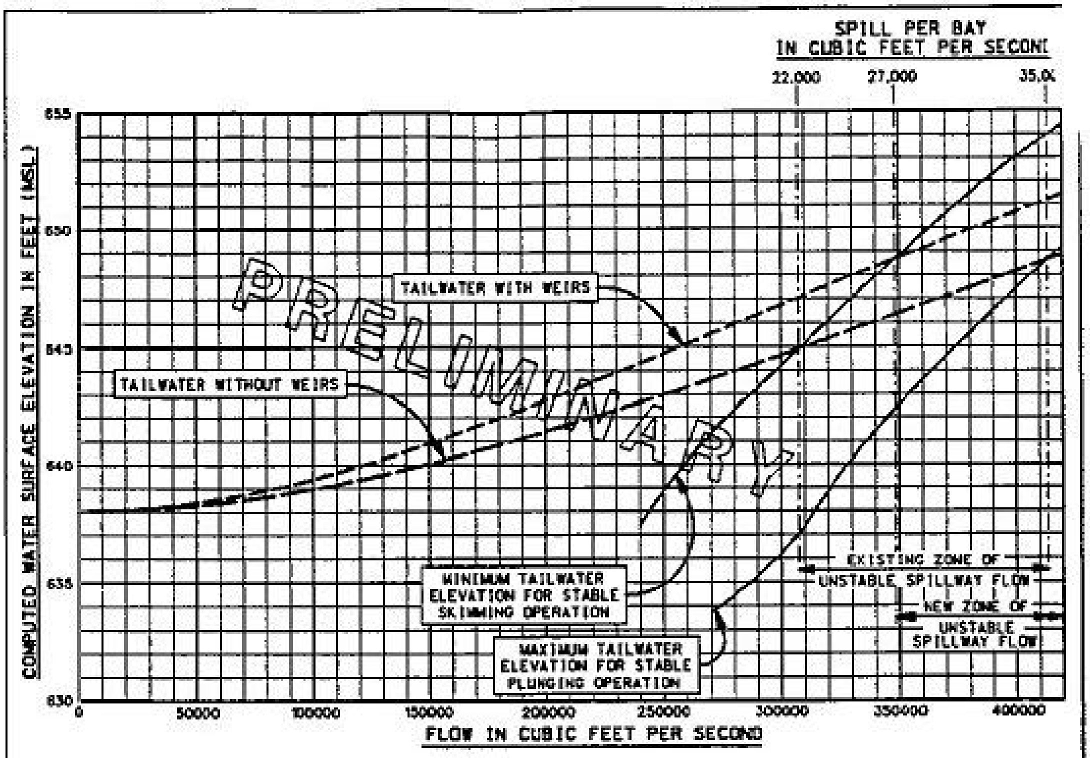
2-WEIR SYSTEM
LITTLE GOOSE FOREBAY = 633.0

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

DESIGNED	DRAWN	DATE
SPAULDING	SCHUSTER	SEP 1993

A00231

Chart 19. Lower Granite Dam Effects of Weirs on Spillway Operation--Two-Weir System
Little Goose Forebay = 633.0



NOTES:

1. TAILWATER ELEVATIONS FOR THESE CURVES WERE COMPUTED USING THE HYDROLOGIC ENGINEERING PROGRAM "WATER SURFACE PROFILES" (HEC-2.)

2. CROSS SECTIONS USED IN THE MODEL WERE DEVELOPED FROM TWO SOURCES: (1) SEDIMENT RANGE SOUNDINGS TAKEN AT VARIOUS TIMES AFTER LITTLE GOOSE DAM WAS CONSTRUCTED, AND (2) SOUNDINGS TAKEN IN 1934 PRIOR TO PROJECT CONSTRUCTION. ELEVATIONS ALONG THE OVERBANK PORTIONS OF THE CROSS SECTIONS WERE UPDATED IN 1956, 1959, 1966, 1968 WITH TOPOGRAPHIC INFORMATION DEVELOPED FROM AERIAL PHOTOGRAPHY.

3. THE HEC-2 MODELS WERE APPROXIMATELY CALIBRATED TO THE VALUES OBTAINED IN THE MODEL TEST RESULTS DESCRIBED IN THE TECHNICAL REPORT NO. 121-1, "HYDRAULIC MODEL INVESTIGATION," FOR LOWER GRANITE DAM, PUBLISHED IN AUGUST, 1984. THE CURVES ON THIS CHART DELINEATING THE LIMITS OF STABLE SKIMMING AND PLUNGING ACTION IN THE SPILLWAY OPERATION WERE TAKEN FROM PLATE 13 OF THAT REPORT.

4. SPILLWAY OPERATION CHARACTERISTICS ARE DEPENDENT ON (A) DISCHARGE THROUGH THE POWERHOUSE, (B) DISCHARGE PER SPILLWAY BAY, AND (C) TAILWATER ELEVATIONS. THE CURVES SHOWN ON THIS CHART ASSUME THAT ALL SNAKE RIVER FLOWS UP TO 130,000 CUBIC FEET PER SECOND ARE DISCHARGED THROUGH THE POWERHOUSE. AT SNAKE RIVER FLOWS OVER 130,000 CUBIC FEET PER SECOND, THE EXCESS DISCHARGE IS DISTRIBUTED EVENLY AMONG THE EIGHT SPILLWAY BAYS.

5. PROPOSED WEIR LOCATIONS AND CREST ELEVATIONS

WEIR NUMBER	1	2
RIVER MILE	107.21	106.85
CREST ELEVATION	627.0	621.0

SNAKE RIVER BASIN
SYSTEM CONFIGURATION STUDY
LOWER GRANITE DAM

EFFECT OF WEIRS ON
SPILLWAY OPERATION

2-WEIR SYSTEM
LITTLE GOOSE FOREBAY = 638.0

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

DESIGNED	DRAWN	DATE
SPAULDING	SCHUSTER	SEP 1993

A00271

Chart 20. Lower Granite Dam Effects of Weirs on Spillway Operation--Two-Weir System
Little Goose Forebay = 638.0

Plates

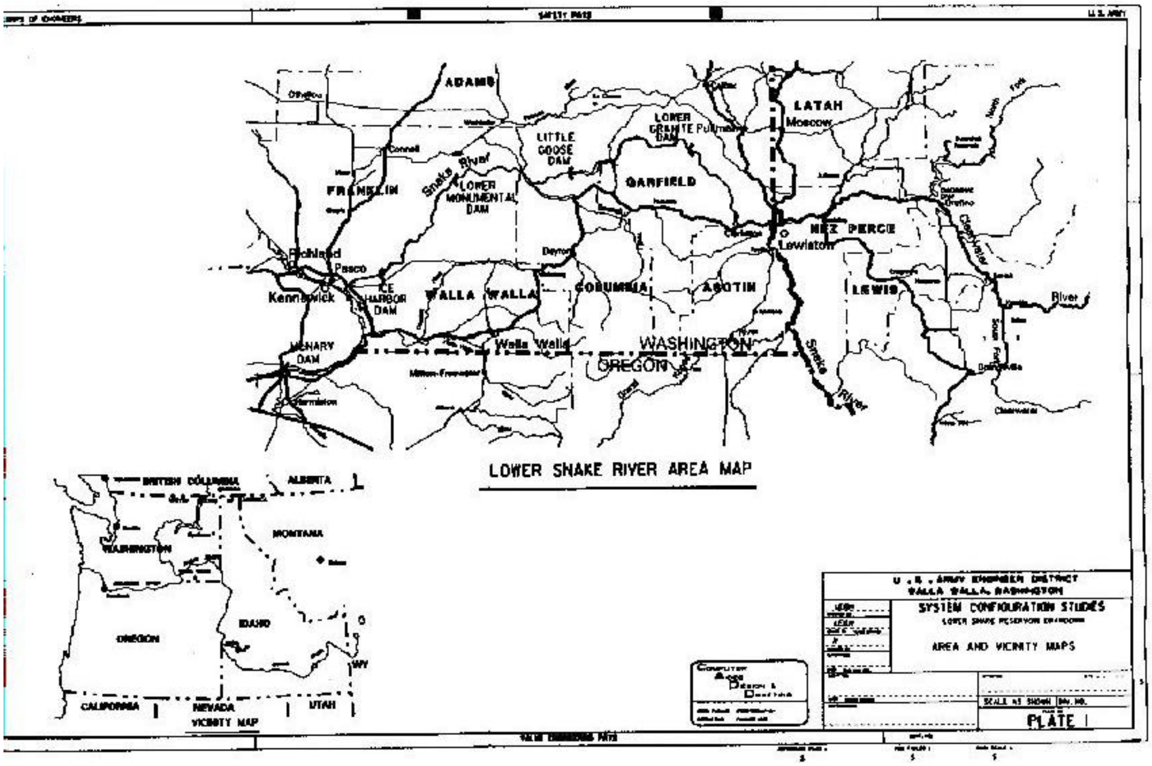


Plate 1. Area and Vicinity Maps

Alternative 4A--Natural River Option

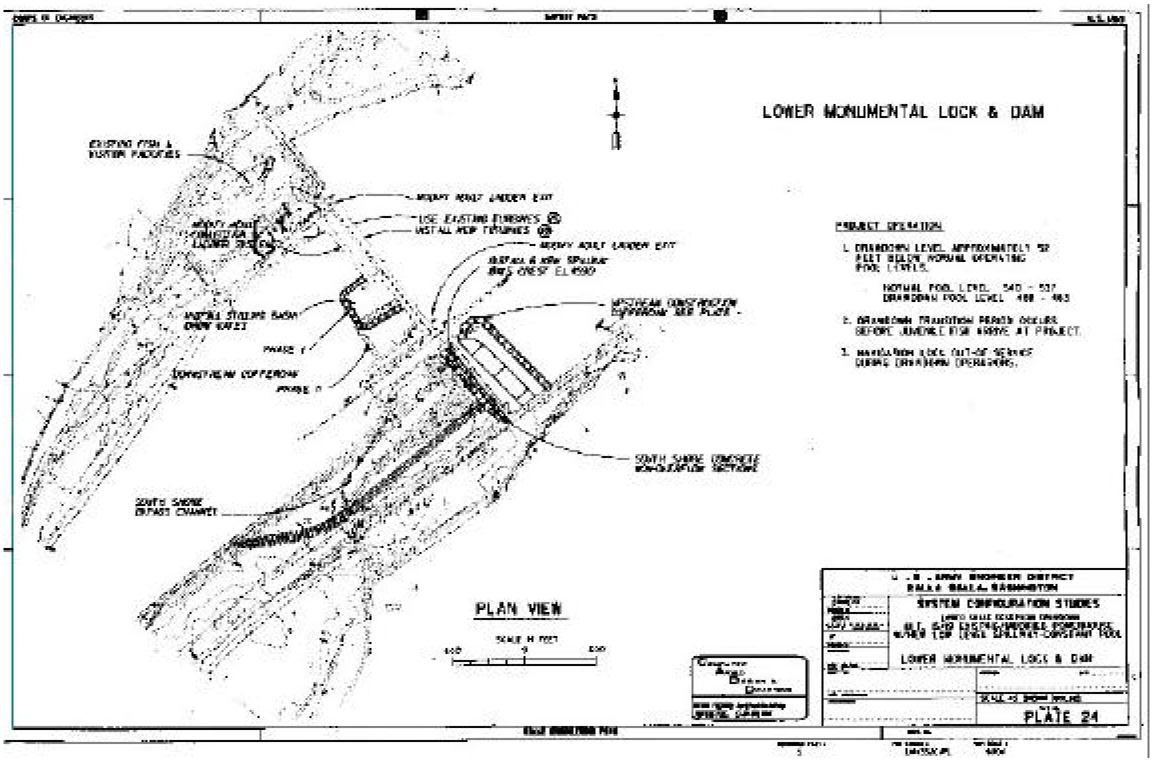


Plate 2. Lower Granite Lock and Dam

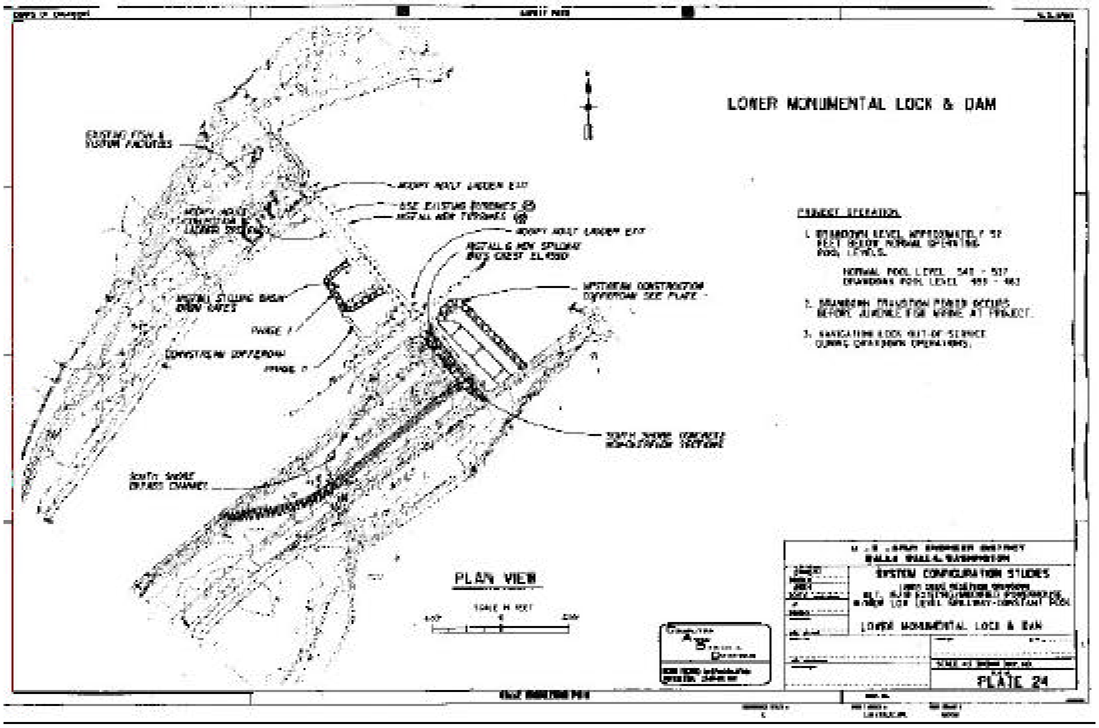


Plate 3. Little Goose Lock and Dam

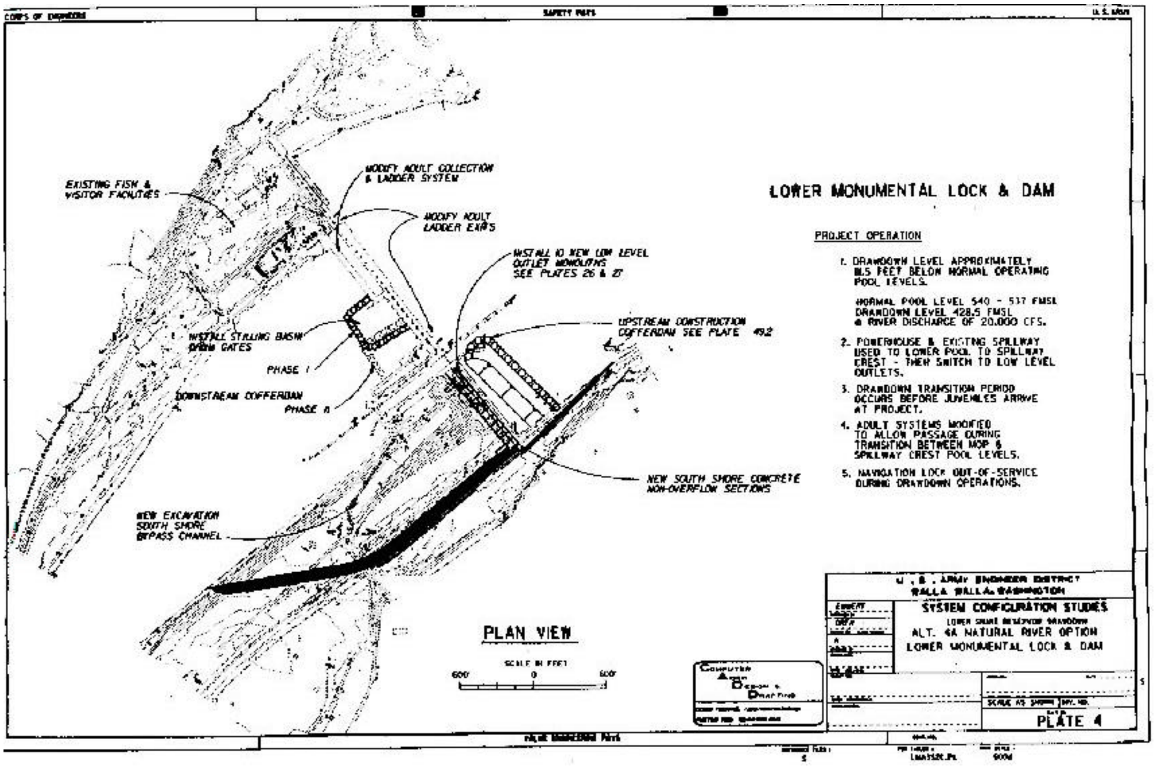


Plate 4. Lower Monumental Lock and Dam

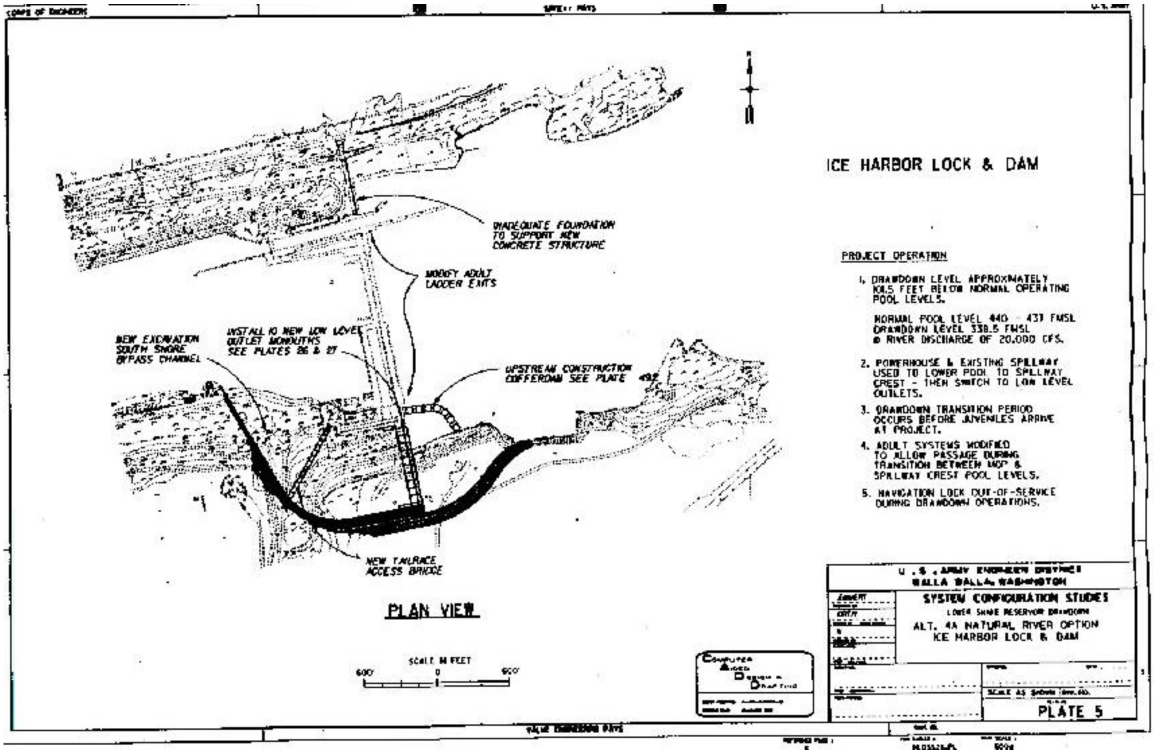


Plate 5. Ice Harbor Lock and Dam

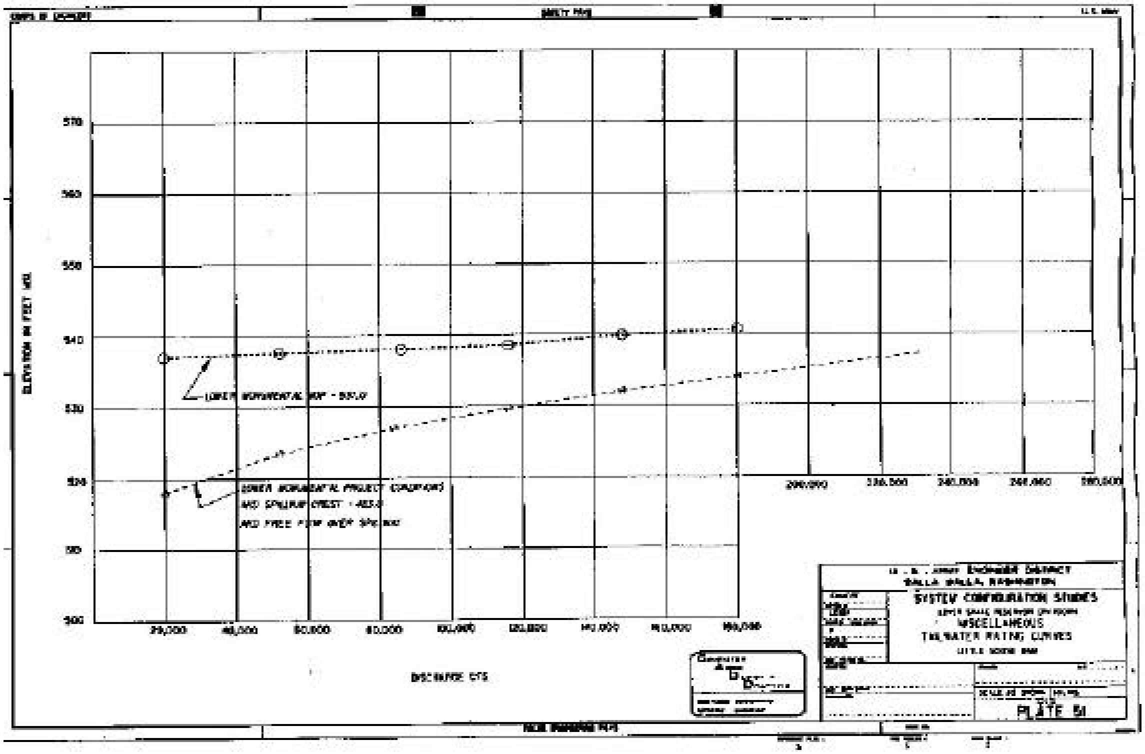


Plate 5.1. Alternative 4A Implementation Plan

Alternative 5/9--Existing/Modified Powerhouse and Existing Spillway--Variable Pool

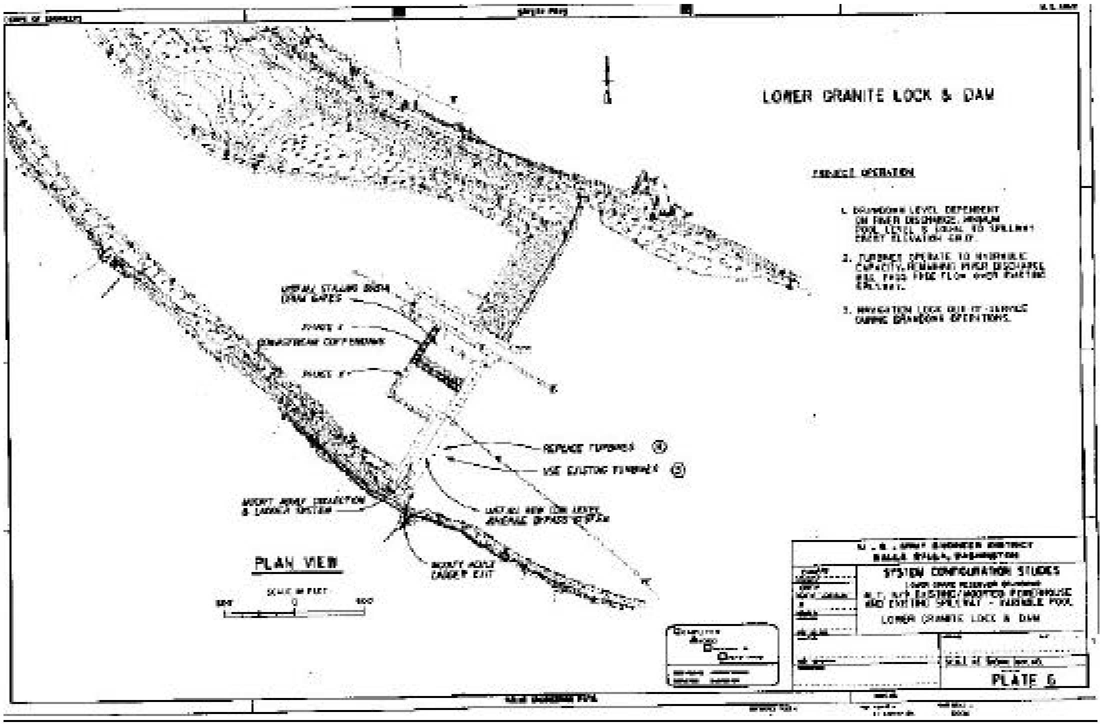


Plate 6. Lower Granite Lock and Dam

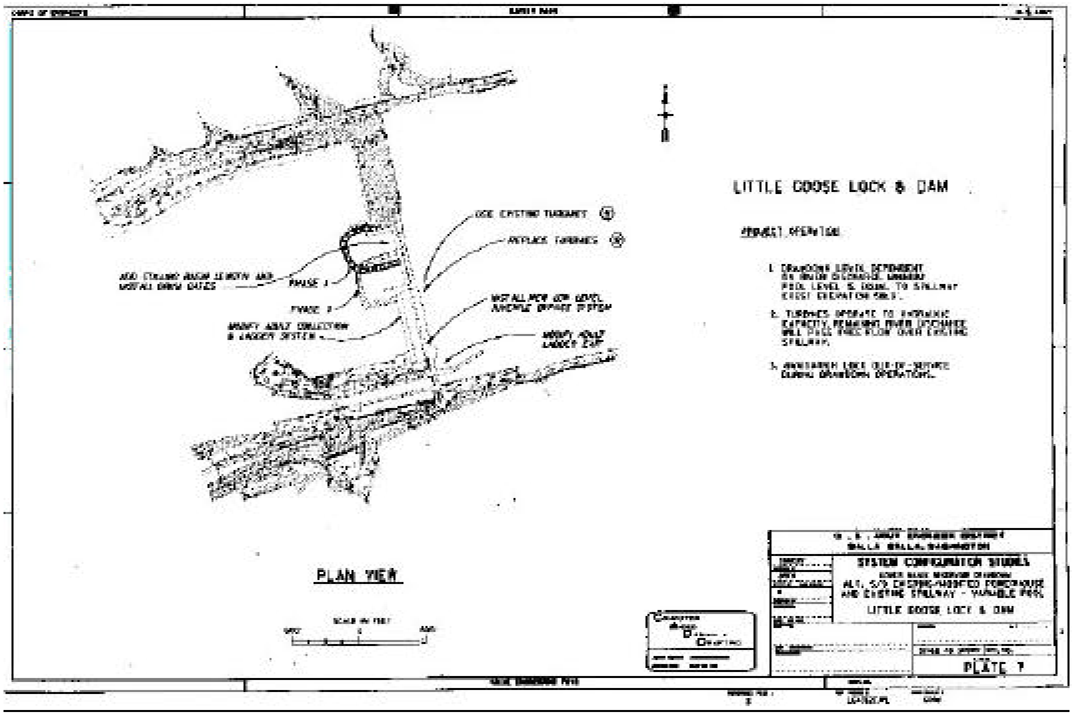


Plate 7. Little Goose Lock and Dam

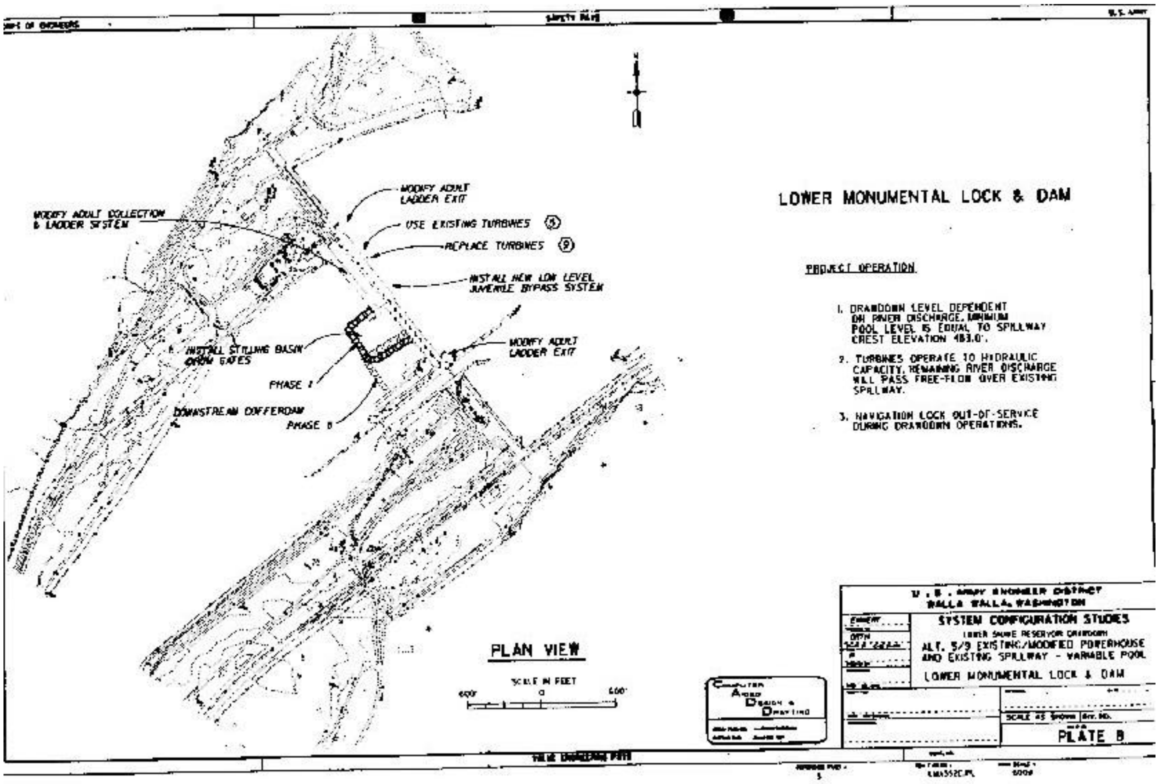


Plate 8. Lower Monumental Lock and Dam

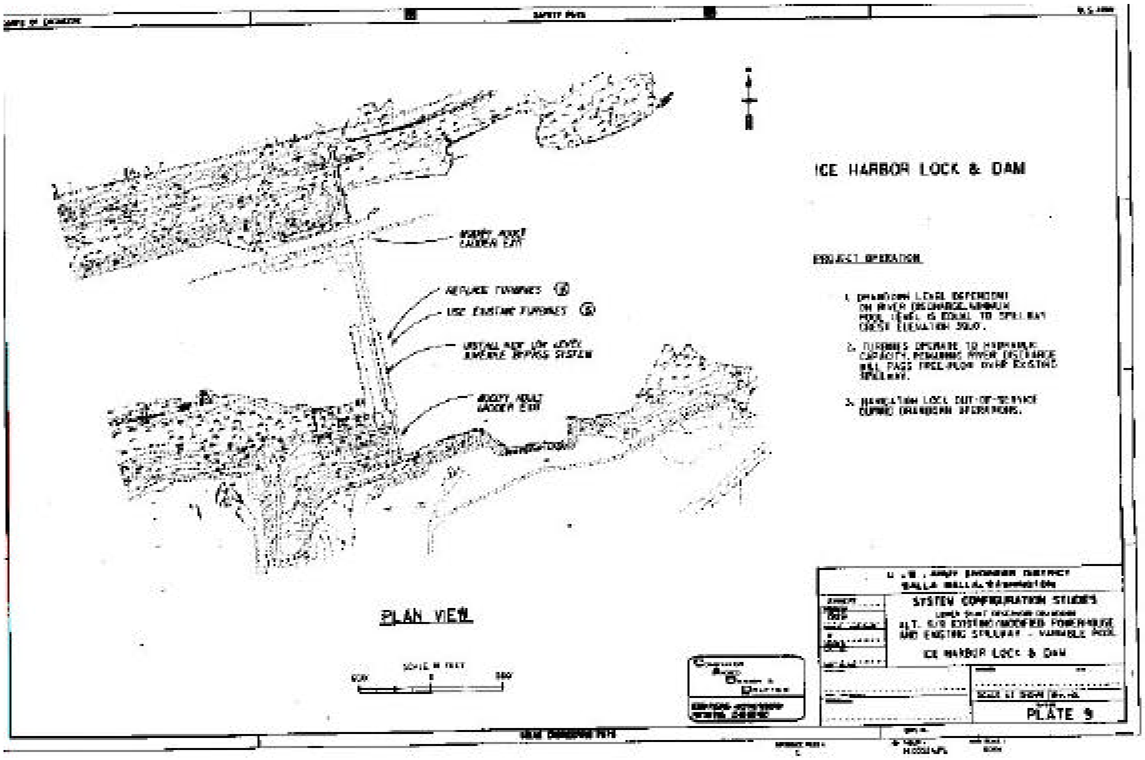
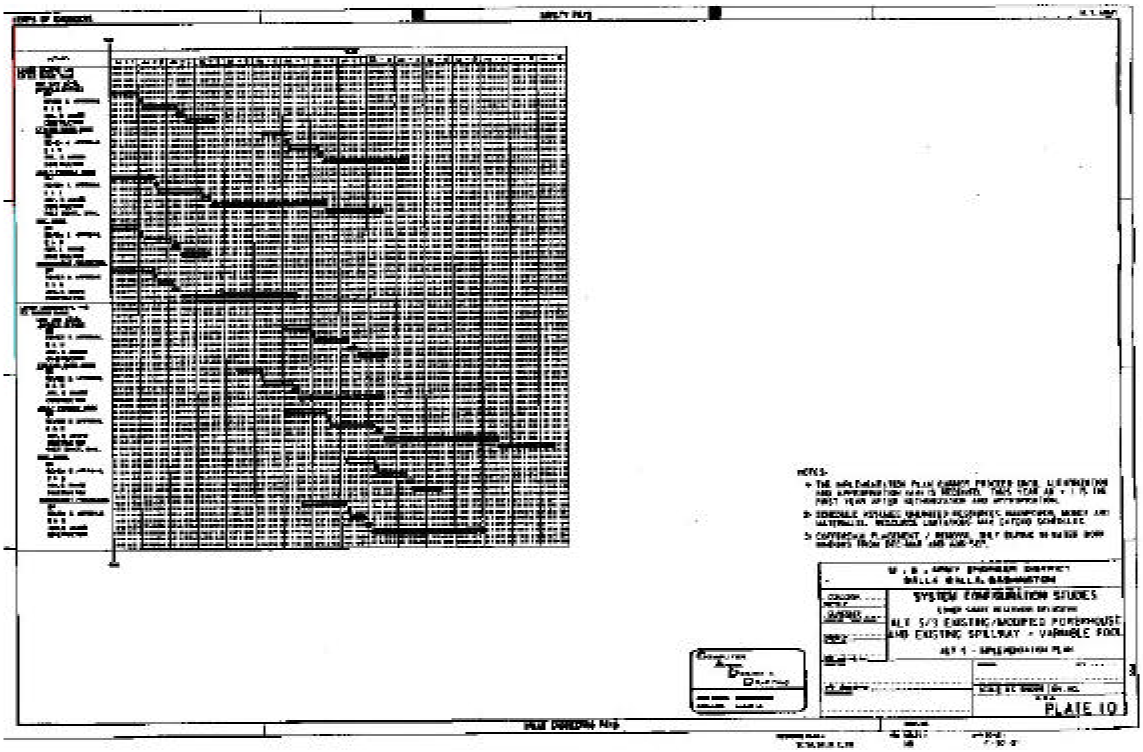


Plate 9. Ice Harbor Lock and Dam

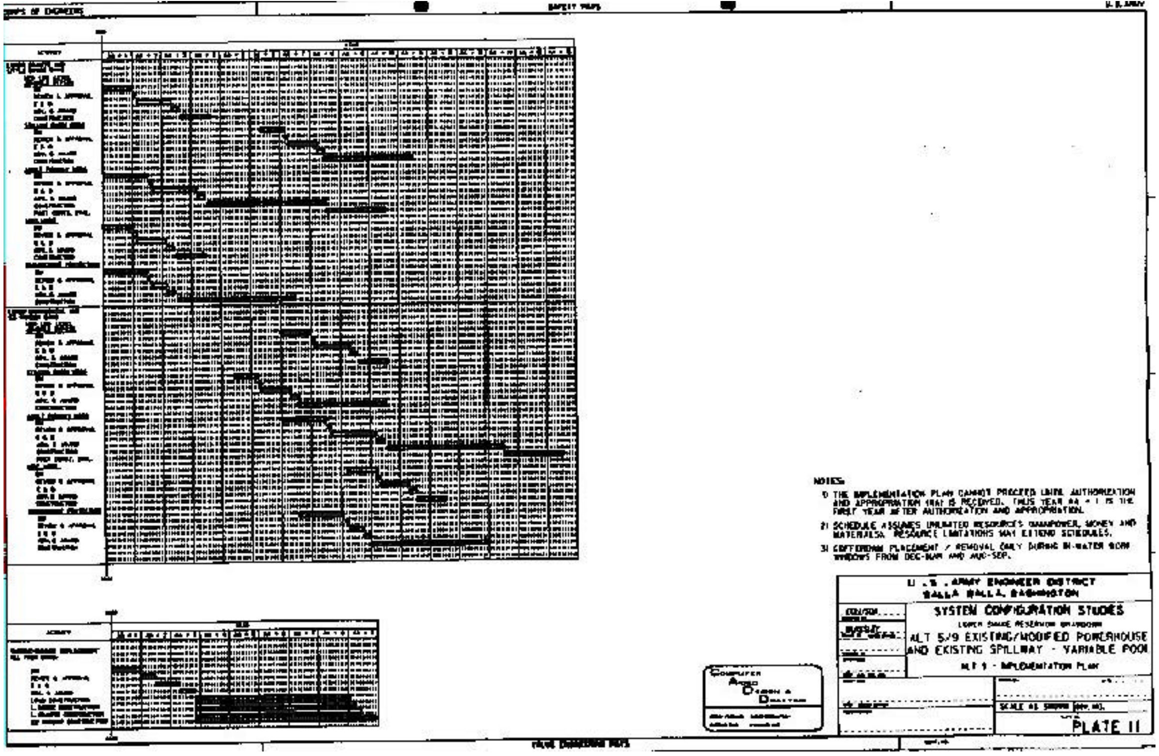


1) THE IMPLEMENTATION PLAN CANNOT PROCEED UNTIL AUTHORIZATION AND APPROPRIATION THAT IS RECEIVED. THUS YEAR #1 IS THE FIRST YEAR AFTER AUTHORIZATION AND APPROPRIATION.

2) SCHEDULE ASSUMES UNLIMITED RESOURCES (MANPOWER, MONEY AND MATERIALS). RESOURCE LIMITATIONS MAY EXTEND SCHEDULES.

3) COFFERDAM PLACEMENT / REMOVAL ONLY DURING IN-WATER WORK WINDOWS FROM DEC-MAR AND AUG-SEP.

Plate 10. Alternative 5 Implementation Plan



1) THE IMPLEMENTATION PLAN CANNOT PROCEED UNTIL AUTHORIZATION AND APPROPRIATION THAT IS RECEIVED. THUS YEAR #1 IS THE FIRST YEAR AFTER AUTHORIZATION AND APPROPRIATION.

2) SCHEDULE ASSUMES UNLIMITED RESOURCES (MANPOWER, MONEY AND MATERIALS). RESOURCE LIMITATIONS MAY EXTEND SCHEDULES.

3) COFFERDAM PLACEMENT / REMOVAL ONLY DURING IN-WATER WORK WINDOWS FROM DEC-MAR AND AUG-SEP.

Plate 11. Alternative 9 Implementation Plan

Alternative 13/17--Existing/Modified Powerhouse and Existing Spillway--Constant Pool

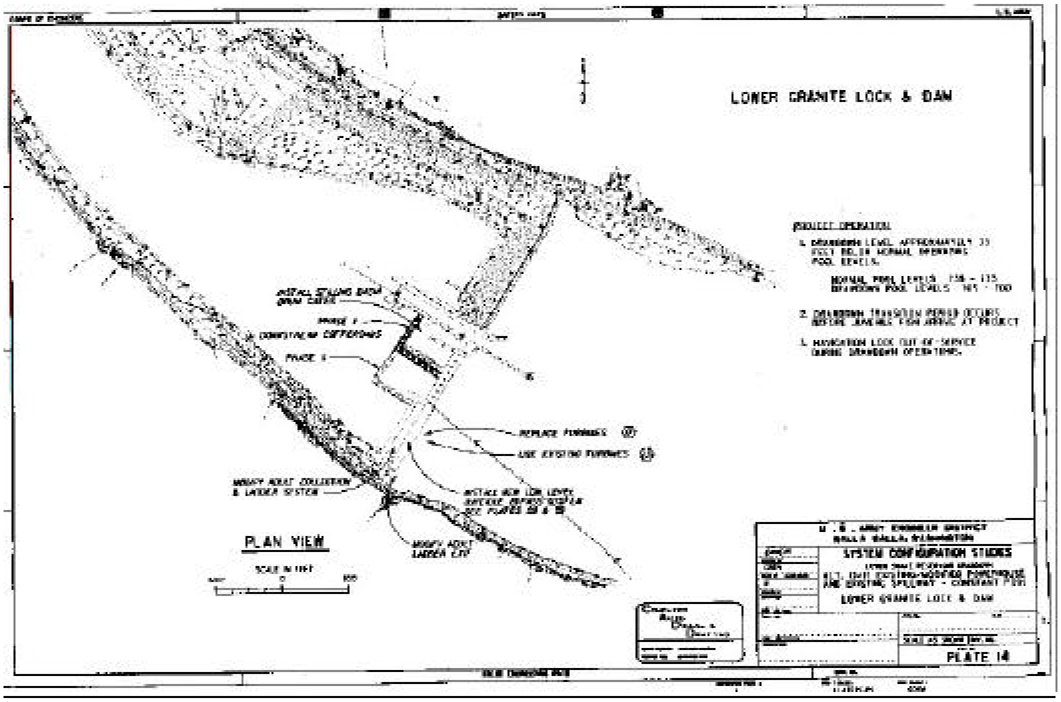


Plate 14. Lower Granite Lock and Dam

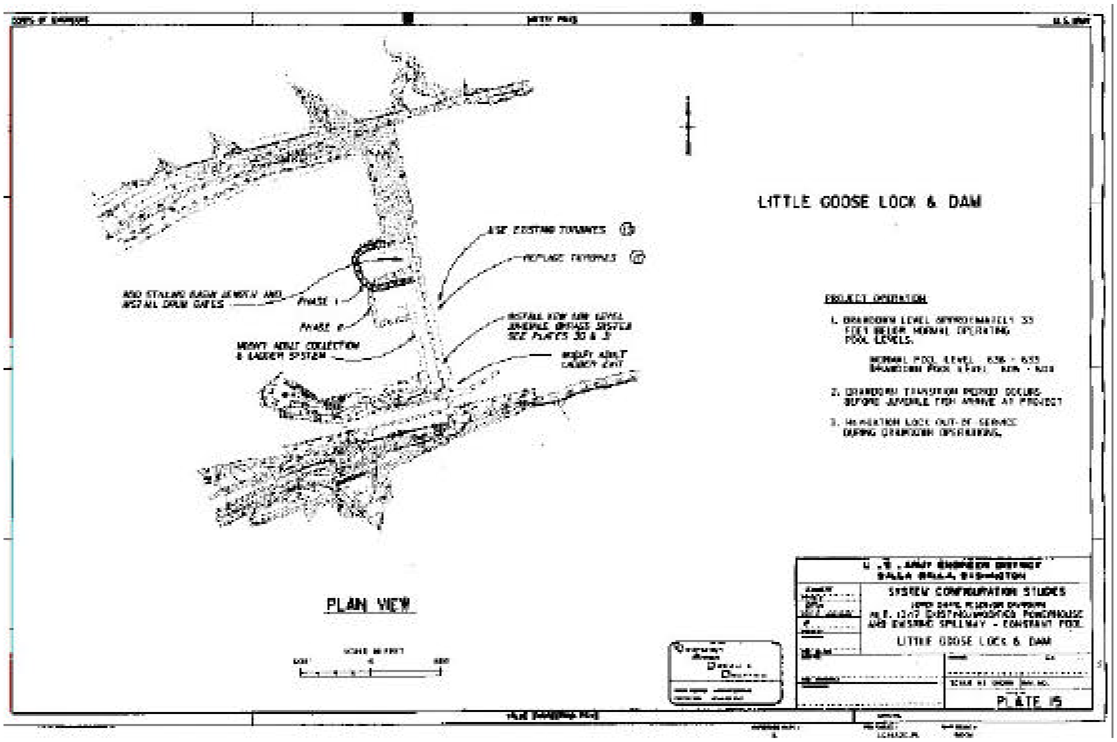


Plate 15. Little Goose Lock and Dam

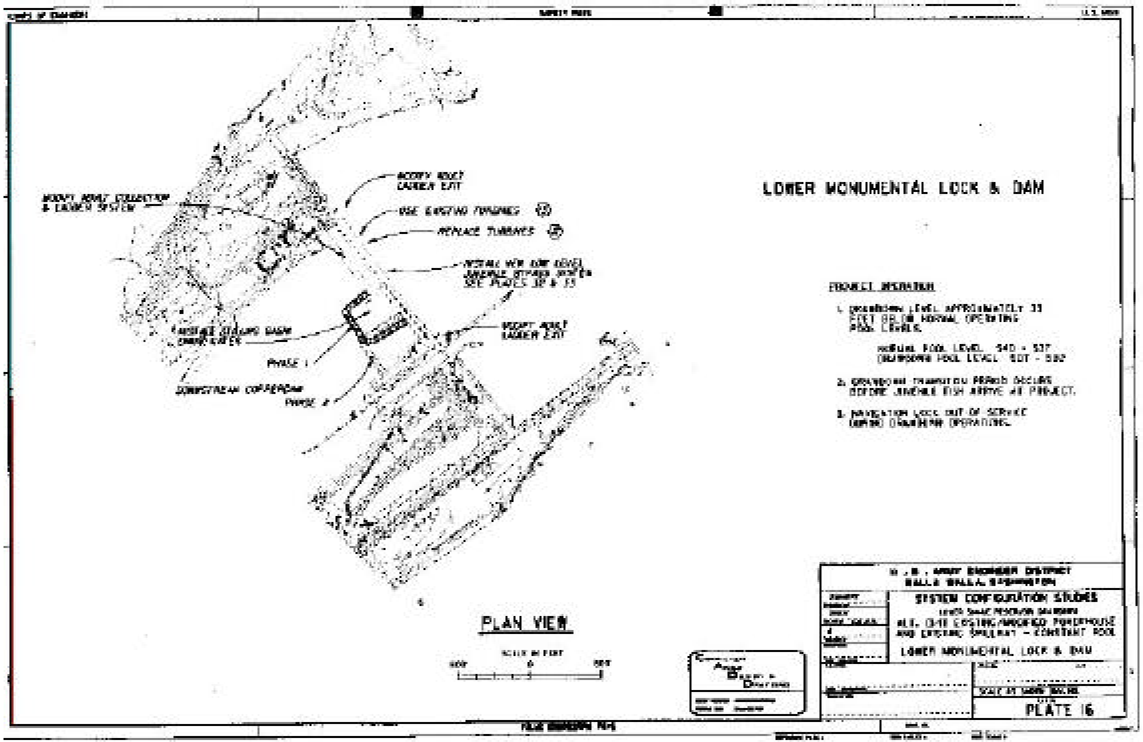


Plate 16. Lower Monumental Lock and Dam

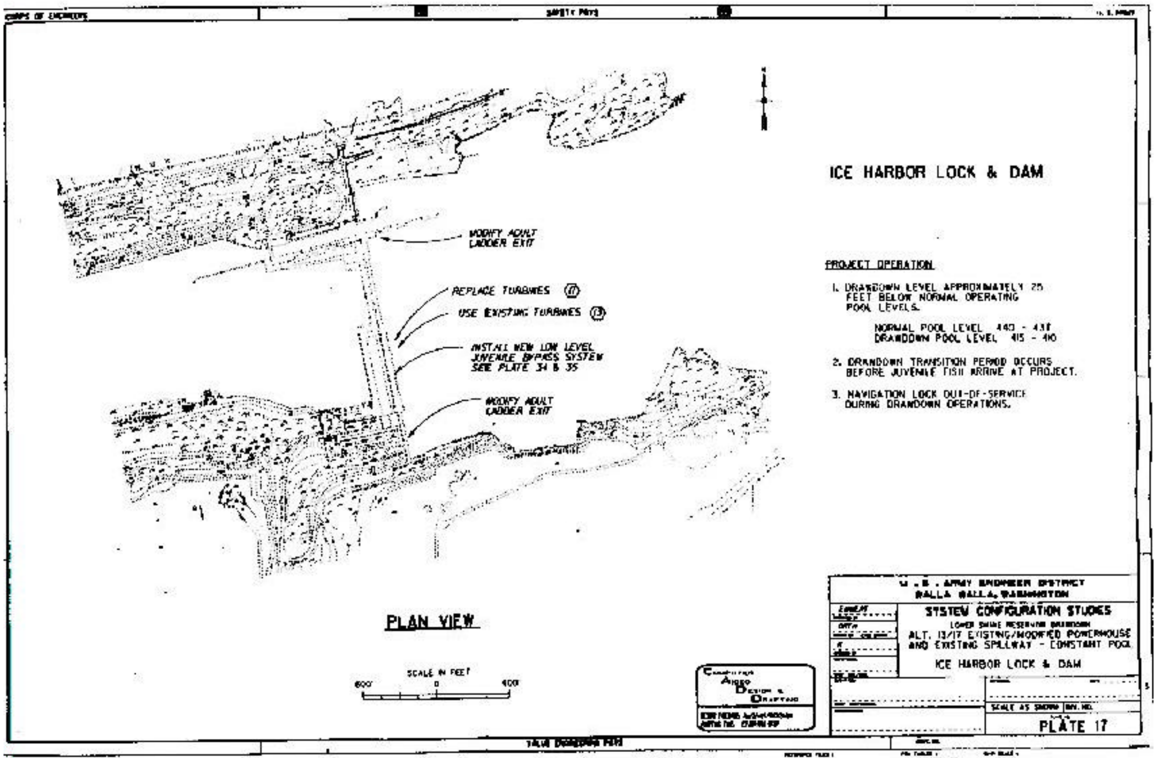


Plate 17. Ice Harbor Lock and Dam

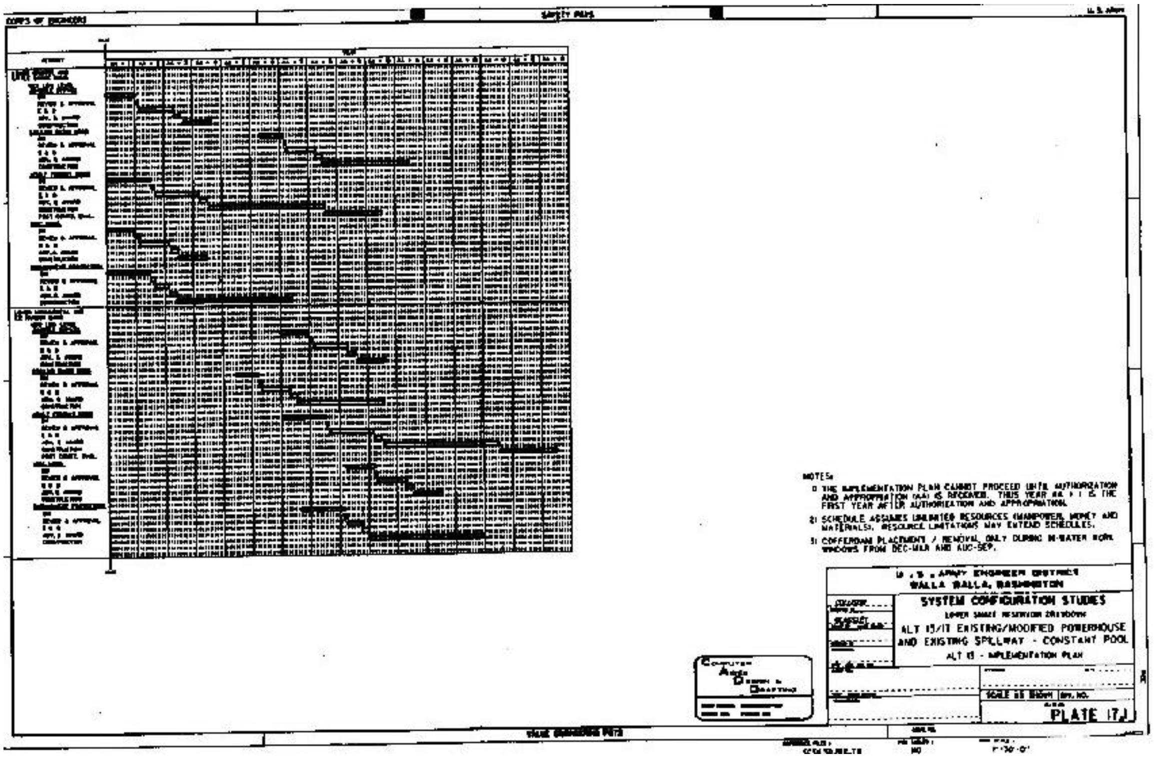


Plate 17.1. Alternative 13 Implementation Plan

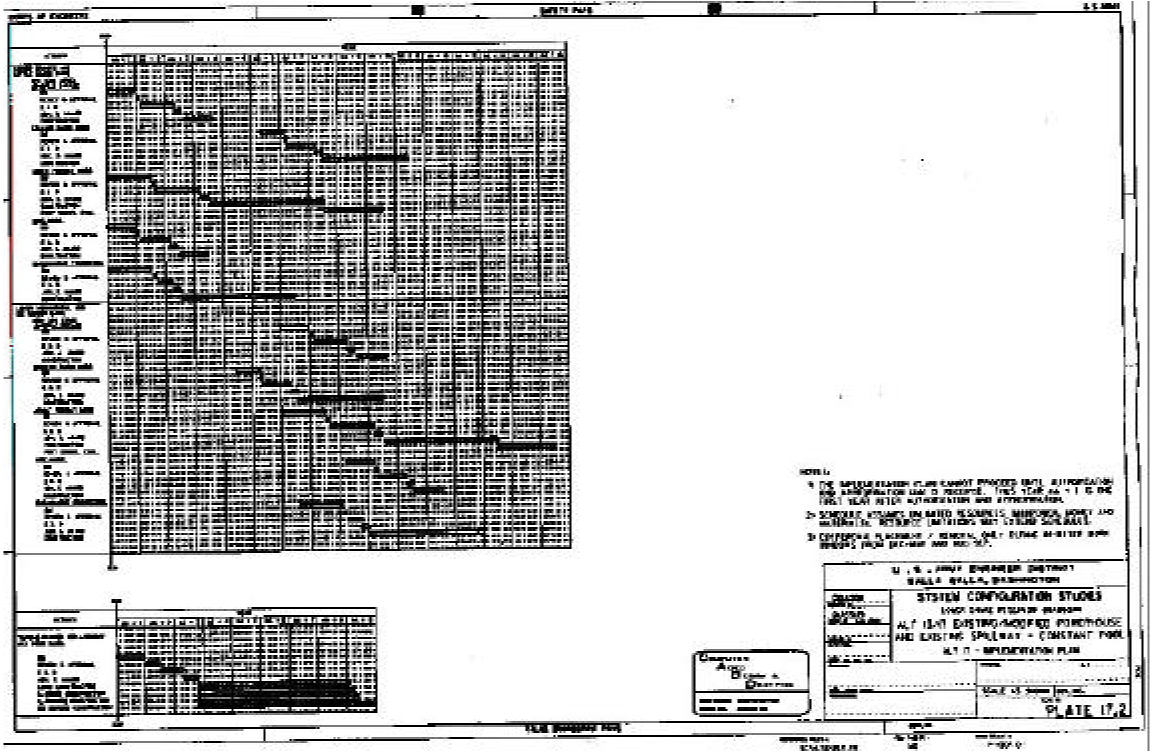


Plate 17.2. Alternative 17 Implementation Plan

Alternative 14/18--Existing/Modified Powerhouse and Modified Existing Spillway--Constant Pool

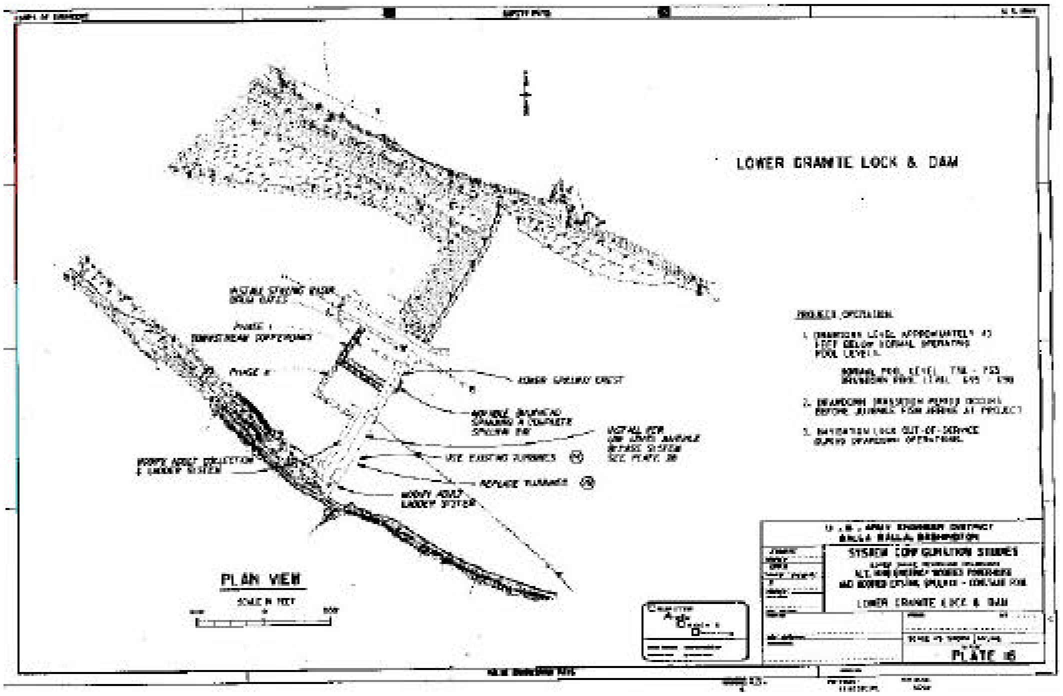


Plate 18. Lower Granite Lock and Dam

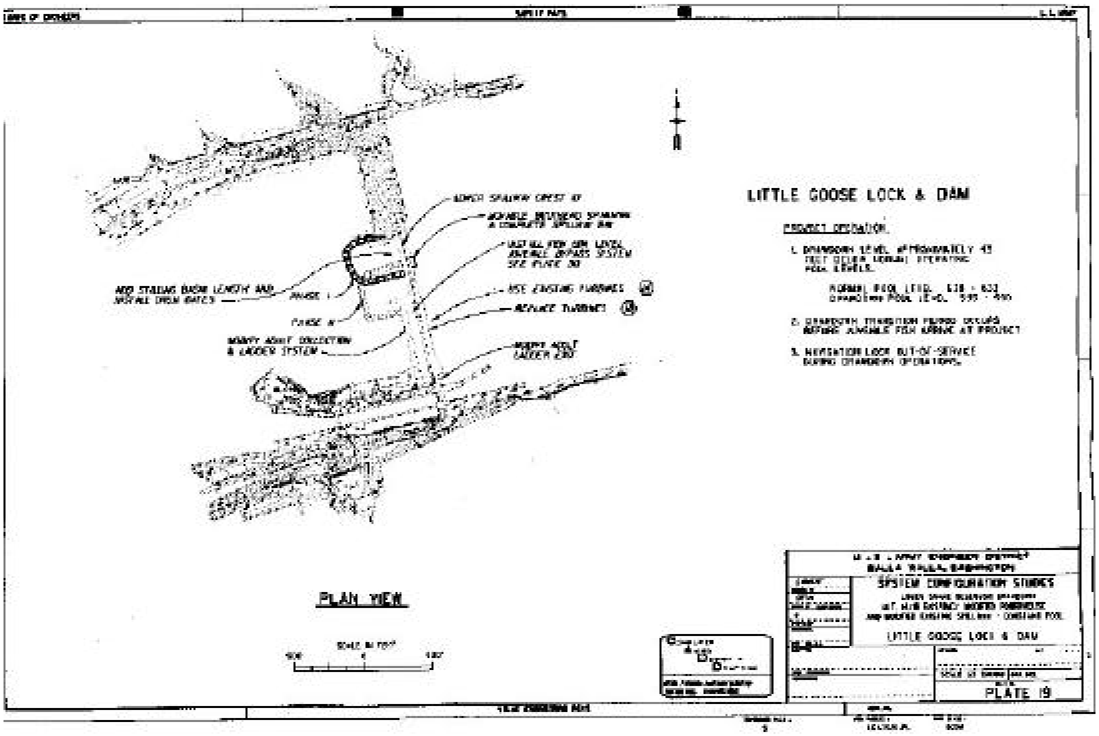


Plate 19. Little Goose Lock and Dam

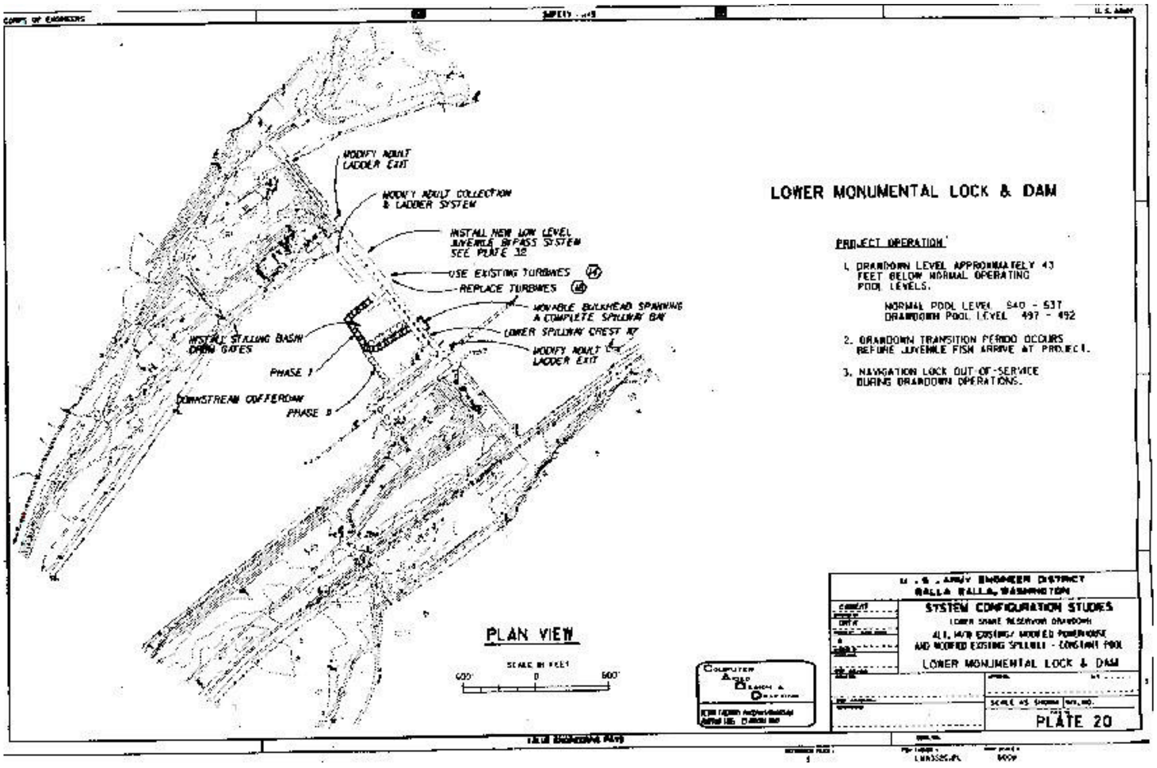


Plate 20. Lower Monumental Lock and Dam

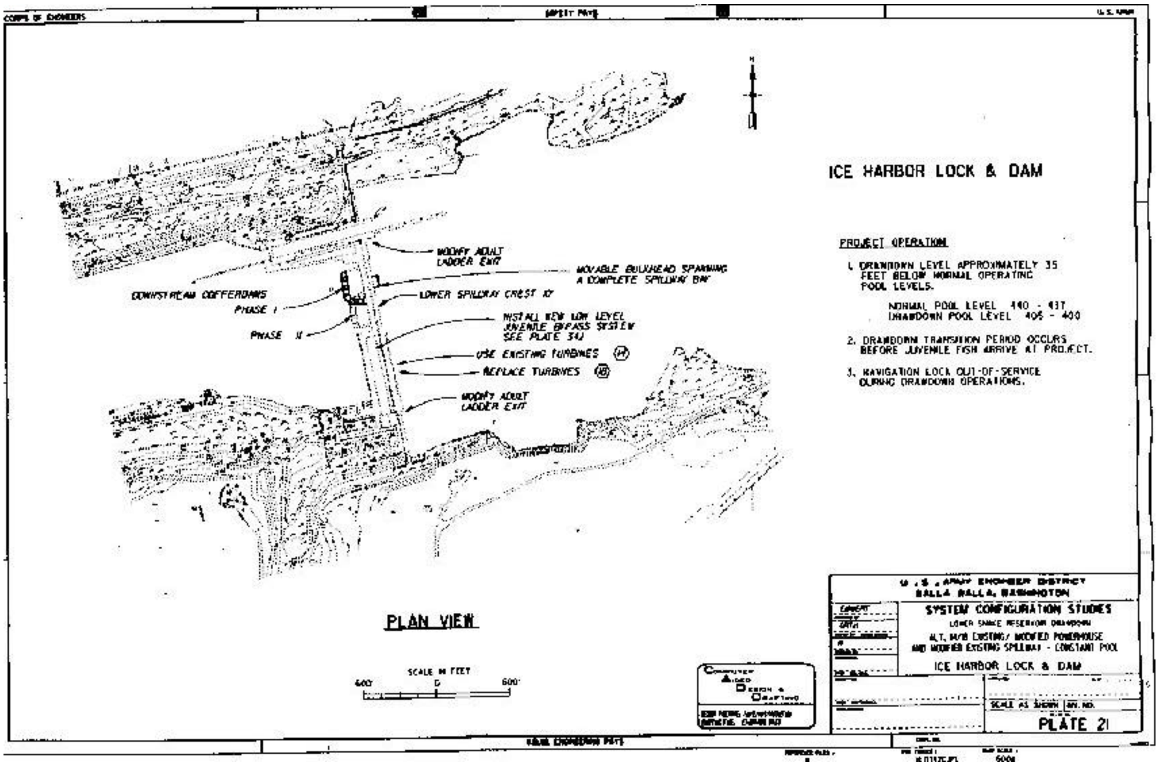


Plate 21. Ice Harbor Lock and Dam

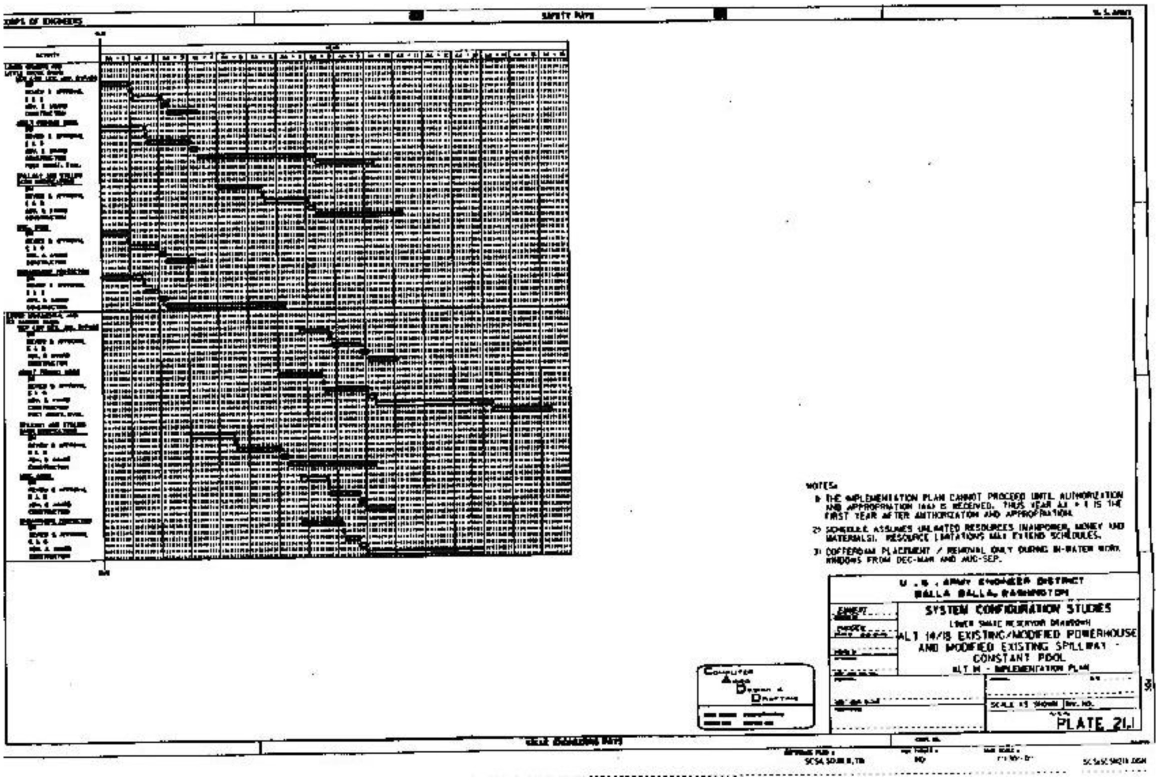


Plate 21.1. Alternative 14 Implementation Plan

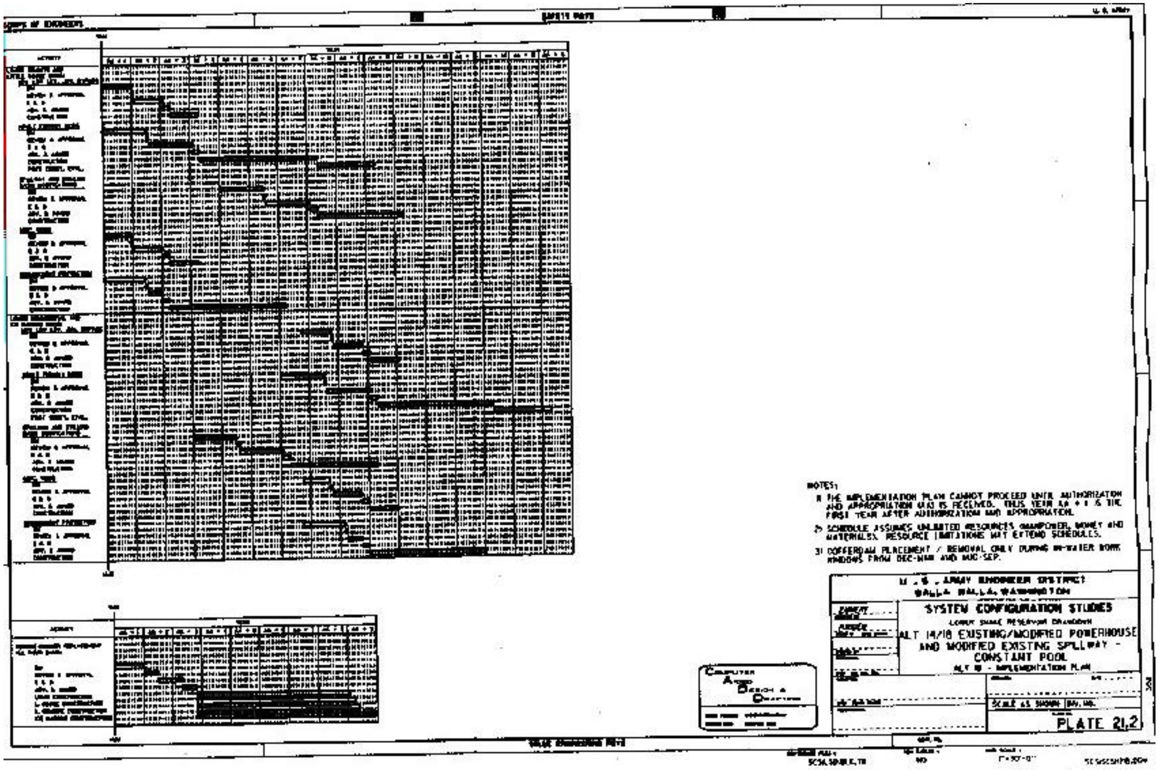


Plate 21.2. Alternative 18 Implementation Plan

Alternative 15/19--Existing Modified Powerhouse With New Low-Level Spillway--Constant Pool

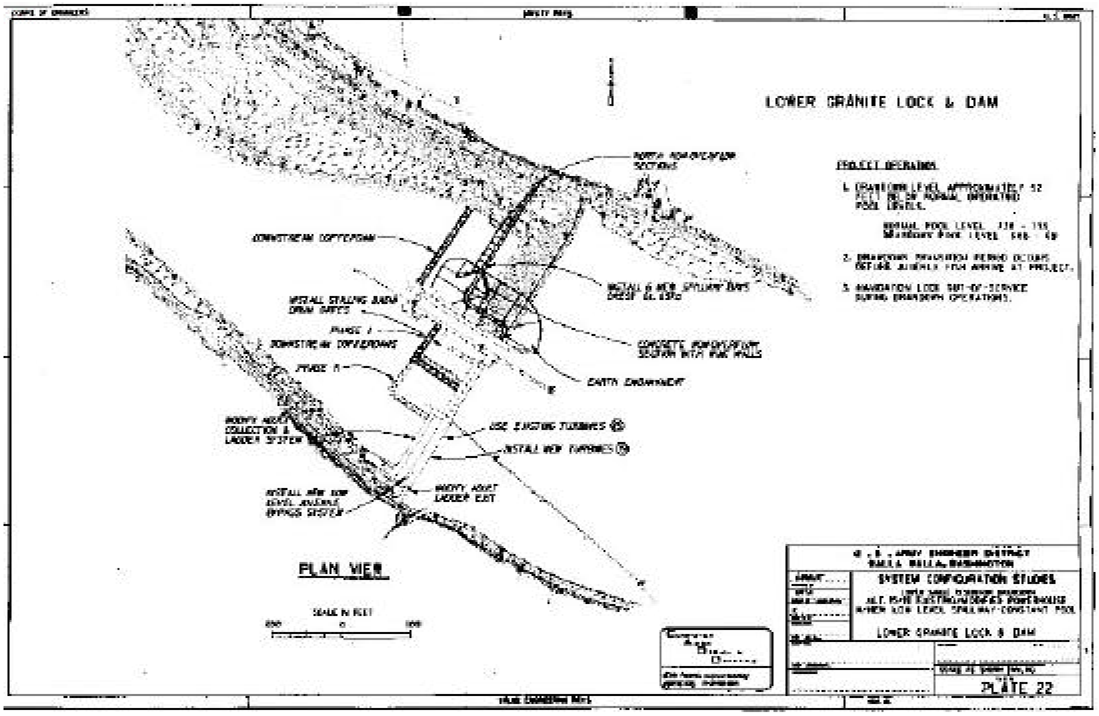


Plate 22. Lower Granite Lock and Dam

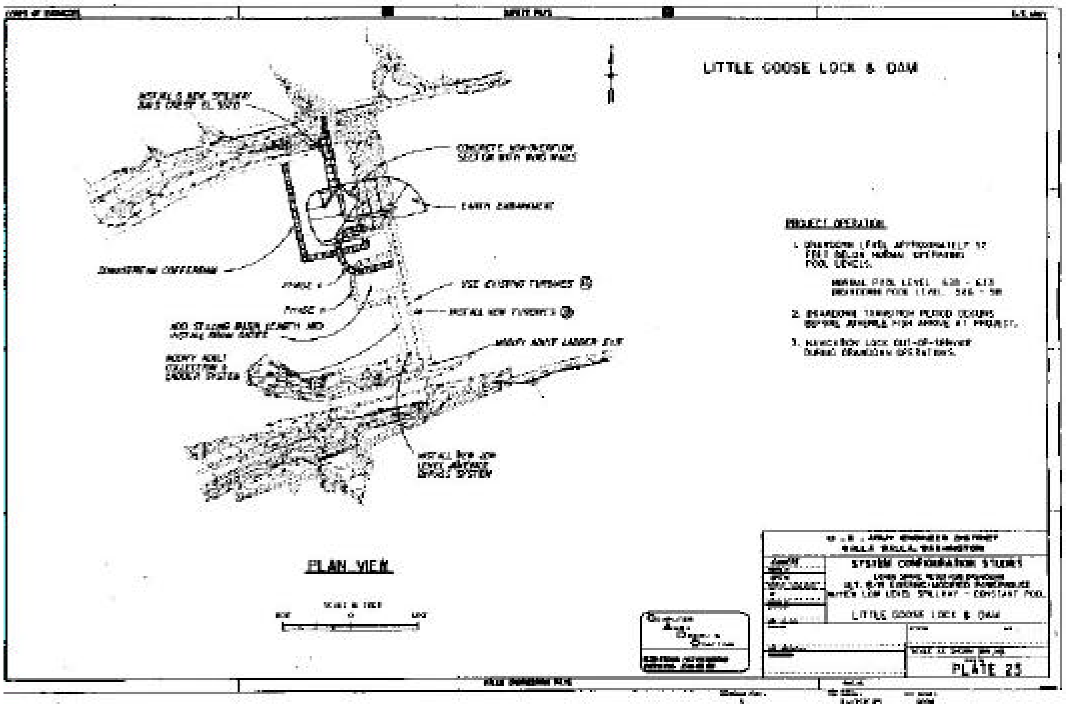


Plate 23. Little Goose Lock and Dam

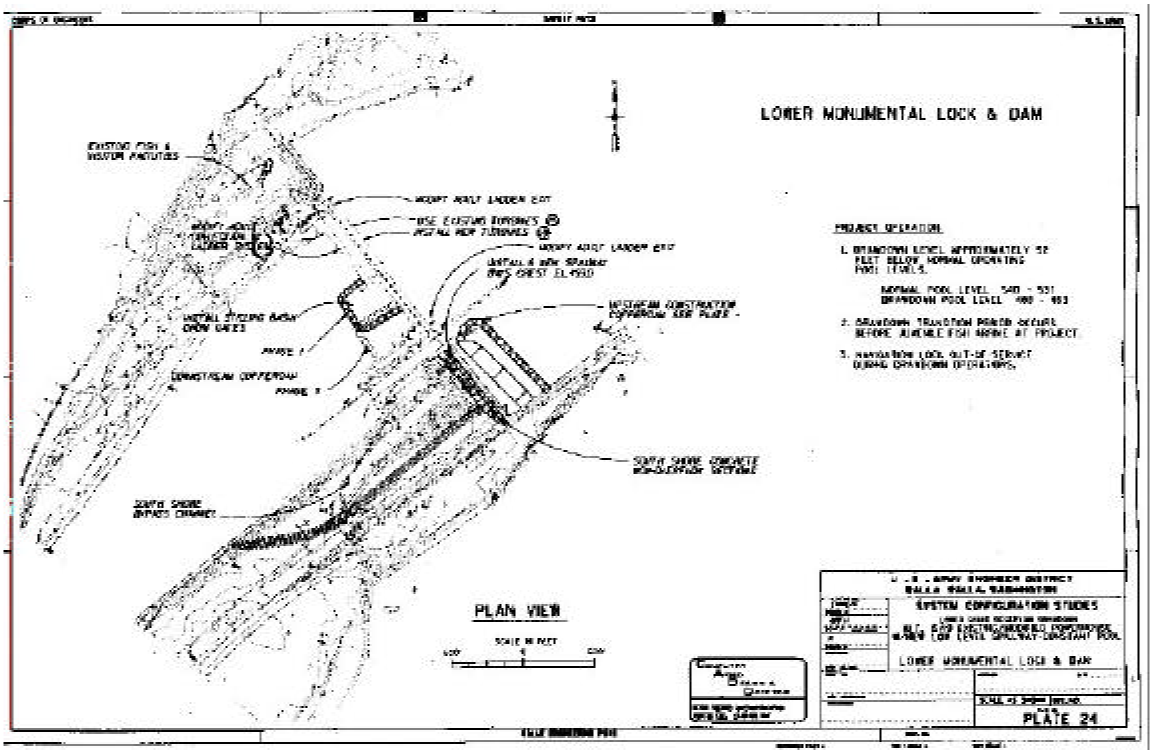


Plate 24. Lower Monumental Lock and Dam

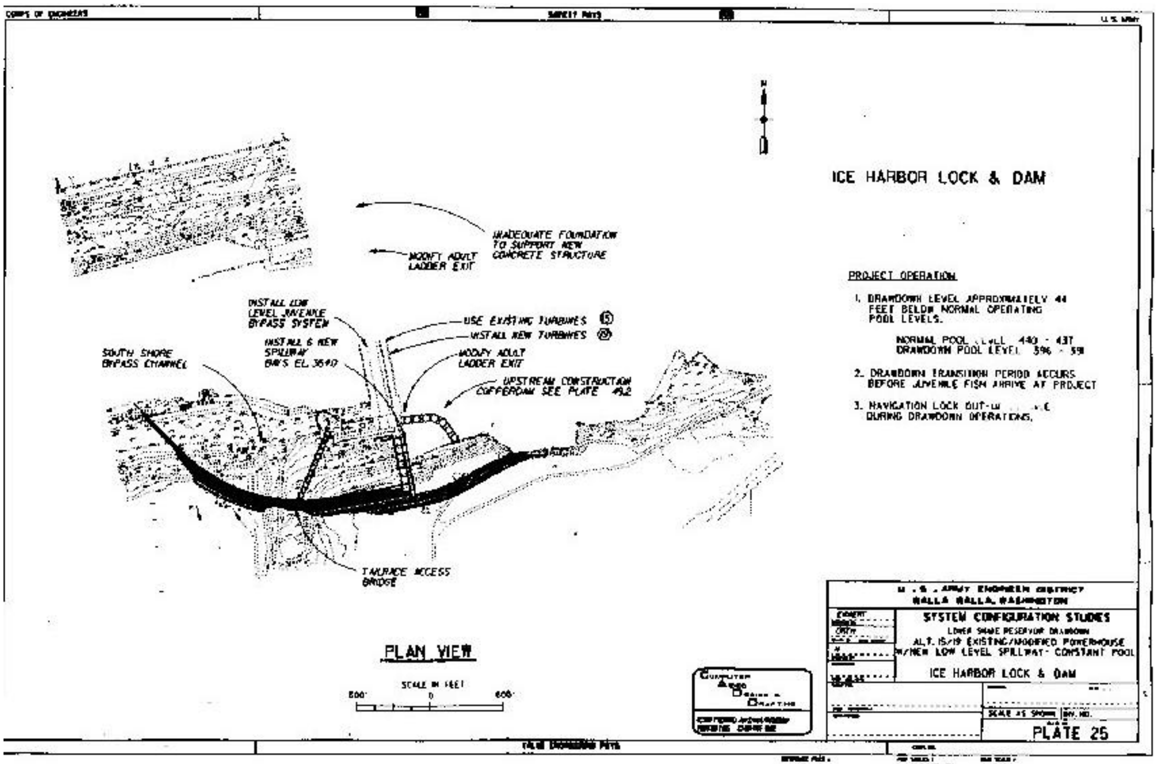
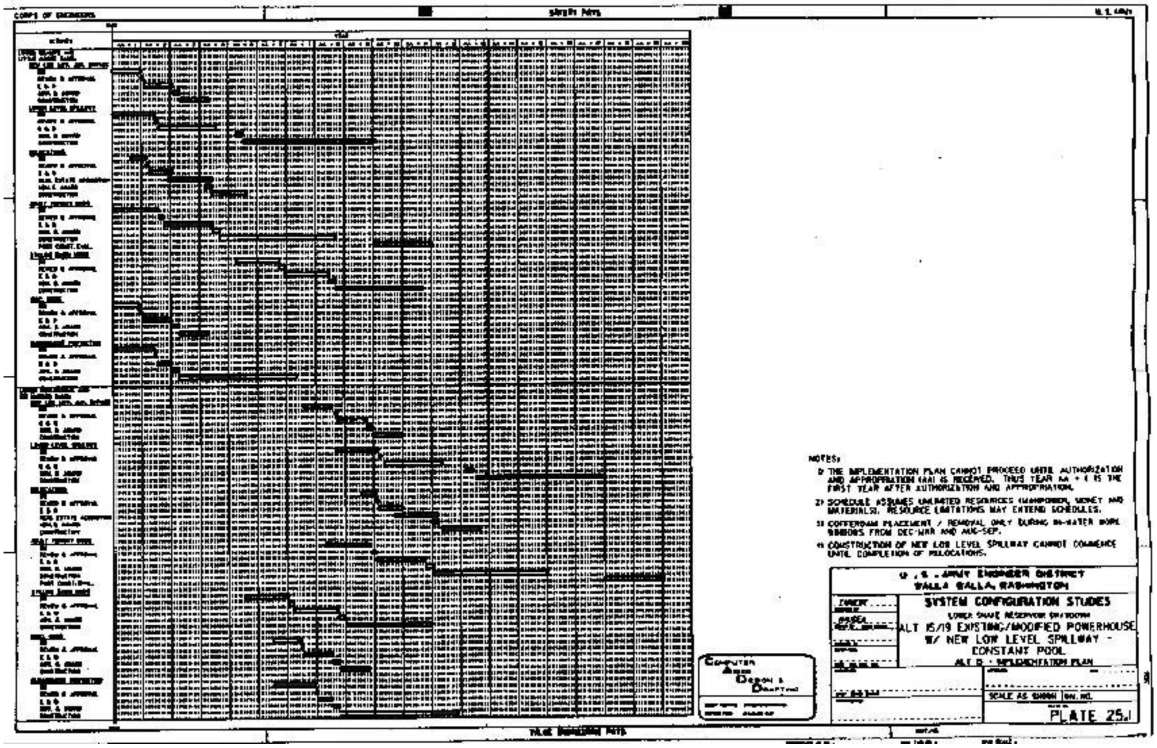


Plate 25. Ice Harbor Lock and Dam



NOTES:

1) THE IMPLEMENTATION PLAN CANNOT PROCEED UNTIL AUTHORIZATION AND APPROPRIATION (AA) IS RECEIVED. THUS YEAR AA + 1 IS THE FIRST YEAR AFTER AUTHORIZATION AND APPROPRIATION.

2) SCHEDULE ASSUMES UNLIMITED RESOURCES (MANPOWER, MONEY AND MATERIALS). RESOURCE LIMITATIONS MAY EXTEND SCHEDULES.

3) COFFERDAM PLACEMENT / REMOVAL ONLY DURING IN-WATER WORK WINDOWS FROM DEC-MAR AND AUG-SEP.

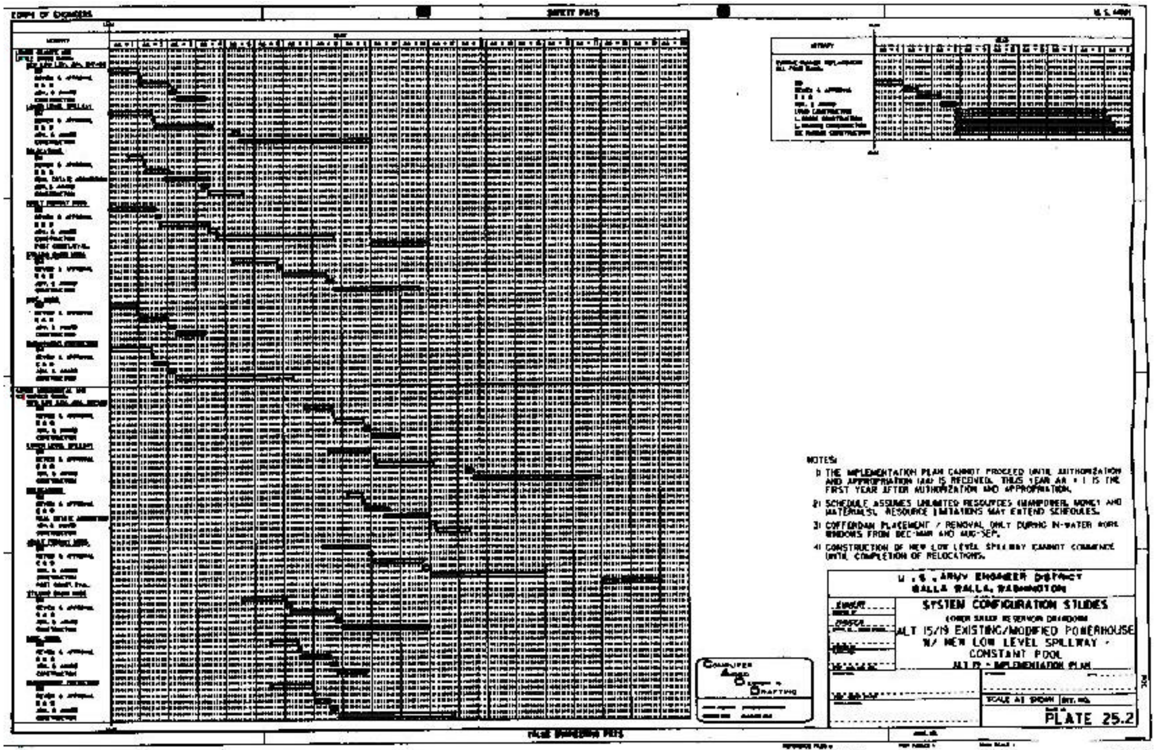
4) CONSTRUCTION OF NEW LOW LEVEL SPILLWAY CANNOT COMMENCE UNTIL COMPLETION OF RELOCATIONS.

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

SYSTEM CONFIGURATION STUDIES
LOWER SNAKE RESERVOIR DRAWDOWN
ALT 15/19 EXISTING/MODIFIED POWERHOUSE
W/ NEW LOW LEVEL SPILLWAY -
CONSTANT POOL
ALT 15 - IMPLEMENTATION PLAN

SCALE AS SHOWN
PLATE 25.1

Plate 25.1. Alternative 15 Implementation Plan



NOTES:

1) THE IMPLEMENTATION PLAN CANNOT PROCEED UNTIL AUTHORIZATION AND APPROPRIATION (AA) IS RECEIVED. THUS YEAR AA + 1 IS THE FIRST YEAR AFTER AUTHORIZATION AND APPROPRIATION.

2) SCHEDULE ASSUMES UNLIMITED RESOURCES (MANPOWER, MONEY AND MATERIALS). RESOURCE LIMITATIONS MAY EXTEND SCHEDULES.

3) COFFERDAM PLACEMENT / REMOVAL ONLY DURING IN-WATER WORK WINDOWS FROM DEC-MAR AND AUG-SEP.

4) CONSTRUCTION OF NEW LOW LEVEL SPILLWAY CANNOT COMMENCE UNTIL COMPLETION OF RELOCATIONS.

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

SYSTEM CONFIGURATION STUDIES
LOWER SNAKE RESERVOIR DRAWDOWN
ALT 15/19 EXISTING/MODIFIED POWERHOUSE
W/ NEW LOW LEVEL SPILLWAY -
CONSTANT POOL
ALT 19 - IMPLEMENTATION PLAN

SCALE AS SHOWN
PLATE 25.2

Plate 25.2. Alternative 19 Implementation Plan

FEATURE DRAWINGS
Bypass Structure

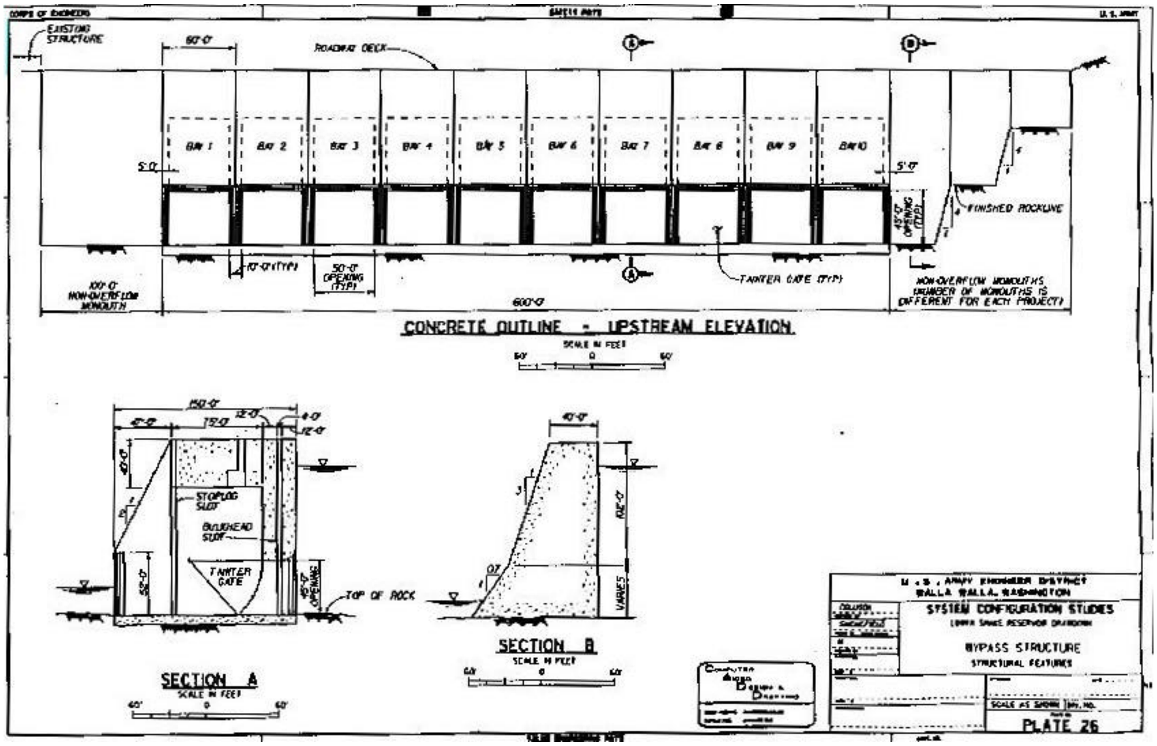


Plate 26. Structural Features

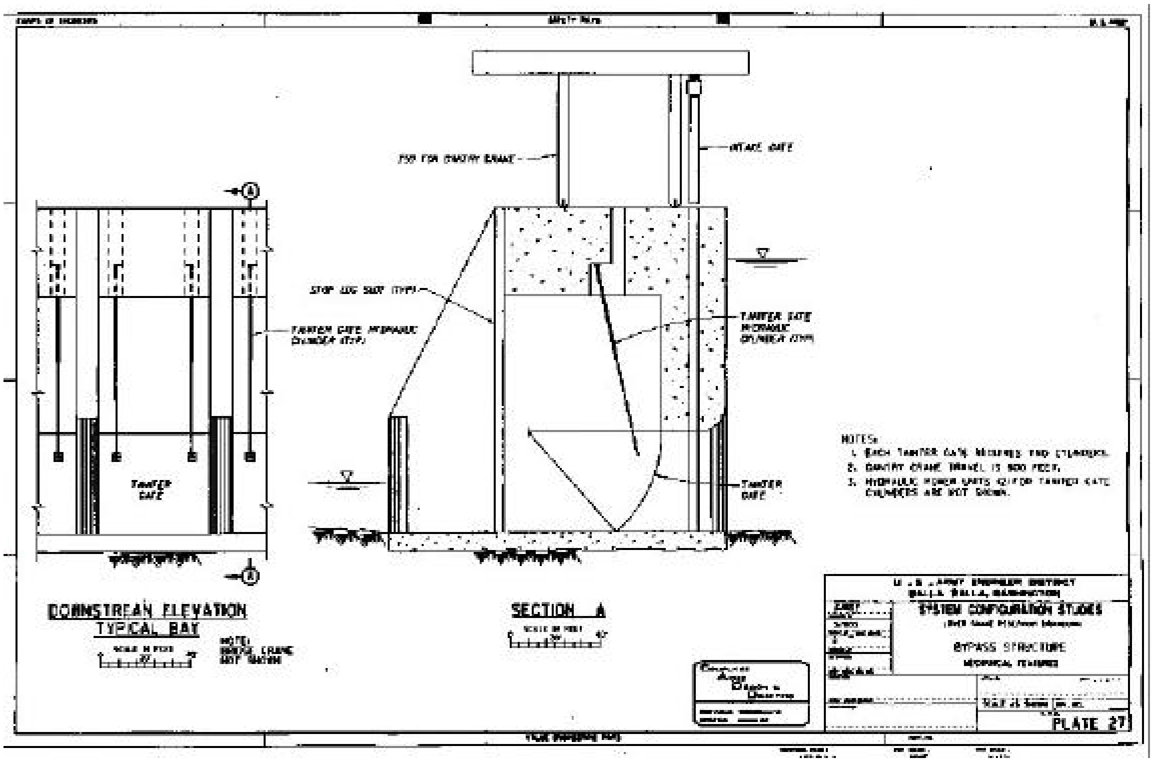


Plate 27. Mechanical Features

Lower Juvenile Bypass Systems

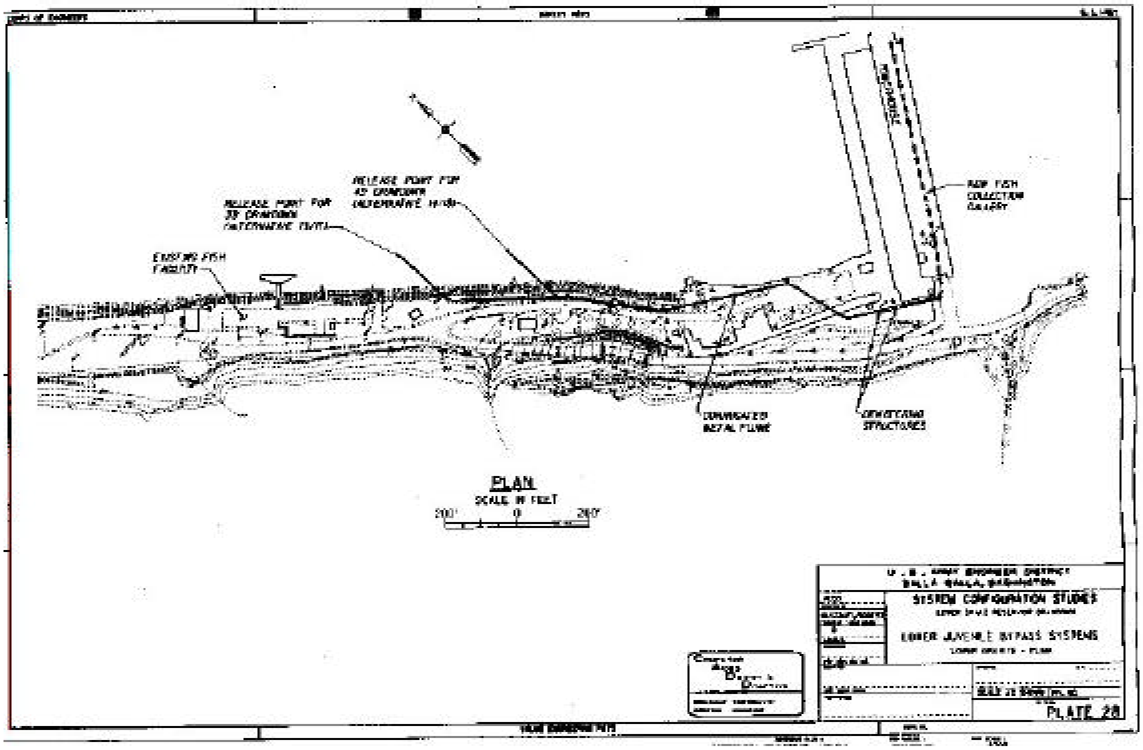


Plate 28. Lower Granite--Plan

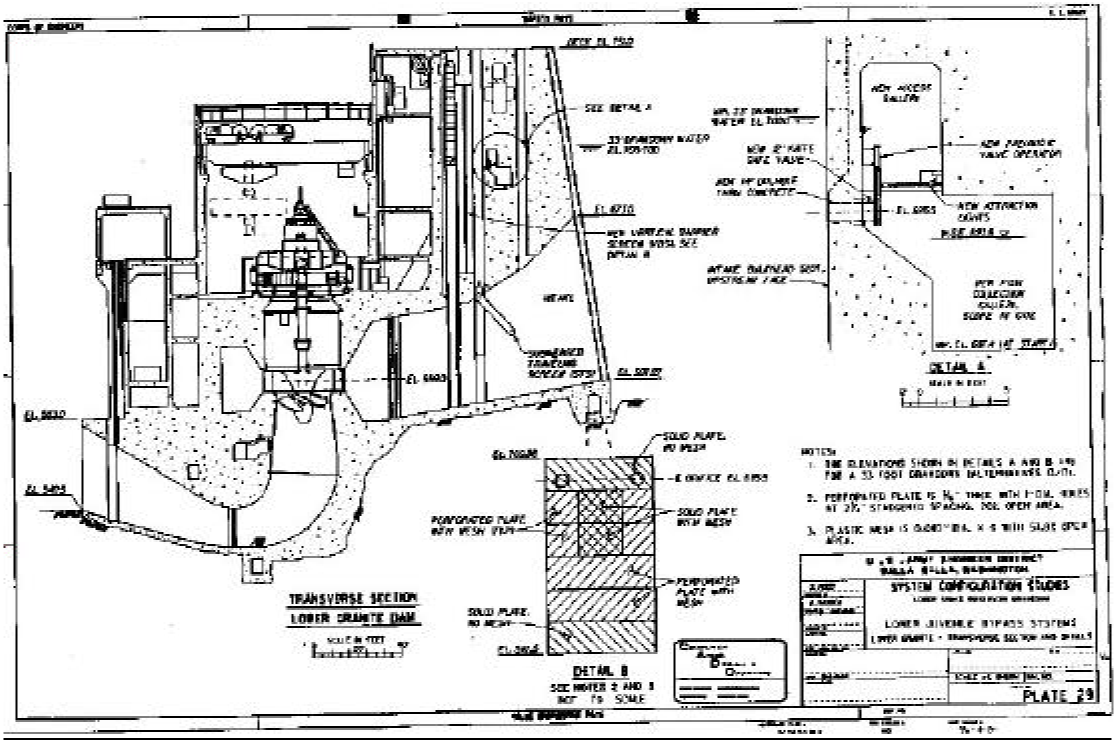


Plate 29. Lower Granite--Transverse Section and Detail

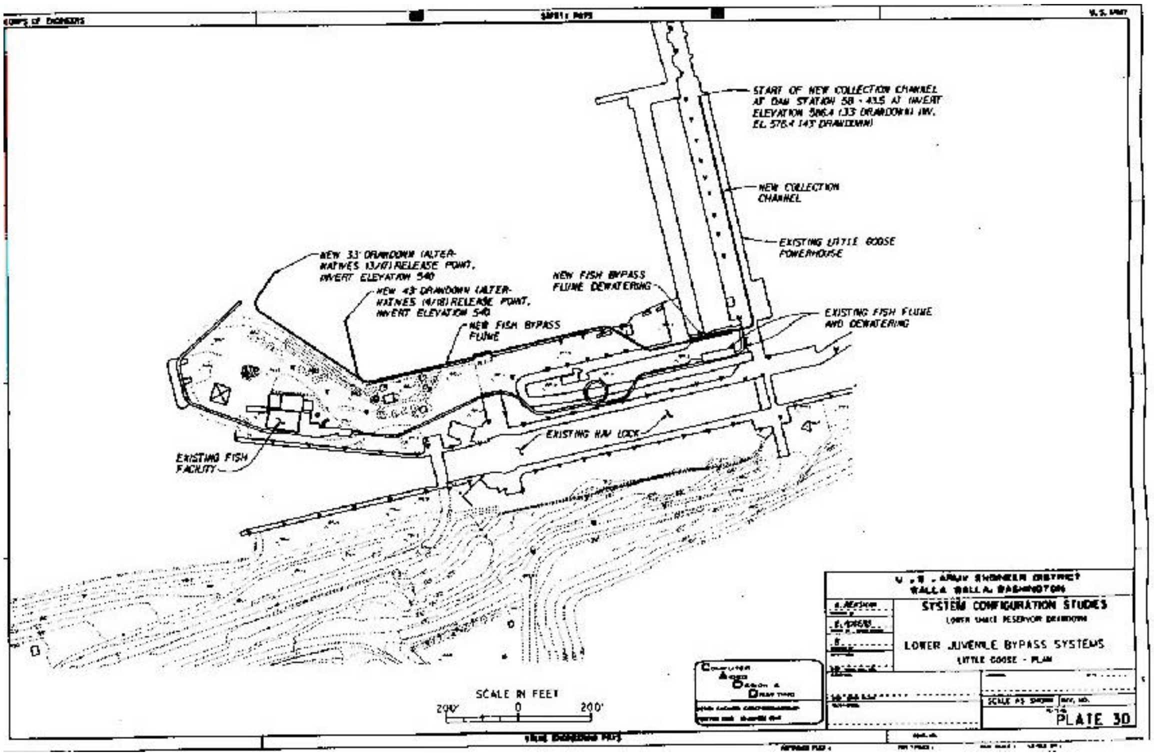


Plate 30. Little Goose--Plan

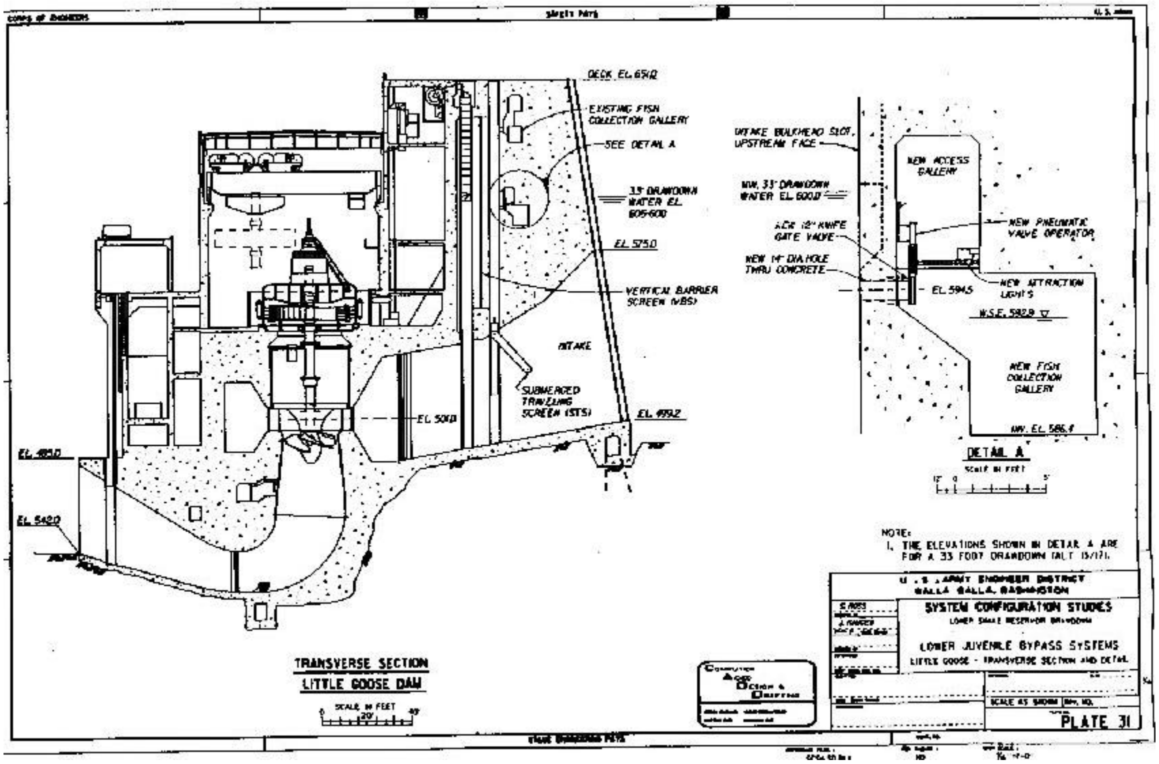


Plate 31. Little Goose--Transverse Section and Detail

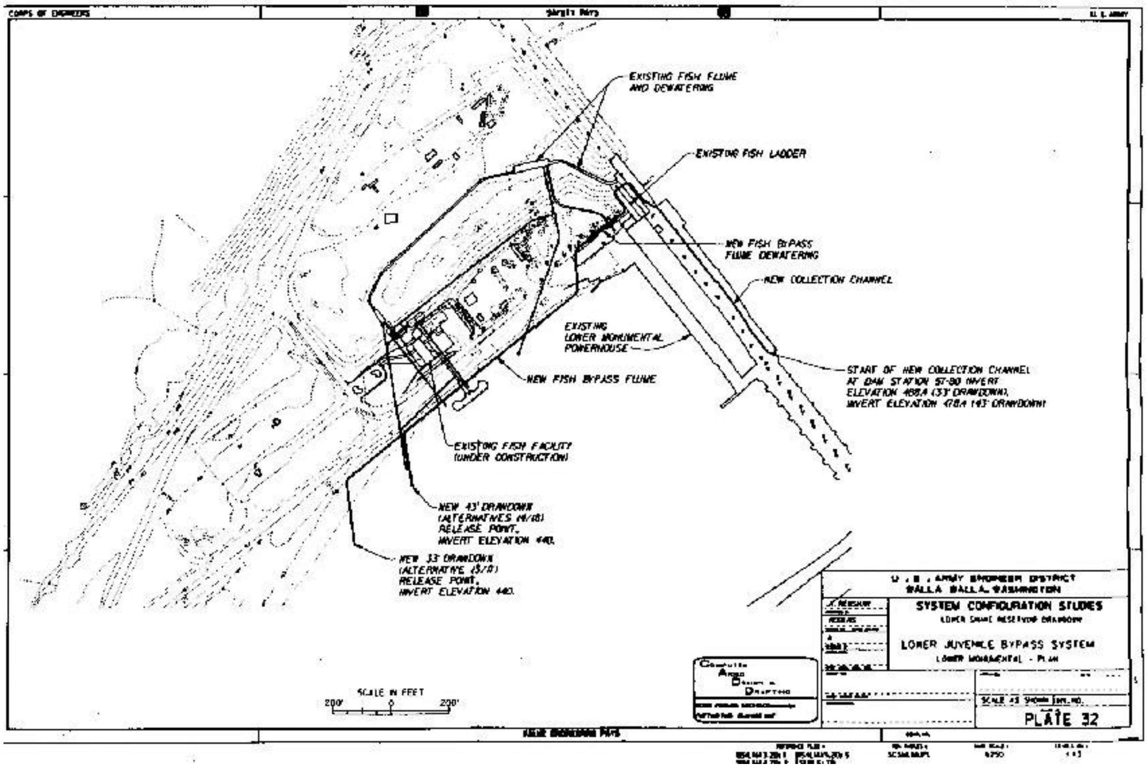


Plate 32. Lower Monumental--Plan

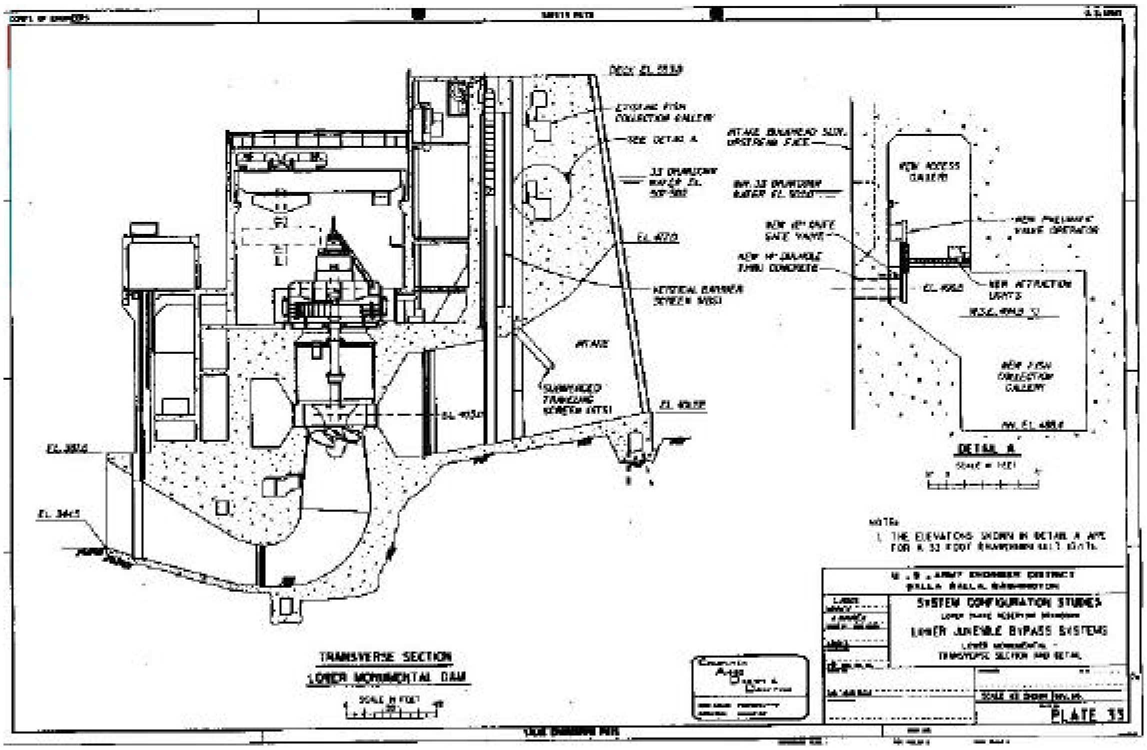


Plate 33. Lower Monumental--Transverse Section and Detail

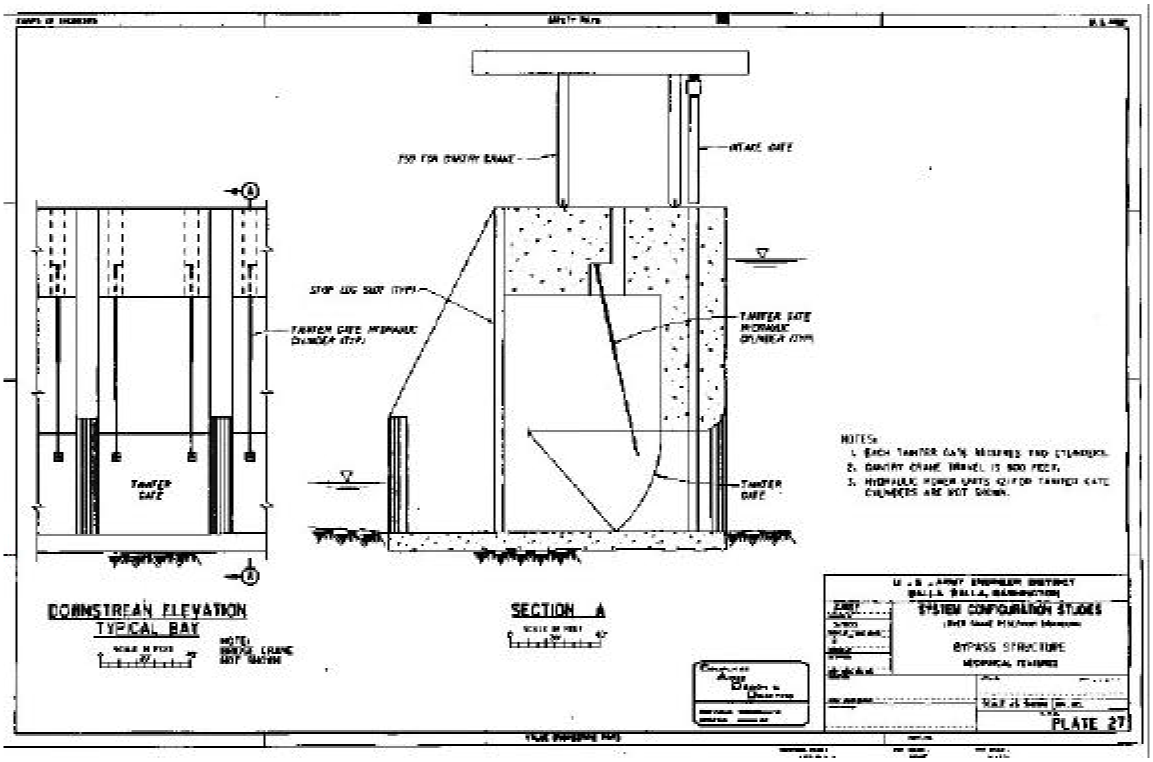


Plate 34. Ice Harbor--Plan Alternatives 13/17

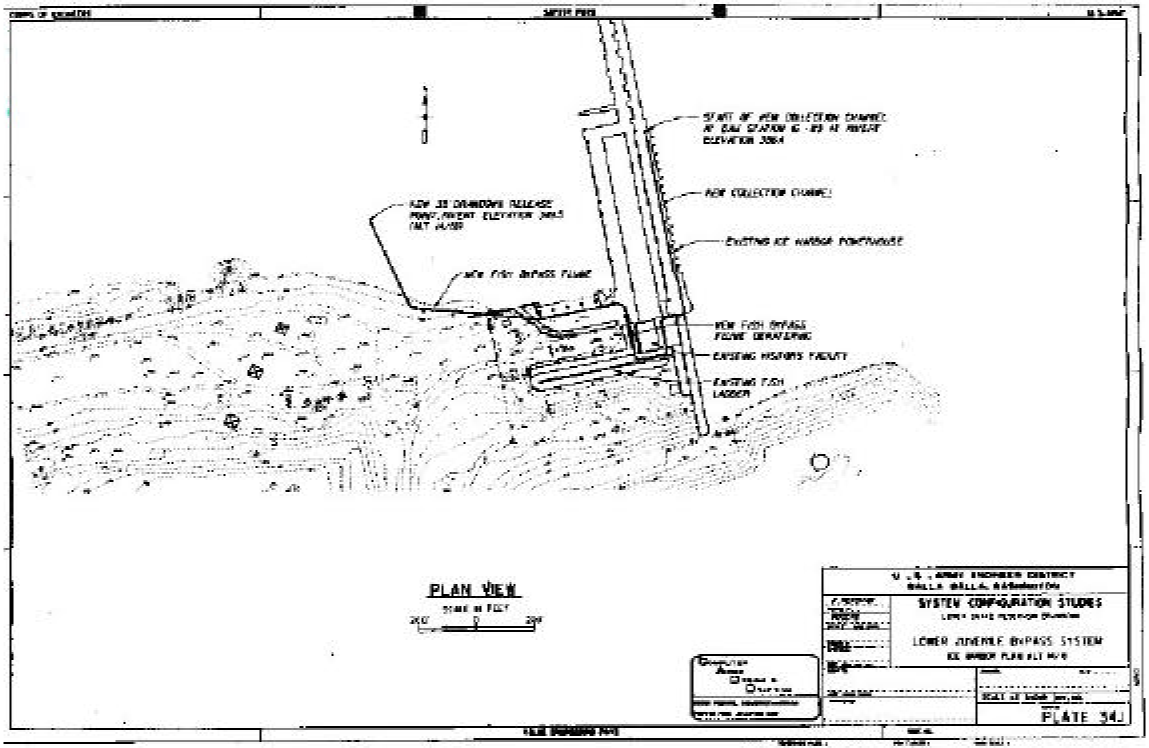


Plate 34.1. Ice Harbor--Plan Alternatives 14/18

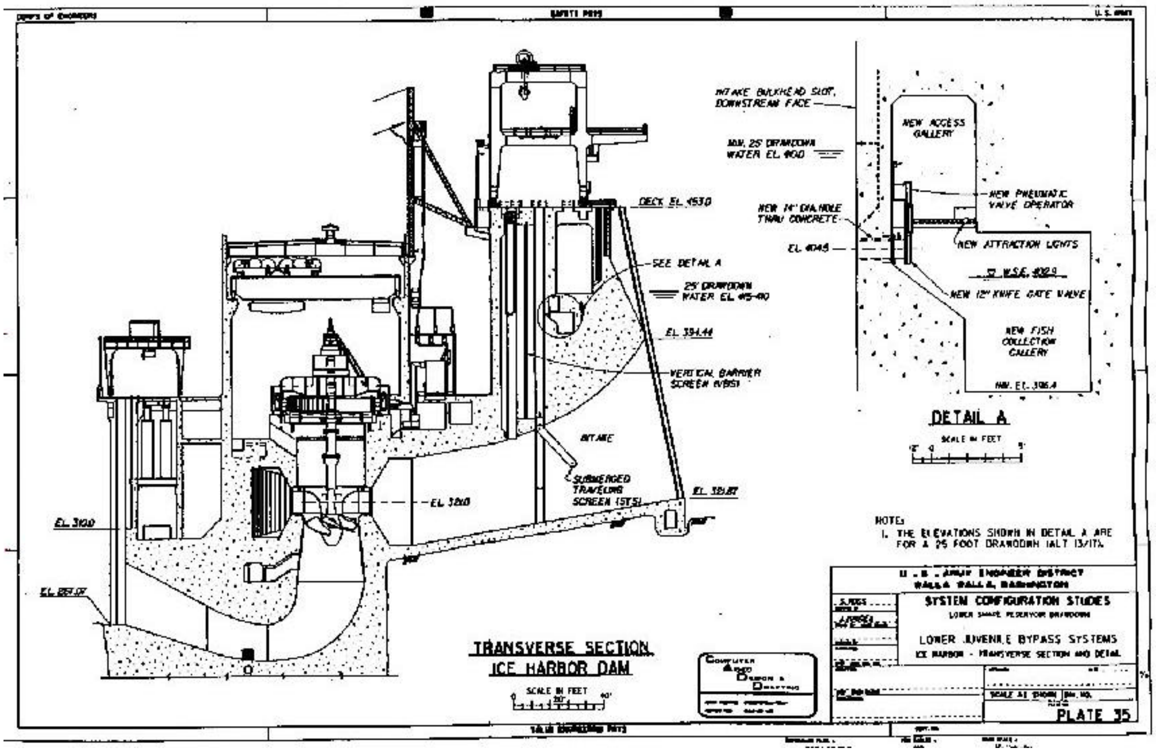


Plate 35. Ice Harbor--Transverse Section and Detail

Adult Collection and Ladder Modifications
Lower Granite Dam

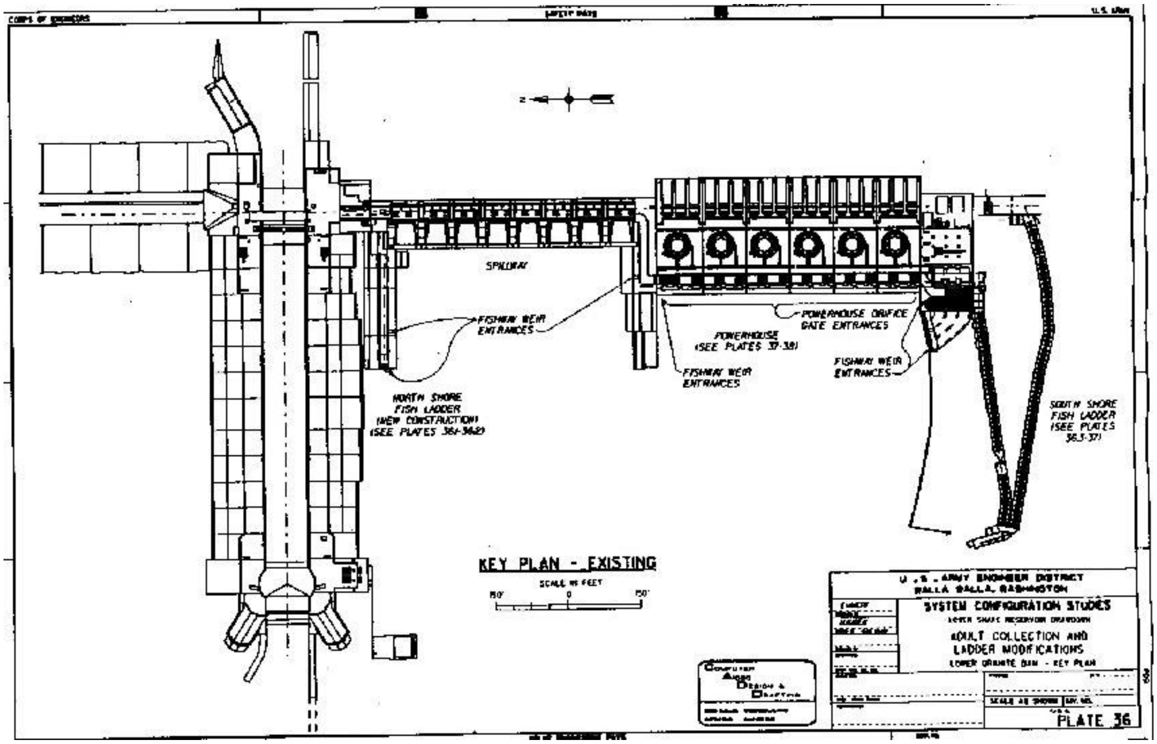


Plate 36. Key Plan

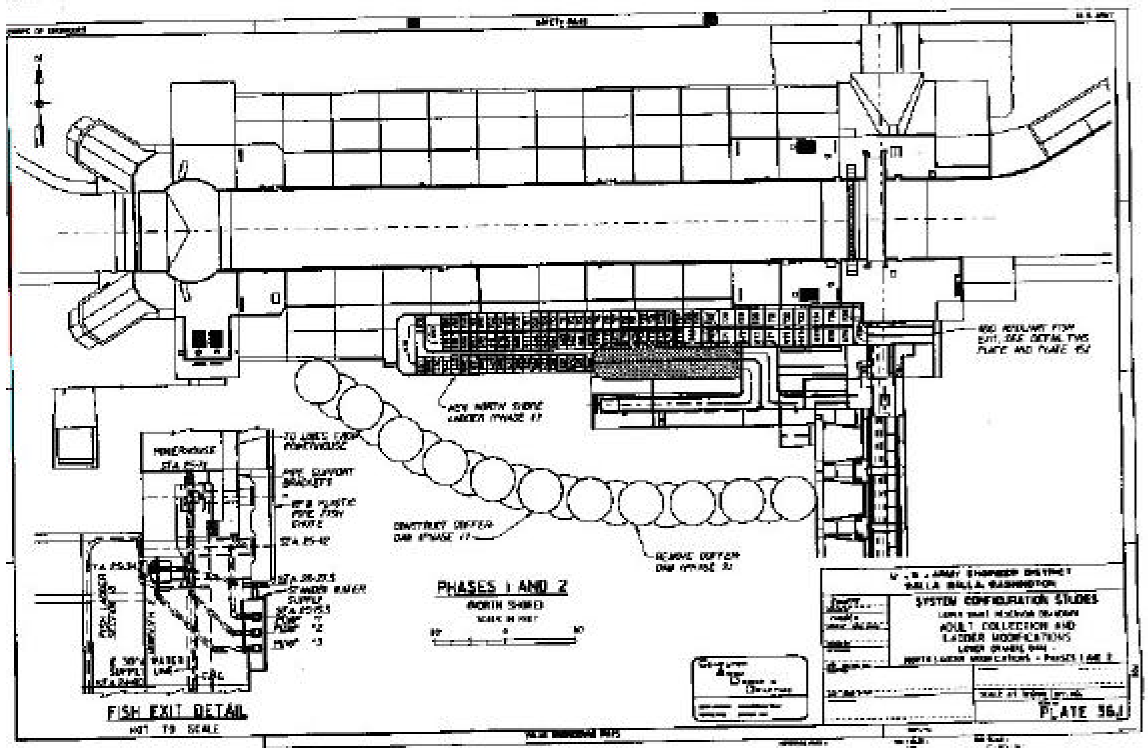


Plate 36.1. North Ladder Modifications--Phases 1 and 2

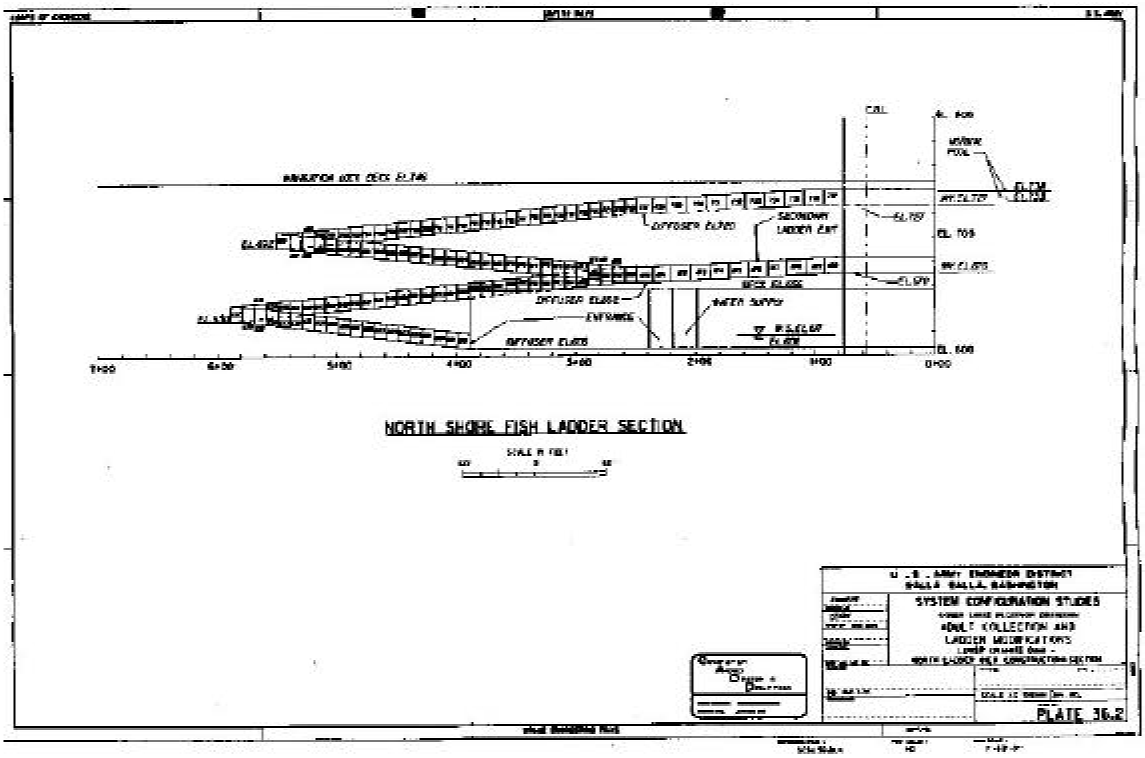


Plate 36.2. North Ladder (New Construction) Section

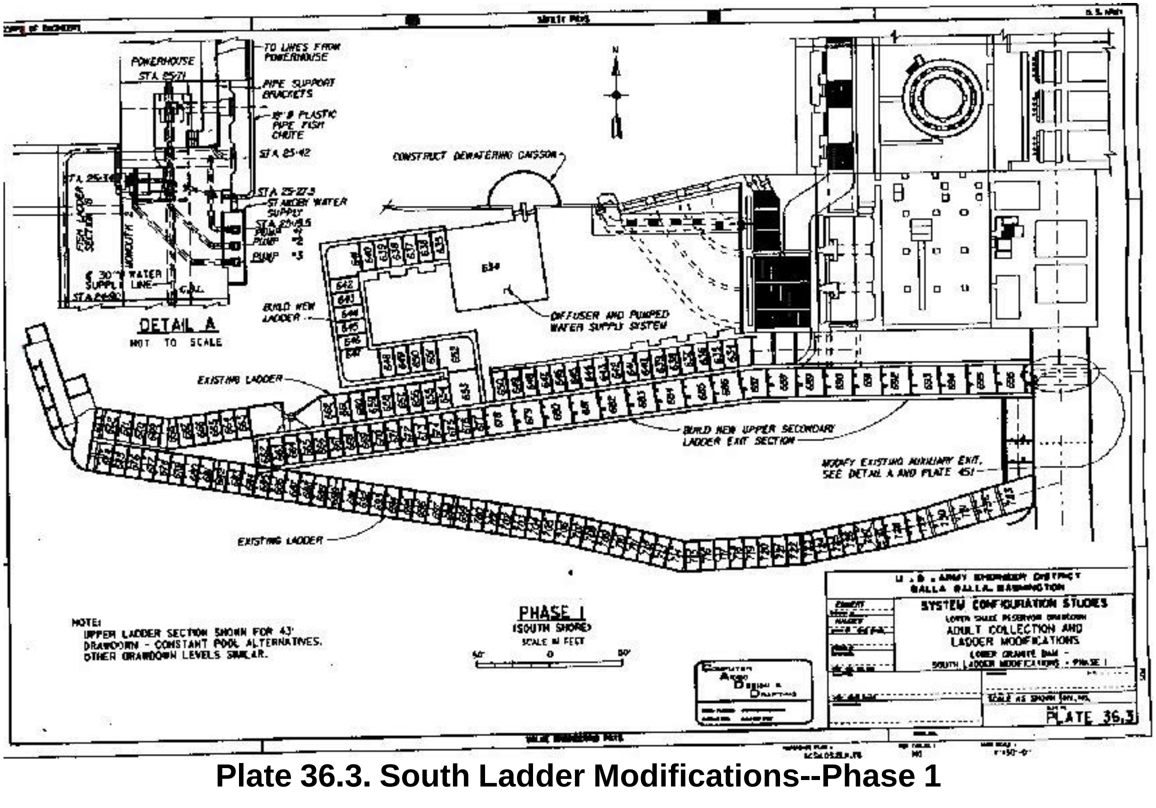


Plate 36.3. South Ladder Modifications--Phase 1

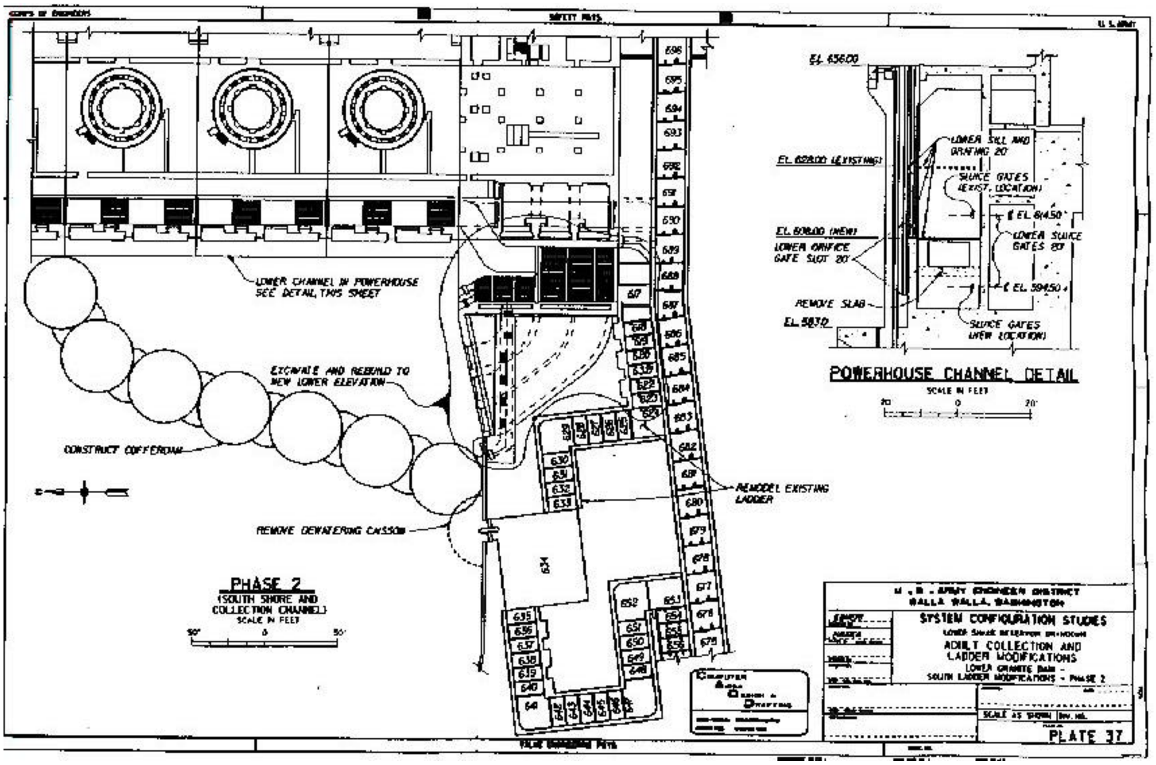


Plate 37. South Ladder Modifications--Phase 2

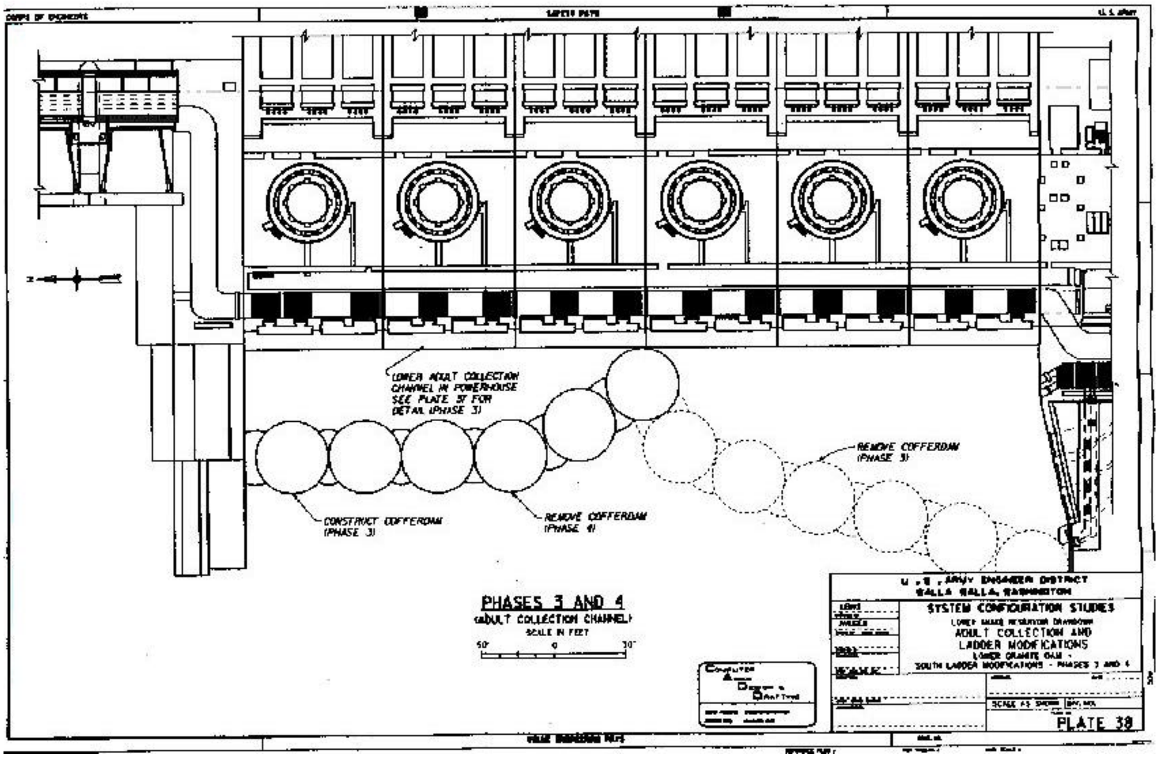


Plate 38. South Ladder Modifications--Phases 3 and 4

Lower Monumental Dam

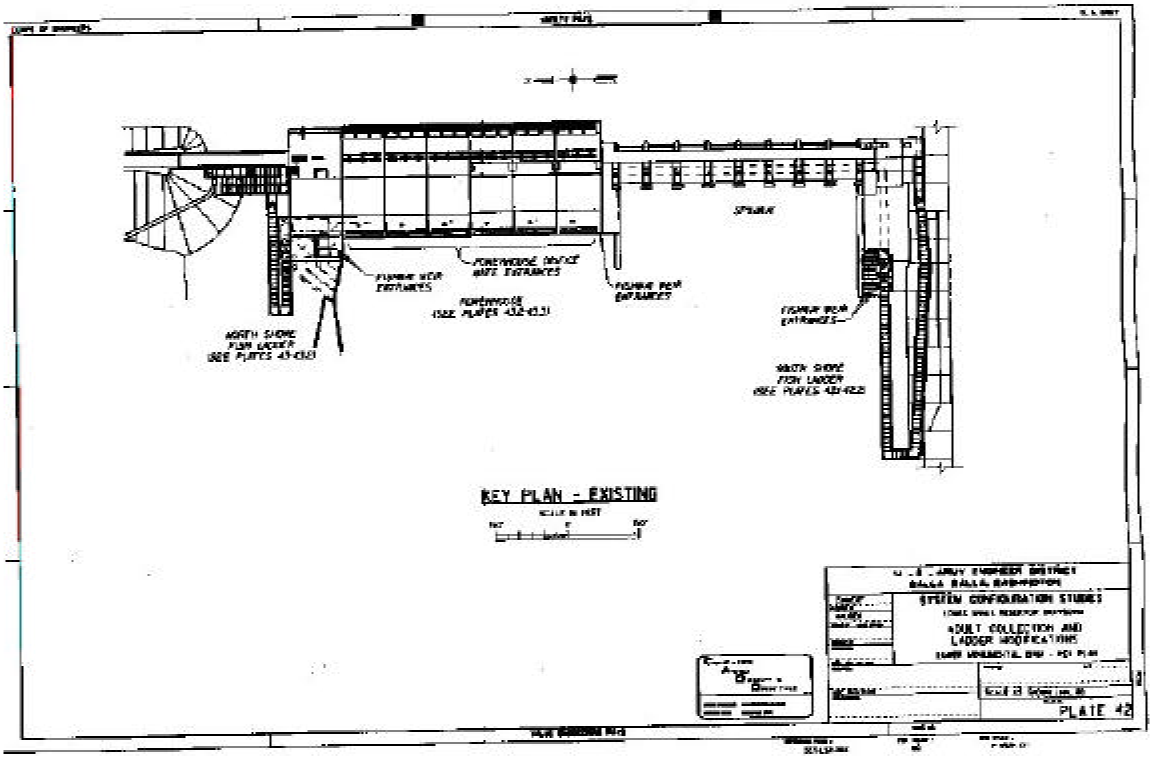


Plate 42. Key Plan

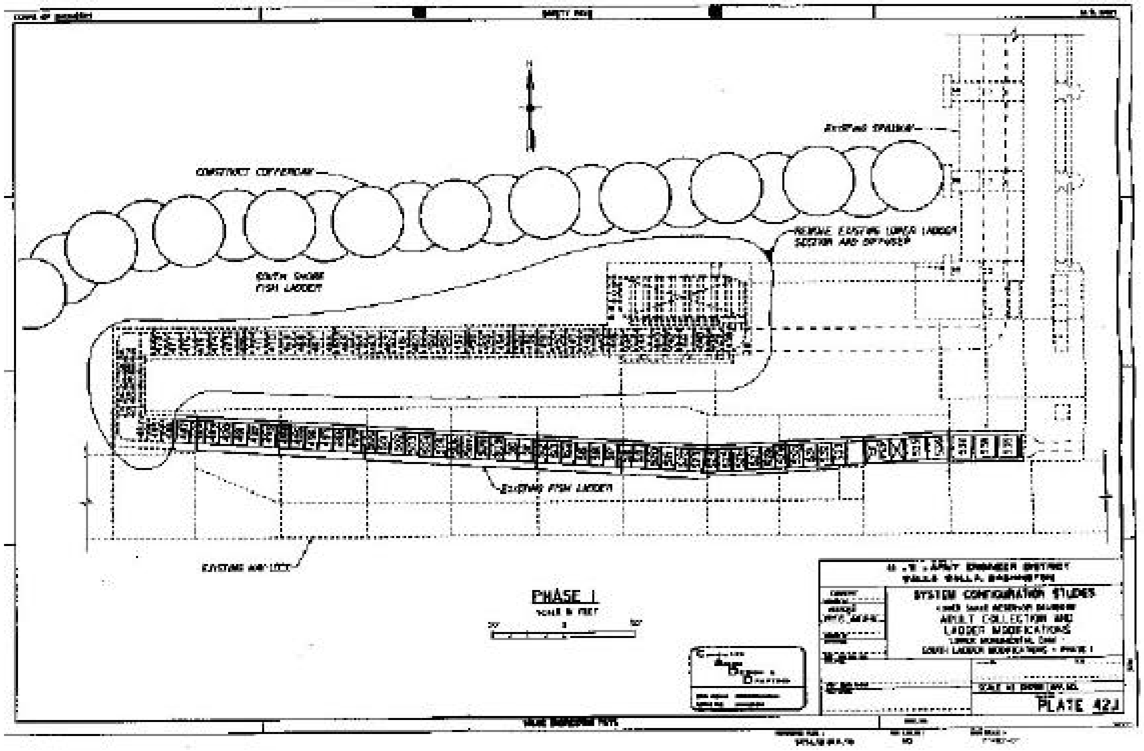


Plate 42.1. South Ladder Modifications--Phase 1

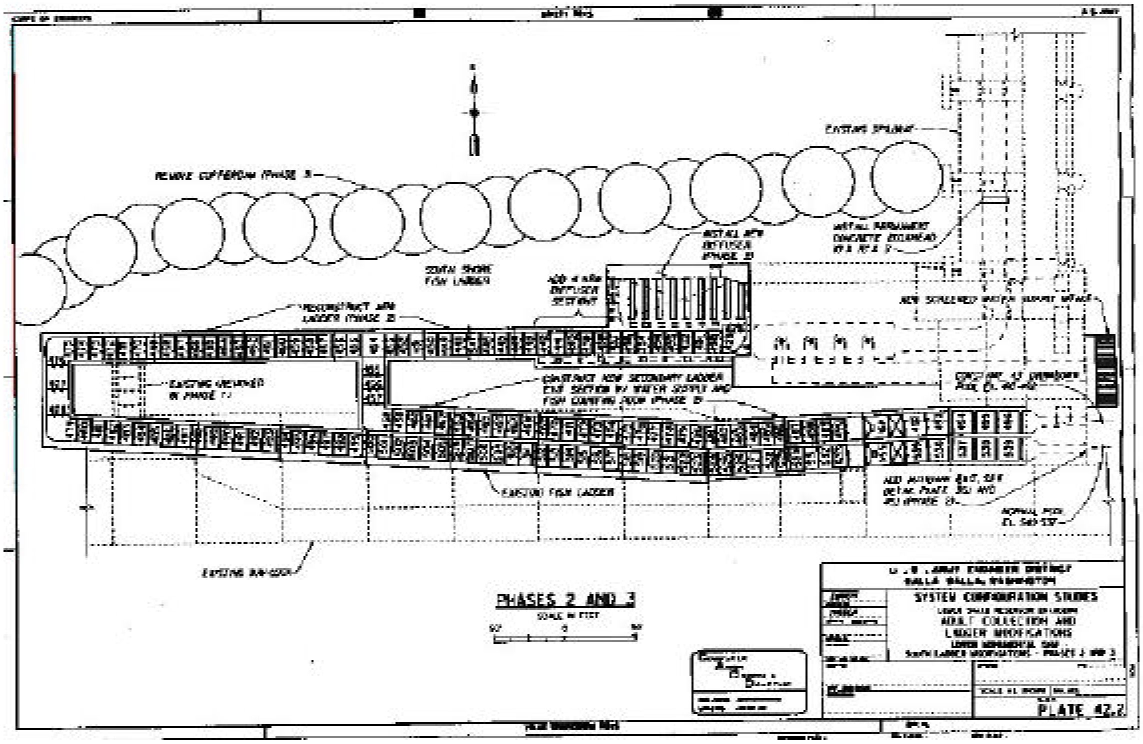


Plate 42.2. South Ladder Modifications--Phases 2 and 3

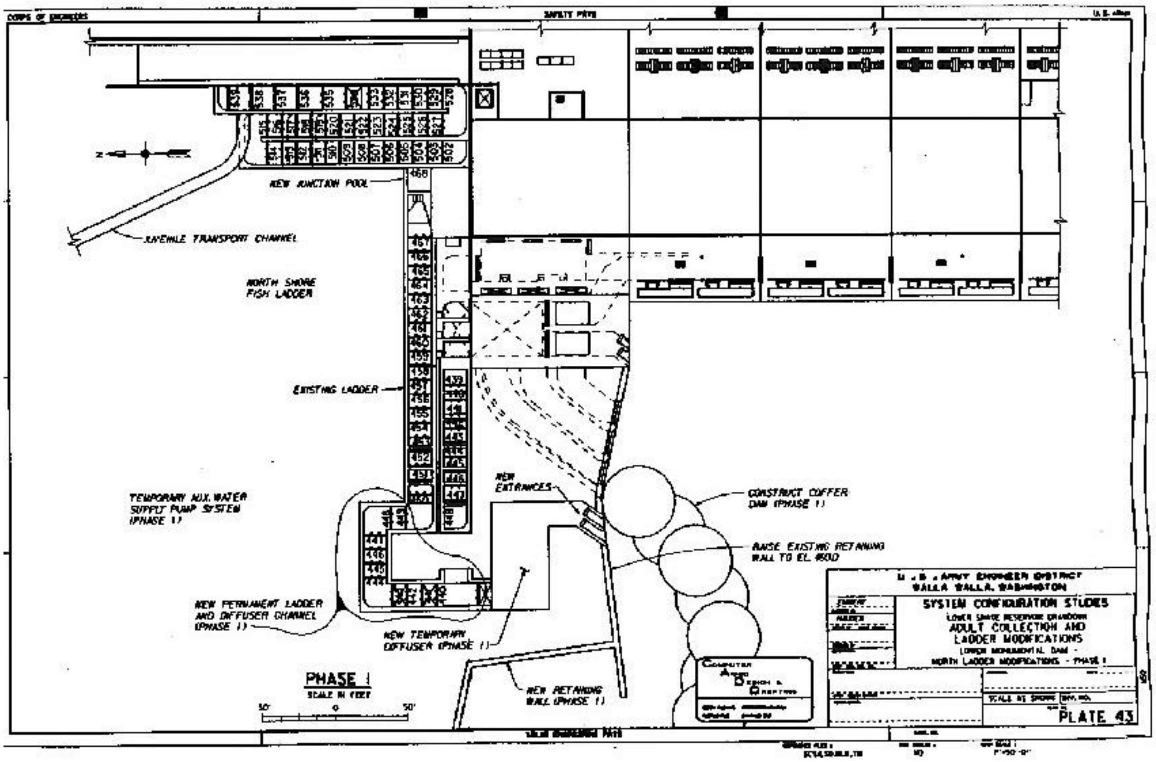


Plate 43. North Ladder Modifications--Phase 1

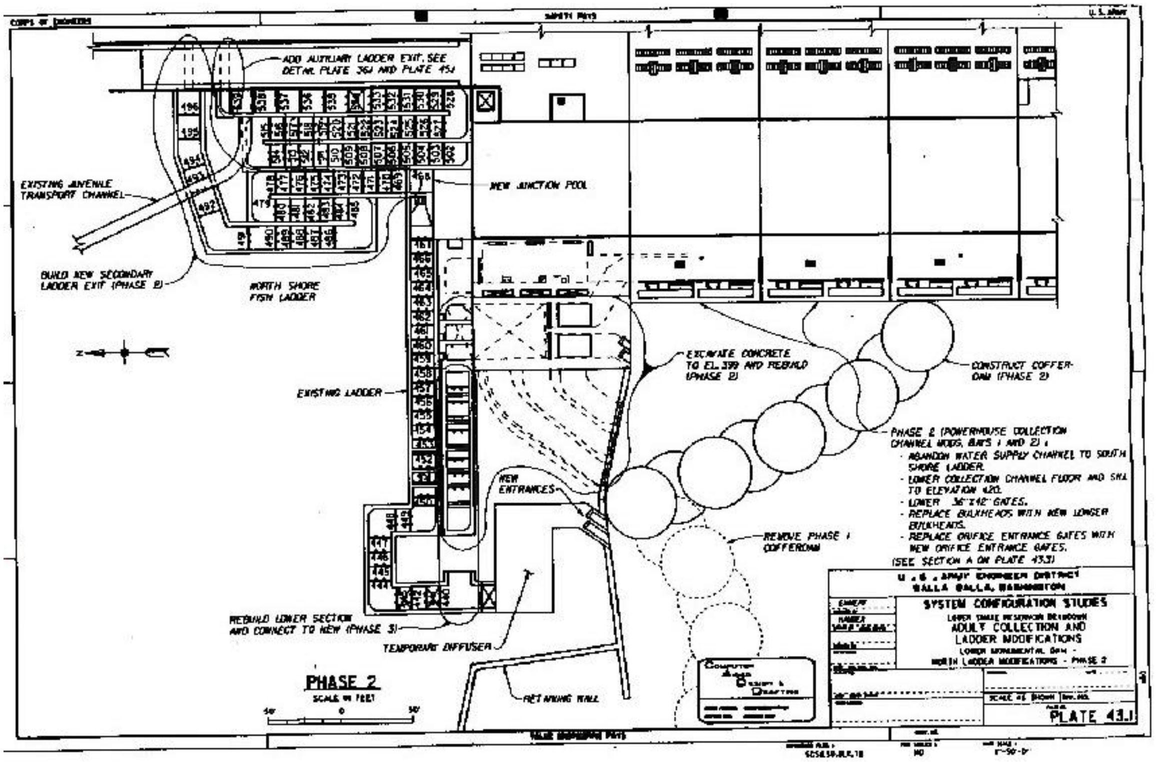


Plate 43.1. North Ladder Modifications--Phase 2

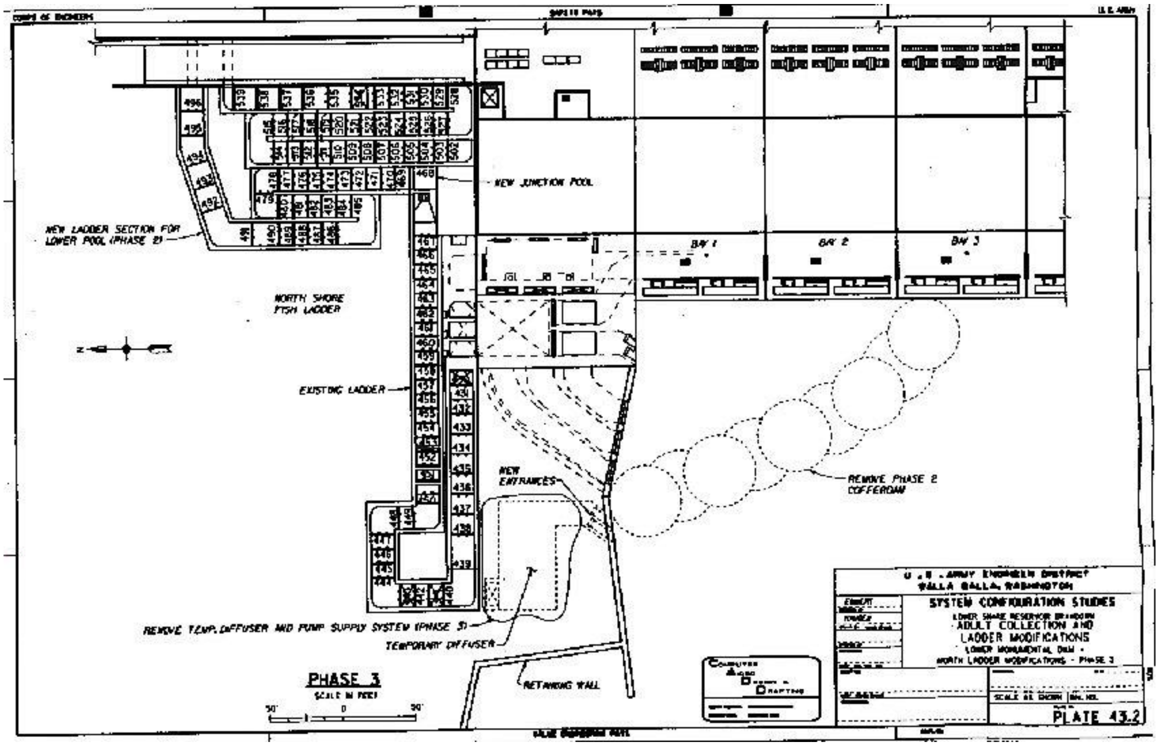


Plate 43.2. North Ladder Modifications--Phase 3

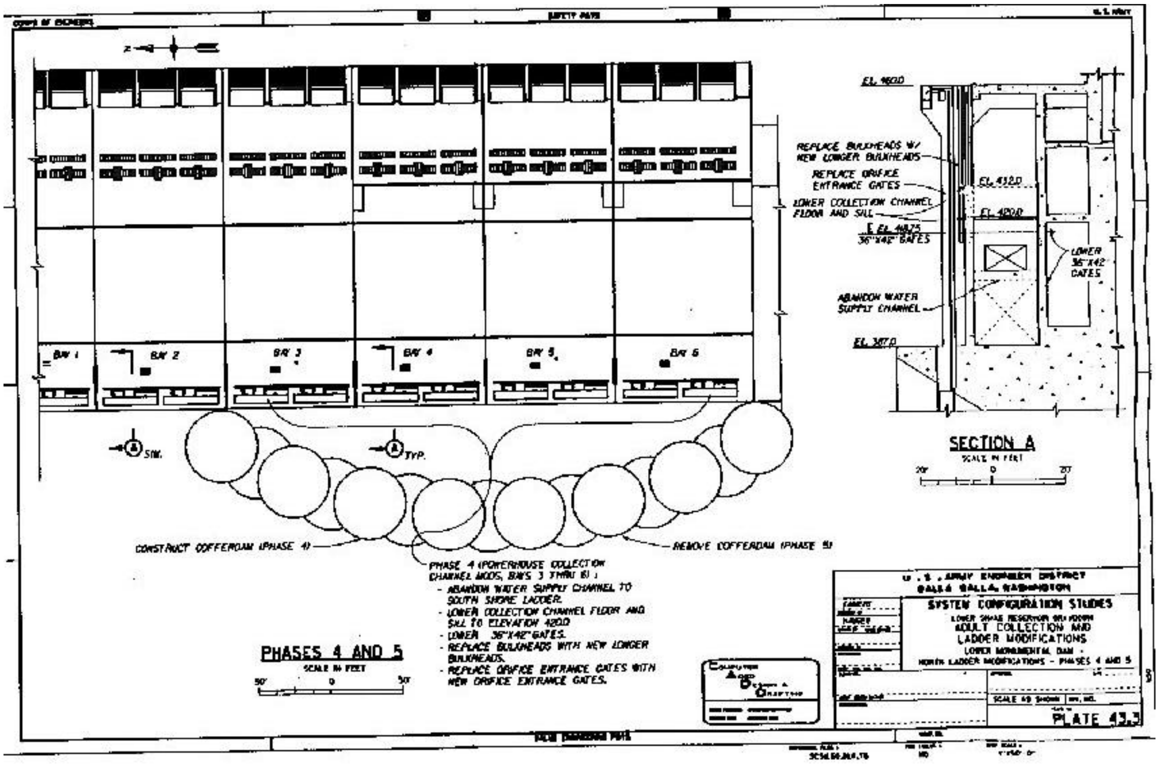


Plate 43.3. North Ladder Modifications--Phases 4 and 5
Ice Harbor Dam

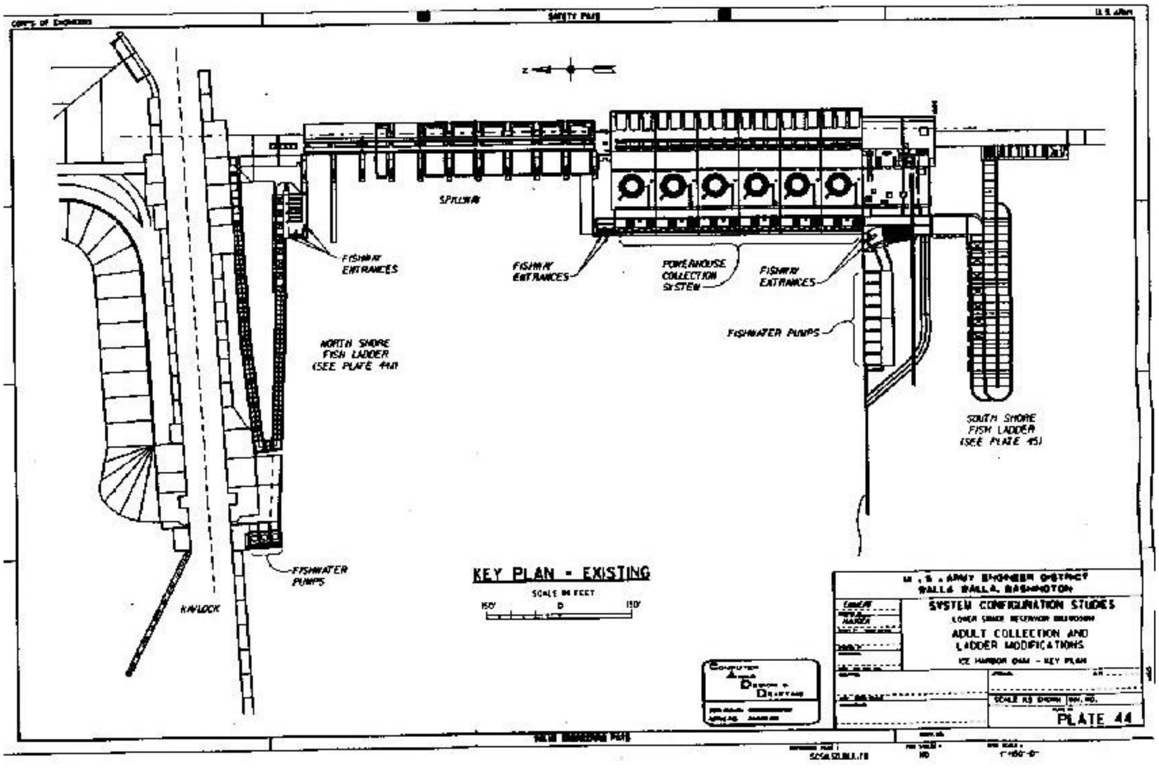


Plate 44. Key Plan

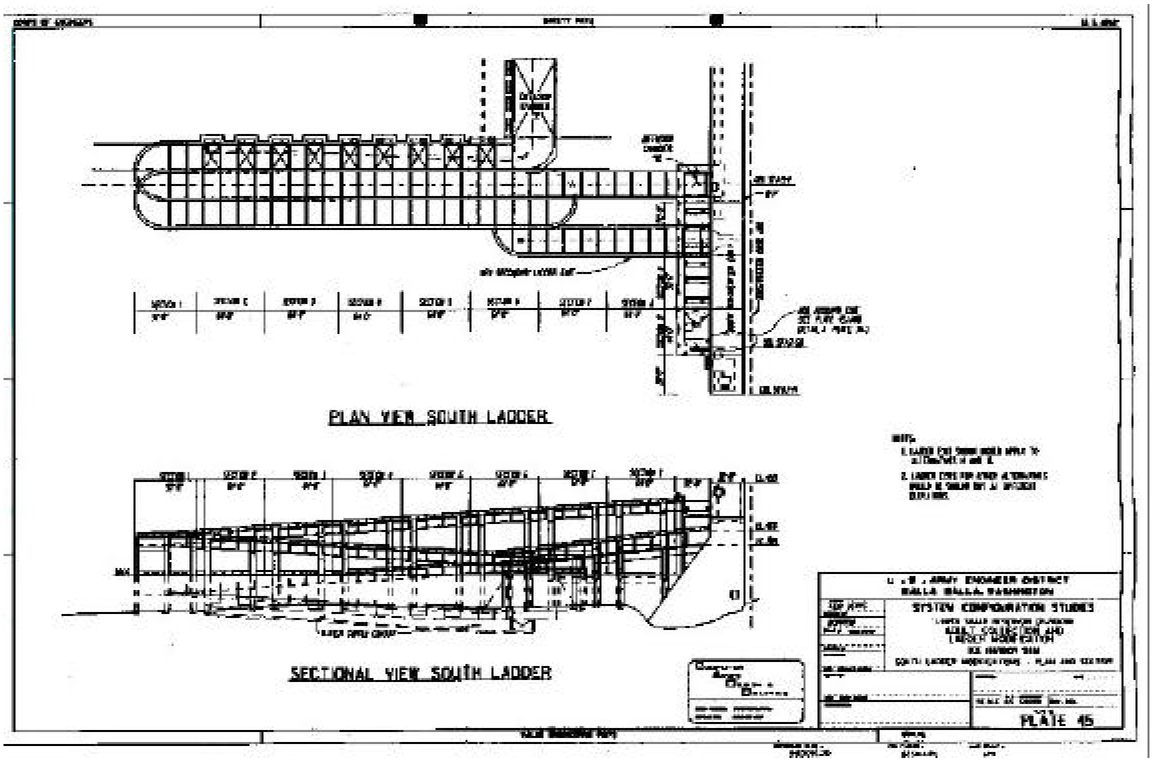


Plate 45. South Ladder Modifications--Plan and Section General

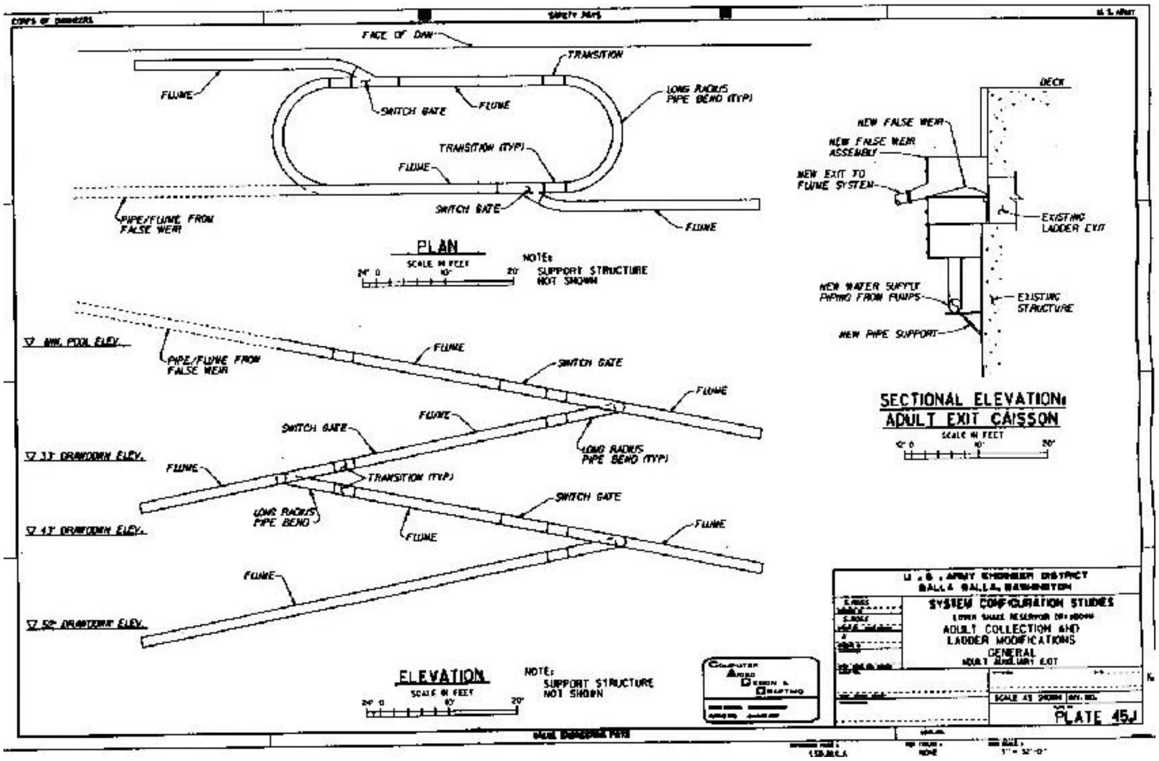


Plate 45.1. Adult Auxiliary Exit

Spillway Modifications

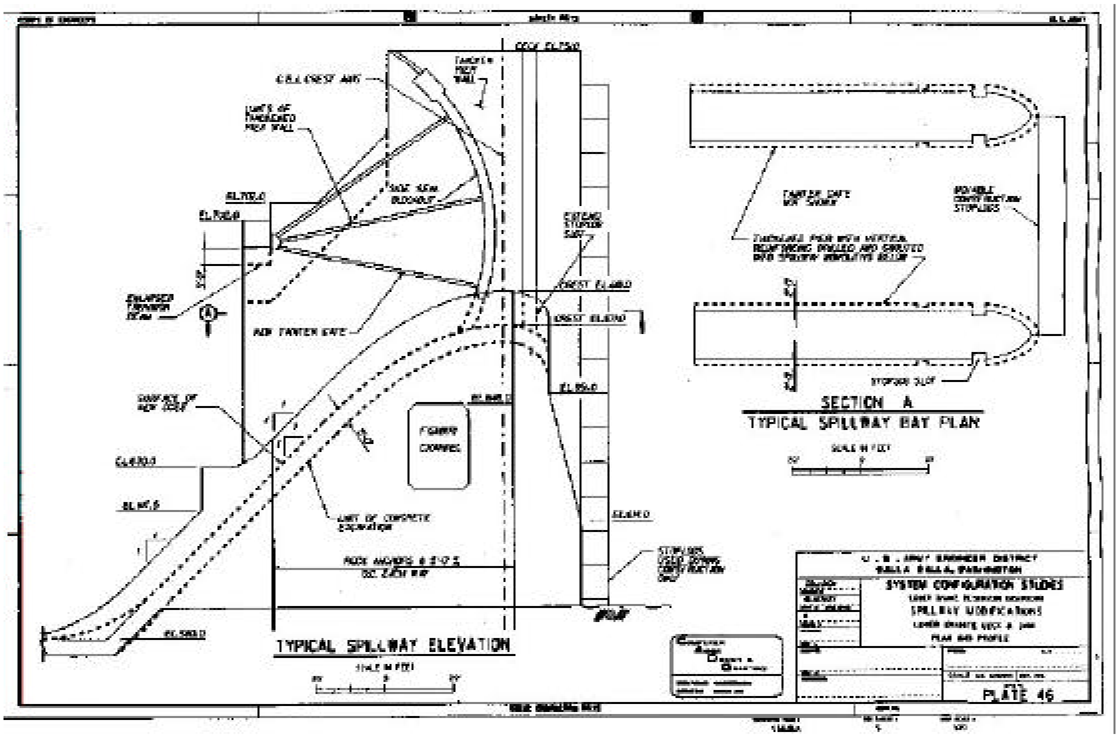


Plate 46. Lower Granite Lock and Dam--Plan and Profile

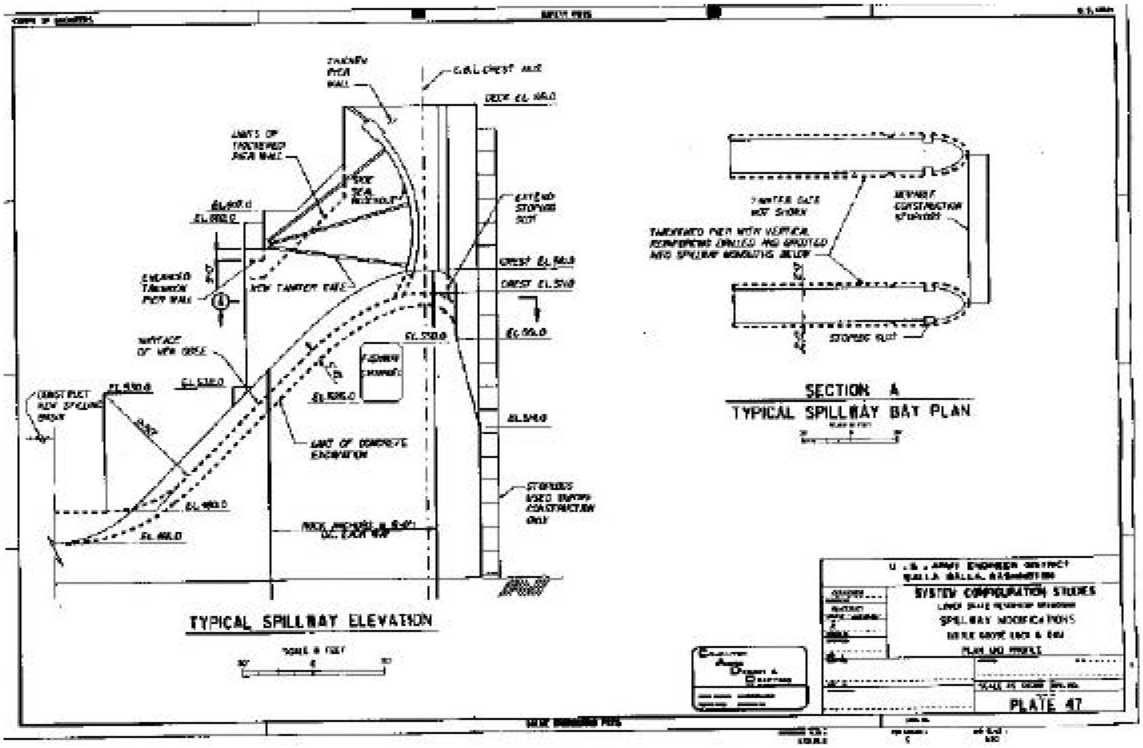


Plate 47. Little Goose Lock and Dam--Plan and Profile

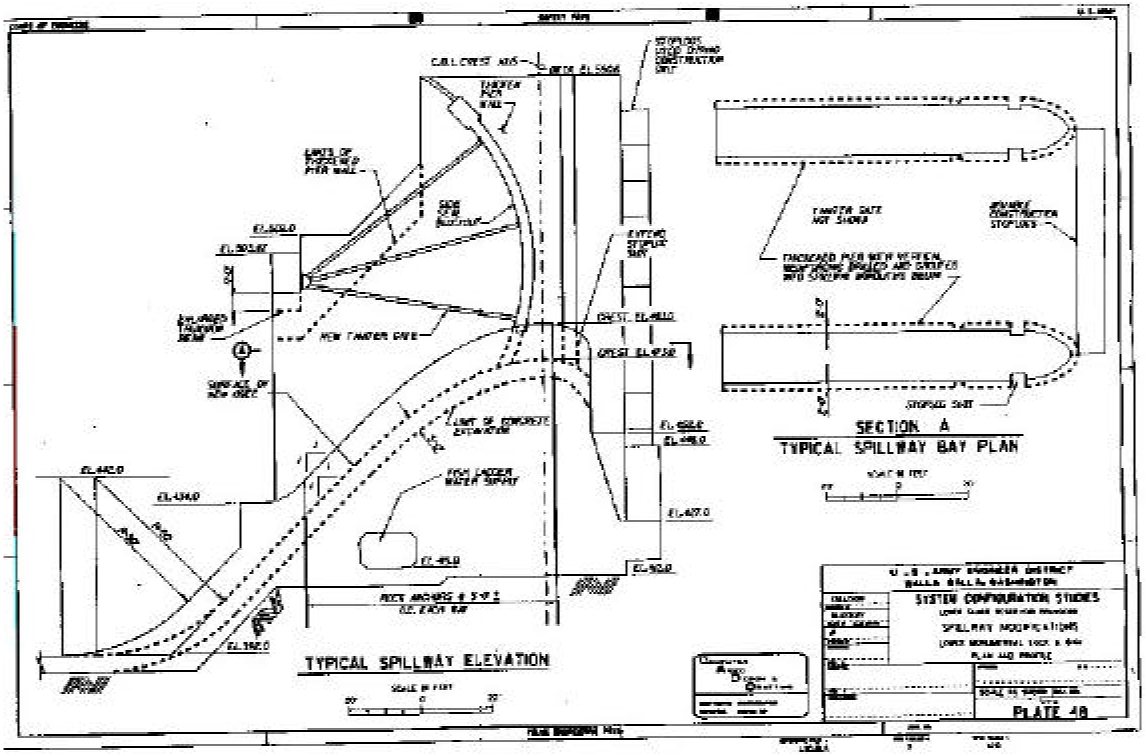


Plate 48. Lower Monumental Lock and Dam--Plan and Profile

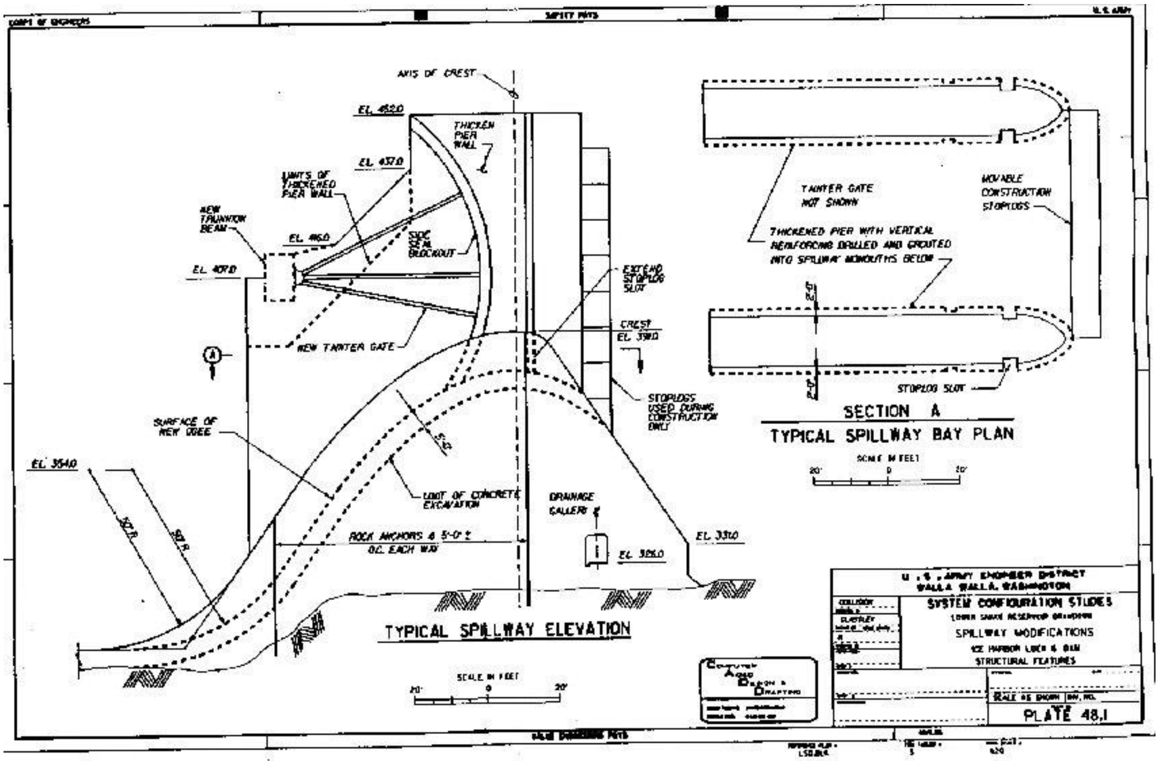
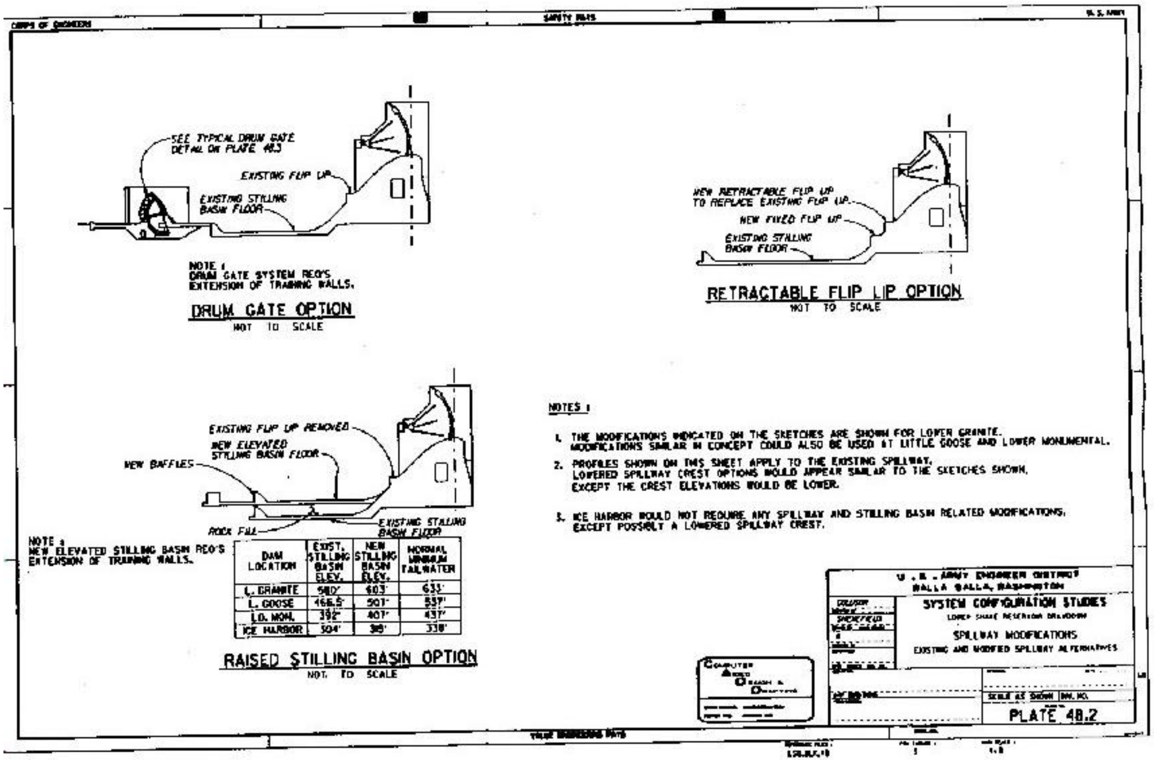


Plate 48.1. Ice Harbor Lock and Dam--Plan and Profile



NOTE:
DRUM GATE SYSTEM REQ'S EXTENSION OF TRAINING WALLS.

NOTE:
NEW ELEVATED STILLING BASIN REQ'S EXTENSION OF TRAINING WALLS.

DAM LOCATION	EXIST. STILLING BASIN ELEV.	NEW STILLING BASIN ELEV.	NORMAL MINIMUM TAILWATER
L. GRANITE	580'	603'	633'
L. GOOSE	466.5'	501'	537'
LO. MON.	392'	407'	437'
ICE HARBOR	304'	319'	338'

NOTES:

1. THE MODIFICATIONS INDICATED ON THE SKETCHES ARE SHOWN FOR LOWER GRANITE. MODIFICATIONS SIMILAR IN CONCEPT COULD ALSO BE USED AT LITTLE GOOSE AND LOWER MONUMENTAL.
2. PROFILES SHOWN ON THIS SHEET APPLY TO THE EXISTING SPILLWAY. LOWERED SPILLWAY CREST OPTIONS WOULD APPEAR SIMILAR TO THE SKETCHES SHOWN, EXCEPT THE CREST ELEVATIONS WOULD BE LOWER.
3. ICE HARBOR WOULD NOT REQUIRE ANY SPILLWAY AND STILLING BASIN RELATED MODIFICATIONS, EXCEPT POSSIBLY A LOWERED SPILLWAY CREST.

Plate 48.2. Existing and Modified Spillway Alternatives

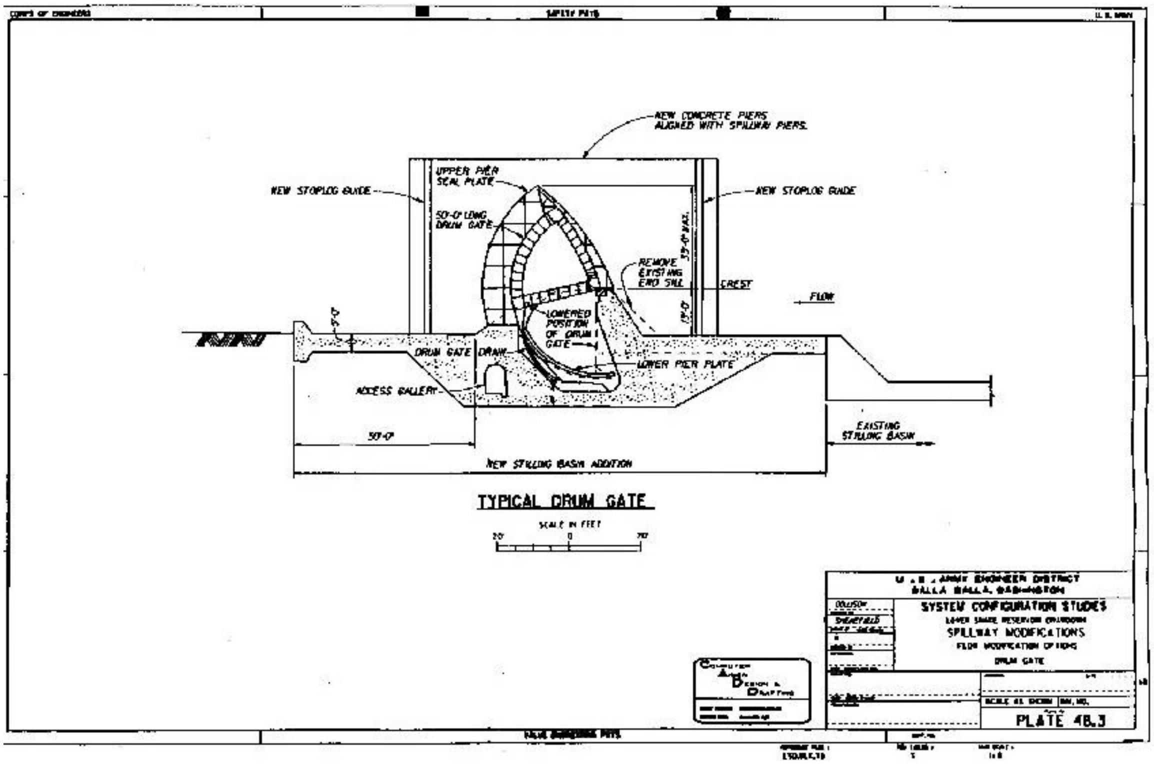


Plate 48.3. Flow Modification Options--Drum Gate

New Low-Level Spillway

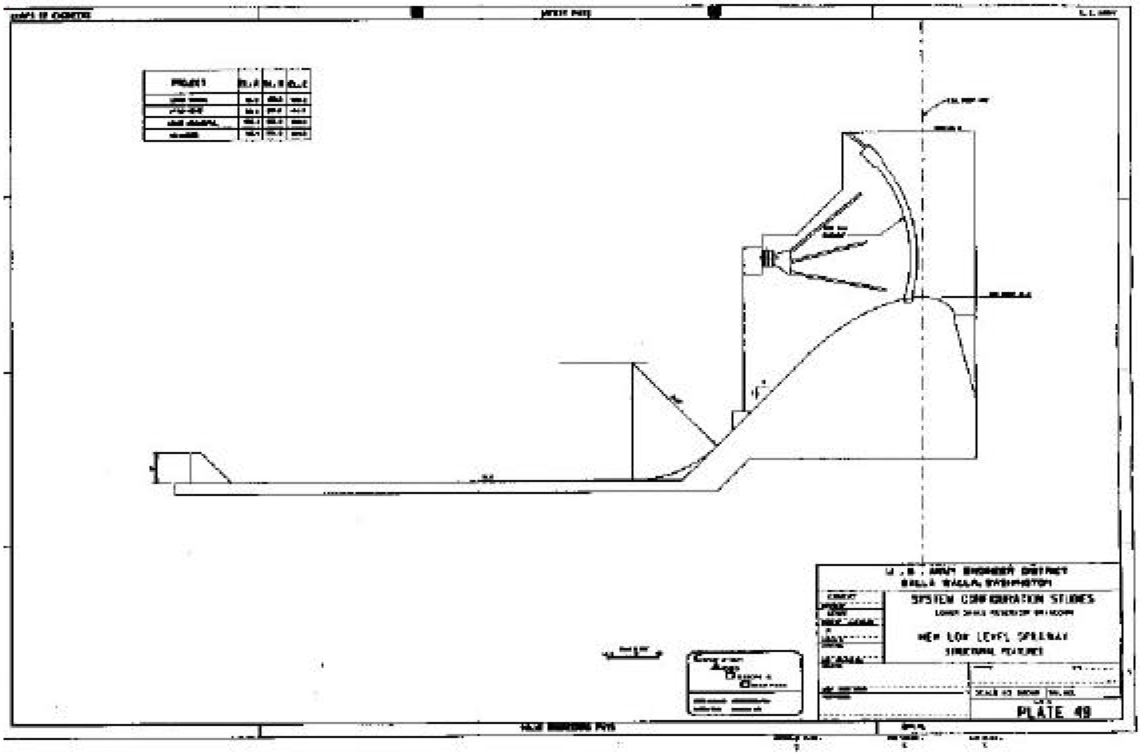


Plate 49. Structural Features

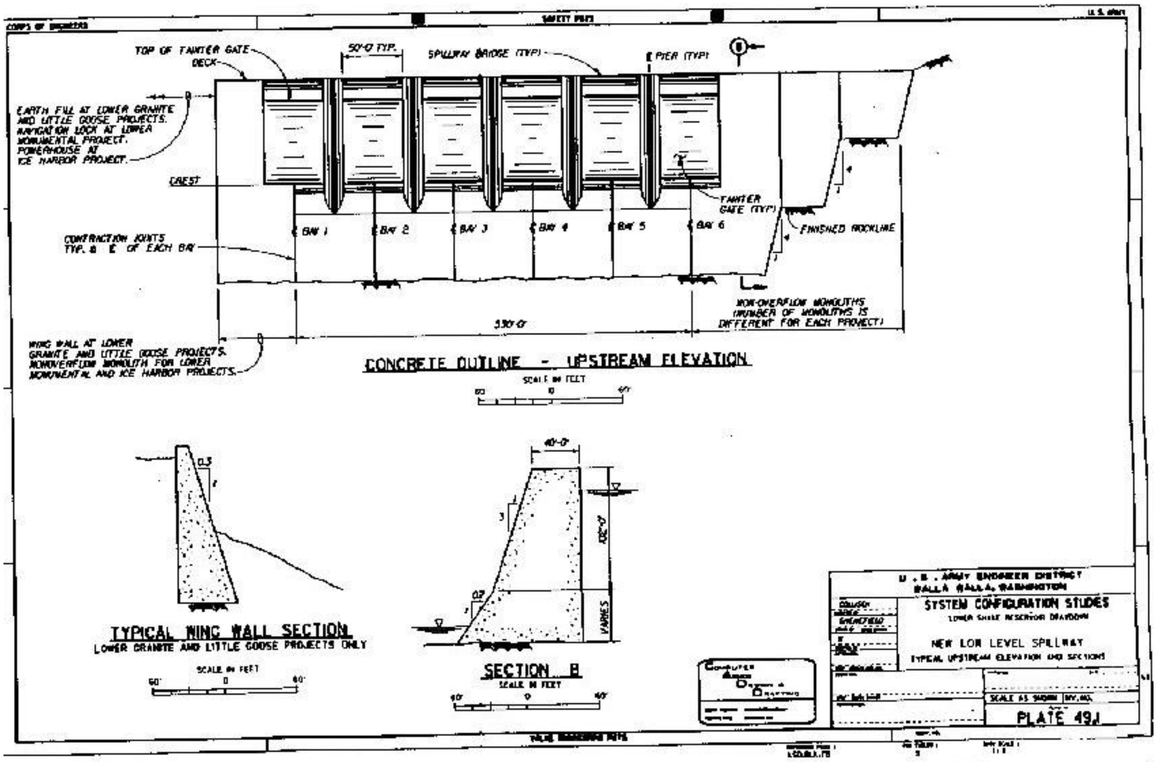


Plate 49.1. Typical Upstream Elevation and Sections

Upstream Cofferdams

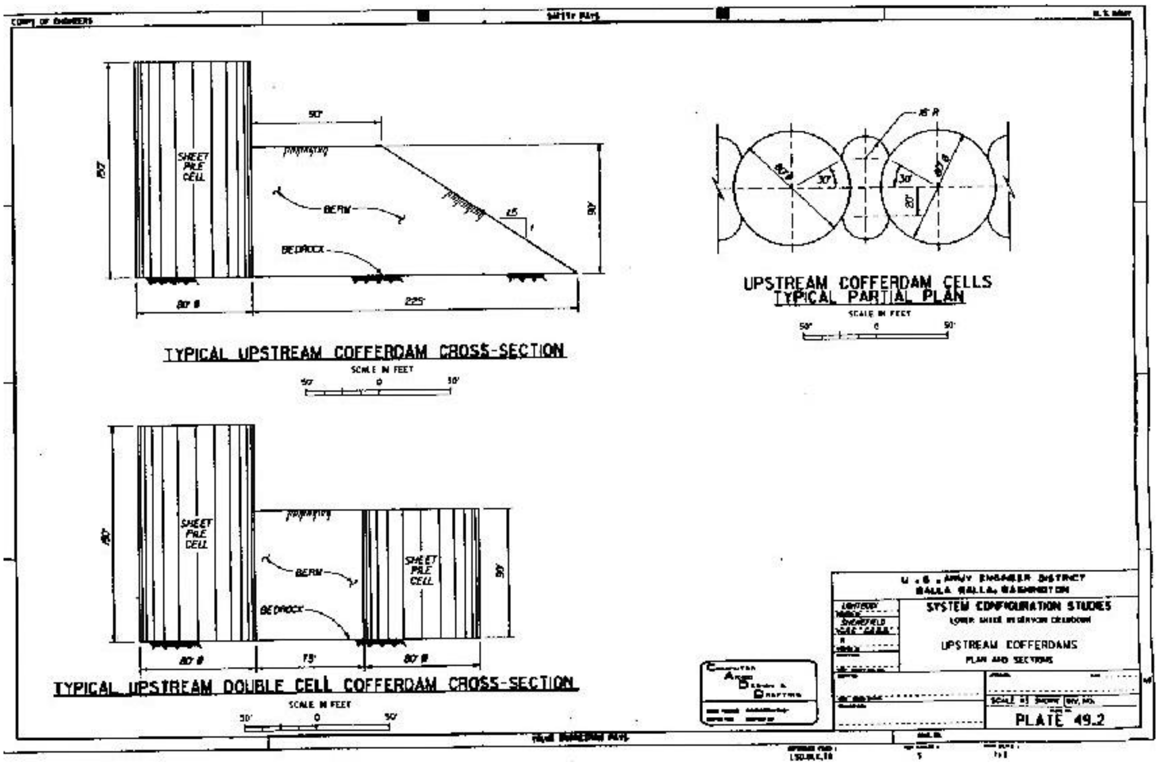


Plate 49.2. Plans and Sections

Miscellaneous

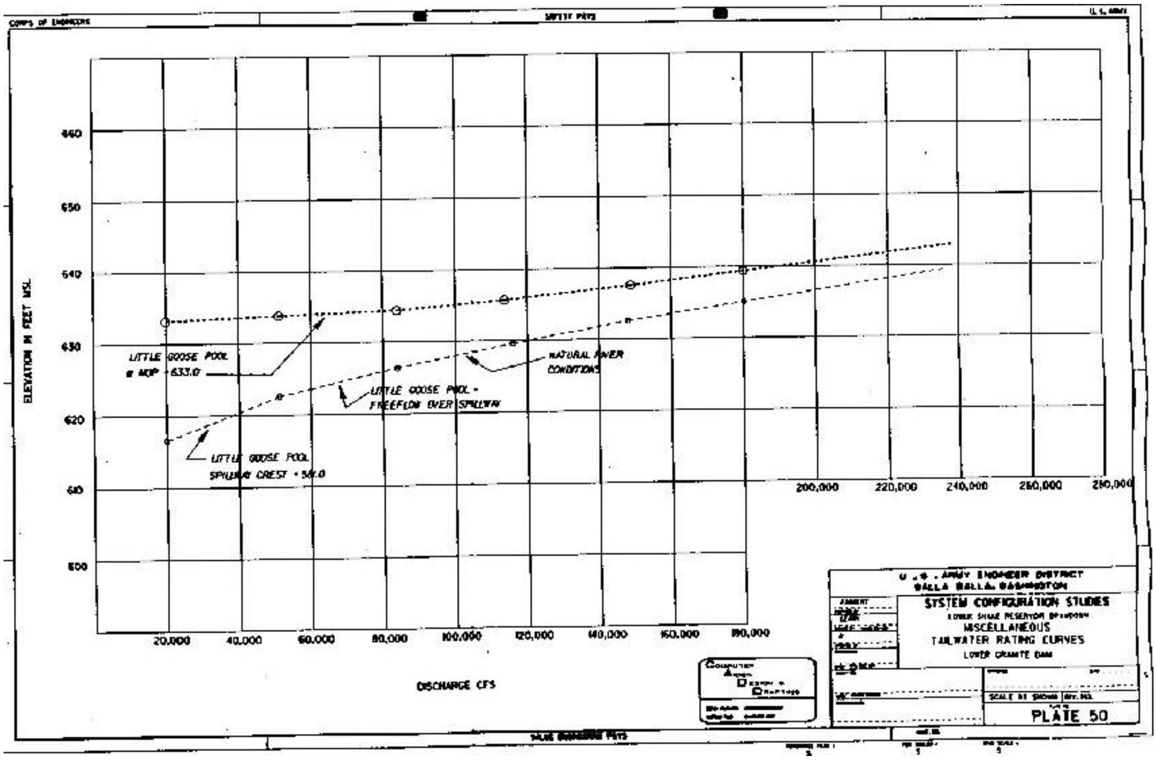


Plate 50. Tailwater Rating Curves--Lower Granite Dam

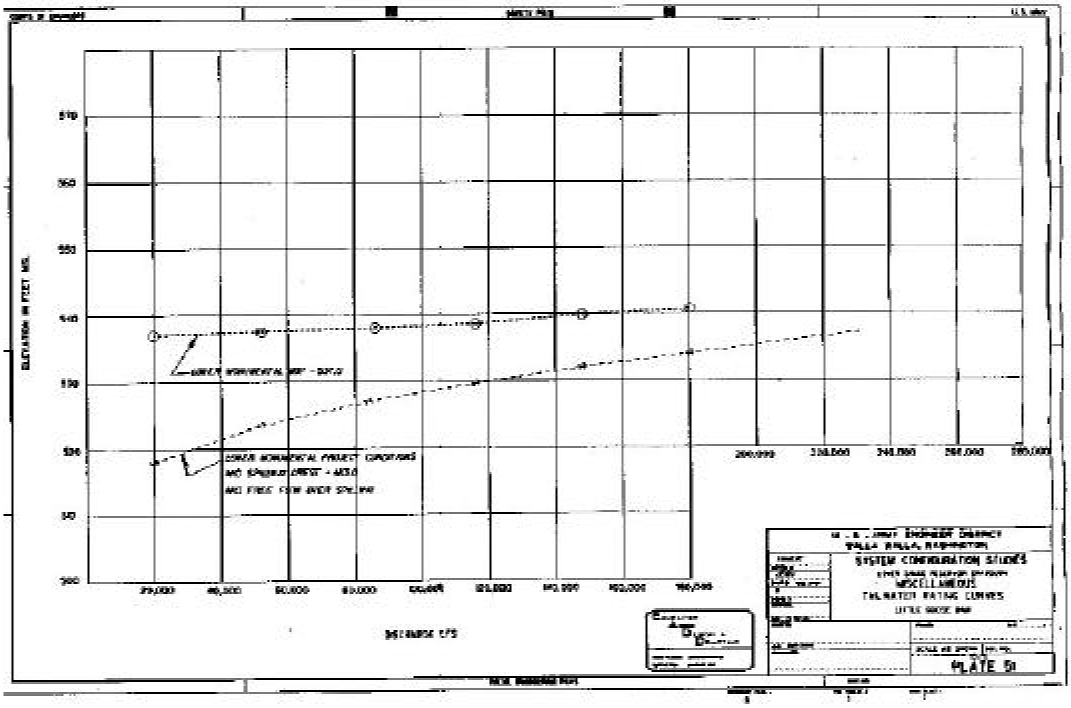


Plate 51. Tailwater Rating Curves--Little Goose Dam

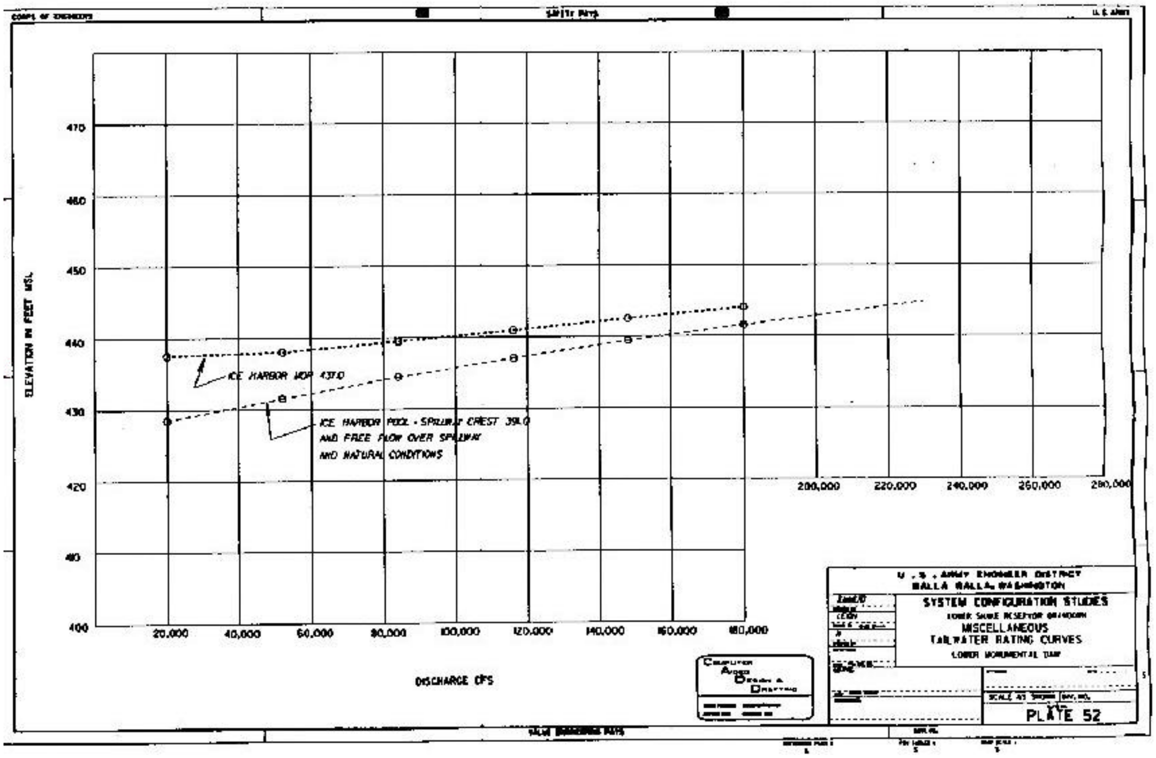


Plate 52. Tailwater Rating Curves--Lower Monumental Dam

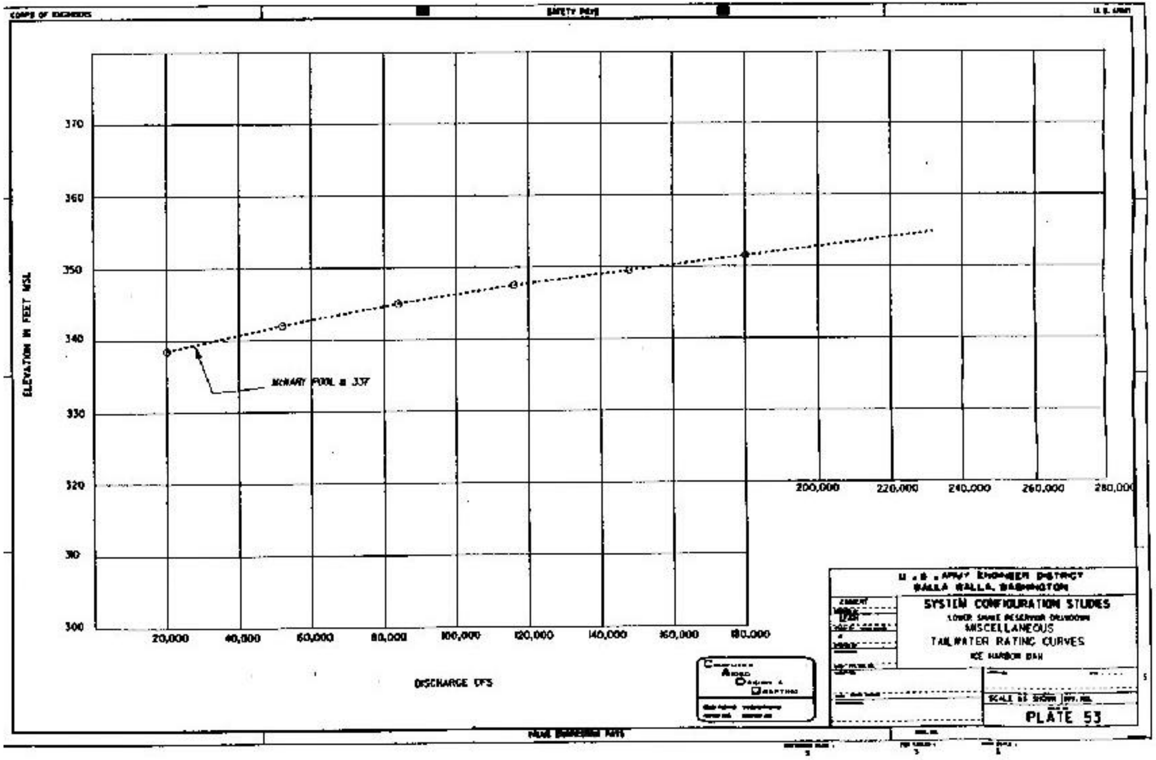


Plate 53. Tailwater Rating Curves--Ice Harbor Dam

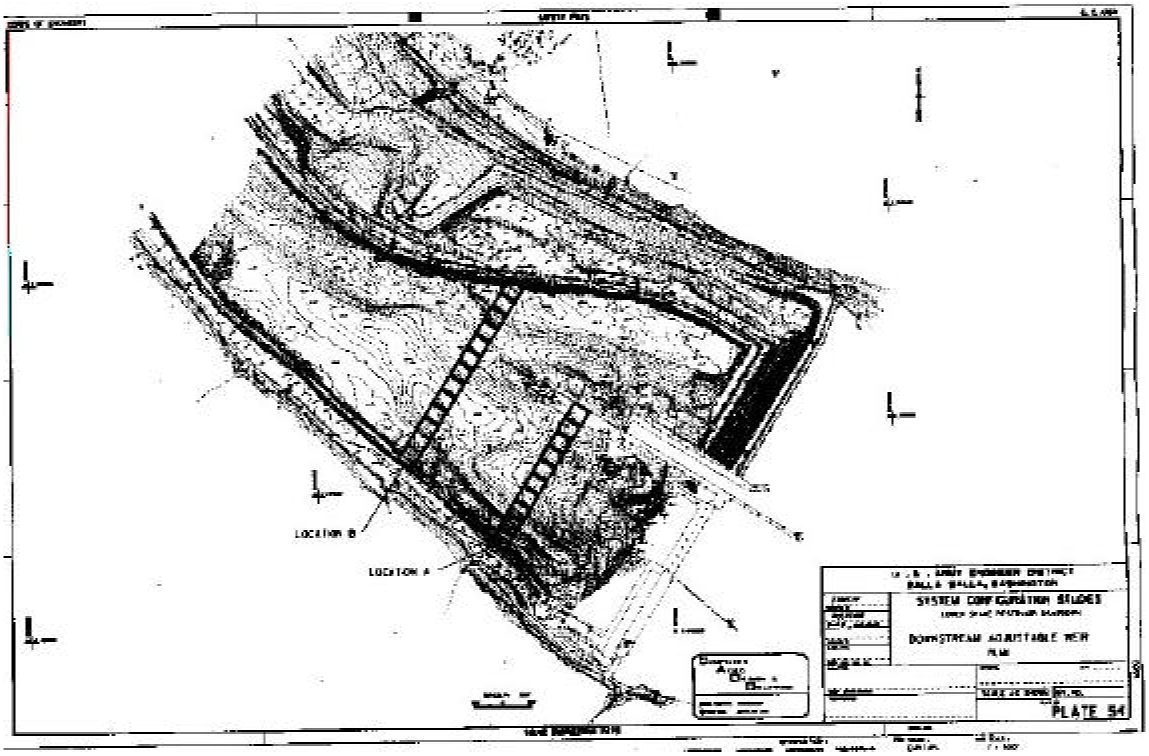


Plate 54. Downstream Adjustable Weir--Plan

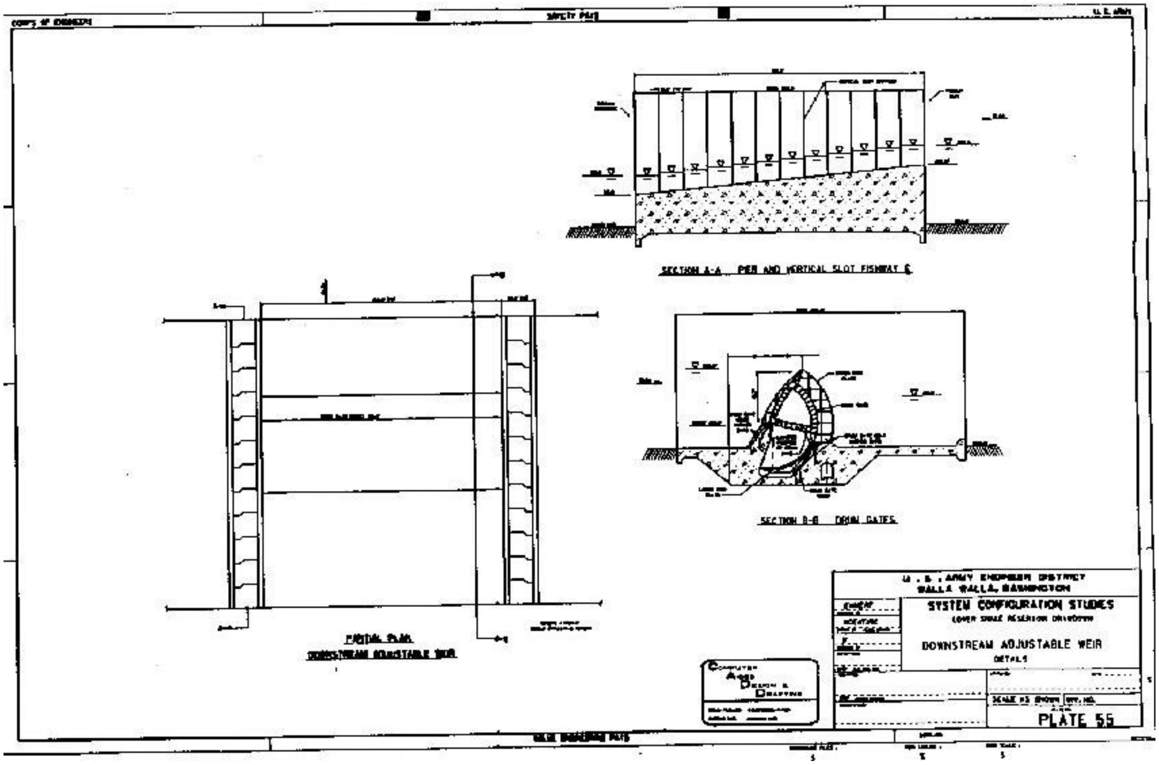


Plate 55. Downstream Adjustable Weir--Details

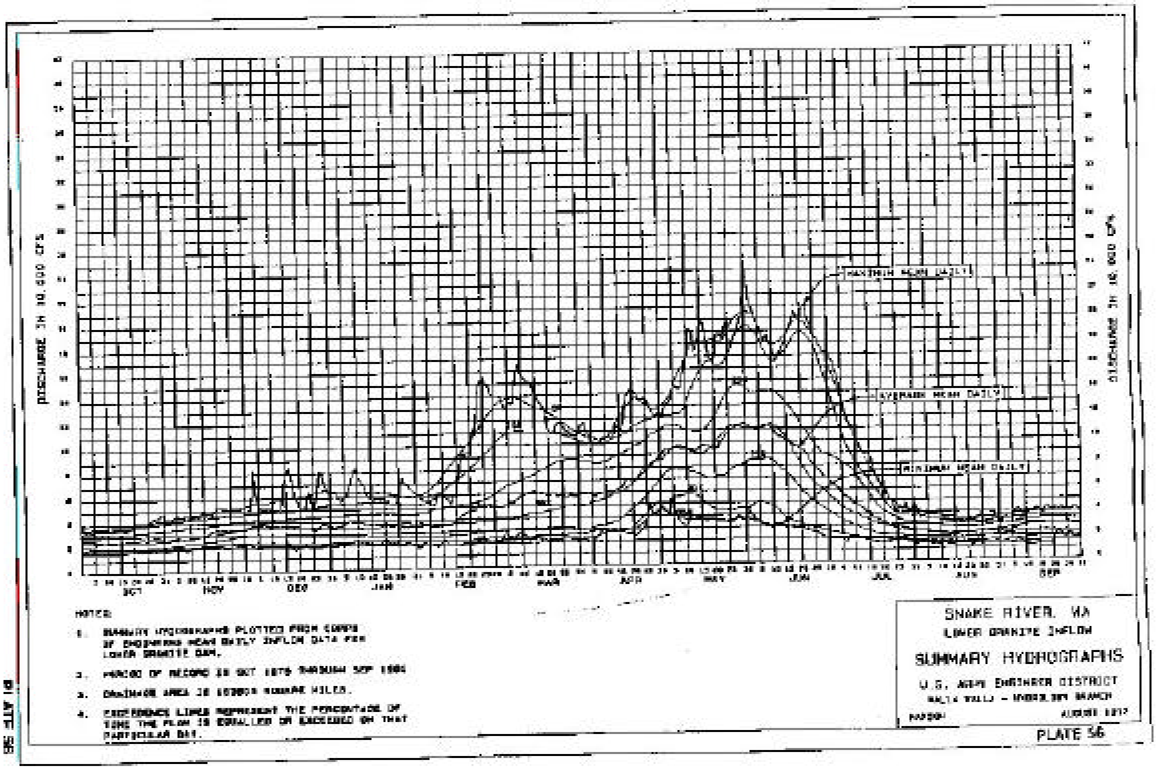
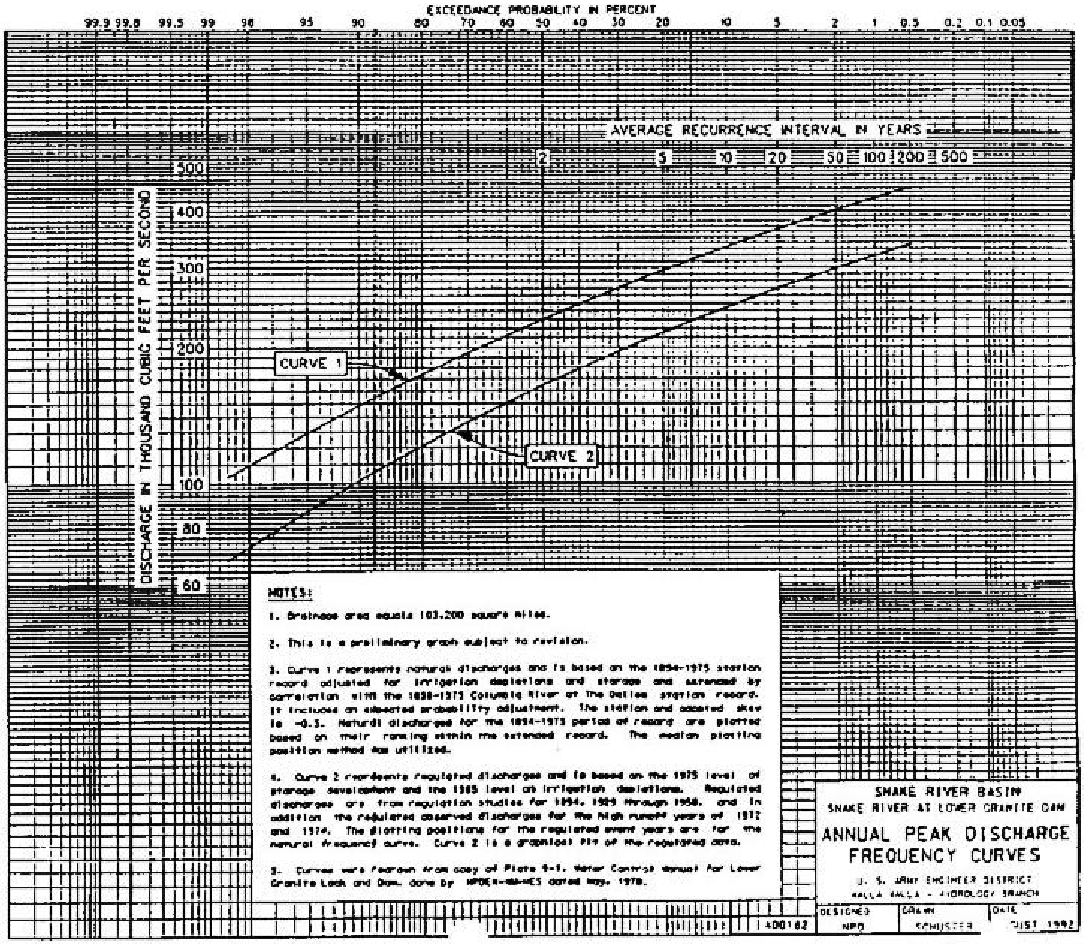


Plate 56. Summary Hydrographs



NOTES:

1. Drainage area equals 103,200 square miles.

2. This is a preliminary graph subject to revision.

3. Curve 1 represents natural discharges and is based on the 1894-1975 station record adjusted for irrigation depletions and storage and extended by correlation with the 1858-1975 Columbia River at The Dalles station record. It includes an expected probability adjustment. The station and adopted skew is -0.5. Natural discharges for the 1894-1975 period of record are plotted based on their ranking within the extended record. The median plotting position method was utilized.

4. Curve 2 represents regulated discharges and is based on the 1975 level of storage development and the 1985 level of irrigation depletions. Regulated discharges are from regulation studies for 1894, 1929 through 1958, and in addition the regulated observed discharges for the high runoff years of 1972 and 1974. The plotting positions for the regulated event years are for the natural frequency curve. Curve 2 is a graphical fit of the regulated data.

5. Curves were redrawn from copy of Plate 9-1, Water Control Manual for Lower Granite Lock and Dam, done by NPDEN-WM-HES dated May, 1978.

SNAKE RIVER BASIN
SNAKE RIVER AT LOWER GRANITE DAM
ANNUAL PEAK DISCHARGE
FREQUENCY CURVES
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA - HYDROLOGY BRANCH

DESIGNED	DRAWN	DATE
NPD	SCHUSTER	AUGUST 1992

PLATE 57

Plate 57. Annual Peak Discharge Frequency Curves

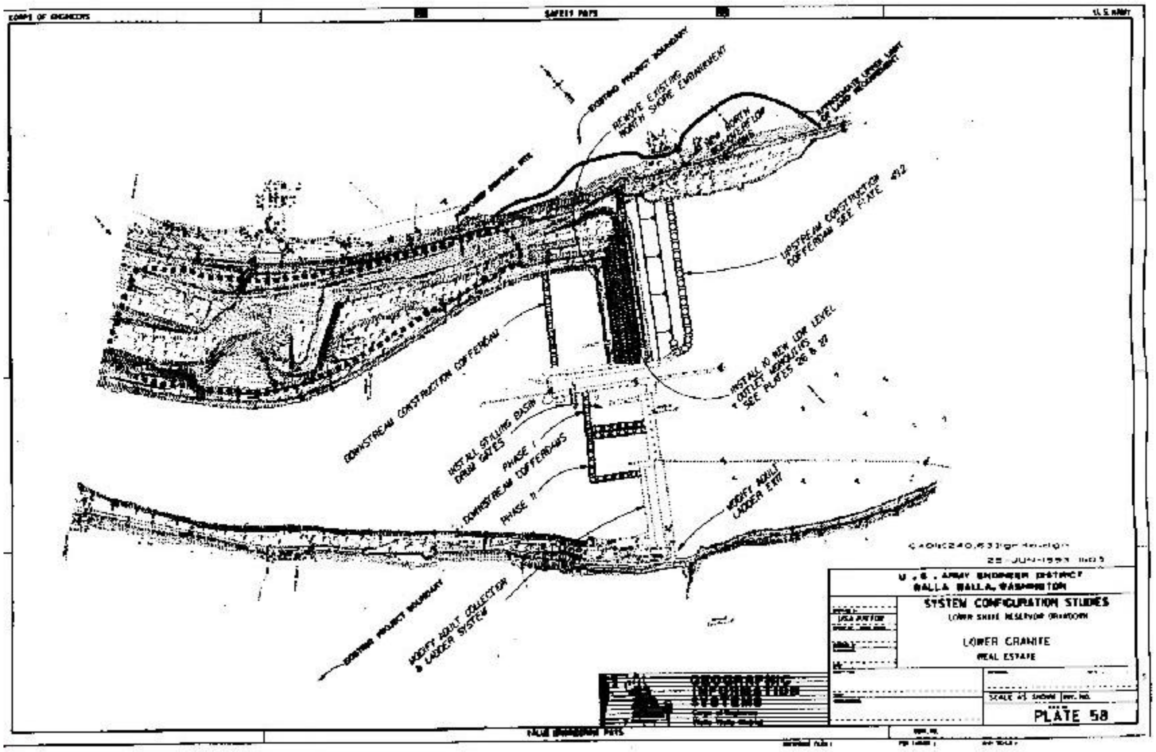


Plate 58. Lower Granite--Real Estate

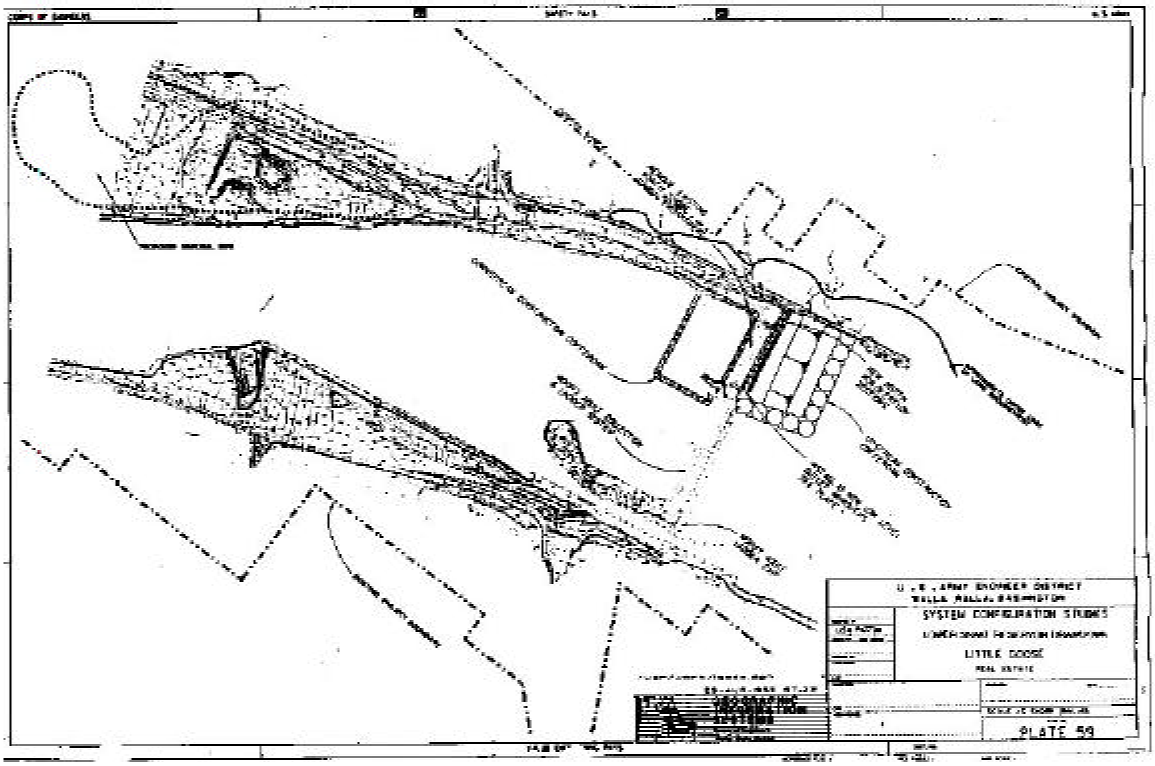


Plate 59. Little Goose--Real Estate

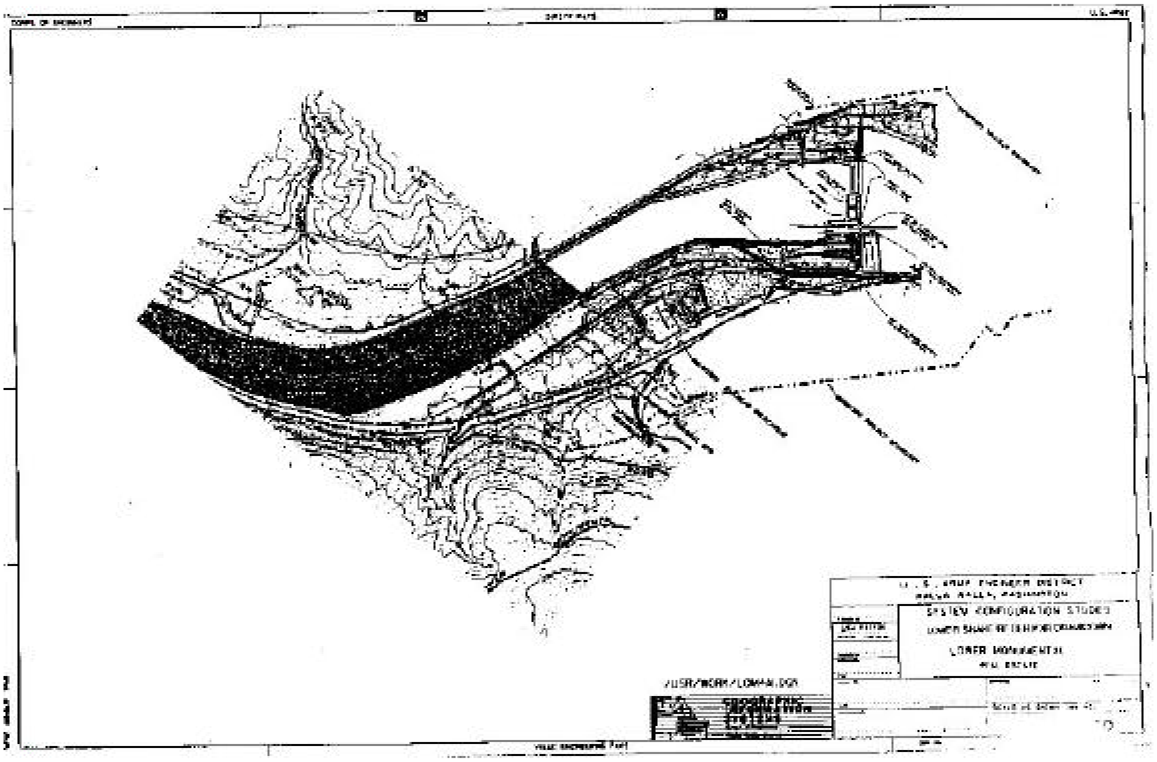


Plate 60. Lower Monumental--Real Estate

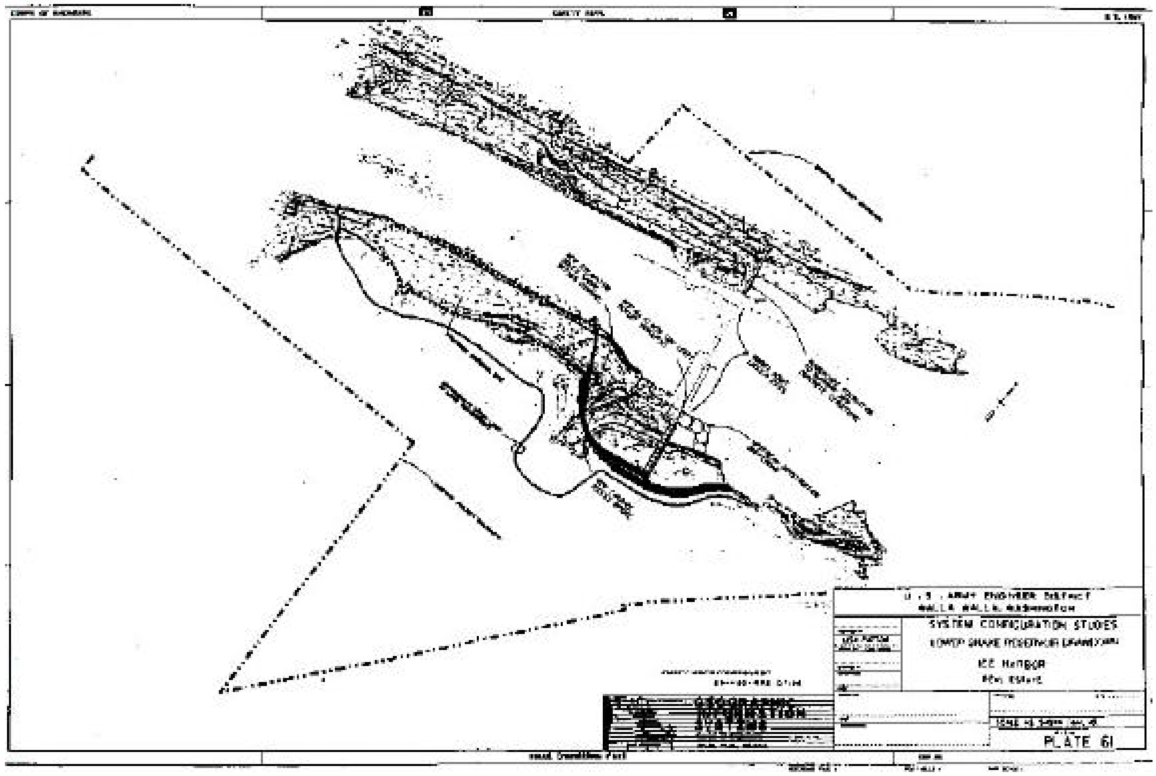


Plate 61. Ice Harbor--Real Estate

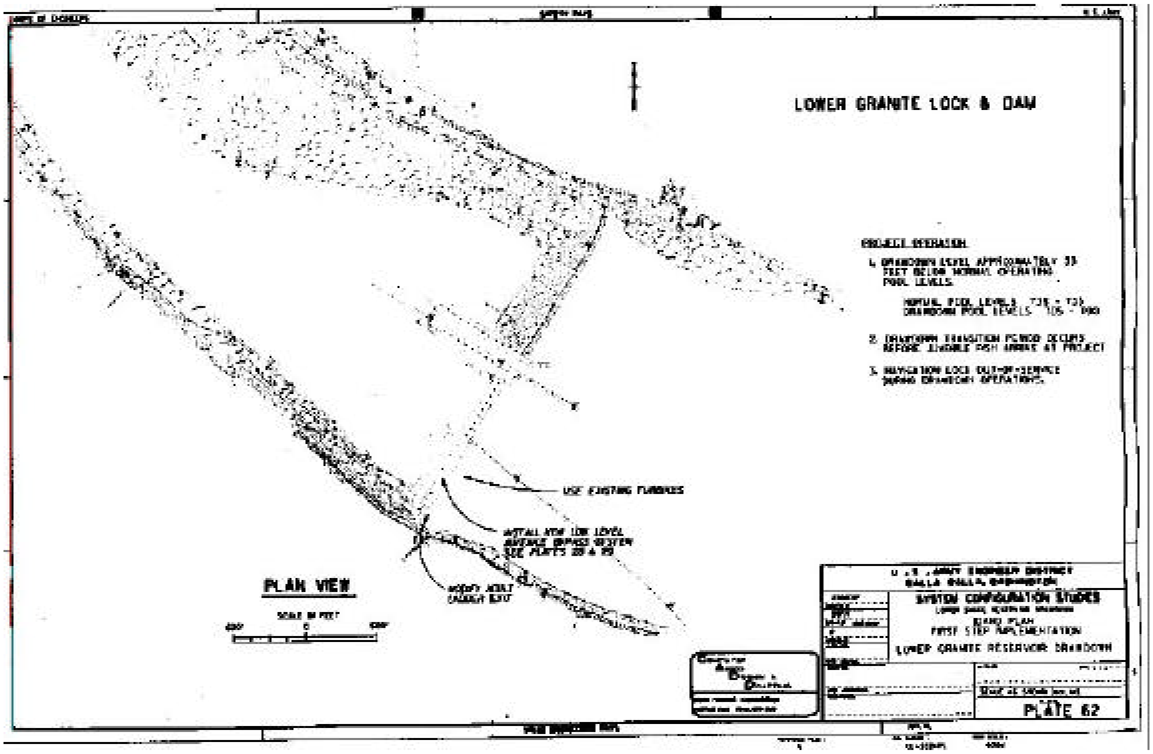


Plate 62. Idaho Plan--First Step Implementation--Site Plan

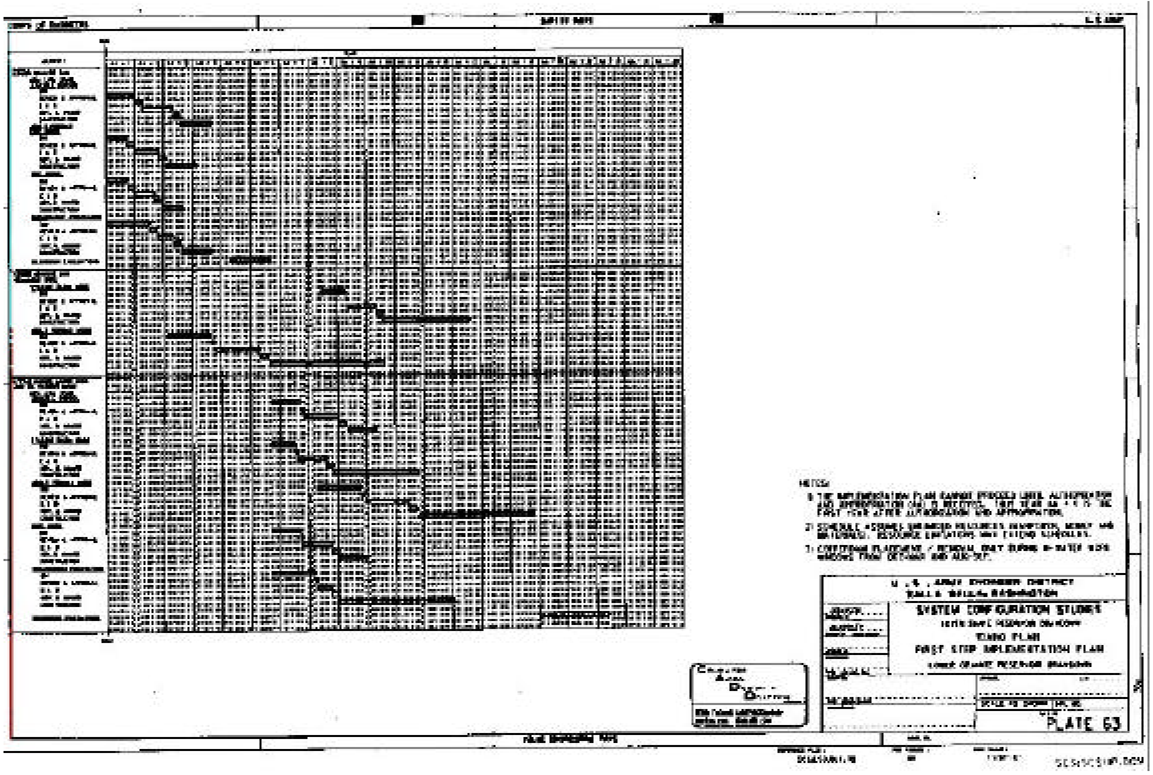


Plate 63. Idaho Plan--First Step Implementation Plan

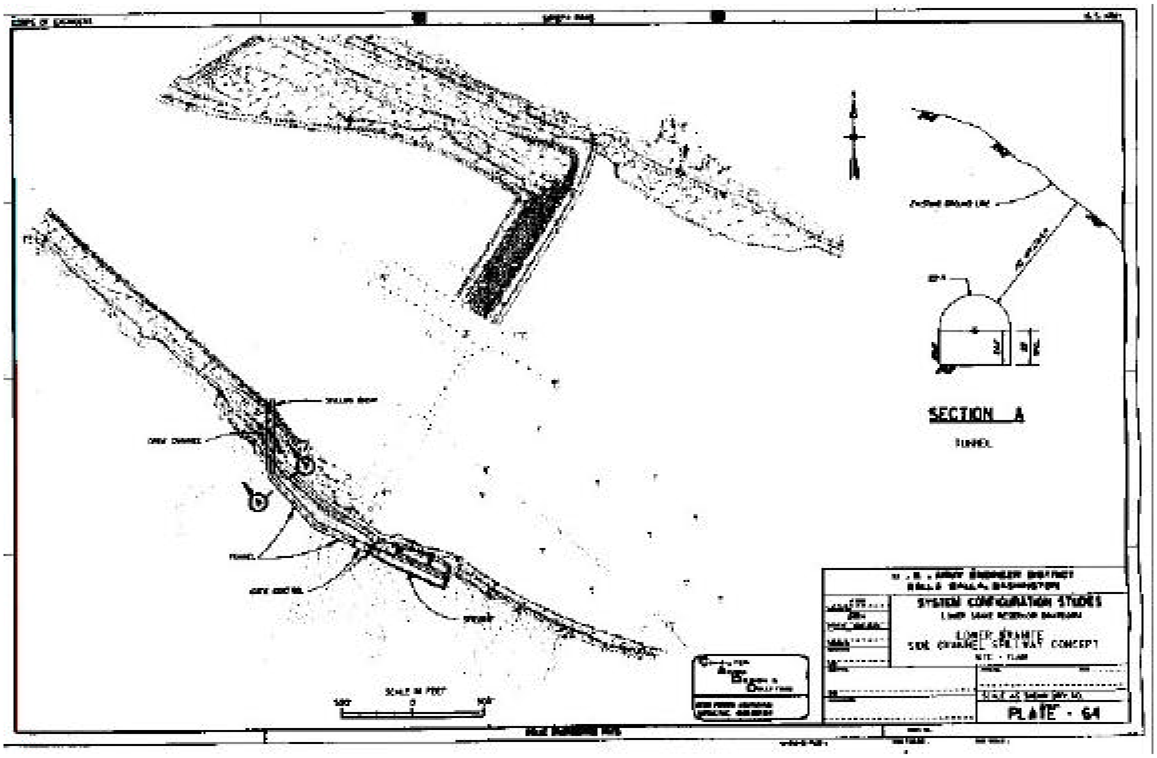


Plate 64. Side Channel Spillway Concept--Site Plan

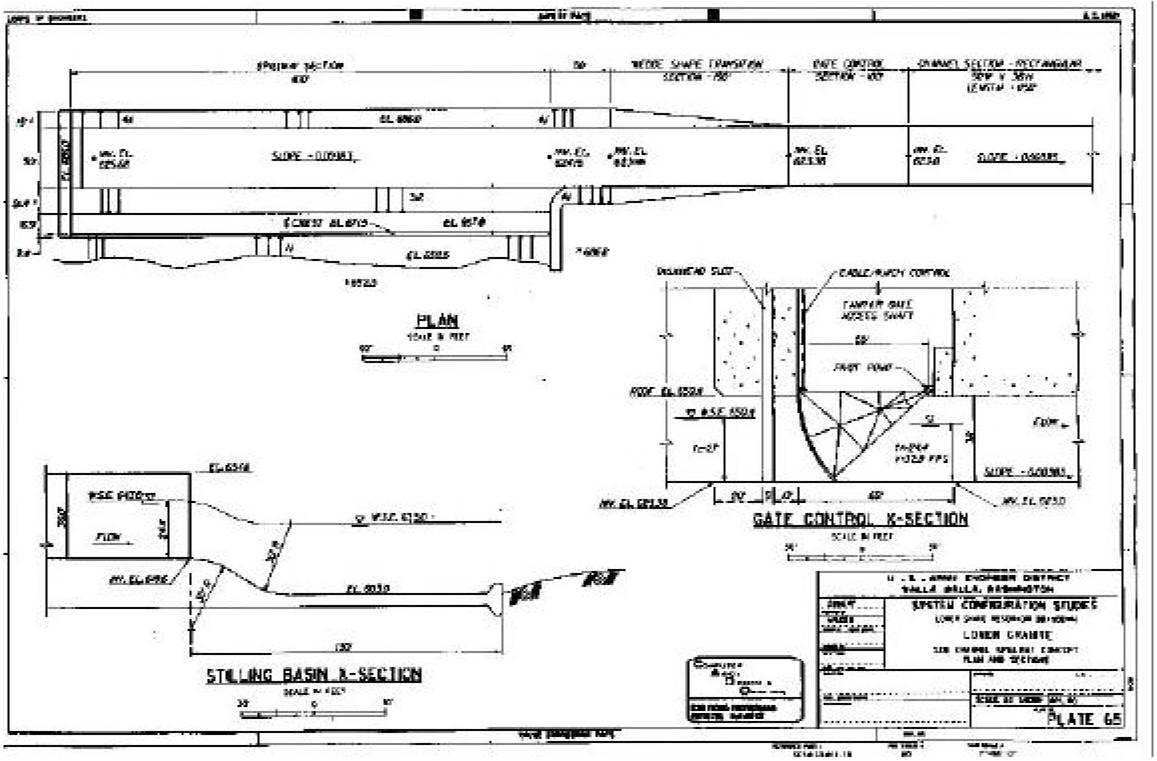


Plate 65. Side Channel Spillway Concept--Plan and Sections

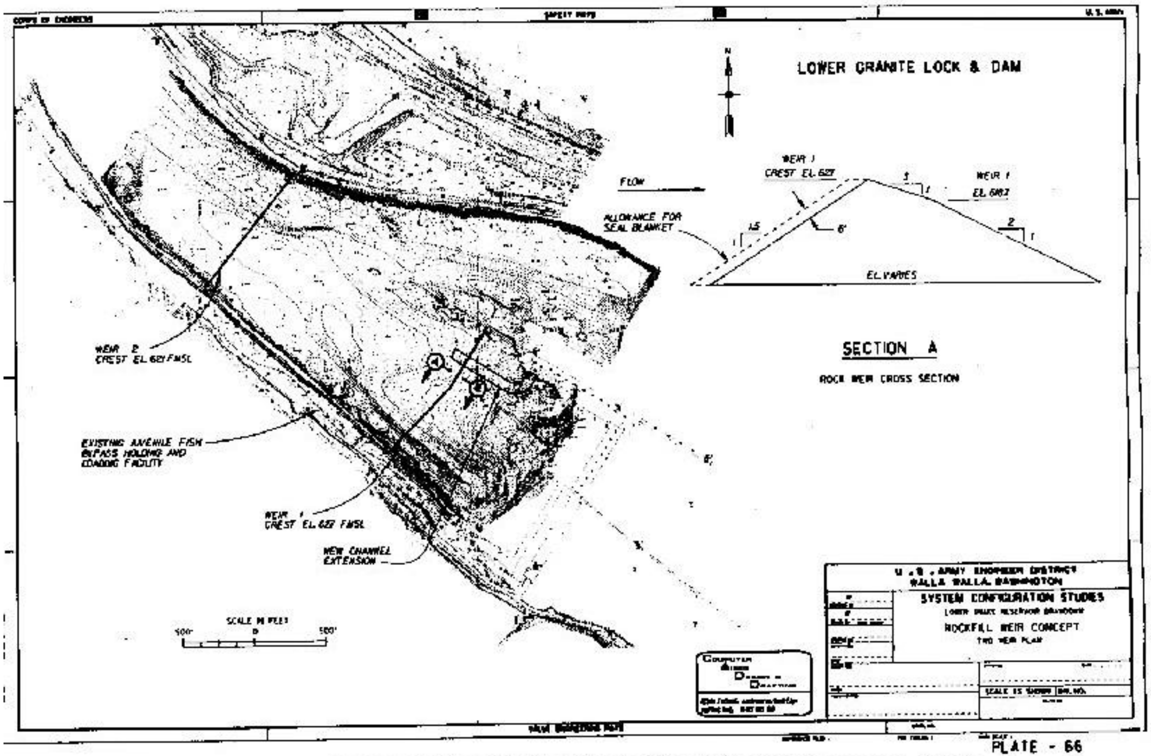


Plate 66. Rockfill Weir Concept--Two-Weir Plan

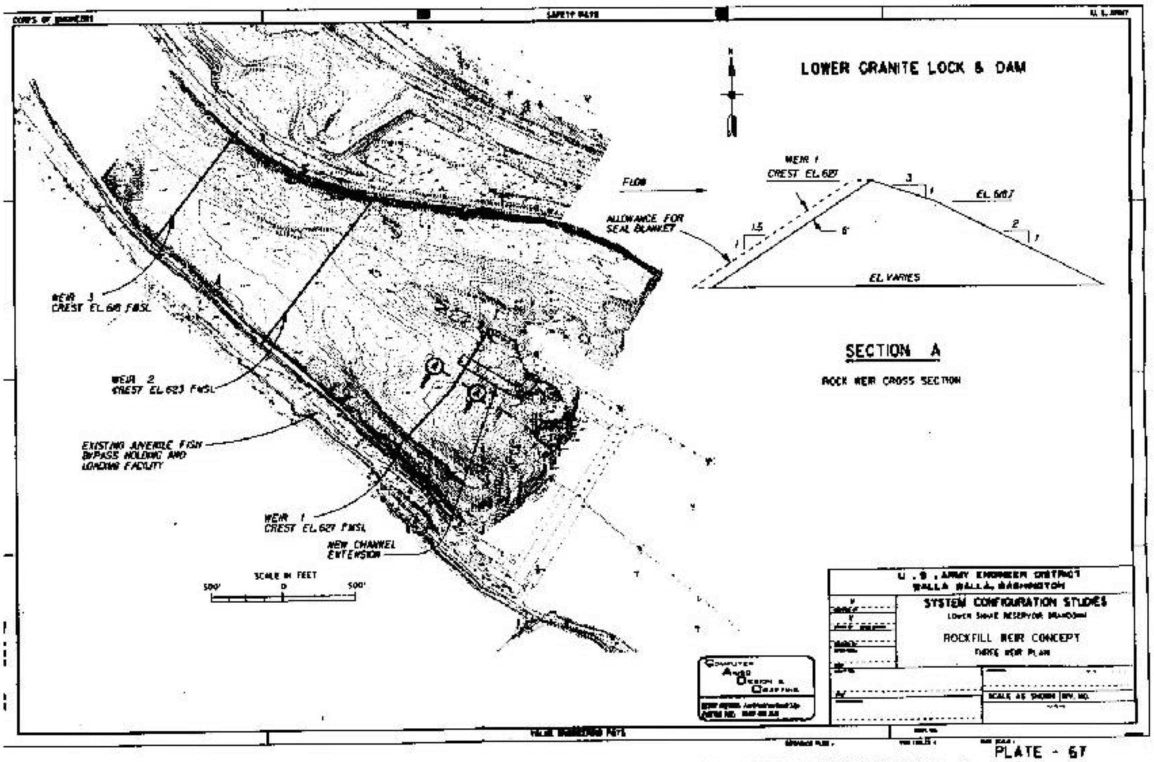


Plate 67. Rockfill Weir Concept--Three-Weir Plan

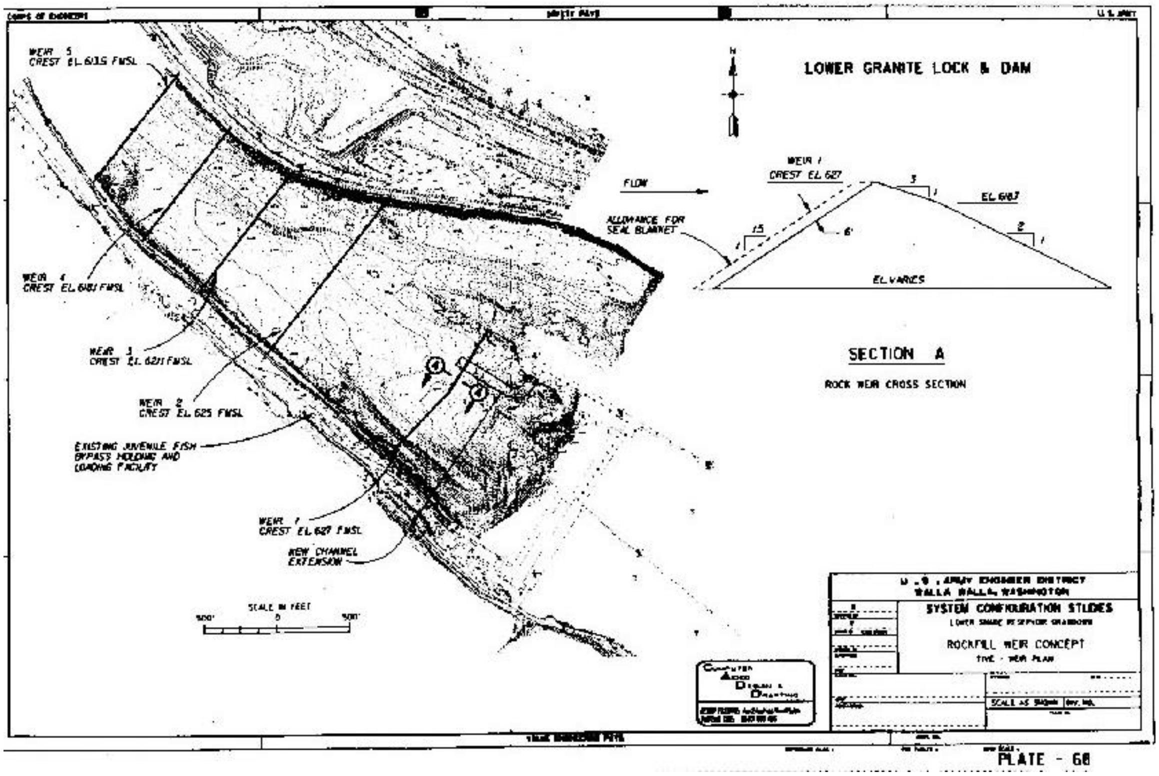


Plate 68. Rockfill Weir Concept--Five-Weir Plan

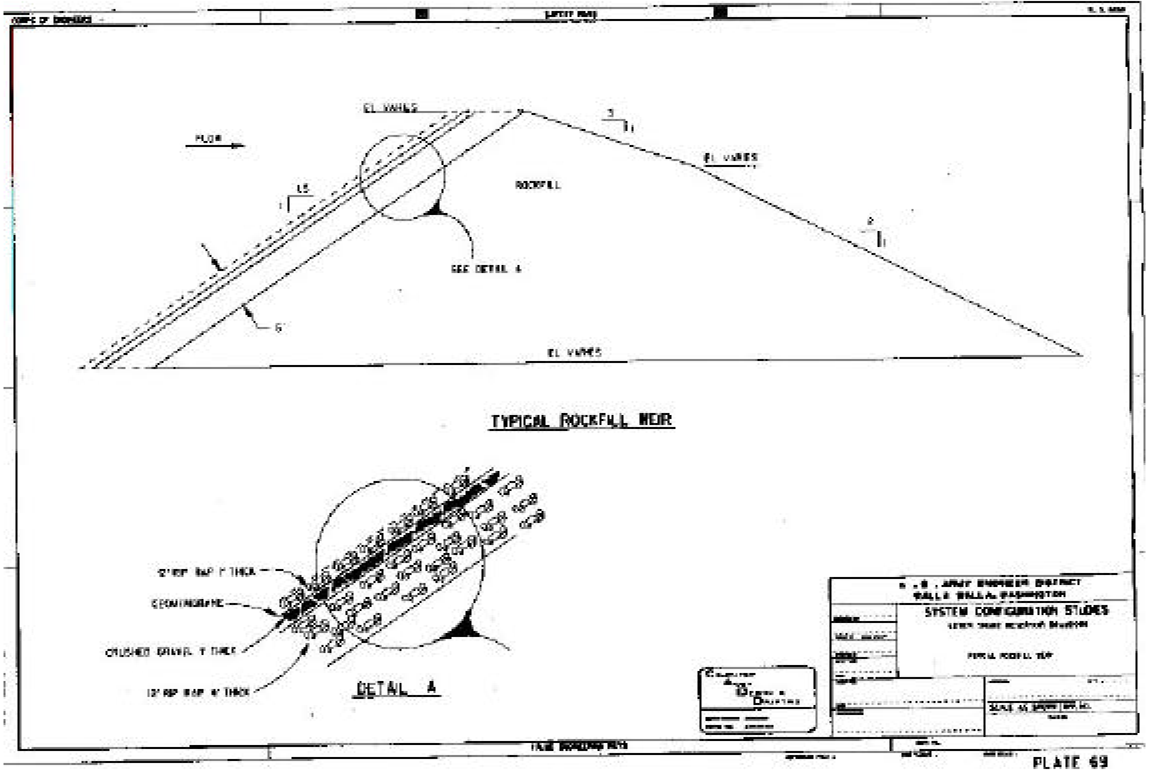


Plate 69. Typical Rockfill Weir

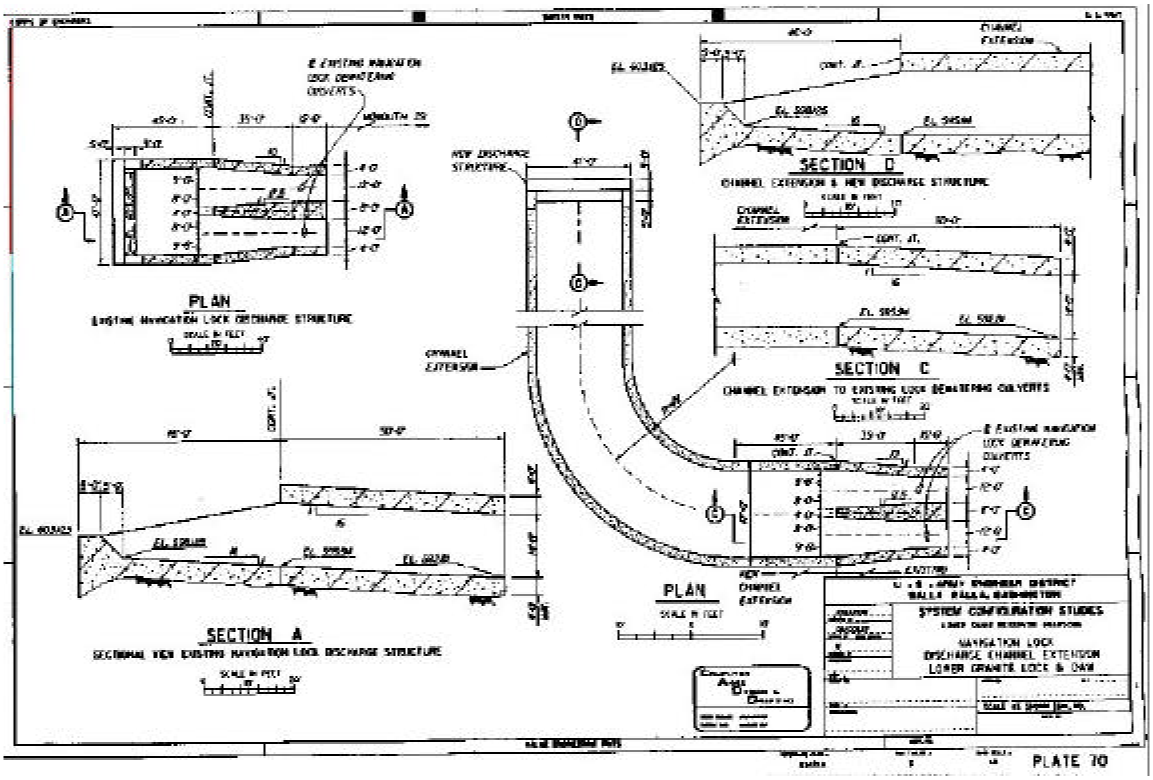


Plate 70. Navigation Lock--Discharge Channel Extension

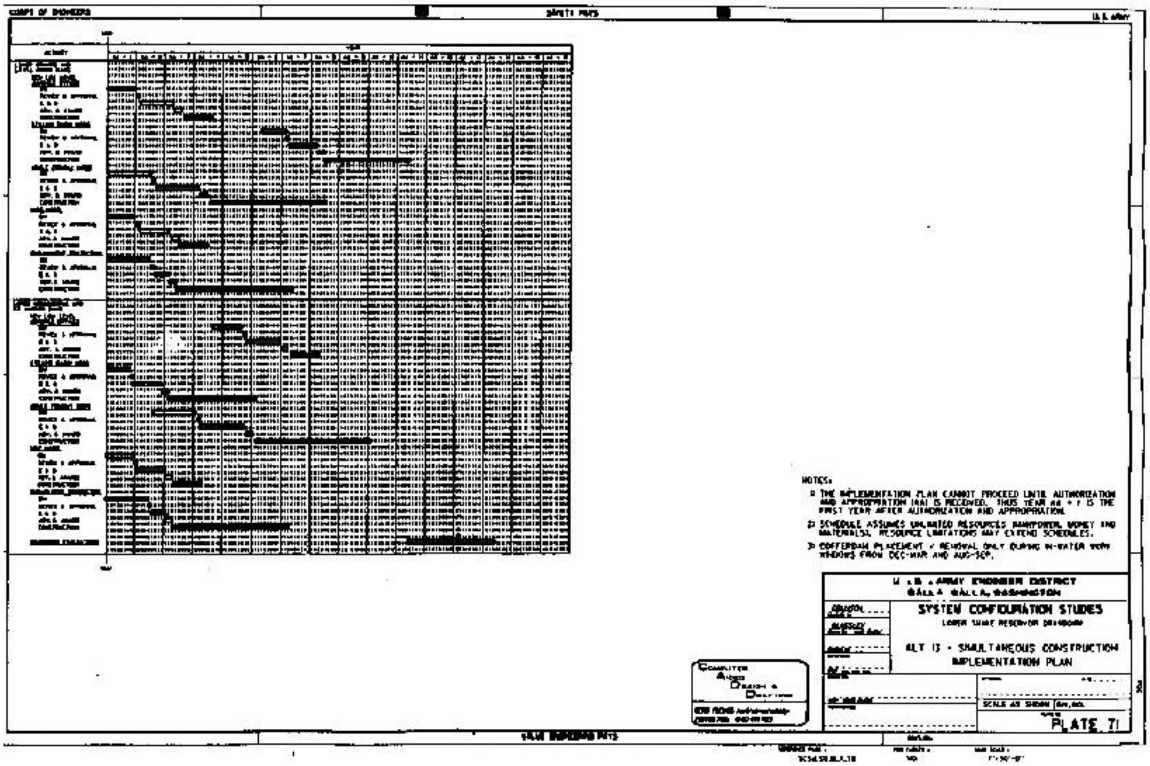


Plate 71. Alternative 13--Simultaneous Construction--Implementation Plan

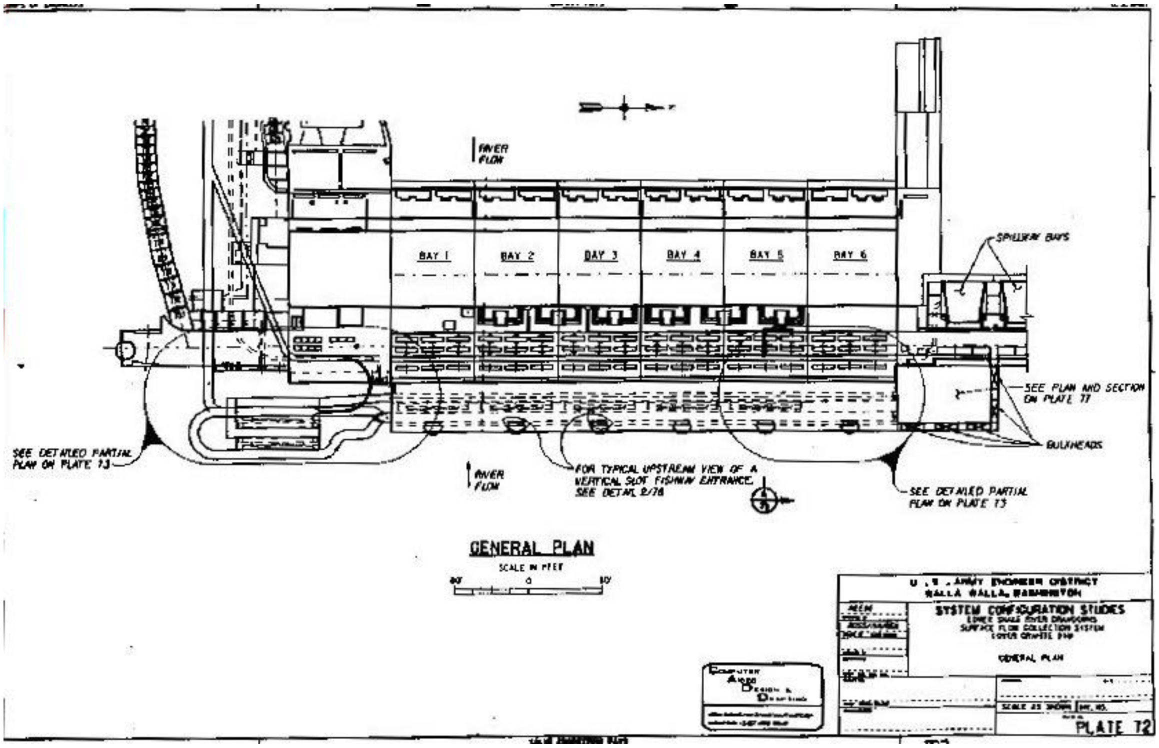


Plate 72.Vertical Slot Fishway Entrance Concept--General Plan

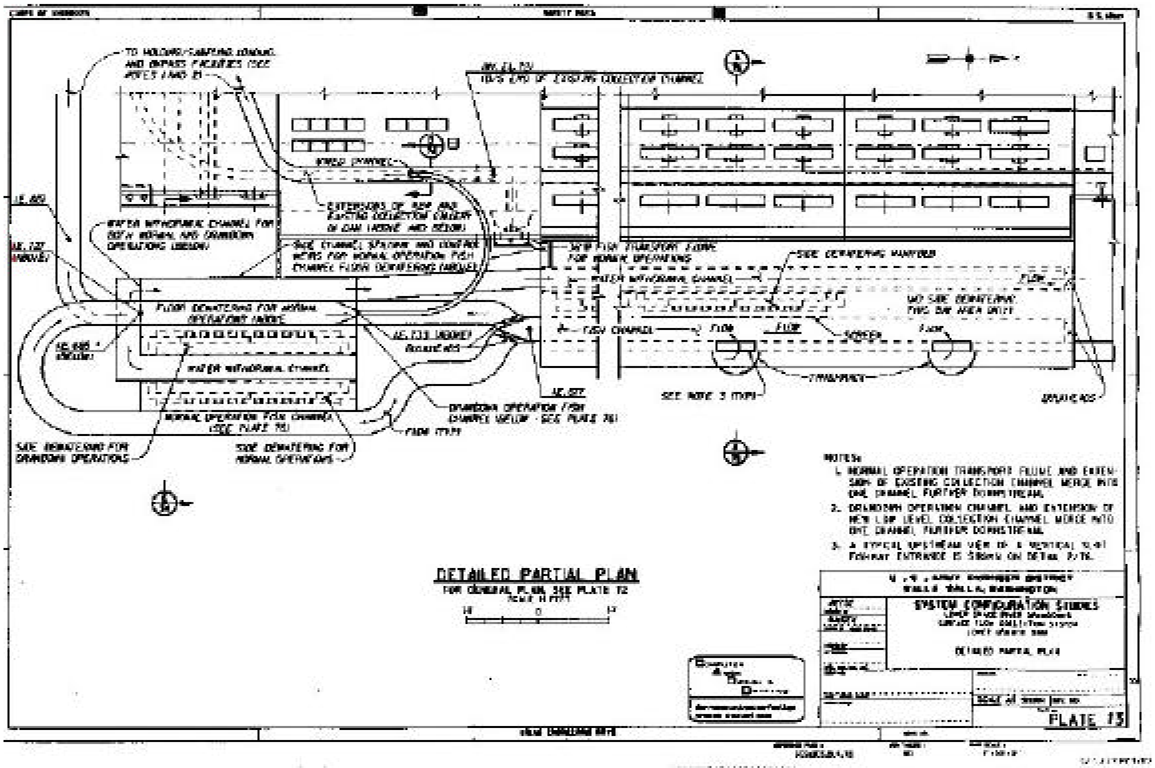


Plate 73. Vertical Slot Fishway Entrance Concept--Detailed Partial Plan

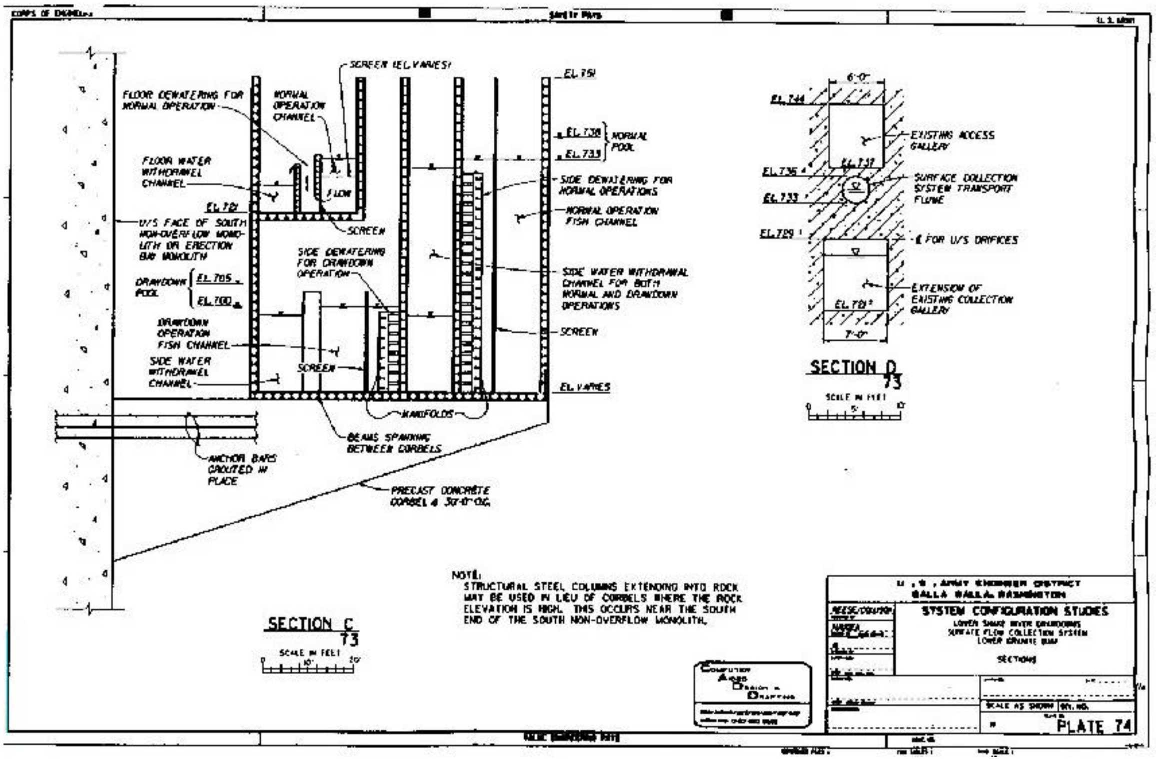


Plate 74. Vertical Slot Fishway Entrance Concept--Section and Details I

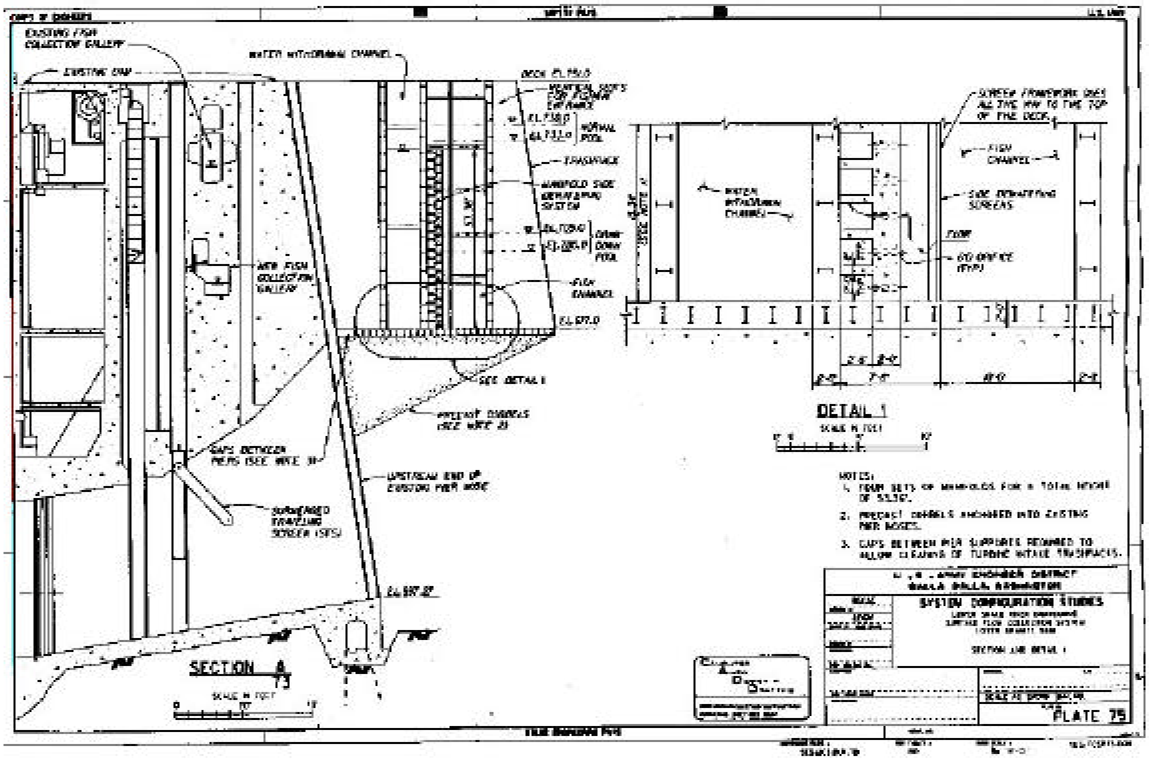


Plate 75. Vertical Slot Fishway Entrance Concept--Section and Details II

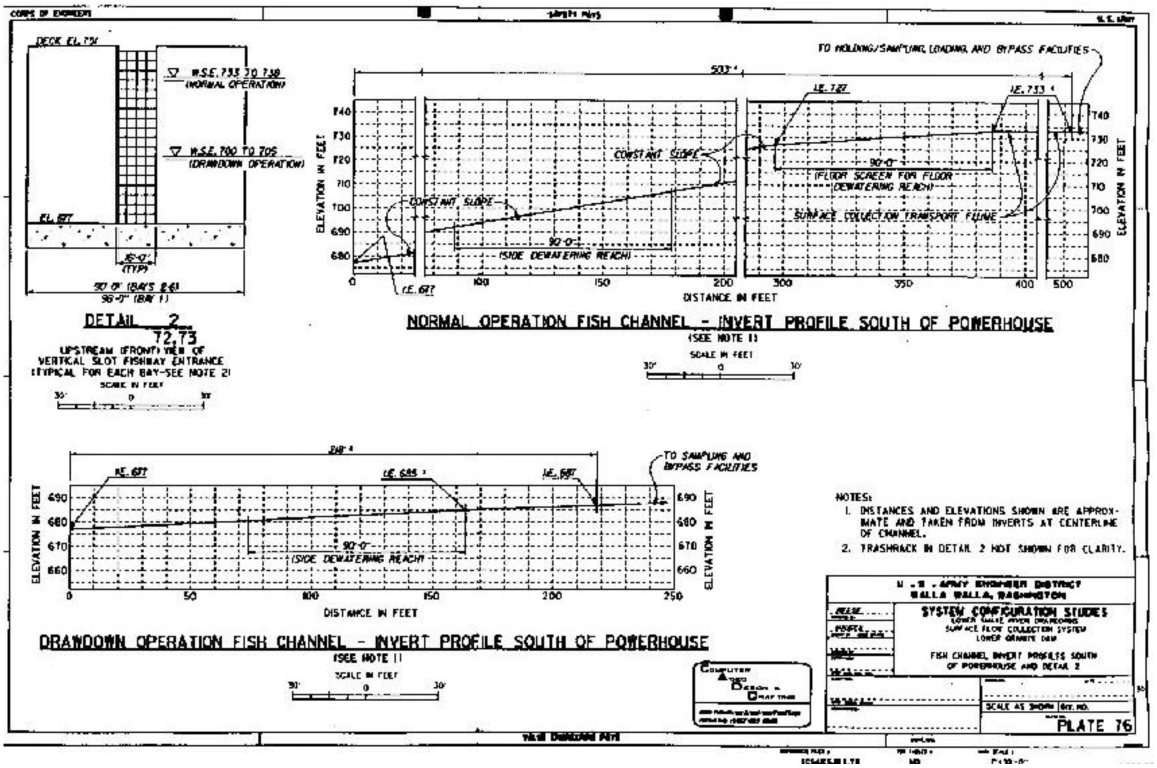


Plate 76. Vertical Slot Fishway--Implementation Plan

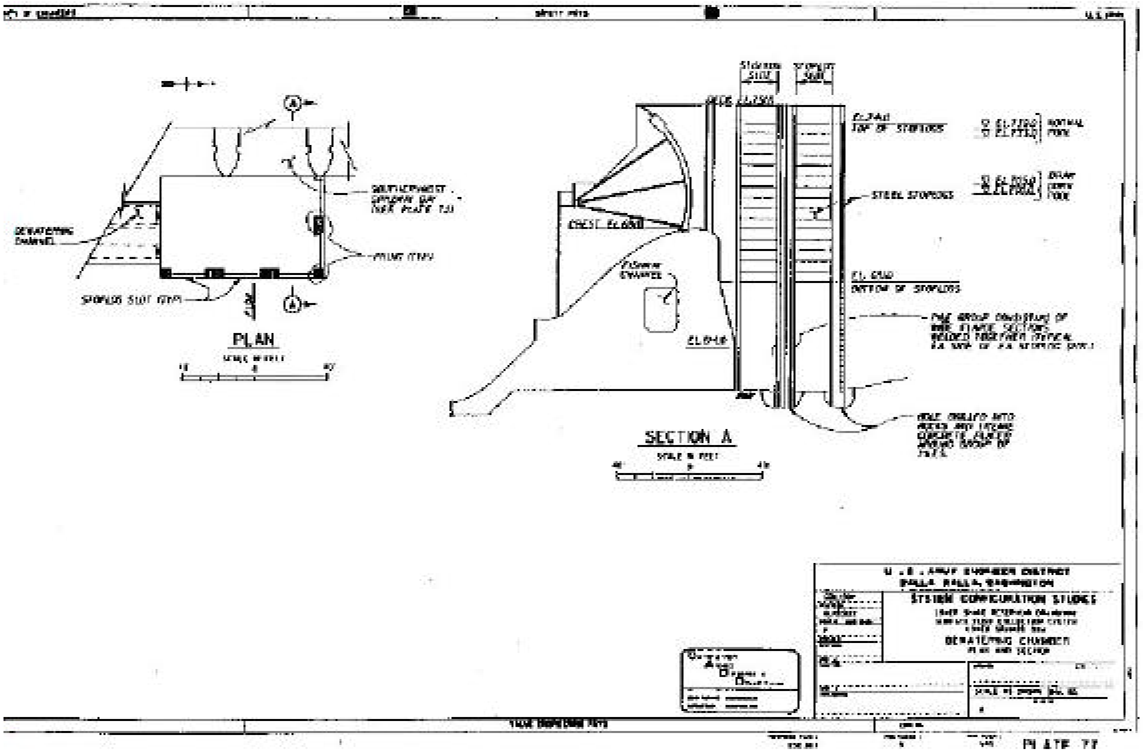


Plate 77. Surface Flow Collection System--Dewatering Chamber Plan and Section

Appendix A
Feature Modifications--Technical Discussions

Section 1 - Adult Collection and Ladder Systems

1.01. General

Adult fish passage facilities exist at all four lower Snake River dams. These facilities are operated from March 1 through December 31 each year. Annual maintenance and repairs normally take place from January 1 through February 28.

a. Adult Collection System

It will be necessary to modify existing adult collection systems at all four dams for each proposed drawdown alternative. Lowering pool levels below normal minimum operating levels at adjacent dams will result in the lowering of tailwater elevations. For example if the reservoir above Little Goose Dam is lowered, the water surface elevation immediately below Lower Granite Dam will also be lowered. When this occurs, fishway entrances and collection channels become inoperable. Modifications to existing system, or construction of alternate systems, are required to allow adult fish collection during drawdown operations.

b. Adult Ladders

The fish ladders on the Snake River projects were designed to operate under normal fluctuations in forebay water surface elevations. As the forebay elevations drop below the invert elevations of the fish ladder exits, flow into the ladder exits will be interrupted. The flow into each fish ladder is supplemented by auxiliary water supply systems coming from the forebay. The auxiliary water supplies deliver water to the ladder just below the water control section to maintain sufficient flow down the ladder. As the forebay drops below the intake elevations of auxiliary supply systems, flow into and down the ladder cases. Therefore, as the forebay water surfaces are lowered from normal levels to the drawdown levels, the existing fish ladder exits and auxiliary fish ladder supply systems will not be functional. Modifications to existing systems, or construction of alternative systems, are required to allow adult fish passage during drawdown operations.

This section describes the existing adult facilities and their operation at each of the lower Snake River dams. In addition, the modifications required to allow the systems to operate with lower tailwater and pool conditions are discussed.

1.02. Lower Granite Lock and Dam

a. Existing System

A single fish ladder, located on the south shore is used for adult fish passage around Lower Granite Lock and Dam (refer to plate 36). The fishway is a weir and pool fish ladder approximately 940 feet long and 20 feet wide, with a 160-foot-long vertical slot water control section at the top of the ladder. The ladder accommodates a total elevation difference of 633.0 to 738.0 (1o5 feet). The ladder exit into the forebay is at elevation 727.0.

A forebay-fed, gravity-flow diffuser, located at the bottom of the water control section, automatically adjusts for forebay and tailwater fluctuations and maintains a constant flow of 75 cubic feet per second (cfs) in the fish ladder. The design operational range for the ladder is from 733 to 738 feet mean sea level (fmsl) at the forebay, and 633 to 642 fmsl at the tailwater. The corresponding river discharge varies from zero to 225,000 cfs.

An auxiliary ladder exit and water supply system is available for those extreme high water years when the pool level must be reduced at the dam to prevent overtopping the flood control levees that protect the city of Lewiston. The existing auxiliary exit system consists of an arrangement of three pumps, a false weir, and release piping. One of the three pumps supplies water to the false weir, while the remaining two pumps supply the upper portions of the fish ladder. At forebay elevation 710.0, each pump delivers 11,000 gallons per minute (gpm), for a total supply of 33,000 gpm (73.5 cfs). The false weir is located at the end of an exit channel adjacent to the normal fish exit channel. When the auxiliary exit is used, the auxiliary pumps are started, the gravity-fed auxiliary supply is closed, and the normal fish exit channel is closed. The auxiliary-pumped supply maintains ladder water flows, and provides attraction flow for the false weir. The fish go over the false weir, into a chute, and out to the forebay through an 18-inch-diameter fish release pipe.

A long radius bend directs the fish release pipe parallel to the face of the dam, and the pipe is extended towards the powerhouse at a 20-percent slope. The pipe terminates at elevation 710.0. The top portion of the last 35 feet of the release pipe is removed, creating a half-round pipe, so that fish may exit the pipe at the forebay water surface over a range of forebay water elevations.

Entrances located in the north (right) spillway training wall, a transportation channel (constructed beneath the spillway), a powerhouse collection system, and south shore entrances provide adult fish access to the south shore ladder. An auxiliary water supply system distributes water to a variety of strategically placed diffusers, which supply high volume discharges through the fish entrances to attract adult fish into the fish passage system.

The two north shore (downstream) entrance gates (entrance invert elevation 625 fmsl) are 6 feet wide and 17.5 feet high, and the single-side entrance gate into the spillway stilling basin is 6 feet wide and 12.5 feet high. The transportation channel invert elevation connecting the north entrances is 622.0. The channel is 900 feet long and 17.5 feet wide. The discharge within the channel, and out the north shore entrances, ranges from approximately 515 to 763 cfs. The minimum velocity and depth requirements through fishway entrances are 8 feet per second (fps) and 6 fps, respectively.

The powerhouse collection system is composed of 10 floating orifices, two 6-foot-wide by 15.5-foot-high downstream entrance gates (invert elevation 628 fmsl), and one 6-foot-wide by 12.5-foot-high side entrance into the spillway stilling basin, and a common transportation channel. Four of the floating orifices, and the two downstream entrances at the north end of the collection system, are normally used. Attraction flows from the downstream entrances range from 500 to 600 cfs.

Two 4-foot-wide by 17.5-foot-high south shore entrances, with invert elevations of 625.0, supply attraction flows from 500 to 600 cfs.

Water for fish entrance attraction flows and the transportation channel is supplied by three electric pumps that pump water from the tailrace to the diffusers. Each pump has a capacity of 1050 cfs.

The existing ladder system also has facilities for trapping adult fish and a vertical-slot fish counting station.

b. Effect of Drawdown Alternatives

Tailwater elevations under the current operational mode vary from 633 to 542 fmsl, and existing adult facilities can successfully operate over this range. For each of the proposed drawdown alternatives, the tailwater elevations will vary between elevation 616 and 642 fmsl, depending on river discharge and downstream pool levels (refer to plate 50, Lower Granite Tailwater Rating Curves). This plate shows the 17 feet of change in the lower limit of tailwater elevation. Modification to the adult facilities will be required for continued operation during reservoir drawdown conditions.

Drawdown pool levels below minimum operating pool will be below the invert elevation of the fish exit and ladder make-up water supply intake. Modifications or additions to the upper sections of the ladder, including fish exits and water supply, will be required.

c. Required Modifications

(1) General

Existing adult fish entrances, as well as the powerhouse collection and transportation channels, must be lowered 17 feet to allow fish access to the bypass system under drawdown alternatives. By lowering the channels and entrances, additional attraction water will be required to maintain minimum channel velocities and entrance head differential and attraction velocities (refer to paragraph 4.04., Adult Fishway Criteria). In addition, ladder revisions will be required at the lower and upper ends of the existing ladder system to accommodate the lowered pool level and the additional 17 feet of operational range.

(2) Entrances and Collection System

Plates 36 through 38 illustrate modifications necessary to allow continued operation of adult facilities during reservoir drawdown operations.

Initially (Phase 1), a new, permanent ladder section will be added to the south shore and connected to the existing ladder in a junction pool. A new temporary water supply diffuser and ladder entrance; and a new temporary water supply pumping system that includes an intake channel, pump chamber, discharge piping, and flow control gates will be constructed. Intake stoplogs and screens will also be required. The pump will be sized to pump 800 cfs at a head of 4 to 5 feet. An electrical power supply for the pump will be installed from the dam. The intake structure will be made from reinforced concrete, with steel liners for the pump discharge passageways.

A new, permanent north shore ladder will be constructed between the spillway right training wall and the navigation lock. The new north ladder will operate under normal pool levels as well as drawdown levels. Entrance attraction water will be supplied by isolating the channel beneath the spillway, and mining through a spillway monolith to the forebay. Energy dissipating valves and a screened water intake will be installed to regulate flow through the channel. The attraction water will be introduced, through floor diffusers, to supply the north shore fishway entrances. Cofferdams will be removed following the completion of phase I work.

With the temporary south shore ladder section and the new north shore ladder system in place and operational, Phase 2 construction can proceed. During this phase, only two major fishway entrances will be operational: the new ladder entrance on the north shore, and the temporary entrance on the south shore. With a new cofferdam in place (as shown on plate 37), modifications to the existing south shore entrances, diffuser, collection channel (units 1-3), including orifice entrances, and auxiliary water supply system can be made. Fish collection and passage through the powerhouse collection system will cease during construction of modifications. The collection channel, water supply channel, diffusers, orifice gates, bulkheads, and weir gates will be modified or replaced, as appropriate, to accommodate the lower tailwater elevations.

(3) Fishway Entrance Gates

The modifications that will e done to the fish entrances will require new or extended fish entrance gates. New or extended stoplogs will also be required for the transverse bulkheads along the fish collection channel through the dam.

The 10 floating orifice gates will need to be lengthened by approximately 20 feet. This can be done by adding another 20-foot section of gate with construction similar to the existing gates. This new addition will be made neutrally buoyant so the whole assembly will float at the current elevation. Because the new gates will be 20 feet longer, and the gates will have to operate at a 20-foot lower elevation, the combined effect will result in the bottom of the new gates extending a total of 40 feet below the current level. This is below the top of the draft tube sill, and it may not be possible to extend the guide slots that low. In that case, it will be necessary to have a telescoping gate arrangement, possibly requiring an additional gate slot.

Longer bulkheads will be required for the ten floating orifice slots, six transverse bulkhead slots, and four other fish entrances on the south shore. These can be constructed like those already in existence. Longer weir gates will also be required for the four entrance gates around the spillway. These gates will be constructed much like those already in use at this location.

Ten new diffusion chamber sluice gates will be required to replace the existing gates that will need to be lowered. New gates will be required because of the greater pressures that will exist across the gates.

Longer fish water pump intake trash racks will be required. These trash rack extensions will be similar to the existing trash racks.

Phase 3 construction will remove the cofferdam required for phase 2, build a new cofferdam around units 4 through 6, dewater the area, lower the adult collection channel, and modify entrances for units 4 through 6. The final construction phase will remove the last cofferdam (refer to plate 38).

(4) Secondary Adult Ladder Exit

The adult ladder exit modification will consist of constructing a secondary gravity feed exit that will tie into the exiting ladder at a junction pool. The adult ladder exit modification is dependent on the drawdown alternative selected. Plate 36.3 illustrates the secondary section for a 43-foot drawdown alternative (constant pool). The secondary ladder exit can be built at any phase of the entrance and collection channel construction since it is above water and is, therefore, somewhat independent of other work.

Alternatives 14 and 18 (constant pool) will lower pool levels to between 695 and 690 fmsl (43-foot drawdown). A new section of ladder will be constructed parallel to the existing ladder, and will run from the fish counting facility to the dam directly under the existing exit (refer to plate 36.3). A sluice gate will be installed on the upstream face of the dam and over the new fish ladder exit (to close it off), thereby allowing operation at normal pool elevations without flooding the fish ladder. The gate will be 14 feet high by 6 feet wide. Junction pool stoplogs will also be installed to block off portions of the fish ladder while still allowing operation of the remaining portions. These stoplogs will be 8 feet high and 20 feet long. Cranes will have to be installed to lift the stoplogs in and out of the fish ladder channels. These cranes could be similar to those currently used for raising the gates at the fish ladder entrances. A diffuser will be installed in the new ladder in the last pool of the control section to ensure a constant 75 cfs flow. Since the supply line entrance for the existing diffuser is located at elevation 720, a new supply line will need to be installed. The new ladder section will measure approximately 550 feet in length. It will have sixteen 10-foot pools, each with a 1-foot rise. The control section will measure approximately 375 feet in length, with a slope of 1 on 32. It will have nineteen 19-foot 8 7/8-inch pools, and one 12-foot pool. Each pool will have a slotted baffle to dissipate energy and regulate flow.

Alternatives 13 and 17 (constant pool) will lower the pool levels to between 705 and 700 fmsl (33-foot drawdown), and alternatives 15 and 19 will lower the pool levels to between 686 and 681 fmsl. In the constant pool alternatives, a new secondary ladder exit can be constructed in a fashion similar to that described for the 43-foot drawdown. The only differences will be the elevation and the number of weirs.

Alternatives 5 and 9 (variable pool) will require a control section 24 feet wide, with a dewatering system installed in the last pool to remove all water in excess of 75 cfs. This is necessary to achieve a 57-foot drawdown with an 11-foot fluctuating pool. The design for this option will be the same as for the 52-foot drawdown, with the exception of the width and height of the control section.

The existing counting facility will be usable, as designed, without any modification. The adult fish trap will not be usable since the new ladder will totally bypass it during drawdown operations. There does not appear to b any reasonable place to build a trap on the new secondary ladder exit.

(5) Auxiliary Ladder Exit

To make the auxiliary ladder exit system function during the transient stages of drawdown, the auxiliary supply pumps must be replaced and the release piping must be extended. The column lengths, performance characteristics, and motor horsepower of these pumps is different for each drawdown alternative. The release piping should be extended to the drawdown water surface elevation. However, extending the release piping in the existing direction at the existing slope, will discharge fish perilously close to the turbine intakes. Therefore, the extended release piping should be rerouted for safer adult release. One possible means of achieving this is to construct a system of rectangular flumes, long radius 180-degree bends, and switch gates that will allow the fish to be safely released over the entire range of forebay fluctuation. This system will resemble a staircase arrangement, where straight flights of negatively-sloped flume will be connected by the 180-degree pipe bends (see plate 45.1). The switch gates will be installed in the system upstream of the 180-degree bends, and used to divert fish past the bends and into an open flume. In this manner, fish may be released at any point over the entire range of forebay fluctuation, including the elevations where the 180-degree bends occur. As the extent of the drawdown increases, the staircase arrangement of release piping must be extended accordingly. It is important to note that the sections of the switch gates connected to the enclosed pipe bends must also be enclosed, and the switch gates should remain in the closed position until the forebay water surface is below the elevation of the corresponding switch gate. This is necessary to prevent debris from becoming lodged in the pipe bends when the forebay water surface fluctuates through the installed elevations of the switch gates.

1.03. Little Goose Lock and Dam

a. Existing System

A single fish ladder, located on the south shore, is used for adult fish passage around Little Goose Lock and Dam. The fishway is a weir and pool fish ladder approximately 900 feet long and 20 feet wide, with a 160-foot-long vertical-slot water control section at the top of the ladder. The ladder accommodates a total elevation difference of 57.0 to 638.0 (101 feet). The ladder exit into the forebay is at elevation 627.0. Little Goose Dam does not have an auxiliary adult fish ladder exit on the existing ladder system.

A forebay-fed, gravity-flow diffuser, located at the bottom of the water control section, automatically adjusts for forebay and tailwater fluctuations and maintains a constant flow of 75 cfs in the fish ladder. The designed operational range for the ladder is 633 to 638 fmsl at the forebay, and 537 to 544 fmsl at the tailwater. The corresponding river discharge varies form zero to 225,000 cfs.

Entrances located in the north (right) spillway training wall, a transportation channel (constructed beneath the spillway), a powerhouse collection system, and south shore entrances provide for adult fish access to the south shore ladder. An auxiliary water supply system distributes water to a variety of strategically placed diffusers. These diffusers supply high volume discharges through the fish entrances to attract adult fish into the fish passage system.

The two north shore (downstream) entrance gates (invert elevation 529.0 fmsl) are 6 feet wide and 13.5 feet high, and the single side entrance gate into the spillway stilling basin is 6 feet wide and 10.5 feet high. The transportation channel invert elevation connecting the north entrances is 532.0. The channel is 900 feet long and 17.5 feet wide. The discharge within the channel and out the north shore entrances ranges from approximately 560 to 796 cfs. The minimum velocity and depth requirements through fishway entrances are 8 fps and 6 fps, respectively.

The powerhouse collection system is composed of ten floating orifices, two -foot-wide by 15.5-foot-high downstream entrance gates (invert elevation 532.0 fmsl), one 6-foot-wide by 12.5-foot-high side entrance gate (into the spillway stilling basin), and a common transportation channel. Four of the floating orifices, and the two downstream entrances at the north end of the collection system, are normally used. Attraction flows from the downstream entrances range from 500 to 600 cfs.

Two 4-foot-wide by 18-foot-high south shore entrances, with invert elevations of 529.0 fmsl, supply attraction flows from 500 to 600 cfs.

Water for fish entrance attraction flows and the transportation channel is supplied by three turbine-driven pumps that pump water from the tailrace to the diffusers. The pumps each have a capacity of 850 cfs.

b. Effect of Drawdown Alternatives

At Little Goose Dam, tailwater elevations under the current operations vary from 537 to 544 fmsl. Existing adult facilities are designed to operate throughout this range. For each proposed drawdown alternative, the tailwater elevations at Little Goose Dam will vary between elevation 518 and 544 fmsl, depending on river discharge and downstream pool levels (refer to plate 51, Little Goose Tailwater Rating Curves). The 19-foot change in the lower limit of the tailwater elevation range will require modifications to the adult facilities in order to allow continued operation during reservoir pool drawdown conditions.

Drawdown pool levels below minimum operating pool will be below the invert elevation of the fish exit and ladder make-up water supply intake. Modifications to lower the upper ladder sections, including fish exits and water supply, will be required.

c. Required Modifications

(1) Entrances and Collection System

Revisions to adult facilities for Little Goose Lock and Dam will be very similar to those described for Lower Granite Lock and Dam, except that the fishway pumps at Little Goose Dam are driven by turbines that use water from the forebay. Under drawdown conditions, the water intake for these turbines will be above the water surface, and the turbines will not operate. The turbines will need to be replaced with electric motors that can drive the fishway pumps. Further investigation will be required to determine if the pumps themselves will need replacement or modifications.

(2) Ladder Exits

Secondary ladder exits will be very similar to those described for Lower Granite Dam except that, to provide new gravity-feed ladder exits for the various alternatives, it will be necessary to move the visitor center to the north side of the ladder. The existing counting facility can be used with any modifications, however, For this reason, it may be better to move the fish viewing windows to the north side of the ladder as well.

(3) Auxiliary Ladder Exit

An auxiliary fish exit similar to that described for Lower Granite Dam can be installed for the fish ladder at Little Goose Dam. The auxiliary exit water supply can be provided by installing new vertical-turbine pumps on a new pump platform mounted to the face of the dam (in the forebay). These pumps should be sized to provide the entire 75-cfs ladder design flow at the minimum forebay elevation during drawdown. The discharge from the pumps can be plumbed to supply a new false weir assembly and a new auxiliary supply assembly. In this concept, the new false weir and auxiliary supply assemblies will be installed in the existing bulkhead slot of the fish ladder exit and the auxiliary supply inlet, respectively. A new system of fish release piping will be required to pass fish safely from the false weir assembly to the forebay water surface.

The false weir assembly will be comprised of a chamber where the water supply enters from the bottom, is divided to pass over the weir into the ladder exit, and then pass through diffusers directly into the ladder exit. The water supply to the false weir assembly will come from a caisson fixed to the face of the dam, with the screened top surface of the caisson flush with the invert elevation of the ladder exit. The open bottom of the false weir assembly will sit directly upon the screened top surface of the caisson and form a watertight seal. The pump discharge will be plumbed directly into this caisson. The pumped flow will pass upward through the screened surface and into the false weir assembly. Fish passing over the false weir will be guided by an integral chute into the fish release piping. The fish release piping will be connected to the false weir assembly by using a flanged joint, or some other means of removable connection. Under this concept, the false weir assembly could easily be removed to allow normal ladder operations.

The new auxiliary supply assembly will be arranged much like the false weir assembly. This new supply assembly will consist of a bulkhead with an open-bottomed chamber that rests upon a supply caisson in a manner similar to that described for the false weir. The pumped discharge will be plumbed into the supply caisson so that the pumped flow will pas upward through the screened top surface of the supply caisson, into the auxiliary supply bulkhead, and then into the existing auxiliary supply piping. The auxiliary supply bulkhead can be removed to allow normal operation of the auxiliary supply system.

The fish release piping system will be a stairwell arrangement of flumes, 180-degree-long radius bends, and switch gates similar to those described for Lower Granite Dam.

1.04. Lower Monumental Lock and Dam

a. Existing System

The adult fish passage facilities at Lower Monumental Lock and Dam consist of north and south shore fishways with main entrances, a powerhouse collection system with transportation channel, and a common auxiliary water supply system serving all fishway entrances with attraction flows. Both fishway systems have a weir/orifice and pool fish ladder. A vertical-slot water control section at the top of each ladder compensates for pool fluctuation, and regulates the ladder discharge. Forebay-fed, gravity-flow diffusers (make-up water supply) are located at the bottom of the water control sections. They provide the additional water necessary to maintain a constant 75-cfs discharge within the fish ladders. The invert elevation of the ladder exits into the forebay is 530.5 fmsl. There are no auxiliary exit systems at Lower Monumental Lock and Dam.

The 16-foot-wide north shore fish ladder connects to two north shore entrances and the powerhouse collection system. The powerhouse collection system has two major weir-gate downstream entrances, one weir-gate side entrance into the spillway stilling basin, ten floating orifices, and a common transportation channel. The two north entrances, two downstream south powerhouse entrances, and five of the floating orifices are used during normal operation. The sills on the north shore entrances are at elevation 429.0, and the south powerhouse entrance sills are at elevation 432.0 fmsl.

The south shore fish ladder has a small collection system with two weir-gate downstream entrances and a side entrance into the spillway stilling basin. The two downstream entrances are used during normal operation. The sills on the south shore fishway entrances are at elevation 431.0 fmsl.

The auxiliary water for both fish ladder collection systems is supplied by three hydraulic turbine-driven pumps, located in the powerhouse on the north side of the river. The water is pumped into a supply conduit that travels under the powerhouse collection channel (distributing water to the powerhouse diffusers), and then goes under the spillway to the diffusers in the south shore collection system. Each of the three turbine-pumps is rated at 850-cfs discharge. The new juvenile bypass system provides an additional 200 to 240 cfs of excess water to the adult fishway auxiliary water supply system.

b. Effect of Drawdown Alternatives

Lower Monumental tailwater elevations under the current operational mode vary from 437 to 448 fmsl. Existing adult facilities were designed to operate over this range. For each proposed drawdown operational alternative, the tailwater elevations at Lower Monumental will vary between elevation 428 and 448 fmsl, depending on river discharge and downstream pool levels (refer to plate 52, Lower Monumental Tailwater Rating Curves). The 9-foot change in the lower limit of the tailwater elevation range will require modifications to the adult facilities in order to allow continued operation during reservoir pool drawdown conditions.

Drawdown pool levels below minimum operating pool will be below the invert elevation of the fish exit and ladder make-up water supply intake. Modifications to lower the upper ladder sections, including fish exits and water supply, will be required.

c. Required Modifications

Because tailwater elevations will be reduced by 9 feet from the designed elevations, all fishway entrances must be lowered by at least 9 feet to be operational. Some features may have to be lowered even more to meet the current adult fishway criteria (see paragraph 4.04). The following modifications will also be required:

(1) South Shore Ladder

Fish passage through the south shore ladder system will not be possible during construction of the required modifications (refer to plate 42.1). Passage will be possible by utilizing the north shore ladder and powerhouse collection system. A cofferdam will be installed from spillway bay 1, around the south shore ladder, and tie into the navigation lock wall. The area within the cofferdam will then be dewatered. The lower section of ladder (from weir 485), including the spillway left training wall diffuser section and fishway entrances, will be removed and rebuilt to a new lower invert elevation of 420 fmsl (from 432). The lower elevation will allow a required 8-foot depth over entrance weir gates. The diffuser will be increased in size to allow for increased entrance water requirements, due to the greater water depths at the entrances. Additional ladder pools will be required to accommodate the increased elevation difference.

A second upper ladder section will be constructed from the dam that parallels the old upper section. This section will be at a level consistent with the selected drawdown level, and will allow for a gravity-feed ladder exit at the drawdown pool elevation. A new fish counting facility will be required (see criteria list) on this low-level section of the ladder. Plate 42.2 illustrates this concept for a 43-foot constant pool drawdown. To accommodate fish movement past Lower Monumental Dam during the transition period between normal pool operations and drawdown pool operations, a forebay pump system, auxiliary exit, and false weir will be installed. This is similar to the existing Lower Granite Dam system.

The water supply for the diffusers normally comes from the north shore water supply system. However, this system will have to be interrupted to allow modification of the powerhouse collection system. Therefore, another method of supplying water to the south shore entrances is required. One possible method of supply water to the diffuser is to access the forebay and provide a gravity-flow system. An intake can be excavated from the channel beneath the spillway into the forebay. A series of energy-dissipating valves (polyjet) would be installed to control the amount of flow from the forebay.

The intake structure will be located directly in front of the 10-foot-square intake channel at the bottom of the reservoir. The structure will consist of a steel framework supporting the intake screens on the front face, and an 0.5-inch skin plate on the sides and top. The back of the intake structure will be the front face of the dam, and the bottom will be a concrete pad. The screen surface will consist of eighty-four 6-foot by 4.25-foot wedge-wire bar screen panels resting on the steel framework. The screen panels will be designed for 300 pounds per square food loading (approximately2 pounds per square inch pressure drop), with .125-inch-wide slots between screen bars. A differential pressure-sensing device that can warn of high pressure drop will be necessary in order to prevent excess pressure drop from occurring across the intake structure.

A 12-foot-square sluice gate will be installed on the face of the dam, behind the intake screen, to shut off the 10-foot-square intake channel. This gate will be operated from the deck of the dam by using an extended gate operator shaft. Installed in this gate, or in a small bypass channel next to the gate, will be a filling port that will allow the channel to be filled without using the large sluice gate.

A screen-cleaning system will be installed to clean debris from the intake screen. This cleaning system will be controlled by the differential pressure-sensing device. The cleaning system will consist of four individual screen-cleaning machines that use brushes, air, and water blasts to clean the screen surface. The screen-cleaning machines will be similar to those used at the juvenile fish facilities, but will be more elaborate because of the greater operating depths. They will have no cross-flow to help sweep debris away.

Four 54-inch-diameter polyjet valves will be installed after mining out the new 10-foot-square supply channel and enlarging the existing supply channel. A valve chamber, large enough to house the upper portions of all of the polyjet valves, will be mined adjacent to the new supply channel and over the existing supply channel. Passageways, large enough for installing the 54-inch-diameter supply pipes, will be mined between the supply channel and the valve chamber. Flanged pipe sleeves will be installed in these passageways, and can be grouted in the proper positions by using the actual valve components. Four 19.5-foot by 14-foot hatch covers will be used to cover the valve chamber. An access ladder will be installed in the valve chamber, along with a sump pump, to remove any water that may collect there.

A modulating-type valve operate will be required on only one of the polyjet valves, since the other valves have standard electric operators.

A concrete plug will be installed in the channel beneath the spillway to isolate the south shore system from the north shore system. Once the south shore system has been reinstalled, the cofferdams will be removed. The new modified system may then begin operation.

(2) North Shore Ladder

Construction of modifications to this system will require several phases (refer to plates 43 through 43.3).

(a) Phase 1

During this phase, fish passage will occur through existing north shore entrances, the powerhouse collection system, and the newly rebuilt south shore system. A cofferdam will be constructed (as shown on plate 43.1), and the area will be dewatered. A new permanent ladder section will be built, including a new temporary water supply diffuser and ladder entrance, a new temporary water supply diffuser and ladder entrance, a new temporary water supply pumping system (with intake channel, pump chamber, and discharge piping), and flow control gates. Intake stoplogs and screens will also be required. The pump will be sized to pump 800 cfs at a head of 4 to 5 feet. An electrical power supply for the pump will e installed from the dam. The intake structure will be made from reinforced concrete, with steel liners in the pump discharge passageways. New piping, to divert excess water from the juvenile facility to the river, will be installed. The cofferdam around the new entrances and pump intakes will be removed. The final step will be the connection of the new ladder section to the old ladder section to allow for continued fish passage.

(b) Phase 2

This phase will require the modification of north shore entrances, the diffuser, and powerhouse collection channel units 1 and 2. It will also require construction of a new low-level fishway exit and control section. A construction cofferdam will be built around the north shore entrances, by tying into the retaining wall (upstream of the new temporary north entrance) and extending around powerhouse units 1 and 2. The cofferdam will tie into the tailrace in front of unit 3. Units 1 through 3 will be inoperable during this process. Fish passage during this phase will be available through the newly constructed ladder section on the south shore (Phase 1 construction), and through the rebuilt temporary north shore ladder system. Fish collection, via the powerhouse collection system, will be interrupted. Model studies will be required to simulate project discharges with the proposed construction cofferdams. Final configuration of the cofferdams will be adjusted to obtain the most desirable tailrace flow and velocity conditions for attraction of adults to operating entrances.

The north shore entrances, the diffuser, and the lower ladder section will be removed to elevation 399. The water supply channel currently used to supply the south shore ladder will be abandoned. The diffuser, north shore entrances, and lower ladder section will be reconstructed at the required lower elevations. The existing collection channel floor and orifice gate entrance sills, spanning units 1 through 3 (elevation 432), will be removed and reconstructed at elevation 420.0 to allow the 8-foot minimum depth criteria requirement. The diffuser floor will be removed and not replaced, since the abandoned south shore water supply channel is immediately below the diffuser area and will serve as the diffuser. The 36-inch by 42-inch gates from the collection channel water supply channel will be relocated to an appropriate lower level. The floor diffuser area may need to be increased in order to maintain appropriate velocities. This will be necessary, since the entrance depth will require higher channel flows to achieve attraction and transportation velocities, as required by current criteria. New orifice and weir gates, as well as bulkheads, will be necessary since the operational range will be greater. Further analysis will be required to determine if the collection channel water supply conduits will need to be enlarged to accommodate increased flow demands. In this study, it is assumed that the conduits are sufficient. The final step will be to remove the construction cofferdam and place the modified system into operation. However, the powerhouse collection channel will be inoperable until Phase 3 construction (see following discussions) is complete. The existing auxiliary pump systems, which provide the entrance attraction water, may not need to be replaced even though water supply requirements will increase. The pump system will no longer need to supply water to south shore ladder systems, due to the newly constructed gravity-flow system (see Phase 1 discussion). The added capacity can be used to make up for the increased demand at the south shore entrances.

During this phase, a new secondary ladder section (with auxiliary exit) can be constructed to accommodate the selected drawdown elevation. To accommodate fish movement past Lower Monumental Dam during the transition period between normal pool operations and drawdown pool operations; a forebay pump system, auxiliary exit and false weir will be installed on the north shore fish ladder. This will be similar to the existing Lower Granite Dam system.

The fishway pumps at Lower Monumental Dam are driven by turbines that use water from the forebay. Under drawdown conditions, the water intake for these turbines will be above the water surface, and the turbines will not operate. The turbines will need to be replaced with electric motors that can drive the fishway pumps. Further investigation will be required to determine if the pumps themselves will need replacement or modifications.

Auxiliary ladder exit systems, similar to those described for the ladder at Little Goose Dam, can be provided for the fish ladders at Lower Monumental Dam. These ladders are similar in design, having the same general dimensions and design flows, but they differ in their orientation.

(c) Phase 3

This phase of construction involves lowering the collection channel (units 3 through 6). To complete the lowering of the powerhouse collection channel, a cofferdam will be constructed in the tailrace around units 3, 4, 5, and 6. The cofferdam would tie into the tailrace deck, directly in front of unit 3 and the right training wall of the spillway. Units 3 through 6 will not be operable with the cofferdam in place. The existing collection channel floor and orifice gate entrance sills (elevation 432) will be removed, and reconstructed at elevation 420.0 to allow for the 8-foot minimum depth criteria requirement. The diffuser floor will be removed and not replaced, since the abandoned south shore water supply channel is immediately below the diffuser area and will serve as the diffuser. The 36-inch by 42-inch gates from the collection channel water supply channel will be relocated to an appropriate lower level. Floor diffuser area may need to be increased to maintain the appropriate velocities. This will be necessary, since the entrance depth will require higher channel flows to achieve the attraction and transportation velocities required by current criteria. New orifice and weir gates, as well as bulkheads, will be necessary since the operational range will be greater. Further analysis will be required to determine if the collection channel water supply conduits will need to be enlarged to accommodate the increased flow demands. In this study, it is assumed that the conduits are sufficient. The final step will be to remove the construction cofferdams.

The modifications that will be done to the fish entrances will require new or extended fish entrance gates. New or extended stoplogs will also be required for the transverse bulkheads along the fish collection channel through the dam.

The ten floating orifice gates will need to be lengthened by approximately 12 feet. This can be done by adding another 12-foot section of gate, with construction similar to the existing gates. This new addition will be made neutrally buoyant, so the whole assembly will float at the current elevation. Because the new gates will be 12 feet longer and will have to operate at 12-foot lower elevations, the combined effect will result in the bottom of the new gates extending a total of 24 feet below the current level.

Longer bulkheads will be required for the ten floating orifice slots, five transverse bulkhead slots, and three other fish entrances at the north shore. These can be constructed much like those already in existence. Longer weir gates will also be required for the three entrance gates on the south shore. These gates will be constructed like those already in use at this location.

Nine new diffusion chamber sluice gates will be required to replace the existing gates scheduled to be lowered. New gates will be required because much greater pressures will flow across them.

Longer fish water pump intake trash racks will be required. These trash rack extensions will be similar to the existing trash racks.

1.05. Ice Harbor Lock and Dam

a. Existing System

The adult fish facilities at Ice Harbor Dam consist of north and south fish ladders, a powerhouse collection system and transportation channel, 11 fishwater pumps (8 south, 3 north), and a fish counting station on each ladder. Total normal discharge through the ladders (from the forebay) is approximately 170 cfs; 74 cfs north and 96 cfs south (refer to plate 44).

The north shore fish ladder is located between the spillway and the navigation lock, and is 16 feet wide. The normal flow in the ladder, 74 cfs, is regulated by a vertical-slot control section located at the upstream end of the ladder. Three 250-cfs pumps are located near the downstream end of the ladder supply auxiliary water. Discharge of the auxiliary water system varies from 250 to 750 cfs, in increments of 250 cfs, depending on the number of pumps operating. Weirs are fixed, with an 18-inch by 18-inch orifice on each side of the center nonoverflow portion of the weir.

The south shore fish ladder is located south of the powerhouse, and includes the powerhouse collection and transportation system. The ladder is 24 feet wide, and has fixed weirs with 21-inch by 23-inch orifices. Normal flow in the ladder from the forebay is approximately 96 cfs, and is controlled by a vertical-slot control section at the ladder exit. The auxiliary water supply is provided by eight 300-cfs pumps located just downstream of the powerhouse on the left bank. The auxiliary water supply varies from 1,200 to 2,400 cfs, in increments of 300 cfs, depending on the number of pumps operating.

The powerhouse collection and transportation system consists of a 17.5-foot-wide channel across the length of the powerhouse, with 12 submerged orifices through which water is released to the powerhouse tailrace. Entrances are also provided for the collection of fish at the south end of the spillway, and on the south shore between the powerhouse and the pump intake for the auxiliary water system. This powerhouse collection and transportation system joins the south shore fish ladder near the south end of the powerhouse.

b. Effect of Drawdown Alternatives

Ice Harbor tailwater elevations, under the current operational mode, vary from 337 to 354 fmsl (refer to plate 53). The actual tailwater elevation is dependent on the McNary Dam pool elevation, as well as discharges in the Columbia and Snake Rivers. Existing adult facilities were designed to operate over this tailwater elevation range. The proposed drawdown alternatives do not suggest changes to the McNary Dam operation. Therefore, no changes are anticipated in tailwater elevations at Ice Harbor Dam. Changes to adult collection, attraction water supplies, or adult entrances will not be required.

Drawdown alternatives will affect the pool upstream of Ice Harbor, however, and pool levels below minimum operating pool will require modifications to adult fishway exits and control sections. Pool levels below minimum operating levels will be below the invert elevations of the fish ladder exits and ladder make-up water supply intakes. Modifications to lower the upper ladder sections, including fish exits and water supplies, will be required.

c. Required Modifications

(1) Secondary Ladder Exits

Normal operating pool levels fluctuate between 440 and 437 fmsl. Alternatives 14 and 18 (constant pool) will lower the pool level range to 405 to 400 fmsl (35-foot drawdown). A new section of ladder will be installed parallel to the existing ladder, and will run from weir 384 directly to the dam. A sluice gate will be installed on the upstream face of the dam over the new fish ladder exit to close it off, allowing operation at normal pool elevations without flooding the fish ladder. The gate will be 14 feet high by 6 feet wide. Junction pool stoplogs will also be installed to block off portions of the fish ladder, but still allow operation of the remaining portions. These stoplogs will be 8 feet high, and 16 or 24 feet long. Cranes will have to be installed to lift the stoplogs in and out of the fish ladder channels. These cranes can be similar to those currently used for raising the gates at the fish ladder entrances at Lower Monumental Dam. A diffuser will be installed in the new ladder, in the last pool of the control section, to ensure a constant flow of 74 cfs. Since the supply line entrance for the existing diffuser is located at elevation 416.5, a new supply line will need to be installed. The new ladder section will be approximately 194 feet in length. It will have twelve 16-foot pools, each with less than a 1-foot rise, and will constitute the control section. Each pool will have a slotted baffle to dissipate energy and regulate flow. A similar installation will be constructed to accommodate the north ladder operation during these drawdown alternatives (refer to plates 44.1 and 45 for information on these modifications).

Alternative 13 and 17 will provide for pool operation between 415 and 410 fmsl (25-foot drawdown), and alternatives 15 and 19 will operate between 396 and 391 fmsl (44-foot drawdown). Ladder modifications similar to that described above will be provided for these alternatives.

Alternatives 5 and 9 will allow a pool fluctuation (spillway free flow) from spillway crest elevation 391 and up. A gravity-fed ladder exit similar to the one at John Day Dam (11-foot fluctuation) can be installed. It will accommodate river flows of up to 127,000 cfs. This operation will require a 28-foot-wide control section, with a dewatering system, to remove water in excess of 74 cfs. The design for this option will be the same as for alternatives 15 and 19, with the exception of the width of the control section.

The existing counting facility will be usable without any modifications. A false weir, used to pass fish while drawing down the reservoir, will need to be installed.

(2) Auxiliary Ladder Exits

Auxiliary ladder exit systems, similar to that described for the ladder at Little Goose Dam, can be provided for the fish ladders at Ice Harbor Dam. These ladders are similar in design, having the same general dimension and design flows, but they differ in orientation. The exception to this is the south shore ladder at Ice Harbor Dam. This ladder is considerably larger than the others, and will require an auxiliary exit system that has correspondingly larger components.

Section 2 - Juvenile Bypass System

2.01. General

Alternatives utilizing powerhouse operation during drawdown operations will require low-level juvenile bypass systems for the protection of juvenile fish. The following discussion applies to alternatives 5, 6, 10, 13 through 15, and 17 through 19.

2.02. Existing Systems

Lower Granite, Little Goose, and Lower Monumental Dams each have juvenile bypass systems designed to collect and bypass anadromous fish around the turbines. The juvenile bypass systems at Lower Granite, Little Goose, and Lower Monumental Dams are comprised of submerged traveling screens (STS's), vertical barrier screens (VBS's), fish orifices, attraction lighting, a collection channel, dewatering systems, and a transportation channel. Little Goose and Lower Monumental have a corrugated metal flume (CMF) that serves as the transport channel. A juvenile bypass system is currently being designed for Ice Harbor Dam that will be similar to the existing facilities upriver.

Each turbine has three intake bays. Each intake bay has a slot for an intake gate and a bulkhead gate. At each bulkhead gate slot, an STS is installed and is lowered into the flow upstream of the turbines (see plates 29, 30, and 33). Three STS's are required to screen one turbine. The VBS's are installed as a barrier between the intake and bulkhead gate slots. Water and fish are diverted, by the STS, into the bulkhead slot. The water passes through the VBS's, down the intake gate slot, and through the turbine. The VBS prevents fish that have been guided by the STS from passing through the other slot and entering the turbines. The VBS's were designed to maintain less than an average of 0.5 fps flow velocity across the surface of the VBS. This is necessary to prevent injury to the collected fish as they rise toward the water surface in the intake gate slot. Fish follow this current along the screen and into the intake gate slots.

Two 12-inch-diameter orifices (10-inch at Lower Granite) are installed in each intake gate slot approximately 5.5 feet below the minimum pool water surface. These orifices pass the fish from the bulkhead gate slot into the fish collection channel. Each orifice discharges a flow ranging from 11 to 15 cfs, depending on forebay elevations. The orifices operate in a nonsubmerged condition, and discharge freely into the fish collection channel. The fish are attracted to the orifice by the flow moving through it, as well as by the attraction lighting placed on the collection channel side of the orifices. The attraction lighting is directed through the orifice towards the bulkhead gate slot. From a gallery located above the collection channel, access is provided to each orifice, allowing inspection and maintenance of the orifices and the fish attraction lighting.

The fish collection channel is a 7-foot-wide by 8-foot-high rectangular channel mined (and shotcrete finished) through the dam parallel to the longitudinal axis of the dam. The fish collection channel extends across the full length of the powerhouse. The orifices discharge a total flow of approximately 270 cfs into the collection channel.

The transportation channel is a rectangular channel that carries the water from the collection channel, through the downstream face of the dam, to the primary dewatering structure. A portion of the transportation channel is mined through the dam and shotcrete finished. The remainder of the transportation channel is a fully-enclosed rectangular conduit, 7 feet wide by 8 feet high, and is external to the dam.

The primary dewatering structure is a 100-foot-long elevated structure designed to remove all but 30 cfs of the incoming transportation channel flow. Dewatering occurs as the flow passes across a screened surface located in the floor of the structure. The water level in the primary dewatering structure is maintained by spilling the surplus water over automatically-controlled weirs. The surplus water from the primary dewatering chamber discharges into the river. The screened floor of the dewatering chamber is kept clean by using automatic screen-cleaning equipment.

The fish, now concentrated in a 30-cfs flow, exit the primary dewatering chamber, and enter secondary dewatering. The facility operator uses the secondary dewatering to fine tune the flow entering the CMF and, therefore, optimize the hydraulic performance of the flume.

The CMF begins at the outlet of the secondary dewatering structure and extends to the fish facilities located downstream. The CMF is placed at a 3.4-percent slope. This allows it to pass approximately 30 cfs at a mean velocity of 9 fps and a mean depth of 18 inches. At Little Goose Dam, flow through the CMF may be diverted around the fish facilities, through the use of a switch gate, and then passed through a CMF to the river release point. At Lower Monumental Dam, the flow from the CMF may also be diverted around the fish facilities through the use of a switch gate, but the flow is directed to the river release point with a polyethylene pipe.

The river release points are located at least 800 feet downstream of the powerhouse, in an area where the river velocity is sufficient to minimize losses due to in-river predation when the fish enter the river. The portions of the bypass system within Lower Granite Dam are similar to those at Lower Monumental and Little Goose Dams. The major differences are that the Lower Granite system uses a pressurized pipe rather than an open channel CMF, and dewatering occurs at the fish facility rather than near the dam.

2.03. Effect of Drawdown Alternatives

The existing juvenile bypass systems, as well as the one currently being designed for Ice Harbor Dam, were designed to operate under normal fluctuations in forebay elevations. These bypass systems will not function under drawdown conditions because the fish orifices would be above the forebay water surface and, therefore, the entire bypass system would be dry. Juvenile bypass, under drawdown, will require the construction of new bypass systems at each dam.

2.04. Required Modifications

Some provisions of the new bypass systems will involve mining new fish collection and access galleries, installing new fish orifices and attraction lighting, and constructing new dewatering structures and bypass flumes (see plates 29 through 35). Each dam will require a new bypass system for all drawdown alternatives (e.g., the bypass system for a 33-foot drawdown will not be operational at a 43-foot drawdown, etc.). An additional modification required for the lowered bypass systems to operate properly will be to change the design of the existing VBS's. A VBS is installed between each gate slot to prevent the fish going up on e slot from passing down into the other slot. The VBS's were designed to optimize orifice passage efficiency (OPE) at current operating pool levels. At lower pool levels, the current VBS's will provide less than desirable OPE and, therefore, will require modification or replacement for operation at lower pool levels. The new drawdown bypass systems will be similar to the bypass system at Little Goose Dam. The primary dewatering structures will be elevated near the downstream face of the dam with CMF transporting the fish to the river release point. Access to the fish orifice area cannot be gained through an existing gallery and, therefore, a new access gallery must be provided at each dam.

Section 3 - Spillway Modifications

3.01. General

This section discusses the changes necessary to make spillways and stilling basins fully functional over the entire operational ranges for the various drawdown alternatives. The spillways and stilling basins will have to provide adequate energy dissipation and dissolved gas-related functions for both normal and drawdown-related spill operations.

Spillway operation and functions, related to adult fish passage, are discussed in appendix A, sections 1 and 9.

3.02. Description of Existing Spillways and Stilling Basins

a. General

The stilling basins were designed to provide optimum energy dissipation for the regulated standard project flood of 420,000 cfs (for some projects, original studies used 340,000 cfs). In addition, the stilling basins were to provide adequate energy dissipation to ensure safety of the projects during the designed spillway flow of 850,000 cfs. For flows of less than the standard project flood, the spillways were designed to operate optimally, assuming full powerhouse flows in addition to spillway flows.

Lower Granite, Lower Monumental, and Ice Harbor Dams, utilize a hydraulic jump-type stilling basin. The design of these basins requires that the hydraulic jump used for energy dissipation be confined partly, or entirely, within the stilling basin. A critical parameter used to determine how effective the energy dissipation will be has to do with tailwater elevations downstream of the stilling basin. In a normal hydraulic jump-type basin, if the tailwater elevation drops below what the basin was designed for, the jump will recede downstream from its originally intended location. The end result might be that the jump will occur downstream of the scour-resisting apron and possibly severely erode downstream of the basin. It should be noted, however, that both Lower Granite and Lower Monumental Dams have spillway flow deflectors that alter how these basins perform under lower tailwater conditions. (It was observed during 1992 reservoir drawdown-related testing for Lower Granite, in both a hydraulic spillway sectional model and in prototype testing, that once the tailwater elevation dropped below the top of the deflector, the stilling basin operated like a plunge pool dissipator, with spillway discharges dropping off the end of the deflector and diving into the basin.)

Little Goose utilizes a toothed roller bucket-type of energy dissipator. The design of these basins requires that for adequate energy dissipation to occur, the tailwater depth must be within defined limits. Insufficient tailwater depth will result in the flow sweeping out of the bucket and forming a jet, typical of a flip bucket. A more undesirable condition can occur just prior to sweep-out, when an instability develops that can result in excessive erosion and undesirable wave conditions in the tailrace and downstream channel. Because the bucket is located immediately adjacent to the toe of the spillway, the roller bucket is designed to efficiently dissipate the energy of the spillway design discharge to ensure against compromising the integrity of the dam structure. (NOTE: It has not been determined what influence the flow deflector on the spillway will have on the function of the stilling basin once the tailwater elevation drops below the top of the deflector. A future sectional hydraulic model of the Little Goose spillway may be used to evaluate this condition.)

b. Lower Granite Dam

The spillway at Lower Granite Dam has a total length of 512 feet between the abutment centerline (including seven intermediate piers); and consists of eight gate-controlled bays, each 50 feet wide. Piers, 14 feet in width, separate the bays. The elevation of the spillway crest is 681 fmsl. Spillway discharges are controlled by eight tainter gates, each 50 feet wide by 60.15 feet high. The design capacity of the spillway is 850,000 cfs, with a corresponding maximum pool of 746.5 fmsl. At the normal pool elevation of 738 fmsl, the spillway will pass a maximum of 678,000 cfs.

The energy of water discharging through the spillway is dissipated by a hydraulic jump in a horizontal apron-type stilling basin. The stilling basin has been designed to contain the jump for discharges up to 850,000 cfs. Nitrogen-related flow deflectors, 12.5 feet long and located at elevation 630 fmsl, were installed in bays 1 through 8 of the eight-bay spillway.

c. Little Goose Dam

The spillway at Little Goose Dam has a total length of 512 feet between the abutment centerline (including seven intermediate piers); and consists of eight gate-controlled bays, each 50 feet wide. Piers, 14 feet in width, separate the bays. Elevation of the spillway crest is 581 fmsl. Spillway discharges are controlled by eight tainter gates, each 50 feet wide by 60.03 feet high. The design capacity of the spillway is 850,000 cfs, with a corresponding maximum pool of 646.5 fmsl. At the normal pool elevation of 638 fmsl, the spillway will pass a maximum of 676,000 cfs.

The energy of water discharging through the spillway is dissipated by a hydraulic jump in a bucket slab with a tooth-type stilling basin. The stilling basin has been designed to contain the jump for discharges up to 850,000 cfs. Nitrogen-related flow deflectors, 8 feet long and located at elevation 532 fmsl, were installed in bays 2 through 7 of the eight-bay spillway.

d. Lower Monumental Dam

The spillway at Lower Monumental Dam has a total length of 498 feet (including seven intermediate piers), and consists of eight gate-controlled bays, each 50 feet wide. Piers, 114 feet in width, separate the bays. Elevation of the spillway crest is 483 fmsl. Spillway discharges are controlled by eight tainter gates, each 50 feet wide by 60.56 feet high. The design capacity of the spillway is 850,000 cfs, with a corresponding maximum pool of 548.3 fmsl. At the normal pool elevation of 540 fmsl, the spillway will pass a maximum of 676,000 cfs.

The energy of water discharging through the spillway is dissipated by a hydraulic jump in a horizontal apron-type stilling basin with a sloping end sill. The stilling basin has been designed to contain the jump for discharges up to 850,000 cfs. Nitrogen-related flow deflectors, 12.5 feet long and located at elevation 434 fmsl, were installed in bays 2 through 7 of the eight-bay spillway.

e. Ice Harbor Dam

The spillway at Ice Harbor Dam has a total length of 590 feet (including nine intermediate piers), and consists of ten gate-controlled bays, each 50 feet wide. Piers, 10 feet in width, separate the bays. Elevation of the spillway crest is 391 fmsl. Spillway discharges are controlled by 10 tainter gates, each 50 feet wide by 52.9 feet high. The design capacity of the spillway is 850,000 cfs, with a corresponding maximum pool elevation of 446.4 fmsl. At the normal pool elevation of 440 fmsl, the spillway will pass a maximum of 685,000 cfs.

The energy of water discharging through the spillway is dissipated by a hydraulic jump and baffles, in a horizontal apron-type stilling basin. One row of baffles (8 feet high, 10.5 feet long, and 10 feet wide), plus an end sill (12 feet high and 590 feet long) assists in dissipating the energy. The stilling basin has been designed to contain the jump for discharges up to 850,000 cfs. There are no nitrogen-related flow deflectors at Ice Harbor Dam.

3.03. Impact of Drawdown Operations on Existing Facilities

a. General

Projects were designed for safe operations under tailwater conditions, assuming both spillway and powerhouse operations. Therefore, any plan that has a spillway-only feature or significantly reduced powerhouse discharges, may create spillway unit discharges for a given tailwater that exceed design limits. In addition, any change in tailwater elevations below design levels might significantly reduce the effectiveness of spillway deflectors that were installed to minimize dissolved gas level problems during spill. Because of possible structural and/or dissolved gas-related problems associated with existing spillways and stilling basins under drawdown conditions, modifications to some or all of the stilling basins and related features may be required.

Judgments relating to the impact drawdown might have on existing spillway stilling basins are based on an examination of existing technical information for the projects, and on observations made during 1992 spill and drawdown-related tests at Lower Granite and Little Goose dams. Impacts that drawdown could have on other features, such as adult and juvenile fish facilities, are presented elsewhere in this report.

Under normal operating pool levels, large volumes of spill (with or without operation of powerhouses) increases the dissolved gas levels within the river. Spillway flip-lips help dissolved gas levels within the river. Spillway flip-lips help under normal operating pool levels but, as the volume of spill increases, so does the level of dissolved gasses even with flip-lip operation. Operation of powerhouses allows reductions in the amount of spill required and, when operated in conjunction with spillway, flip-lips assist by diluting the higher dissolved gasses created by the spillway operations. However, as spill volumes increase, the dissolved gas levels within the river eventually increase beyond acceptable levels, even with the powerhouse operation at a maximum. As the river passes each of the lower Snake River dams, spill will cause the level of dissolved gas in the river to be incrementally increased. Also, drawdown of lower Snake River reservoirs will reduce hydraulic capacities of existing powerhouses, resulting in more spill and higher than normal river dissolved gas levels.

b. Impacts to Lower Granite

A drawdown test, completed on the Lower Granite and Little Goose reservoirs in 1992, provided information on a variety of physical and engineering-related topics, and included an evaluation of the Lower Granite spillway and stilling basin under reservoir drawdown conditions. Some biological monitoring accompanied the physical test. Based on preliminary observations from the test (including information obtained from a hydraulic sectional model of the Lower Granite spillway and stilling basin) the following conclusions are made:

- It is unacceptable to operate the existing Lower Granite spillway and stilling basin for an extended time under lowered tailwater conditions unless all rock and gravel material can be removed from the basin prior to spill. If the rock and gravel material can be totally removed, the spillway and stilling basin will operate like a flip-bucket type of basin, and be structurally safe. However, if all the material is not removed, the basin will be damaged by the churning action of the rock caused by the plunging flow over the deflectors.

- It is unacceptable to operate the existing Lower Granite spillway and stilling basin for an extended period of time, under drawdown conditions, for spill levels much in excess of 20,000 cfs. If flows are much higher than this, dissolved gas levels generated by the spill will exceed levels considered safe for fish.

- In summary, from the dissolved gas standpoint, it is unacceptable to operate the existing Lower Granite spillway for an extended period under drawdown conditions, unless spill rates are very low. In addition, from the structural integrity standpoint, it will probably be difficult to keep the basin clean enough, or to keep materials from entering the basin under normal tailwater conditions, to ensure that there would be no damage to the basin if the tailwater was below the level of the deflector. Therefore, some type of structural modifications will be required to operate the system under long-term drawdown conditions.

c. Impacts to Little Goose

Much of the discussion and trends for Lower Granite, related to energy dissipating and dissolved gases, will also apply to Little Goose. Since Little Goose utilizes a toothed roller bucket-type of energy dissipator, which is even more sensitive to tailwater changes than the hydraulic jump-type basin at Lower Granite, it may be even more risky to operate Little Goose under drawdown conditions. The Little Goose basin has already experienced some erosion in the areas downstream and adjacent to the concrete spillway structure under normal operations. Given known facts about the existing stilling basin, it is believed unacceptable to operate the Little Goose spillway under drawdown conditions without some structural modifications, due to expected problems with both the structural integrity of the basin and dissolved gases.

d. Impacts to Lower Monumental

The discussion and trends for Lower Granite, related to energy dissipation and dissolved gases, will also apply to Lower Monumental. Because of expected problems related to both structural integrity and dissolved gases during operation in a drawdown condition, it is believed unacceptable to operate the spillway and stilling basin of Lower Monumental Dam under these conditions without structural modifications.

e. Impacts to Ice Harbor

There are no study options that require dropping McNary pool (e.g., Ice Harbor tailwater) below current normal minimum levels. The spillway unit discharges for a given tailwater may exceed the original design for normal river flows, since the design alternatives involve reduced powerhouse discharges. Since the project was originally designed to pass high flood flows, assuming no powerhouse operations, there will be no significant change in the system related to energy dissipation in the stilling basin under maximum design river discharges. Thus, structural damage to the Ice Harbor spillway operating under drawdown levels is not anticipated and no structural modifications to the spillway, related to dam safety concerns, would be required.

The Ice Harbor spillway does not have flip-lips and, under normal operations, the dissolved gas level in the river approaching Ice Harbor is relatively low because of powerhouse and spillway flip-lip operations of upriver dams. Spillway operation sin conjunction with powerhouse operations at Ice Harbor increase dissolved gas levels in the river below the project. However, because of the low dissolved gas river levels above Ice Harbor, the additive effect is normally below critical levels. In addition, the distance between Ice Harbor and the confluence of the Snake and Columbia Rivers is relatively short, and dissolved gasses are diluted at the confluence.

Under reservoir drawdown conditions, river dissolved gas levels approaching Ice Harbor will be higher than normal, and operating the Ice Harbor spillway will exaggerate the dissolved gas levels in the river below the dam. Dissolved gasses may be much greater than acceptable levels before the river reaches Ice Harbor Dam. Adding flip-lips to the Ice Harbor spillway would not reduce the dissolved gas level in the river approaching Ice Harbor Dam. In addition, adding flip-lips at Ice Harbor Dam to reduce the anticipated increase in dissolved gas levels as water is passed over the spillway during drawdown operations would have only marginal benefits. There are no known structural modifications that could be completed at Ice Harbor that would significantly reduce dissolved as levels during drawdown operations.

In summary, no structural modifications to the spillway, related to dam safety concerns, are required at Ice Harbor in order to operate the system in a drawdown mode. However, dissolved gas levels will probably increase because of more flows passing over the spillway during drawdown operations.

3.04. Project Modifications Required to Match Existing Project Operations

a. General

Different levels of project modifications can be attempted to either match, or possibly improve, future drawdown-related spillway operations with existing project performances. (In this section, existing project operations refer to spillway and stilling basin functions pertaining to energy dissipation and dissolved gases.) It is assumed, for this study, that a target for spillway operations relative to drawdown options will be to match, with as much confidence as possible, drawdown conditions to existing project operations.

b. Discussion of Alternatives Considered

(1) General

Three different methods to modify the projects were considered in an attempt to solve spillway and stilling basin-related problems associated with drawdown alternatives. These options include: 1) tailwater control devices; 2) adjustable spillway flow deflectors; and 3) elevated (shallower) stilling basins. Each of these alternatives will require extensive analysis, including hydraulic model studies and prototype testing, of existing and newly constructed projects in order to evaluate and optimize the various designs. These options are presented and discussed below.

(2) Tailwater Control Structures

One method of solving the problems associated with drawdown operations includes creating an artificial tailwater downstream of the spillway that will match original design conditions. This will allow for spillway energy to be dissipated into the stilling basin at elevations that are similar to original design conditions. In addition, the artificial tailwater will be set to keep the spillway deflectors fully functional. (It might even be desirable to set the tailwater deeper than existing normal operations if it will improve the performance of the existing deflectors.)

It will be necessary to make the tailwater control device fully retractable so as not to limit the capacity of the spillway under high flood flows. The height of the drop, from the water level upstream of the control device (e.g., in the stilling basin) to the downstream tailwater, will have to be minimized. If the drop is too high, dissolved gases may be created in the secondary drop. In addition, a high drop will create another energy dissipation problem that must be handled.

An expanded discussion, related to tailwater control devices, is presented in appendix A, section 9.

(3) Adjustable Spillway Flow Deflectors

Another method of solving problems associated with drawdown operations includes using the logic of the present flow deflectors to minimize flow conditions that lead to dissolved gas problems. It may be possible to develop an adjustable flow deflector that can adjust either higher or lower, and be more effective over a wider range of tailwater. Another solution could be to have one retractable deflector at the elevation of the existing deflector, and one fixed deflector at a lower elevation. Under normal operations, the upper retractable deflector would operate in a manner similar to existing deflectors. Under drawdown conditions, the upper deflector would retract into the face of the spillway so that the lower level deflector could function.

The effectiveness of an adjustable/retractable deflector system can not be precisely predicted, although hydraulic model studies can be used to give an indication of relocated deflector efficiency. It will require prototype installation and testing of deflectors set at different elevations to evaluate and optimize new designs.

(4) Elevated (Shallower) Stilling Basins

A final method to consider in solving problems associated with drawdown operations is constructing entirely new stilling basins at the projects to make the basins shallow enough to prevent deep-plunging flow conditions that lead to dissolved gas problems. Shallower stilling basins will require that the basins be longer and/or contain baffles in an effort to ensure that the energy from the spillway is fully dissipated over a wide range of discharges and tailwater elevations.

One example of how a shallower stilling basin might be used in reducing dissolved gas levels from the forebay to the tailwater can be found at The Dalles project on the Columbia River. Although it is not fully understood, it appears that passing flows over the spillway at The Dalles may reduce river dissolved gas levels past the project.

The major similarities and differences between The Dalles and the lower Snake River projects include the following:

- The Dalles spillway and stilling basin is somewhat comparable in design to the hydraulic jump and baffle-type basin at Ice Harbor. The stilling basin floor, however, is substantially shallower. Depending on flow conditions, it appears that The Dalles tailwater depth can be anywhere from 10 to 30 feet shallower, depending on the lower Snake River project and flow conditions that are being compared.

- The Dalles and the lower Snake River projects have different orientations of powerhouses, in respect to the spillways. This may be a factor in the effectiveness powerhouse flows have in diluting dissolved gas levels generated by spill.

An attempt to determine the effectiveness of elevated stilling basins on reducing dissolved gas levels will require extensive research of existing projects (such as prototype testing at The Dalles), in addition to conducting hydraulic model studies of the different projects. It will probably require prototype installation and testing of an elevated stilling basin to fully evaluate and optimize new designs.

c. Alternative Selected for Concept Designs and Cost Estimates

(1) General

It is assumed, for this study, that a target for spillway operations related to drawdown options will be to match drawdown conditions to existing project operations with as much confidence as possible. Although a single plan will be selected for each project in order to arrive at a concept design and cost estimate that best fits this goal, it is recommended that all of the modifications previously discussed (plus new ones that may be developed) be pursued in later stages of the study if any drawdown alternatives are carried forward.

(2) Selected Modifications

The following stilling basin-related modifications will be used as an aid to development of concept designs and cost estimates attempting to solve spillway-related energy dissipation and dissolved gas problems associated with drawdowns:

- Lower Granite: New tailwater control structure with existing stilling basin.

- Little Goose: New stilling basin and tailwater control structure.

- Lower Monumental: New tailwater control structure with existing stilling basin. P
- Ice Harbor: No modifications required.

The tailwater control structure, although probably much more expensive, is judged most likely to solve the dissolved gas problems associated with drawdown predictably, especially when compared to adjustable spillway deflectors. In addition, the tailwater control structure was determined to meet the goals of the spillway and stilling basin outlined earlier, and at a lower cost, when compared to elevated (shallower) stilling basins.

3.05. Description and Construction Methods of Selected Spillway Modifications

a. General

The spillway and stilling basin-related modifications discussed in the following paragraphs were selected to present concept methods that could potentially solve operations problems related to the various drawdown alternatives. The selected designs were briefly evaluated to check for feasibility and constructibility of the modifications, in addition to developing preliminary cost estimates and schedules to implement the plans.

The work sites for each modified project must be dewatered to allow construction. To accomplish this, the spillway gates or stoplogs upstream of the stilling basins will be used to contain upstream water. Downstream of the stilling basins, cofferdams will contain water. The cofferdams will be installed in two phases. At each project, phase one includes installing the cofferdams to allow the dewatering of half of the stilling basin. Following modification of the first half of the stilling basin, the cofferdams will be relocated to allow the dewatering of the remaining portion of the stilling basin. This will allow half of the spillway and stilling basin to remain operational at all times.

b. Lower Granite and Lower Monumental - New Tailwater Control Structures with Existing Stilling Basins

Submerged drumgates will be constructed downstream of the existing stilling basin and sills at both Lower Granite and Lower Monumental Dams (see plate 43.3). In addition, existing stilling basin training walls will be extended, and will tie into the drumgate system. The gates will rise to an elevation that will create water levels in the stilling basins that will satisfy concerns about both energy dissipation and dissolved gas levels.

Concrete piers, aligned with the existing spillway piers, will separate the drumgates. A gallery will be provided for access to mechanical equipment. Stoplog guides will be located both upstream and downstream of the gates, allowing for maintenance-related dewatering requirements of the drumgates.

c. Little Goose--New Tailwater Control Structure With a New Stilling Basin

A new hydraulic jump-type stilling basin (including training walls), similar in function and appearance to the existing Lower Granite stilling basin, will be constructed first. It will be built downstream of the existing rollerbucket stilling basin. Rock fill will be placed downstream of the rollerbucket and above the rockline. Included in this rock fill will be a drainage system, designed to reduce hydrostatic uplift forces acting on the new stilling basin. The new stilling basin will be placed over the rock fill.

Submerged drumgates will then be constructed downstream of the new stilling basin end sill, along with appropriate extensions or adjustments to the existing stilling basin training walls. The description and construction method for the new drumgates will be similar to that previously described for Lower Granite and Lower Monumental Dams.

Section 4 - Construction Cofferdams

4.01. General

Cofferdams will be required, by several of the alternatives, to dewater the construction work area. The cofferdams will be constructed of earth-filled sheet-pile circular cells. The earth fill will consist of a rocky gravel material that is available within approximately 3 miles of the construction site.

4.02. Upstream Cofferdams

Upstream cofferdams will be required for alternatives 4A, 15, and 19. The cofferdams will be approximately 150 feet high, and will consist of 80-foot-diameter cells with an earth berm 90 feet wide by 90 feet high located on the dry side of the cells. In areas of limited space, a second row of 80-foot-diameter circular cells will be used in place of a portion of the earth berm.

4.03. Downstream Cofferdams

Downstream cofferdams will be used extensively with each drawdown alternative. Downstream cofferdams will be approximately 50 feet high, and will consist of 50-foot-diameter cells.

4.04. Cofferdam Embankments

The cofferdams will be connected to the abutments with an embankment section that has an impervious core wall. The embankment will be an extension of the berm that supports the cells. It will wrap around the front of the cells and slope (1 vertical to 2 horizontal) to the natural groundline. The 1 vertical-to-2 horizontal front face will project out into the river, and must be protected with riprap.

Excavation and placement of concrete to create a wall will suffice as the impervious core. The wall section will have to extend to, and be sealed against, the rock abutment.

Construction of the cofferdam embankment section will be done under full pool conditions. Fill materials will be bucketed into position to minimize segregation of the aggregates. Once the embankment is constructed, a trench will be excavated for placement of the concrete wall.

Section 5 - Relocations

5.01. General

The following relocation plans are applicable to alternatives 4A, 15, and 19. Other alternatives that consider modifications to the powerhouse or to the existing spillway do not impact the railroads and highways that surround the projects. Associated real estate issues are discussed in appendix A, section 10.

5.02. Lower Granite Lock and Dam

a. Existing Conditions

The Camas Prairie Railroad passes the dam on the north abutment. A county road, connecting Walla Walla and Whitman Counties, transverses the dam and extends north.

The Camas Prairie Railroad is a joint-venture subsidiary between the Union Pacific and Burlington Northern Railroads. In the vicinity of the dam the trackage of the Camas Prairie Railroad is known as the Riparia Branch Line. For the most part, the line is a single mainline track.

Railroad relocation procedures prior to raising the Lower Granite reservoir entailed design and construction of embankments to elevate the tracks above the reservoir. An alignment, measuring 22 feet across the top and comprised of cut and fill sections to grade, was provided to the railroad. The railroad placed ballast and track on the newly constructed subgrade.

A county road exits off the embankment of the dam and heads west along the north abutment. The road parallels the railroad and the Little Goose Reservoir for approximately 3 miles before turning north at Almota. The road also provides access to a visitor park on the downstream north abutment. Dam modifications will require the relocation of the road and park in the vicinity of the dam.

The road was build in conjunction with the dam, and then turned over to the county. A typical cross section of the road shows a pavement section 28 feet wide, with a bituminous surface and 9 inches of base materials.

b. Effect of Drawdown Alternatives

Drawdown alternatives 4A, 15, and 19 require the installation of a river bypass structure or a new low-level spillway. Installation of these features will require extensive reconstruction to the north shore embankment and abutment. The modifications will displace the existing north shore railroad, highway, and visitor park.

c. Required Modifications

Prior to the modifications, realignment of the railroad will be necessary to provide uninterrupted rail service along the Riparia Branch.

Vehicular traffic will be impacted because of the dam modifications. Because the modifications entail the removal of the dam embankment, the road will have to be closed for short periods of time. To minimize the impact to the public, a temporary access road across the dams can be provided along the top of the cofferdams.

Analysis for relocating the railroad changes the alignment of the track by approximately 1 mile on either side of the dam. This distance is adequate to transition "S" curves into the existing alignment, which moves the tracks to the north in the vicinity of the dam.

Assessment for the relocation of the roadway indicate that transition from a new structure to the existing alignment can be provided in 1 mile. In addition, a ½-mile road will have to be provided on the downstream side of the new structure.

The north shore visitor area is impacted, too, and will be relocated and provided with an access road.

d. Construction Procedures

Construction of the railroad and highway alignments will follow standard practices for cut and fill. Additional fill materials or aggregates for base, will have to be developed near the project. Estimates for a source fall within a 3-mile radius of the dam.

Design considerations and estimated construction costs will be similar to the methodology used for the initial relocations.

Realignment of the railroad must be initiated prior to any dam modifications.

e. Predesign Considerations

Extensive surveys of the area will be required for developing economical alignments. The data will also be necessary for establishing design and construction quantities.

5.03. Little Goose Lock and Dam

a. Existing Conditions

The Camas Prairie Railroad passes by the dam on the north abutment. A county road, which connects Columbia and Whitman Counties and provides access to visitor and recreational facilities, transverses the dam and extends north.

The Camas Prairie Railroad is a joint-venture subsidiary between the Union Pacific and Burlington Northern Railroads. In the vicinity of the dam, the trackage of the Camas Prairie Railroad is known as the Riparian Branch Line. For the most part, the line is a single mainline track.

Railroad relocation procedures, prior to raising Little Goose reservoir, entailed design and construction of embankments to elevate the tracks above the reservoir. An alignment, measuring 22 feet across the top and comprised of cut and fill sections to grade, was provided to the railroad. The railroad placed ballast and track o the newly constructed subgrade.

A county road exits the embankment of the dam and heads west along the north abutment. This road parallels the railroad and the Lower Monumental reservoir for approximately 3 miles before turning north at Riparia. The road also provides access to the navigation lock, visitor center, and a boat launching facility. In the vicinity of the embankment, modifications will require the relocation of the railroad, the county road, and the recreational facilities.

The road was built in conjunction with the dam, and then turned over to Whitman County. A typical cross section of the road shows a pavement section 28 feet wide, with a bituminous surface and 9 inches of base materials.

b. Effect of Drawdown Alternatives

Drawdown alternatives 4A, 15, and 19 will require the installation of a river bypass structure or a new low-level spillway. Installation of these features will require extensive reconstruction to the north shore embankment and abutment. The modifications will displace the existing north shore railroad, highway, boat launching facility, and visitor enter.

c. Required Modifications

Construction and modifications to the embankment will require extensive work in the vicinity of the north abutment. Prior to the modifications, realignment of the railroad will be necessary to provide uninterrupted rail service along the Riparia Branch.

Vehicular traffic will also be impacted because of dam modifications. Because the modifications entail the removal of the dam embankment, the road would have to be closed for short periods of time. To minimize impact to the public, a temporary river crossing can be provided along the top of the cofferdams.

Analysis for relocation of the railroad changes the alignment of the track by approximately 1 mile on either side of the dam. This distance is adequate to transition "S" curves into the existing alignment, which moves the tracks to the north in the vicinity of the dam.

Assessments for the relocation of the roadway indicate that transition from a new structure to the existing alignment can be provided in 1 mile. In addition, a ½-mile road will have to be provided on the downstream side of the new structure.

The north shore recreational facilities will also be impacted. Reestablishing the upstream boat launching facility may not be practical, but a north shore visitor center can be established in the new proposed structure.

d. Construction Procedures

Construction of the railroad and highway alignments will follow standard practices for cut and fill. Additional fill materials, or aggregates for base, will have to be developed near the project. Estimates for a source fall within a 3-mile-radius of the dam.

Design considerations and estimated construction costs will be similar to the methodology used for the initial relocations.

Realignment of the railroad must be initiated prior to any dam modifications.

e. Predesign Considerations

Extensive surveys of the area will be required for developing economical alignments. The data will also be necessary for establishing design and construction quantities.

5.04. Lower Monumental Lock and Dam

a. Existing Conditions

The Union Pacific Railroad passes by the dam on the south abutment. The railroad settlement of Matthew also lies here. A county road, connecting Franklin and Walla Walla Counties, transverses the dam and extends south.

In the vicinity of the dam, the Union Pacific Railroad trackage is comprised of a single mainline track and two sides. Railroad relocation procedures, prior to raising Lower Monumental reservoir, entailed design and construction of embankments to elevate the tracks above the reservoir. An alignment, comprises of cut and fill sections to grade, was provided to the railroad. The settlement of Matthew is also associated with the railroad but, at the present time, the buildings have been vacated.

A county road exits off the embankment of the dam and heads southwest. The road also provides access to the visitor park located on the embankment. In the vicinity of the dam, modifications will require the relocation of the road and park.

The road was built in conjunction with the dam, and then turned over to the county. A typical cross section of the road shows a pavement section 28 feet wide, with a bituminous surface and 9 inches of base materials.

b. Effect of Drawdown Alternatives

Drawdown alternatives 4A, 15, and 19 require the installation of a river bypass structure or new low-level spillway. Installation of these features will require extensive reconstruction to the south shore embankment and abutment. The modifications will displace the existing south shore railroad, highway, visitor park, boat launch facility, and the settlement of Matthew.

c. Required Modifications

Construction modifications to the embankment will require extensive work in the vicinity of the south abutment. Prior to the modifications, realignment of the railroad will be necessary to provide uninterrupted rail service for the Union Pacific Railroad.

Vehicular traffic will also be impacted due to the dam modifications. Because the modifications entail the removal of the dam embankment, the road will have to be closed for short periods of time. To minimize the impact to the public, a temporary river crossing can be provided along the top of the cofferdams.

Analysis for relocation of the railroad changes the alignment of the track, beginning approximately 1 mile upstream of the dam and extending 2.5 miles downstream. Most of the trackage within the proposed relocation is double track, a mainline, and one siding.

Justification to relocate the now abandoned railroad settlement of Matthew does not appear warranted. Compensation to the railroad for the loss of the buildings may solve this dilemma.

Assessments for the relocation of the roadway indicate that transition from a new structure to the existing alignment can be provided within ½ mile. In addition, 1.5 miles of roadway relocation will be required for providing access to visitor and recreational facilities. A new visitor facility can be housed in the new proposed structure, or located on the south abutment. Relocation of the boat launching and recreational areas will be downstream, below the constructed channel.

d. Construction Procedures

Construction of the railroad and highway alignments will follow standard practices for cut and fill. Additional fill materials, or aggregates for base, will have to be developed from a quarry site near the project. Estimates for a source fall within a 3-mile radius of the dam.

Design considerations and estimated construction costs will be similar to the methodology used for the initial relocations.

Realignment of the railroad will have to be initiated prior to any dam modifications.

e. Predesign Considerations

Extensive surveys of the area will be required for developing economical alignments. The data will also be necessary for establishing design and construction quantities.

5.05. Ice Harbor Lock and Dam

a. Existing Conditions

A county road, connecting Franklin and Walla Walla Counties, transverses the dam and extends south. From the south shore, the road also provides access to the powerhouse tailrace and a visitor park that overlooks the backside of the dam. Branching off the county road, and extending upstream of the dam, is a project road that accesses the Indian Memorial overlook and picnic area. This road terminates at Charbonneau Park.

The roads were built in conjunction with the dam, or as access roads to recreational areas. A typical cross section of the road shows a pavement section 28 feet wide, with a bituminous surface and 9 inches of base materials.

b. Effect of Drawdown Alternatives

Drawdown alternatives 4A, 15, and 19 require the installation of a river bypass structure or new low-level spillway. Installation of these features will require extensive reconstruction to the south nonoverflow monoliths and the south shore abutment. The modifications will displace the existing south shore highway, Indian Memorial, and visitor park.

c. Required Modifications

Construction modifications will require extensive work in the vicinity of the south abutment. Vehicular traffic will be impacted because of this. The necessary modifications entail the removal of the nonoverflow sections, the road crossing the dam, and the overlook recreational area (which must be closed). To minimize the impact of crossing the dam, a temporary river crossing can be provided along the top of the cofferdams.

Approximately 1 mile of new roads will be required to accomplish all transitions from the existing roadways to the new proposed alignments. The most notable feature will be a highway bridge accessing the powerhouse tailrace. In addition, the visitor area and the Indian Memorial will require relocation.

d. Construction Procedures

Highway alignment designs and construction will follow standard practices for cut and fill. Additional fill materials, or aggregates for base, will have to be developed from a quarry site near the project or processed from the channel excavation. Estimates for an aggregate source fall within a 3-mile radius of the dam.

Design considerations and estimated construction costs will be similar to the methodology used for the initial relocations.

e. Predesign Considerations

Extensive surveys of the area will be required for developing economical alignments. The data will also be necessary for establishing design and construction quantities.

Section 6 - Embankment, Levee, and Relocation Protection

6.01. General

At the time of construction, earth embankments at each lower Snake River dam and the associated reservoirs that would be susceptible to wave action or excessive scour were armored with riprap. The limits of the armored sections were defined by the anticipated maximum and minimum operating pool elevations. Operating the reservoirs below the established minimum operating pool limits will expose portions of the earth embankments not protected with riprap. To protect these embankments from failure, embankment protection must be implemented prior to long-term reservoir drawdown operations.

The general practice is to protect the face of the embankments with a 2-foot layer of large angular stones weighing from 100 to 400 pounds. The stones are individually placed, and keyed into one another on the face of the embankment. The large mass and angular fracture of the stones create an armor layer, or riprap cover, to protect the finer grain materials within the embankment. By design, the mass and the interlocking action of the stones resist movement of the embankment materials, due to wave action or increased river velocities.

To provide the necessary protection, a blanket of new riprap must be placed along the embankments prior to lowering the reservoirs. Placement of the riprap will require in-water work permits, and land acquisition for quarry development. Construction schedules will have to be coordinated, and must consider both the urgency for completion and the required environmental needs.

6.02. Lower Granite Lock and Dam

a. Existing Conditions

The Lower Granite reservoir extends 39 river miles upstream from the dam, with a shoreline of 91 miles. The north shore accommodates 37.5 miles of mainline track for the Camas Prairie Railroad, and 24 miles of county road. On the south shore, and extending west from Lewiston, Idaho, for 12.8 miles, is State Highway 12. Levees, totaling 8.6 miles, protect the city of Lewiston from the Snake and Clearwater Rivers.

The construction of Lower Granite Lock and Dam required the relocation of highways, railroads, and the city of Lewiston, Idaho. To minimize disruption, many of the relocations followed the alignment of the river's normal pool. To gain the required elevation, fill material was used for railroad and highway embankments, and levees were constructed to protect the city of Lewiston.

Because of the tremendous amount of surface area along the railroad, highway, and levee embankments, riprap was only placed on a portion of the embankment face. The lower elevation of riprap varies between elevation 726 and 730.

An earth embankment section was constructed between the navigation lock and the north shore abutment. For protection on the upstream face of the embankment, riprap was only placed on the upstream face of the embankment to elevation 719.

b. Effect of Drawdown Alternatives

The proposed drawdown alternatives all suggest lowering the reservoir pool elevations below minimum operating pool. This operation will expose substantial portions of unprotected railroad, roadway, and dam embankments. The exposed material in the embankments is either rock or gravel fill. The particle size of the rock and gravel fill is much smaller than the stones used for riprap, and the small particle size is susceptible to erosion from wave action or increased river velocities.

c. Required Modifications

Existing embankments that are susceptible to erosion or scour will require placement of riprap on the face of the slopes. For the majority of the slopes, ease of construction will dictate extending the riprap to the toe of the embankment. By building the riprap cover from the toe, a foundation is created that supports the mass of material as stones are placed up the slope.

Embankments that extend a substantial distance beyond the proposed surface of the reservoir require extending riprap to the toe of the fill and, therefore, the cost becomes excessive. One method of cost reduction is to create a foundation trench in the face of the slope, 10 feet below the surface of the reservoir. The trench will be used to support the large stones keyed into the existing materials of the embankment. The large stones can then be used to support the riprap as it is placed up the slope.

Alternatives 13 and 17 will require the least amount of additional protection, with approximately 431,000 square yards of embankment surface area to cover.

Alternatives 14 and 18 drop the reservoir by 43 feet, and will require approximately 475,000 square yards of riprap cover.

Alternatives 5, 9, 15, and 19 suggest lowering the reservoir by 57 feet. Alternatives 5 and 9, which advocate modifications to the existing spillway, will require riprap protection to the dam embankment. Approximately 525,000 square yards of riprap will be required. Alternatives 15 and 19 require the construction of a new spillway to replace the existing embankment. Therefore, protection of the existing embankment is not applicable, and approximately 500,000 square yards of riprap cover will be required.

The natural river option, alternative 4A, requires the most protection of embankments, with an estimated 550,000 square yards of riprap cover.

Alternatives 4A, 15, and 19 require the dam embankment to be removed and replaced with a concrete structure. Therefore, protection of the dam embankment is not applicable for these alternatives.

6.03. Little Goose Lock and Dam

a. Existing Conditions

The Little Goose reservoir extends 37.2 river miles upstream from the dam, with a shoreline of 92 miles. The north shore accommodates 36 miles of mainline track belonging to the Camas Prairie Railroad. Combined state, county, and project access roads along both shorelines comprise 36.1 miles of roadway adjacent to the reservoir,

The construction of Little Goose Lock and Dam required the relocation of highways and railroads. To minimize disruption, many of the relocations followed the alignment of the river's normal pool. To gain the required elevation, fill material was used for railroad and highway embankments.

Because of the tremendous amount of surface area along slopes supporting the railroad and roadways, riprap was only placed on a portion of the embankment face. The lower elevation of riprap terminates around elevation 628 fmsl.

An earth embankment section was constructed between the spillway and the north shore abutment. For protection on the upstream face of the embankment, riprap was only placed to elevation 628 fmsl, which is only 5 feet below minimum operating pool. On the downstream face of the embankment, a band of riprap between elevation 532 and 553 fmsl protects the fill.

b. Effect of Drawdown Alternatives

Lowering the pool elevations below minimum operating pool will expose a substantial portion of unprotected railroad, roadway, and dam embankments. The exposed material in the embankments is either rock or gravel fill. The particle size of the rock and gravel fill is much smaller than the stones used for riprap, and the small particle size is susceptible to erosion from wave action or increased river velocities. The primary protection of the rock and gravel fill will be the placement of riprap prior to the implementation of drawdown.

c. Required Modifications

Existing embankments that are susceptible to erosion or scour will require the placement of riprap on the face of the slopes. For the majority of the slopes, ease of construction will dictate extending the riprap to the toe of the embankment. By building the riprap cover from the toe, a foundation is created that supports the mass of material as stones are placed up the slope.

Embankments that extend a substantial distance beyond the proposed surface of the reservoir require riprap extending to the toe of the fill and, therefore, the cost becomes excessive. One method of cost reduction is to create a foundation trench in the face of the slope 10 feet below the surface of the reservoir. The trench is used to support the large stones keyed into the existing materials of the embankment. These stones can then be used to support the riprap as it is placed up the slope.

Alternatives 13 and 17 will require additional embankment protection, as there will be approximately 66,000 square yards of surface area to cover.

Alternatives 14 and 18, which drop the reservoir by 43 feet, require approximately 72,000 square yards of riprap cover will be required.

Alternatives 5, 9, 15, and 19 propose lowering the reservoir by 57 feet. Alternatives 5 and 9, which propose modifications to the existing spillway, will require riprap protection to the dam embankment. Approximately 79,000 square yards of riprap cover will be required. Alternatives 15 and 19 require the construction of a new spillway to replace the existing embankment. Therefore, protection of the existing embankment is not applicable, and approximately 57,000 square yards of riprap will be required.

The natural river option, alternative 4A, creates the most drastic change in the river elevation. An estimated 63,000 square yards of riprap cover will be necessary for embankment protection. This quantity is reduced from alternatives 5 and 9, because protection of the dam embankment is not applicable for this alternative.

6.04. Lower Monumental Lock and Dam

a. Existing Conditions

The Lower Monumental reservoir extends 28.7 river miles upstream from the dam, with a shoreline of 78 miles. Extending upstream of the dam on the south shore, lies 14 miles of mainline track belonging to the Union Pacific Railroad. On the upper reaches of the reservoir, located on both the north and south shores, lie 15 miles of mainline track owned by the Camas Prairie Railroad. State, county, and project access roads combine to make 14.2 miles of shoreline roadways along the reservoir.

The construction of Lower Monumental Lock and Dam required the relocation of highways and railroads. To minimize disruption, many of the relocations followed the alignment of the river's normal pool. To reach the required elevation, fill material was used for railroad and highway embankments.

Because of the tremendous amount of surface area along slopes supporting the railroad and roadways, riprap was only placed on a portion of the embankment face. The lower elevation of riprap terminates around elevation 532 fmsl.

An earth embankment section was constructed between the powerhouse and north abutment, and between the navigation lock and south abutment. For protection, riprap was placed on the upstream face of the embankment to elevation 532 fmsl (5 feet below minimum operating pool).

b. Effect of Drawdown Alternatives

Lowering the pool elevations below minimum operating pool will expose substantial portions of unprotected railroad, roadway, Marmes levee, and dam embankments. The exposed material in the embankments is either rock or gravel fill. The particle size of the rock and gravel fill is much smaller than the stones that are used for riprap, and the small particle size is susceptible to erosion from wave action or increased river velocities. The primary protection of rock and gravel fill is the placement of riprap prior to the implementation of drawdown.

c. Required Modifications

Existing embankments that are susceptible to erosion or scour will require placement of riprap on the face of the slopes. For the majority of the slopes, ease of construction will dictate extending the riprap to the toe of the embankment. By building the riprap cover from the toe, a foundation is created that supports the mass of material as the stones are placed up the slope.

Embankments that extend a substantial distance beyond the proposed surface of the reservoir require that riprap be extended to the toe of the fill and, therefore, the cost becomes excessive. One method of cost reduction is to create a foundation trench in the face of the slope, 10 feet below the surface of the reservoir. The trench will be used to support the large stones keyed into the existing materials of the embankment. The large stones can then be used to support the riprap as it is placed up the slope.

Alternatives 13 and 17 will require the least amount of additional protection, with approximately 111,000 square yards of embankment surface area to cover.

Alternatives 14 and 18, which drop the reservoir by 43 feet, will require approximately 121,000 square yards of riprap cover.

Alternatives 5, 9, 15, and 19 propose lowering the reservoir by 57 feet. Alternatives 5 and 9, which propose modifications to the existing spillway, will require riprap protection to the dam embankment. Approximately 133,000 square yards of riprap will be required. Alternatives 15 and 19 require the construction of a new spillway to replace the existing embankment on the south shore. Therefore, protection of the existing south shore embankment is not applicable, and approximately 120,000 square yards of cover riprap will be required.

The natural river option, alternative 4A, creates the most drastic change in the river elevation. An estimated 136,000 square yards of riprap cover will be necessary for embankment protection.

6.05. Ice Harbor Lock and Dam

a. Existing Conditions

The Ice Harbor reservoir extends 31.9 river miles upstream from the dam, at river mile 9.7 on the Snake River. The reservoir has 67 miles of shoreline, and the south shore accommodates 27.2 miles of mainline track belonging to the Union Pacific Railroad. The north shore supports 29.1 miles of mainline track for the Burlington Northern railroad, and 4.9 miles of highway.

The construction of Ice Harbor Lock and Dam required the relocation of highways and railroads. To minimize disruption, many of the relocations followed the alignment of the river's normal pool. To gain the required elevation, fill material was used for railroad and highway embankments.

Because of the tremendous amount of surface area along slopes supporting the railroad and roadways, riprap was only placed on a portion of the embankment face. The lower elevation of riprap terminates around elevation 432 fmsl.

An earth section was constructed between the navigational lock and north abutment. For protection, riprap was placed on the upstream face of the embankment to elevation 432 fmsl (5 feet below minimum operating pool).

b. Effect of Drawdown Alternatives

Lowering the pool elevations below minimum operating pool will expose substantial portions of unprotected railroad, roadway, and dam embankments. The exposed material in the embankments is either rock or gravel fill. The particle size of the rock and gravel fill is much smaller than the stones used for riprap, and the small particle size is susceptible to erosion from wave action or increased river velocities. The primary protection of the rock and gravel fill will be the placement of riprap prior to implementation of drawdown.

c. Required Modifications

Existing embankments that are susceptible to erosion or scour will require the placement of riprap on the face of the slopes. On the majority of the slopes, ease of construction will dictate extending the riprap to the toe of the embankment. By building the riprap cover from the toe, a foundation is created that supports the mass of material as the stones are placed up the slope.

Embankments that extend a substantial distance beyond the proposed surface of the reservoir require riprap extending to the toe of the fill and, therefore, the cost becomes excessive. One method of cost reduction is to create a foundation trench in the face of the slope, 10 feet below the surface of the reservoir. The trench is used to support the large stones keyed into the existing materials of the embankment. The large stones can then be used to support the riprap as it is placed up the slope.

Alternatives 13 and 17 will require the least amount of additional protection, with approximately 84,000 square yards of embankment surface area to cover.

Alternatives 14 and 18, which drop the reservoir by 43 feet, require approximately 94,000 square yards of riprap cover.

Alternatives 5, 9, 15, and 19 propose lowering the reservoir by 57 feet. Approximately 105,000 square yards of riprap cover will be required for the protection of the exposed slopes.

The natural river option, alternative 4A, creates the most drastic change in the river elevation. An estimated 116,000 square yards of riprap cover will be necessary for embankment protection.

6.06. Construction Procedures

All riprap protection will be placed prior to drawdown operations. Because the material will be placed underwater, additional material over and above the traditional 2-foot layer is necessary to insure adequate coverage of the embankment. To meet this requirement, riprap will be placed on the slope in a 3-foot layer.

It is anticipated that placement of the riprap will be by a clam bucket, maneuvered by crane and operated from a barge. Initial placement will begin at the toe of the embankment, or in an excavated trench, and progress up the slope. Placement will proceed until the new riprap overlaps the existing riprap by 5 feet.

In this report, it is assumed that the Government will furnish quarries for the production of riprap material. The location of the quarries are assumed to be at 20-mile intervals along the reservoir. Processed material at the quarry will be trucked to a barge loading facility, and barged to the construction area.

6.07. Predesign Considerations

Current embankment information is not adequate for determining the true quantities needed for riprap. In order to obtain quantities for construction, soundings of all the existing embankments will be necessary. Post-construction soundings will also be necessary to show areas that were missed during placement, and to allow for the implementation of protection before the actual drawdown.

Section 7 - Embankment Stability and Drawdown Rates

7.01. General

The rate at which reservoir pool levels can be lowered from minimum operating pool is dictated by stability considerations for dam embankments, levees, railroad and highway fills, and the natural slopes. Soils that make up the fills become saturated during normal pool operations. When the reservoir pool is lowered, the entrapped water slowly drains from the soils. If the entrapped water does not drain at a rate proportional to the lowering of the reservoir, unbalanced forces begin to build within the fill. When the unbalanced forces exceed the strength or shear resistance of the soils, failure of the embankment will occur.

7.02. Existing Conditions

Embankments, or fill sections, are visible along the perimeters of the reservoirs. The stability of these fills is designed by balancing the forces of the soil and the reservoir conditions.

To achieve stability, a 1 vertical-to-2 horizontal slope on the face of the embankments has proven successful. The sloped surface of the fill extends until it intersects the original ground line. Typically, embankments extend for a distance of 20 to 40 feet but, near the dam, a typical embankment will extend to the original river channel for a vertical height of more than 100 feet.

At the time of construction, a 27-inch blanket of riprap was used to cover the embankments and protect the finer grain soils. Existing riprap, or the placement of additional riprap, does not aid in stability requirements. To provide additional stability, the sloped 2-to-1 surface must be flattened. Because the fills border the river, the possibility of extending the slopes of the embankments is limited because of encroachment into the river channel.

7.03. Effect of Drawdown Alternatives

Problems commonly associated with fill sections include pounding of water, saturation, non-uniform consolidation, and stability.

Saturation of the embankment takes place when a soil mass is submerged in water. The water under pressure from the reservoir percolates into the voids, or spaces, that surround the soil particles. The entrapped water takes up space and, depending on reservoir elevation, exerts pressure on the surrounding soil. If the reservoir elevation drops below the level of the entrapped water, the water in the soil begins to drain. As the water leaves, the surrounding soil is no longer supported by pressurized water and begins to consolidate. The result is an embankment that moves and shifts as the forces acting on the soil particles try to reach equilibrium.

Water leaving the soil allows the soil particles to move closer together. The consolidation of these particles results in a densification of the soil mass. As the soil particles move down the fill, they become closer, and lower the overall height of the fill. The drop in the surface is not uniform. Different types of soils allow different rates of consolidation and densification.

As soil movement takes place, the stability of the embankments is also impacted. Stability is the ability of the embankment to support a load. This load can be buildings, vehicles, or the soil mass itself. Movement of the soil reduces the shear strength commonly found in consolidated soil. When the resisting strength forces of the soil are not sufficient, the embankment will slide. The fill will slide until the slopes of the embankment faces flatten, and equilibrium is again achieved.

7.04. Required Modifications

The risk of embankment instability is directly related to the drawdown rate. A drawdown rate of 1 foot per day is considered to have minimal risk and is, therefore, acceptable. A 3-foot-per-day drawdown rate has a great deal of risk, along with great potential for failure. Assuming different strength parameters during an analysis of the slopes, it is concluded that a 2-foot-per-day drawdown rate, although carrying a high degree of risk, is an acceptable compromise.

Tests for justifying a 2-foot-per-day drawdown were implemented during the 1992 Lower Granite drawdown. Predictions on slope stability and the potential for failure were confirmed. Predominately, failures occurred along private embankments constructed from silts or fine grain material. Differential settlement was also noted along roadway and railroad fill sections. Although a catastrophic failure did not occur, measurable soil movement was recorded.

The 2-foot-per-day drawdown rate is still considered applicable, because increasing the rate also increases the risk of failure. Decreasing the rate, while attractive for stability purposes, increases the time needed to reach target pool elevations, and increases the drawdown time.

7.05. Construction Procedures

Because of the potential for embankment failure, precautions must be implemented prior to lowering the reservoirs. Material must be stockpiled, and equipment mobilized, prior to any drawdown. Contracts will have to be initiated for quarry production of remedial fill materials. Contingency emergency plans must be outlined, and observation crews mobilized.

7.06. Predesign Considerations

Pre-drawdown modifications are not practical because the extent of the embankments is too massive, and potential failure areas cannot be clearly defined. The best procedure for protection is a controlled rate of lowering the reservoir and allowing the entrapped water to drain from the fills.

Precautions for reestablishing failed fills must be in place prior to drawdown operations. Even at a 2-foot-per-day drawdown rate, a potential for embankment failure still exists. Due to construction procedures, failure will most likely occur on a highway or railroad fill. Methods, materials, and emergency plans must be initiated prior to lowering the reservoirs. At the time of the drawdown, observation crews will have to monitor the embankments.

Section 8 - Downstream Weir Concept

8.01. General

The Pacific Northwest has suggested the use of the spillways only on the lower Snake River dams as a method to pass juvenile fish past the projects. In addition, the use of a downstream weir has been suggested as a method of controlling tailwater elevations during spill operations. This will minimize flow conditions impacting adult fish passage, avoid modification of adult entrances, and provide for effective stilling basin energy dissipation while still minimizing increases in dissolved gases.

This section is a review of the hydraulic conditions expected if a downstream weir were employed for such purposes. Lower Granite Dam was selected for examination of the downstream weir concept.

8.02. Hydrology

The flow duration curve during the April 15 through June 15 time period (period of record 1976 to 1990, Lower Granite Mean Daily Inflow) provides the following information:

Flow Duration Curve 15 April Through 15 June	
Discharge (cfs)	**Percent Exceedance**
153,000	10
95,000	50
46,000	90

Flow Duration Curve 1 April Through 30 April	
Discharge (cfs)	**Percent Exceedance**
113,000	10
69,500	50
31,400	90

Flow Duration Curve 1 May Through 31 May	
Discharge (cfs)	**Percent Exceedance**
156,500	10
98,400	50
48,900	90

Flow Duration Curve 1 June Through 30 June	
Discharge (cfs)	**Percent Exceedance**
174,000	10
92,500	50
32,600	90

The flows from the April 15 through June 15 duration curve were examined for each of the weir lengths described in paragraph 8.04.

8.03. Description

a. General

The purpose of the downstream weir is to provide tailwater control, during drawdown operations, on the existing spillway and powerhouse by allowing existing fishway entrances to function. It also allows the flip-lip on the spillway to operate effectively, by keeping nitrogen gas levels within acceptable ranges, while still providing effective energy dissipation for spillway discharges.

The flip-lip at Lower Granite is at elevation 630.0 fmsl. If the flip-lip is to function as intended, the water surface must be at an elevation approximately equal to the existing tailwater levels, assuming full powerhouse discharges, in addition to spill operations. This will create a skimming flow, which reduces the plunging action of the water and minimizes nitrogen gas levels.

If existing adult entrances are to function during drawdown operations, the tailwater elevation must be no lower than elevation 633 fmsl and no higher than 642.0 fmsl.

If there is to be effective adult fish passage, any installed weir must maintain a water surface elevation within a range of 633 to 642 fmsl upstream of the weir, in order to allow adult passage through existing entrances. In addition, a tailwater closely matching existing conditions will reduce stilling basin-related dissolved gas problems, while minimizing potential structural damage to the basin.

This analysis assumes that the next downstream project (Little Goose) is being operated at a pool allowing a free-flowing river condition just below Lower Granite Dam.

b. Weir Types

Two weir types are examined in the analysis found in paragraph 8.04: 1) a fixed crest weir; and 2) an adjustable crest weir.

c. Possible Locations.

Two possible locations for weir installation have been identified at Lower Granite. The first possible location (A) is about 900 feet downstream from the powerhouse. A weir can be installed between the south shore and the navigation lock, and will be in front of the powerhouse and spillway only. The river width in this location is approximately 1140 feet (see plate 54) with the river bed in this location generally varying in elevation from 605 to 610 feet across the width.

The second possible location (B) is about 1750 feet downstream of the powerhouse. A weir installed here will span the entire river. The river width in this location is approximately 1550 feet. The river bed in this location generally varies in elevation from 605 to 615 feet across the river width.

8.04. Fixed Weir

a. Location A

At location A, a 1,140-foot broadcrested fixed weir can be installed that spans the front of the powerhouse and spillway. The crest elevation will be set based on the low flow condition expected during the time period. Using 46,000 cfs as the low flow condition, the crest will be set at elevation 627.5 fmsl in order to achieve a water surface elevation upstream of the weir of 633.00 fmsl or greater. The following conditions will be achieved for the various flows:

Discharge cfs	TWEL fmsl	CREST fmsl	UPSWE fmsl	DH feet
46,000	621.5	627.5	633.0	11.5
95,000	627.5	627.5	636.7	9.2
153,000	633.0	627.5	641.1	8.1

(NOTE: TWEL refers to water surface elevation downstream of the weir. UPWSE refers to water surface elevation upstream of the weir. DH refers to the difference between water surface elevation on either side of the weir.)

In general, adult fish begin to have difficulty negotiating a water surface differential greater than 3 feet. Therefore, using a fixed weir crest set at elevation 627.5 feet will block all adult passage at the weir.

b. Location B

At Location B, a fixed crest broadcrested weir can be installed that will increase the weir length, but span the entire river. The length of weir that can be installed in this location is approximately 1550 feet. The crest elevation will be set based on the low flow conditions expected during the time period. Using 46,000 cfs as the low flow condition, the crest will be set at elevation 628.7 fmsl to achieve a water surface elevation upstream of the weir of 633.0 fmsl or greater. The following conditions will occur for the various flows:

Discharge cfs	TWEL fmsl	CREST fmsl	UPSWE fmsl	DH feet
46,000	621.5	628.7	633.0	11.5
95,000	627.5	628.7	635.7	8.2
153,000	633.0	628.7	639.2	6.2

In general, adult fish begin to have difficulty negotiating a water surface differential greater than 3 feet. Therefore, using a fixed weir crest set at elevation 628.5 feet will block all adult passage at the weir.

8.05. Adjustable Weir

The use of an adjustable crest has been suggested as a means of maintaining a differential that allows fish passage around the weir. In this analysis, the crest elevation was varied to minimize the difference in water surface elevation across the weir while still maintaining the water surface above the weir at or above elevation 633.0.

a. Location A

Discharge cfs	TWEL fmsl	CREST fmsl	UPSWE fmsl	DH feet
46,000	621.5	627.5	633.0	11.5
95,000	627.5	623.5	633.0	5.5
153,000	633.0	610.0	633.0	0.0

In the range of flows examined, the weir crest will need to vary in elevation from 610.0 to 627.5 fmsl (17.5-foot range) to minimize upstream water surface elevation. Even with this adjustment capability, adults will not easily be able to negotiate the weir until flows exceed 95,000 cfs. If good adult passage is to occur, the water surface elevation upstream of the weir must be between 633 and 642 fmsl, and the difference between water surface elevations on either side of the weir must be less than 3 feet.

b. Location B

Discharge cfs	TWEL fmsl	CREST fmsl	UPSWE fmsl	DH feet
46,000	621.5	628.4	633.0	11.5
95,000	627.5	625.5	633.0	5.5
153,000	633.0	610.0	633.5	0.0

In the range of flows examined, the weir crest will need to vary in elevation from 610.0 to 628.4 fmsl (18.4-foot range) to minimize upstream water surface elevation. Even with this adjustment capability, adults will not easily be able to negotiate the weir until flows exceed 95,000 cfs. If good adult passage is to occur, the water surface elevation upstream of the weir must be between 633 and 642 fmsl, and the difference between water surface elevations on either side of the weir must be less than 3 feet.

8.06. Adjustable Weir with Fish Ladders

Adult fish passage will be unacceptably inhibited by the use of either fixed or adjustable crest weirs. One possible method of providing passage is to install vertical-slot fishways at various points across the weir. These ladders may allow the passage of fish from below the weir to immediately above the weir. To examine this concept, it was assumed that vertical-slot ladders will be installed in conjunction with an adjustable crest weir. The weir will be made up of ten 100-foot-wide drumgates (see plate 55). Between the drumgates, 14-foot piers will be installed that will contain 10-foot-wide vertical-slot fish ladders. A total of nine fish ladders will be provided. At location A, the total effective weir length will be approximately 1000 feet. [Location B, as evidenced by previous analysis, provides additional weir length but little added benefit. Interference with navigation is exaggerated with piers and fish ladders, and will likely require special (and costly) features to allow barge or tug passage during normal operating pool levels. Location A will accomplish the desired task without interference to navigation. Therefore, for this discussion, location B will not be considered.]

The effect of the piers (and associated ladders) is reflected in the following:

Discharge cfs	TWEL fmsl	CREST fmsl	UPSWE fmsl	DH feet
46,000	621.5	626.8	633.0	11.5
95,000	627.5	622.2	633.0	5.5
153,000	633.0	610.0	633.5	0.0

The ladders will automatically adjust for the changing pool levels. A single ladder will pass around 47.0 cfs at a water surface elevation difference of 11.5 feet, and 42.0 cfs at a water surface elevation difference of 5.5 feet, for the pool water surface elevations shown above. These ladder discharges are insignificant when compared to the flow past the drumgates. Adult fish may have difficulty finding these ladder entrances, and substantial adult migration delays can result.

8.07. Summary

a. General

Few, if any, adult fish will be able to negotiate the fixed crest weir at any discharge. Adult fish should be able to negotiate the adjustable weir under flows higher than 95,000 cfs. Adults that are able to negotiate the weir must still find ladder entrances at the powerhouse. The adjustable weir concept can be improved, in terms of adult fish passage, by the addition of vertical-slot fish ladders. However, substantial adult delay may result, due to the limited amount of water supplied by the vertical-slot ladders as compared to water flowing past the weir.

The use of the spillway only is anticipated to create currents upstream from the weir similar to the conditions observed during the 1992 Drawdown Test. During the drawdown test, large eddy conditions existed in front of powerhouse entrances when the spillway was operated. The eddy conditions may confuse adults, and perhaps even lead them away from operating ladder entrances, resulting in a substantial delay in their migration process.

A downstream weir will not substantially change dissolved gas levels associated with spill operations. Even with existing tailwater elevations, high levels of dissolved gasses occur when large quantities of water are spilled. Dissolved gas levels in the river are theoretically less if both powerhouses and spillways are used to pass river discharges. The low dissolved gas level flows associated with powerhouse operations, combined with the higher dissolved gas level flows associated with spillway operation, will result in a lower dissolved gas level in the river (see appendix A, section 3). Operation of spillways with flip-lips reduces dissolved gas levels over that of spillway operations without flip-lips, but the resulting gas levels are still unacceptable without powerhouse discharges.

b. Recommendation

A downstream weir is not recommended as a solution to adult fish passage problems or as a solution to the dissolved gas problem created by only operating spillways. A downstream weir will create another barrier to adult fish passage and, when used in conjunction with a spillway-only operation, will not resolve adverse eddy conditions above the weir. Fish that get past the weir will have difficulty finding operating fishway entrances. In addition, the weir will not fully resolve the dissolved gas problem. Acceptable tailwater elevations, plus operation of the powerhouse, is required to achieve acceptable levels of dissolved gasses when spillway operation occurs.

If the operation consists of operating powerhouses to hydraulic capacity before allowing water to spill, it is possible that a downstream weir can be used to maintain tailwater elevation so that adults can utilize (without modification) existing fishway systems. However, the additional barrier or obstacle created by the weir will cause additional migration delay, and will likely be unacceptable. A more acceptable approach is to extend the operational range of existing systems, by modification, as described in appendix A, section 1.

Section 9 - Volume Forecasting

9.01. General

The National Weather Service, Portland River Forecast Center, is the official office responsible for issuing coordinated runoff volume forecasts, peak flow forecasts, and floodstage forecasts for key gauging stations within the Columbia River Basin. There is a three-member technical committee that provides technical advice and guidance to the Columbia River Forecasting Service. The three committee members are as follows:

Chief, Hydrologic Engineering Section,
North Pacific Division, U.S. Army Corps of Engineers

Hydrologists-In-Charge, National weather Service,
Portland, Oregon, River Forecast Center

Chief, Hydrometeorology Branch,
Bonneville Power Administration

9.02. Volume Forecasts

Runoff volume forecasts are the basis for operation in the Columbia River Basin system. These forecasts are based on statistical relationships of precipitation. In the winter months, most of the precipitation in the Snake River drainage basin is snow. Runoff volume forecasts do not account for the distribution of flows during the forecast period. Daily flow distributions are a function of temperature, precipitation, snowpack ripeness, and many other factors.

Volume forecasts are used as a general estimate of the total volume of runoff water expected within the drainage above the forecast point.

In the Snake River arm of the Columbia River Basin, snowpack generally accumulates at the following rates:

Date	Percent Snowpack
1 January	33
1 February	60
1 March	80
1 April	95

9.03. Real-Time Forecast

Short-term (about 10 days) daily regulation modeling is conducted beginning about April 1, and continues until the flood potential becomes minimal (usually some time in July). Since weather forecasts are usually reliable for no more than 3 to 5 days in advance, the hydrometeorological factors affecting runoff must be extended during the forecast period, on the basis of average and extreme snowmelt conditions, in order to compare probable flows with the most severe flows likely to occur.

9.04. Conclusion

The use of volume forecasting to determine if a lower Snake River reservoir drawdown should, or should not, occur is not expected to provide a dependable procedure for fish flow operations. Daily fluctuations in streamflows are more temperature dependent, and are not directly related to runoff volumes.

Section 10 - Real Estate

10.01. General

This section discusses real estate issues associated with the relocations required by drawdown alternative 4A, the Natural River Option. Relocations are also discussed in appendix A, section 6. The issues discussed apply equally to alternative 15 - Existing Powerhouse with New Low-Level Spillway and alternative 19 - Modified Powerhouse with New Low-Level Spillway.

10.02. Lower Granite Lock and Dam

All of the real estate necessary for construction at the damsite is currently available within the Government's project boundary (see plate 58). However, in order to facilitate construction, certain considerations must be taken into account as part of project implementation. Work on the right dam abutment will require the relocation of the project access road and approximately 1 mile of Union Pacific Railroad. These relocations can be accomplished on-project. The waste area is to be located on the right bank of the Snake River, on a bench just downstream from the dam. It will accommodate approximately 3.2 million cubic yards of material. Although it is the most efficient location for this purpose, impacts will accrue to a landing strip (outgranted to the State of Washington) lying immediately below and adjacent to the fill site. The magnitude and volume of filling and regrading activities may require reconstruction of the airstrip as part of the project.

10.03. Little Goose Lock and Dam

All real estate necessary for construction at the damsite is currently available within the Government's project boundary (see plate 59). However, in order to facilitate construction, certain considerations must be taken into account as part of project implementation. Work on the right dam abutment will require the relocation of the project access road, an approximate 1½-mile segment of Union Pacific Railroad, and part of a Bonneville Power Administration underground cable. It is anticipated that all of these facilities can be relocated on-project. There is also a cattle-watering corridor reservation that will have to be reconstructed or relocated. The waste area is to be situated on a right bank bench of the Snake River just below Little Goose Dam. Part of the 2.8 million (+/-) cubic yards of fill material will be placed upon the Henley Habitat Management Unit, which is an area recently acquired as partial mitigation for habitat losses created by the four lower Snake River dam and reservoir projects. Depending upon the impacts imposed by the fill in this area, replacement mitigation lands may need to be acquired. At present, this class of land is selling for $1,200 to $1,600 per acre. The waste site will also impact several towers supporting Bonneville Power Administration high tension wires that connect a nearby substation with points south across the river. These Bonneville Power Administration facilities are also likely to require relocation on-project.

10.04. Lower Monumental Lock and Dam

Most real estate necessary for construction at the damsite is currently available within the Government's project boundary (see plate 60). However, because of a requirement to relocate a segment of Union Pacific Railroad, approximately 11 acres of additional land (at a cost of about $100 per acre) must be acquired in fee simple title. This will be accomplished pursuant to the standard estate set forth within paragraph 1, figure 5-6, change 7, to Engineer Regulation 405-1-12. A Walla Walla County road will be impacted, because the railroad's realignment will cause a crossing in a new location on-project. Accordingly, a new license-to-cross will be required. The waste area, slated to accept 6.1 million (+/-) cubic yards of material, will be situated on the left bank of the Snake River (about 1½ miles below the dam). Filling this area will impact several Bonneville Power Administration electric transmission lines. Depending upon final engineering criteria and design, these transmission lines may need to be relocated on-project, or reconstructed in place. Additionally, access to the Matthews Recreational Site will also be affected, as well as the usability of the site. Appropriate reconstruction of this will be required on available project lands.

10.05. Ice Harbor Lock and Dam

All real estate necessary for construction at the damsite is currently available within the Government's project boundary (see plate 61). However, prior to construction certain realty considerations must be taken into account and addressed. Work on the left dam abutment will require relocation of project, Bonneville Power Administration, and Walla Walla County road segments. It may possibly include the Bonneville Power Administration electric transmission lines as well. No new acquisition is anticipated for these relocations. Additionally, two sites of cultural or historic significance will be impacted by construction. The first site is a petroglyph monument, situated above the dam, the commemorates Indian burial grounds that were inundated by reservoir waters. This monument will require relocation. The second area lies just below the dam on the left shore. Rocks at this location were historically used by tribal groups for fishing and other purposes and, therefore, have cultural significance. Any required mitigation or preservation measures will have to be addressed in subsequent assessments before project implementation. The waste area also lies on the left shore, just below Ice Harbor Dam. This is a bench intended to accommodate 4 million (+/-) cubic yards of material. No major facilities will be impacted by this waste site.

10.06. Real Estate Cost/Scheduling

The majority of real estate costs will be administrative in nature, as existing project lands will accommodate most of the proposed construction, waste/borrow material sites, and relocations. It is anticipated that it will take a minimum of 1 to 1½ years to resolve all issues and acquire the necessary real estate. This involves negotiating relocation contracts, acquiring land near Lower Monumental Dam to define project limits, and acquiring suitable habitat mitigation land to replace what will be lost at the Henley Habitat Management Unit near Little Goose dam. The overall real estate costs are estimated (in lump sum) at about $250,000. A line item breakdown is currently not feasible because of the many variables that have yet to be resolved at this level of study. This estimate will become more precisely defined in subsequent planning.

Section 11 - Idaho Plan

11.01. Description

Interests within the region have suggested that modifications to Lower Granite Dam be initiated as a first step in implementing a four reservoir drawdown of the lower Snake River reservoirs. This phased construction was first suggested by the State of Idaho, and has been since labeled the "Idaho Plan." The modification of Lower Granite would represent the first step toward the eventual drawdown at all the lower Snake reservoirs and could provide a method to test the validity of drawdown as a permanent solution. Proponents suggest that a 2-month drawdown of Lower Granite Dam could then be used to demonstrate the effectiveness of drawdown, and test whether juvenile and adult fish can be safely passed through Snake River dams during drawdown operations. This section describes the necessary modifications, schedules, and costs associated with a "first step" implementation of drawdown at Lower Granite Dam. In addition, the remaining modifications, including costs and schedules, at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams required to fully implement a four-reservoir drawdown are discussed. For this evaluation, the 33-foot drawdown, constant pool alternative (alternative 13), was used.

11.02. References

Lower Granite Dam Modification for Drawdown, background and briefing paper, presented by Andy Brunelle to the Northwest Power Planning Council's Drawdown Committee.

11.03. Required Modifications

a. General

The "Idaho Plan" will require changes to Lower Granite Dam initially, as illustrated on plate 62 and described in the following paragraphs. Modifications to the other three dams would follow in later years, assuming that biological drawdown evaluations at Lower Granite Dam are positive. Since Little Goose reservoir (pool) will not be lowered initially, the water surface elevations below Lower Granite will not be affected. Hence, the modifications required at Lower Granite will initially be limited to the upstream forebay side of the dam.

b. First Step Modifications

(1) Low-Level Juvenile Bypass System

With the lowered pool levels, the existing juvenile bypass system will be inoperable. A new lower-level juvenile bypass system will be required to collect and pass juvenile fish around operating turbines to the tailrace. Because of the restricted magnitude of forebay fluctuation at the drawdown level (+/- 5 feet), the collection channel can be constructed as an open channel flow system similar to that currently employed at the lower Snake river dams. Fish and water would be passed directly to the tailrace, or to holding and loading facilities below Lower Granite Dam. Juvenile fish transportation can occur, since navigation below Lower Granite Dam will still be possible with the Little Goose reservoir at normal pool levels. A new set of VBS's will be required to provide for the highest possible levels of OPE. The new screens will be put in place prior to drawdown, and left in place during drawdown and refill. The existing VBS's would be put back in place after refill, for improved efficiency at the normal operational range.

(2) Adult Facilities

The addition of secondary low-level adult ladder exits and auxiliary exits will be required. Once the low-level (drawdown) operating pool has been reached, the secondary low-level ladder exit can be used. As long as Lower Granite is the only reservoir pool to be lowered, tailwater elevations will not initially be changed. Therefore, no modifications to adult fish entrances, collection channels, or auxiliary water systems will be necessary.

(3) Existing Spillway/Stilling Basin Modifications

As long as Lower Granite is the only reservoir pool to be lowered, tailwater elevations will not initially be changed. Therefore, no modifications to the spillway or stilling basin will be necessary.

(4) Miscellaneous Modifications

Miscellaneous features at Lower Granite Dam and in, or adjacent to, the reservoir will require modification to allow operation, or to prevent damage when pool levels are lowered below minimum operating levels. These features include the floating navigation lock guide wall, culvert and pipe outfalls, the debris shear boom, and the water quality siphons (Lewiston Levees).

(5) Embankment Protection

The protection of embankments upstream of Lower Granite will be required.

c. Remaining Modifications at Lower Granite Dam

Following biological evaluations (assuming that benefits are positive), the remaining modifications to the adult fishway collection system and spillway stilling basin would occur. These are the same modifications as previously described for alternative 13.

d. Modifications to the Other Three Dams

Modifications to Little Goose, Lower Monumental, and Ice Harbor Dams would be the same as previously described by alternative 13.

11.04. Operation

For a drawdown operation of Lower Granite to target elevations 700 to 705 fmsl, drafting will begin no later than March 29 in order to reach the lowered pool elevations by April 15. The storage that will be evacuated, from full pool elevations to target drawdown elevations, is estimated to be 231,000 acre-feet (AF). If reservoir pool elevations are maintained at their drawdown levels during the April 15-to-June 15 time period, refill of the reservoirs will take approximately 2 days (with average inflows of 95,000 cfs). Given the 1992 inflows after mid-June (averaging 21,000 cfs), refill of the Lower Granite reservoir will take about 6 days.

For a four-reservoir drawdown operation, the four lower Snake River projects will begin drafting no later than March 29 in order to reach the target drawdown elevations by April 15 each year. The total reservoir system storage that will be evacuated, from full pool elevation to the drawdown elevations, is estimated to be 900,000 AF. If reservoir elevations are maintained at their drawdown levels during the April 15-to-June 15 time period, refill of the reservoirs will take approximately 6 days (with average inflows of 95,000 cfs). However, the refill time will increase dramatically in low water years. Given the 1992 inflows after mid-June, averaging 21,000 cfs, refill of the reservoirs will take about 48 days. If reservoirs are maintained at their drawdown levels from April 15 to after Labor Day, refill of the reservoirs will begin around September 5, and will take approximately 25 days provided average inflows of 30,000 cfs are achieved. The time for refill will vary, depending on inflows. During low water years, when average inflows can drop to around 20,000 cfs, refill may take as long as 54 days.

11.05. Biological Testing

Following the initial modifications of Lower Granite Dam, one or two juvenile fish outmigration periods could be utilized for the biological testing of drawdown. Juvenile fish travel time and survival estimates through the Lower Granite forebay will be attempted. The fish guidance efficiencies of existing submerged traveling intake screens could be measured, as could performance of the new low-level juvenile collection and bypass system. Evaluation of the effects of drawdown on the efficiency of the adult fish collection system will not be possible, since the water surface elevations below Lower Granite Dam will remain at normal levels.

11.06. Implementation Schedule

Assuming that funding and resources are available when required, it is estimated that it will take about 4 years from the date authority and appropriation are received to implement the initial first-step modification of Lower Granite Dam (refer to plate 63). This implementation schedule assumes unlimited resources. Limitations on resources such as manpower, money, or materials may extend this schedule.

Following the first-step construction activities, biological evaluations would commence for two juvenile outmigration periods. No construction would occur to the other three dams below Lower Granite until results of the evaluations are received and analyzed.

If evaluations show benefits to juvenile fish, engineering design and construction would proceed on the remaining modifications to Lower Granite Dam and the other three dams. The completion of all remaining modifications will require an additional 10 years. The total time required to implement a four-reservoir drawdown, following the "Idaho Plan" strategy, is 15 years.

11.07. Cost Estimate

The reconnaissance-level, fully-funded project cost for the first-step modifications of Lower Granite Dam is estimated at $87.2 million. Should biological evaluations be positive and alternative 13 is pursued at the other three dams, then an additional $382.3 million would be needed to complete the remaining modifications to Lower Granite Dam and $963.2 million for modifications to the other three dams. The total reconnaissance-level, fully-funded project cost for all four dams, following the "Idaho Plan" implementation schedule, would be $1.4 billion. These costs include planning, engineering and design, construction management, contingencies, and inflation to midpoint of construction. A cost breakdown is displayed in appendix C.

Project	Costs
Lower Granite--First Step Modifications	$87,210,000
Lower Granite--Remaining Modifications	$382,333,000
Little Goose	$482,826,000
Lower Monumental	$417,930,000
Ice Harbor	$62,479,000
Total	**$1,432,778,000**

Costs for environmental, irrigation, navigation, hydropower, and recreation mitigation are not included. These costs are based on an October 1992 price level, escalated to midpoint of construction. These costs are to be used in the planning process for comparative purposes only. ?they are not of sufficient detail for project authorization or appropriation.

11.08. Summary

The "Idaho Plan" strategy will not allow evaluation of the effects of drawdown on adult fish passage systems until all modifications are completed at all dams. With the Little Goose pool at normal operating levels, the adult collection system would not be modified or functioning at drawdown tailwater elevations. There is concern that the lowered adult collection channels and entrances will be too close to turbine draft tubes. Adults, normally swimming in the upper portions of the water column, may be attracted into the turbine draft tubes rather than the fishway entrances, thus causing considerable delay and stress. An implementation plan that would allow evaluations (including adult systems) would require some modifications to Little Goose Dam, as well as the complete implementation of all modifications to Lower Granite Dam. The total construction time for alternative 13 will be increased by about 1 year over the schedule proposed in section 5 of this report. In addition, the "Idaho Plan" strategy will cost approximately $140 million more to implement than the schedule proposed for alternative 13 in section 5.

Section 12 - Side Channel Spillway Concept

12.01. General

Following their review of the U.S. Army Corps of Engineers (Corps) System Configuration Study Phase I Interim Report, Harza Northwest recommended that a side channel spillway concept be investigated. The side channel spillway concept was promoted as a potentially less expensive option than modifying existing spillways, as proposed in alternatives 14 and 18. Modifying the existing spillways calls for lowering the crests by 10 feet to accommodate drawdown pool levels below the existing spillway crest elevations.

The Drawdown Committee requested that the Corps, in coordination with Harza Northwest, evaluate the cost effectiveness of the side channel spillway concept. This evaluation will: 1) identify preliminary design criteria, designs, and construction cost estimates for the side channel spillway concept; 2) describe the necessary modifications required for the existing spillways (including construction costs); and 3) compare the costs for these alternatives.

This section presents the requested evaluation. For the purposes of evaluation and comparison, construction of a side channel spillway at Lower Granite Dam was compared to lowering the existing spillway crest at Lower Granite Dam.

12.02. References

Engineer Manual (EM) 1110-2-1601, Hydraulic Design of Flood Control Channels, dated 1 July 1970.

EM 1110-2-1603, Hydraulic Design of Spillways, dated 16 January 1990.

"Analysis of Reservoir Drawdowns," draft report to the Drawdown Committee, by Harza Northwest, dated 14 December 1992.

Faxed information from Brian Sadden, Harza Northwest, Inc., dated 20 May 1993.

12.03. Side Channel Spillway Structure

a. Pertinent Design Criteria

The pertinent design criteria includes the following:

- This side channel spillway crest should be set to achieve 40,000 cfs discharge, with water surface equal to the existing spillway crest elevation of 681.0 fmsl.
- Location on left abutment of Lower Granite Dam. If excavation is too large, then split flow between both abutments (15,000 cfs each side) by possibly building two side channel spillways and bypasses.

- Construction as far as possible to be behind a "natural cofferdam" of unexcavated rock.
- Design channel to be "fish friendly."

b. Side Channel Spillway Features

Side cannel spillway features include the following:

- Side channel spillway crest section and channel.
- Transitional section from trapezoidal shape to rectangular shape.
- Gate control section.
- Channel from spillway to tailrace.
- Stilling basin.

c. Preliminary Design (Refer to Plates 64 and 65)

(1) Tailwater Elevation

This design assumes that tailwater elevations would be a minimum of 633.0 fmsl. For a river discharge of 40,000 cfs, this elevation would be achieved if the Little Goose reservoir was operated at normal minimum elevation, or if downstream rock fill weirs were installed. If the Little Goose reservoir was to be operated at a drawdown level, then the minimum tailwater elevation would be 620 fmsl at Lower Granite, for a river discharge of 40,000 cfs.

(2) Crest Length and Shape

A variety of crest lengths were examined. The crest length used was 400 feet, with a crest elevation of 671.5 fmsl. This provides 9.5 feet of head (water surface elevation of 681.0 feet), for a discharge of 40,000 cfs. A coefficient of discharge of 3.4 was assumed. The crest shape conforms to an elliptical shape on the upstream quadrant, and a parabolic shape on the downstream quadrant according to reference 2.b. The shapes match upstream and downstream slopes of 1:1 and 3:2, respectively.

(3) Spillway Channel

Through iterative analysis, the channel width (bottom width) was determined to be 50 feet, with a depth of about 46 feet. Side slopes within the spillway channel section are 4:1 and 3:2. The maximum water surface elevation within the channel for a design flow of 40,000 cfs was found to be 665 fmsl. This provides a freeboard from top of crest to water surface of about 6.5 feet. Invert elevations of the channel in the spillway sections vary from 625.68 to 624.15 fmsl. The water passes through the trapezoidal spillway channel into a symmetrical trapezoidal section with side slopes of 4:1, and then into a wedge-shaped transition from trapezoidal to rectangular. Immediately below the transition section, a gate control section would be installed that housed a tainter gate. This tainter gate would be operated either fully open or fully closed. The gate would be roughly 50 feet wide and 36 feet high. A gate slot and bulkhead would be installed immediately upstream from the gate to allow maintenance on the tainter gate and provide for emergency closure of the spillway, if necessary.

(4) Channel

The channel downstream of the gate control section would be rectangular in shape, and 50 feet wide and 36 feet high. The minimum slope of the channel to maintain supercritical flow would be 0.00383. This allows a normal depth of 0.9 times the critical depth or a depth of 24.4 feet, with a velocity of 32.8 fps. The channel length will be approximately 1150 feet. The channel height is 25 percent greater than the anticipated flow depth for the design condition to allow for waves, turbulence, and air bulking within the channel. The slope of the channel and side channel spillway section is the maximum slope available. In fact, when the spillway is not being operated, water from the tailrace will be standing within the spillway channel to a depth of about 9.0 feet. The invert of the side channel spillway (channel section) is less than the water surface elevation of the tailwater in the river below Lower Granite Dam.

(5) Stilling Basin

A stilling basin will be installed at the downstream end of the channel to dissipate the remaining energy. The basin is about 130 feet long and 50 feet wide, with a sloping end sill. The floor elevation of the basin will be about 603.0 fmsl. The invert of the channel exiting to the stilling basin is below tailwater elevation, or 618.6 feet. The depth of flow for a discharge of 40,000 cfs will be about 10 feet higher than the tailwater elevation (633.0 fmsl).

(6) Excavation/Construction

The depth of excavation for this side channel spillway would be approximately 140 feet to the invert of the channel, or 88.5 feet to the crest of the spillway section. The entire excavation will be in rock. The channel will be installed by tunneling through the left abutment around the dam. The majority of the tunneling is anticipated to be in rock.

(7) Possible Alterations

It may be possible to move the stilling basin downstream of one or two of the downstream rockfill weirs to minimize the tailwater on the system. This action would require additional channel length. In addition, if the rock fill weirs are not installed, the tailwater will be reduced to elevation 620 for a river discharge of 40,000 cfs, without the need to relocate the stilling basin or increasing channel length. It may also be possible to raise the channel in elevation (5 or 6 feet), by partially submerging the upper end of the weir, without adversely impacting the weir control or design discharge.

d. Operation

Operation of the side channel spillway will not occur until river flows are less than 40,000 cfs and the upstream reservoir pool is lowered to elevation 681.0 fmsl. When the side channel spillway is operated, turbine operation would cease and all river flows up to 40,000 cfs would pass through the side channel spillway. Under normal pool levels, the side channel control tainter gate will be closed and the spillway will be totally submerged. At design flows of 40,000 cfs, the hydraulic jump should move into the stilling basin. For flows less than the design flow, or for tailwater elevations in excess of 633.0, the jump will occur within the channel. If the side channel spillway is operated when tailwater elevations exceed 633.0, it may not be possible to pass the design flow since the channel may control the discharge rather than the spillway.

12.04. Existing Spillway Crest Modification

It appears possible to lower the existing spillway crests of all eight bays at Lower Granite Dam. The crest elevations would be lowered by 10 feet, to elevation 671.0 fmsl. This will allow the spillway to pass 40,000 cfs with the upstream pool at elevation 681.0 fmsl. The changes required are identified in the following paragraphs.

a. Spillway Crest Modifications

The existing spillway crest will be lowered 5 feet below its final elevation of 671.0 fmsl. Reinforcing steel will then be grouted into the spillway monolith. A 5-foot-thick layer of highly durable concrete will then be placed to achieve the final spillway crest shape. The lowering of the existing spillway crest will result in a reduction in the weight of the spillway monolith. In addition, the area of the spillway upstream of the tainter gates will have to be dewatered to structurally modify the piers and spillway crest. This eliminates the stabilizing effect from the weight of the water acting on the spillway. For these two reasons, the spillway monolith will become more susceptible to overturning and sliding from upstream hydrostatic loads. Consequently, pre-stressed and grouted rock anchors will be placed through the spillway monolith, approximately 15 feet into the sound rock foundation, to stabilize the structure. The anchors will be located to avoid the fishway channels and galleries within the monolith.

b. Pier Modifications

Because the spillway crest will be lowered 10 feet, the pier height will effectively increase and create higher hydrostatic loads on the piers than original design. In addition, the removal of spillway concrete reduces the embedment of the existing vertical pier reinforcing. This will significantly reduce the effectiveness of the reinforcement, and expose a portion of the spillway monolith where there is no horizontal reinforcing. For these reasons, additional concrete must be placed over the upstream face and sides of the piers. The new concrete will include horizontal and vertical reinforcing steel grouted into the spillway monolith. The reinforcing will be designed to resist horizontal hydrostatic loads, and will extend above the high water line crested during high flows over the newly-shaped spillway crest.

c. New Tainter Gates

Because the spillway crest will be lowered and the pier widths increased under this modification, the existing tainter gates will not be usable. Therefore, they will be replaced with new steel tainter gates. In addition to the new gates, new seal beams, hoisting equipment, side seal heaters, and relocated trunnions will be needed.

d. Modified Trunnion Beam

Because of the increased loads on the tainter gate and the relocation of the trunnions, the existing trunnion beam must be enlarged or replaced. This can be accomplished by placing additional concrete below the trunnion beam. The new portion of the beam will include new pre-stressing strands. Post-tensioned concrete anchors will be placed horizontally in the piers to transfer the loads from the tainter gates into the piers.

e. Modification of Existing Stoplogs

The existing stoplog guides will be extended down to the new spillway crest. Also, additional stoplogs will be required to allow dewatering of the tainter gates for maintenance.

f. Construction Cofferdam

Each spillway crest and pier must be dewatered for construction. To accomplish this, steel stoplogs will be required on the upstream face of the spillway monolith, and cellular cofferdams will be needed on the downstream side of the spillway.

(1) Downstream Cellular Cofferdams

The cofferdams will be installed in two phases. Phase 1 cofferdamming will dewater half the spillway bays and stilling basins. Following modification of the first half of the spillway bays, the cofferdam will be relocated (phase 2) to allow dewatering of the remaining spillway bays.

(2) Upstream Stoplogs

The stoplogs will span between spillway piers on each side of the spillway bay and will extend down to the riverbed. Guides will be placed on the upstream face of the piers. The guides must be installed underwater. Following the installation of the stoplogs, the entire spillway bay may be dewatered. Only one spillway bay may be worked on at a time. Following completion of the construction work for one spillway bay, the stoplogs will be removed with a portable crane and placed in the adjacent spillway bay. This process will be continued until all bays have been modified.

12.05. Costs

The costs for the side channel spillway are estimated at $847 million. Lowering all eight spillway bays at Lower Granite Dam is estimated at $280 million. These costs include contingencies, planning, engineering and design, construction management, and inflation to the midpoint of construction. The cost estimates for both options are detailed in appendix C.

12.06. Summary

The construction of a side channel spillway was proposed as an alternative to lowering the existing spillway crests for drawdown alternatives 14 and 18. To pass 40,000 cfs free flow over the existing spillway, at a pool elevation of 681.0 feet, the existing spillway crests (all eight bays at Lower Granite) would need to be lowered to about elevation 671.0 fmsl.

The side channel spillway was found to be about three times more expensive than lowering existing spillway crests. Original criteria provided by Harza Engineering suggested that, if excavation was excessive, a side channel spillway of lesser capacity could be provided on both shores. In effect, this action would double the costs, since the spillway crest elevation would be near the same depth as a single spillway and each would require a control gate, channel, and stilling basin excavated in rock.

Other concerns with the side channel spillway include the disruptions of tailrace conditions (eddies) that would make it difficult for adult fish to find existing fishway entrances. In addition to creating confusing tailrace conditions, it is likely that the discharge of the side channel spillway would attract adult fish into the channel stilling basin area. Adult fish would not be able to negotiate the velocities within the channel, but they would probably try. This would cause the adult fish to use some of the valuable energy reserves they need for upstream migration unnecessarily. The stilling basin area could possibly be screened to physically prevent adult fish from entering the channel. However, any debris that passes through the system would hold up on the back side of the screens. Also the effect of screening on juvenile fish that pass through the system would not be desirable.

The costs and fishery concerns related to the side channel spillway make this option less desirable than that of modifying existing spillway crests. It is recommended that the side channel spillway option not be considered further.

Section 13 - Rockfill Weir Concept

13.01. General

This concept was suggested by the region in the initial stages of the Corps System Configuration Studies. The TAG reviewed the concept and recommended that it be eliminated from further consideration due to suspected upstream adult fish passage problems. This review was identified in the Interim Report submitted by the Corps in December 1992. Harza Northwest, the contractor for the Drawdown Committee, reviewed the Interim Report and recommended that the weir concept receive additional evaluation. The concept's appeal stems from the belief that a weir system will result in cost savings and reduced construction time. If such a system is workable, modifications to the existing adult ladder system (including entrances, collection and transportation channels, and auxiliary water supply systems) may not be necessary. In addition, if tailwater could be controlled with a weir system, a gated tailwater control system below the existing stilling basins may not be needed. The Drawdown Committee specifically asked the Corps to reevaluate the concept. This analysis presents the results of the more detailed evaluation.

13.02. Scope

This analysis examines river channel hydraulics for two, three, and five rockfill weir installations in the river channel downstream from Lower Granite Dam. Lower Granite is used in this analysis as a typical Snake River project in order to determine the feasibility of installing downstream weirs (channel roughness) to control tailrace water surface elevations during drawdown operations. Design considerations include the effects on river navigation, adult fish passage, and spillway operations. In addition, discussions are presented concerning weir construction, stability, materials, costs, implementation processes, and uncertainties.

13.03. References

- Old River Project Rockfill Initial Closure Dam. Hydraulic Mode Investigation, Technical Report No. 2-496, March 1959.
- Lower Granite Dam, Snake River, Washington, Hydraulic Model Investigation, Technical Report No. 121-1, August 1984.

13.04. Assumptions

a. Operation

This analysis assumes that both Lower Granite and Little Goose Dams would be drawn down significantly, achieving a free-flowing section of river (channel control) between Lower Granite Dam and the reservoir pool at Little Goose Dam. In addition, it is assumed that if river discharges over 160,000 cfs occur, drawdown operations would cease and pools would be returned to normal operating levels.

The analysis also assumes that tug and barge navigation will not occur during drawdown operation of the lower Snake River reservoirs, but that it is desirable to maintain navigation when reservoirs are at normal operating levels.

b. Design Discharge

A weir structure with adjustable gates and adult fish ladder passage was previously examined (see appendix A, section 8) that utilized a low flow design discharge of 46,000 cfs. For comparative reasons, this same discharge value was used to set initial weir crest elevations for the fixed crest rockfill weir concept. This design discharge is exceeded 90 percent of the time during the April 15 through June 15 time period. If the drawdown period occurs outside of these dates, flows would be expected to be different and the discharge used for design would need to be adjusted.

c. Design Tailwater Elevation

The proposed weir systems are intended to provide a minimum tailwater elevation of approximately 633 feet above mean sea level at Lower Granite Dam, given the design discharge of 46,000 cfs and freeflow conditions downstream. At lower flows, the resulting tailwater elevations will be lower than 633.0, while at higher flows they will be higher.

d. Design Crest Elevations

In general, a weir will cause the water surface elevation to be higher on the upstream side of the weir than on the downstream side of the weir. For this analysis, weir crest elevations were chosen so that the elevation differential across each weir in a given configuration would be equal at the design discharge.

e. Number of Weirs

For this analysis, two-weir, three-weir, and five-weir systems were examined. Under freeflow conditions, the total rise in water surface elevation up to the dam from a point downstream from the weirs will be essentially the same, no matter how many weirs are included in the configuration. However, the water surface elevation differential across each weir will decrease as the number of weirs increases. This should be advantageous to adult fish passage.

f. Weir Locations

Locations were tentatively selected from topographical maps developed by soundings and aerial photography. Weir locations were also selected by considering tug and barge access to existing juvenile holding and loading facilities, proximity to the spillway stilling basin, and the navigation lock discharge structure.

g. Weir Spacing

Since the purpose for the weir system is to control tailwater elevations, the distance between weirs must be adequate for correct system operation. Weirs placed too close together will compromise system operation, and analytical prediction of the system's hydraulic performance would not be possible. In areas where tugs and barge tows will be negotiating weirs, under normal pool levels, the minimum weir spacing used was 600 feet. This would allow room for the tugs and tows to maneuver between weirs before attempting to cross the next upstream weir. For adequate hydraulic performance, a minimum spacing of approximately 350 feet is necessary. In addition, the placement of weirs too close to highly turbulent areas (i.e., the stilling basin or the lock discharge structure) could cause the weirs to be damaged or not work effectively. Therefore, a distance of 800 feet from the end sill of the stilling basin was used as a minimum distance criterion for placement of the first downstream weir.

h. Analysis Methods

For this analysis, leakage through the weirs was assumed negligible. Calibrated HEC-2 backwater computer models were used to develop preliminary river hydraulic information for all rockfill weir options.

13.05. General

a. Existing Conditions

All adult fish facilities at Lower Granite Dam are usable when the Little Goose reservoir is operated within its normal range. A minimum navigation channel depth of 14 feet is available for commercial tug/barge combinations throughout the length of the reservoir. In the Lower Granite tailwater reach, the minimum navigation channel depth is typically much deeper, varying from 22 feet to as much as 32 feet. For the purpose of this study, the tailwater reach is defined as the section of river extending from the dam to a point about 4000 feet downstream from Lower Granite Dam (river mile 106.6). The maximum normal operating tailwater elevations occur at Lower Granite Dam when Little Goose Dam is operated with a forebay of 638.0 feet. When Little Goose Dam is operated at its minimum normal operating forebay level of 633.0 feet, tailwater elevations at Lower Granite Dam are at their normal minimum. Corresponding tailwater elevations at Lower Granite Dam are higher than the Little Goose forebay elevations. The difference is small during low flows and large during high flows. River velocities in the Lower Granite tailwater reach increase as the Little Goose pool level drops, and as the discharges rise.

Tables 4, 5, and 6 show existing water surface elevations at river mile 106.6 and at the dam, the range of river velocities in the tailwater reach, and the minimum clearances in the navigation channel for the existing project conditions as well as a range of discharges. Table 4 is applicable to drawdown conditions in the Little Goose reservoir, table 5 relates to the minimum operating pool, and table 6 is applicable to the maximum operating pool.

When the Little Goose reservoir is operated at the maximum operating pool elevation of 638 feet and with a river discharge of 46,000 cfs, the water surface elevations vary from 638.1 (at river mile 106.6) to 638.2 (at Lower Granite Dam). For a discharge of 160,000 cfs, the corresponding values range from 639.6 to 640.3. Water velocities in the reach vary from a minimum of 1.4 fps at 46,000 cfs to a maximum of 6.9 fps at 160,000 cfs.

When the Little Goose reservoir is operated at the minimum operating pool elevation of 633 feet and with a river discharge of 46,000 cfs, the water surface elevations vary from 633.2 (at river mile 106.6) to 633.4 (at Lower Granite Dam). For a discharge of 160,000 cfs, the corresponding values range from 635.5 to 636.7. Water velocities in the reach vary from a minimum of 1.7 fps at 46,000 cfs to 8.2 fps at 160,000 cfs.

During drawdown operations, the portion of the Little Goose pool near Lower Granite Dam will essentially return to a pre-project riverine freeflow state. At river mile 106.6, the water surface elevation will drop to 618.6 at the design discharge of 46,000 cfs. Tailwater elevations at Lower Granite Dam will decrease from the normal minimum elevation of 633.0 to an elevation of 621.5. At a discharge of 160,000 cfs, the water surface elevations will vary from 631.6 (at river mile 106.6) to 636.7 (at Lower Granite Dam). Water velocities will vary from a minimum of 3.9 fps at 46,000 cfs to a maximum of 12.2 fps at 160,000 cfs.

During a drawdown, adult fishway operations at Lower Granite Dam will cease when the Lower Granite tailwater elevations drop below 633.0. In addition, operation of the Lower Granite spillway at tailwater elevations below normal will create high dissolved gas levels. The spillway flip-lips were designed to function within a specified range of normal tailwater elevations.

If the tailwater elevation is lowered below its designed range, the flip-lip action will become noneffective. The rockfill weir systems would serve to control the tailwater elevations so the adult fishway system could remain operational at lowered pool levels. The rockfill weir systems would also allow the spillway flip-lips to operate within their design limit.

b. Proposed Weirs

Rockfill weir configurations with two, three, and five weirs are proposed to control tailwater elevations under drawdown conditions. Plates 66 through 68 illustrate proposed weir locations with respect to Lower Granite Dam. All weirs would be located in the tailwater reach above river mile 106.6. The most downstream weir in the five-weir proposal would be located at river mile 106.6, about 4,000 feet below the dam. Proposed crest elevations are shown on the plates. Weir lengths range from 700 feet to 1300 feet. A typical cross section of a rockfill weir is shown on plate 69.

During drawdown operations, the weirs would alter the free-flowing characteristics of the river in the tailwater reach to a series of pools. These pools would be most noticeable at low river discharges. Most of the change in water surface elevation over a weir will occur in the span from a few feet upstream of the weir crest to a few feet below the downstream toe of the weir, a distance varying from about 40 feet to 75 feet. At a river flow of 46,000 cfs, the maximum differential in the water surface elevation will be about 7 feet for the two-weir system, ranging down to about 2.7 feet for the five-weir system. The depth of the flowing water over a weir will be about 3 to 6 feet. At higher discharges, flow over the weirs will be deeper, faster, and less turbulent; but may also be more unstable. Water depths over the weirs will increase to as much as 14 feet at a river flow of 160,000 cfs. Hydraulic jumps downstream of the weirs are possible under some flow conditions, although it may be possible to design the weirs to prevent this condition. At higher discharges, wave generation around the weirs would add to the normal river turbulence and tend to overwhelm the low-flow pooling regime.

When the reservoirs are operated in their normal pool range, the weirs would be submerged. Even at low discharges, the weirs will likely be noticeable and create some disturbance at the surface. Maximum water velocities will occur at the point where the river flows over the weirs. These velocities will be higher than under existing conditions, but water velocities between the weirs will be less. The differential in the water surface elevations across the weir will be less than 0.3 feet at low flows. As the river flows increase, the elevation differential will become more noticeable, and velocities across the weirs will increase. At a discharge of 160,000 cfs, the largest elevation differential occurs at the most upstream weir. For the two-weir system, the differential could be as much as 2.7 feet with a minimum operating pool, which may be enough to induce large local waves. The differentials will be much less at downstream weirs, and the magnitude of the differentials will decrease as more weirs are added to the system, as discharges decrease, and when the pool is operated at its maximum level.

c. Two-Weir System

Plate 66 illustrates the locations selected for installation of the two-weir system below Lower Granite Dam. Table 7 shows computed hydraulic data for the two-weir system, assuming that both Lower Granite and Little Goose Dams are operated with significantly lowered pool levels. The computations indicate that installing the two-weir system as indicated on plate 66 would provide a minimum tailwater elevation at the dam of approximately 633 feet at a river flow of 46,000 cfs. Chart 16 compares the tailwater rating curves resulting from normal operations to the rating curve expected with the two-weir system in place and operating at lowered pool levels. Under drawdown conditions, the water surface differential across each weir will vary from 4.2 to 6.7 feet for river flows ranging from 46,000 cfs to 160,000 cfs. Velocities across the weirs are estimated to range from approximately 11.0 to 17.2 fps.

Tables 8 and 9 show computed hydraulic data for the weir system when pool levels are returned to normal operating ranges. With the two-weir system in place and Little Goose operating at the minimum normal pool elevation of 633, the water surface differential across the weirs is estimated to vary from 0.1 to 2.7 feet for river flows of 46,000 to 160,000 cfs. The navigation clearance over the downstream weir will be less than the minimum requirement of 14 feet at flows less than 150,000 cfs. With Little Goose operating at the maximum normal pool elevation of 638 and the two-weir system in place, the water surface differential across the weirs will vary from 0.0 to 0.7 feet for river flows from 46,000 to 160,000 cfs. Velocities across the weirs are estimated to vary between 2.6 and 11.6 fps. Navigation clearances will be adequate. Chart 16 demonstrates the changes in tailwater rating curves under normal operations with the two-weir system in place.

d. Three-Weir System

Plate 67 illustrates the proposed locations for the three-weir system in the river channel below Lower Granite Dam. Table 10 shows computed hydraulic data for the three-weir system, assuming that both Lower Granite and Little Goose reservoirs are operating with significantly lowered pool levels. The computations indicate that installing the three-weir system as indicated on plate 67 would provide a minimum tailwater elevation at the dam of approximately 633 feet at a river flow of 46,000 cfs. Chart 17 compares the tailwater rating curves resulting from normal operation to the rating curve expected with the three-weir system in place and operating at lowered pool levels. Under drawdown conditions, the water surface differential across each weir will vary between 1.8 and 4.4 feet for river flows ranging from 46,000 cfs to 160,000 cfs. Velocities across the weirs are estimated to range from 10.8 to 17.2 fps.

Tables 11 and 12 show computed hydraulic data for the weir system when pool levels are returned to normal operating ranges. With the three-weir system in place and Little Goose operating at the minimum normal pool elevation of 633, the water surface differential across the weirs is estimated to vary from 0.0 to 2.5 feet for river flows of 46,000 to 160,000 cfs. The navigation clearance over the two downstream weirs is less than the minimum requirement of 14 feet for discharges less than 100,000 cfs. With Little Goose operating at the maximum normal pool elevation of 638 and the three-weir system in place, the water surface differential across the weirs will vary from 0.0 to 0.7 feet for river flows from 46,000 to 160,000 cfs. Velocities across the weirs are estimated to vary between 2.4 and 11.4 fps. Navigation clearances will be adequate. Chart 17 demonstrates the change in tailwater rating curves under normal operations with the three-weir system in place.

e. Five-Weir System

Plate 68 illustrates the proposed locations for the five-weir system in the river channel below Lower Granite Dam. Table 13 shows computed hydraulic data for the five-weir system, assuming that both Lower Granite and Little Goose Dams are operating with significantly lowered pool levels. The computations indicated that installing the five-weir system as indicated on plate 68 would provide a minimum tailwater elevation at the dam of approximately 633 feet at a river flow of 46,000 cfs. Chart 18 compares the tailwater rating curves resulting from normal operations to the rating curve expected with the five-weir system in place and operating at lowered pool levels. Under drawdown conditions, water surface differentials across the weirs are estimated to vary between 0.6 and 3.5 feet. Velocities across the weirs are estimated to vary between 10.3 and 17.1 feet per second depending on river flows.

Tables 14 and 15 show computed hydraulic data for the weir system when pool levels are returned to normal operating ranges. With the five-weir system in place and Little Goose operating at the minimum normal pool elevation of 633, water surface differentials across the weirs are estimated to vary from 0.0 to 1.9 feet for river flows of 46,000 to 160,000 cfs. Velocities are estimated to vary between 2.9 and 16.7 on the average. The required 14 feet of navigation clearance is not achieved until river flows begin to exceed 215,000 cfs. With Little Goose operating at the maximum normal pool elevation of 638 and the five-weir system in place, water surface differentials across the weirs will vary from 0.0 to 0.6 feet for river flows from 46,000 to 160,000 cfs. Velocities across the weirs are estimated to vary between 2.3 and 11.0 fps. Navigation clearances will be adequate at all weirs except weir number 2. However, the clearance at weir number 2 is, at most, about 1 foot less than the required minimum of 14 feet. However, it is probable that the weir crest elevations can be slightly adjusted to provide the necessary clearance. Chart 18 demonstrates the change in tailwater rating curves under normal operations with the five-weir system in place.

13.06. Lock Discharge Structure Modifications

a. General

All of the weir system options require modifications to the existing navigation lock discharge structure. Weirs installed below the existing discharge structure will create an unbalanced condition between the river and the navigation lock water surface elevations. The existing lock mitre gates could not be operated under this condition. To alleviate the condition, it will be necessary to extend the discharge of the navigation lock to a point below the first weir for each option. In addition, it is desirable to avoid discharging the lock near any of the rockfill weirs. Maximum discharges from the lock can reach as high as 20,500 cfs. If discharged near a rockfill weir, the flow could cause structural failure and affect the hydraulic performance of the weir. A conceptual design for the lock discharge structure extension is illustrated on plate 70.

b. Structural Considerations

Cofferdams would be installed around the perimeter of the work site. The cofferdams would tie into monolith No. 29. Following installation of the cofferdams, the site would be dewatered and rock-excavated to provide a solid foundation at the proper grade. Following rock excavation, the concrete channel extension would be constructed and the cofferdams removed. Cofferdam installation and removal would e performed only during in-water work periods.

13.07. Weir Construction

a. General

Regional interests have suggested that rockfill weirs can be constructed in flowing water by dumping suitable materials from barges. This type of construction technique has been utilized in the past primarily to construct the final closure of a river during dam construction. At least one model study report on the construction procedure was written by the U.S. Army Engineer Waterways Experiment Station. The study was conducted for a rockfill initial closure dam to control flow from the Mississippi River into a tributary. It was also possible to install a seal blanket on the upstream face of the weir (construction under flowing water) to stop some of the leakage through the rockfill weir.

b. Materials

The selection of material type for the underwater weirs was based on the model study for the Old River Project rockfill initial closure dam. Tests indicated that the rockfill dam would be stable under all anticipated flow conditions from 91,000 to 121,700 cfs during rockfill placement. The tested conditions were judged to be similar enough to a rockfill weir installed below Lower Granite Dam that material parameters established from the dam closure model could be used for this evaluation.

(1) Type

For weir stability, the stone sizes would be large enough to prevent particle movement. The proposed weirs would be constructed of stones with a unit weight of at least 160 pounds per cubic foot. The maximum stone size would be approximately 8000 pounds, with 65 percent of the stones weighing at least 4000 pounds. The minimum stone size would be 50 pounds, and stones in the 50- to 4000-pound range would be evenly graded.

(2) Upstream Seal

A geomembrane would be placed over the upstream face of the weir to minimize seepage through the weir. To cushion the membrane, a 5-foot-thick blanket would be placed over the upstream face of the rockfill. A cross section of the weir, with the seepage blanket layers, is shown on plate 69. The blanket would consist of 4 feet of 12-inch riprap overlying the rockfill, and 1 foot of crushed gravel overlying the riprap. A 1-foot layer of riprap would be placed over the membrane to hold it in place.

A similar gradation for a seal blanket without the geomembrane was used in the Old River Model Study. However, the seal blanket only reduced seepage by 28 percent. To obtain a lower degree of permeability for improved hydraulic performance, a geomembrane was used for this study.

Other alternatives considered for decreasing permeability include the use of smaller-sized particles in the seal, and the use of concrete. The smaller sized particles are susceptible to washing out and, for that reason, were dropped from further consideration. The problem with a grouted seal blanket is that the rockfill would shift with time, thus cracking the grout and resulting in seepage. In addition to the alternative of developing an impermeable weir, other types of weir designs were considered. One such weir type would be a series of cellular cofferdams. Other weir types should be considered in further studies if tailwater control by weirs is determined to be an acceptable solution.

(3) Quarry Sites

The availability of large rock within the vicinity of the weirs is limited. The closest quarry site believed to contain the required large stone size and quantities is the Tammany Creek quarry. This quarry site is located south of Lewiston, near Hells Gate State Recreation Area. The approximate unit weight of the stone is estimated to be 170 pounds per cubic foot, which is suitable for the rockfill weirs. However, based on a site visit, it appears that the production rate for the large rock at this site would be low. Hence, for this study, the Tammany Creek quarry was judged to be unsuitable. Rockfill would be obtained from a commercial quarry site near Vancouver, Washington. A rock source near the rockfill weirs would be used for gravel production. This site is located 2 miles downriver from Lower Granite Dam on the south side of the river.

b. Stability

The mechanisms considered for instability problems consisted of undermining, slope failure, and the rolling of particles. Based on boring logs prior to construction of the dam, the underlying material below the weirs is expected to consist of sandy gravel with cobbles. These types of materials are not susceptible to erosion from the expected velocities along the riverbed. Therefore, the undermining of the weirs along the riverbed does not appear to be of major concern. However, river velocities along the river bank are expected to be high enough to erode materials. To minimize this type of erosion, the riverbank on each side of the weir would be protected with riprap. Due to the conservation design of the weir slopes, slope failure is not expected.

c. Methods

The most efficient method for transporting the material to the weir site would be by barge. The barges would travel up the Columbia/Snake River navigational lock system to Lower Granite Dam. Barges would bottom-dump rock sizes smaller than 2000 pounds. Rocks larger than 2000 pounds would be positioned by crane. Due to difficulties in the accurate placement of materials underwater, rockfill quantities were increased by 20 percent. Lifts would be one barge width wide, with a height of 3 feet. The lifts on the downstream face would consist of only rocks of 4000 pounds and larger.

After weir construction to the proposed crest elevation, seal construction would begin. Gravel and riprap would be hauled to the site by barge, and bottom-dumped into the proposed template. The riprap and gravel quantities were also increased by 20 percent because of anticipated difficulties in underwater placement.

Minimal barge clearance over the weirs may be encountered during construction. Barge clearance over the weirs is affected by the pool elevation and the volume of water discharged from Lower Granite Dam. During construction, care should be taken so that discharge and tailwater elevations are high enough for construction access without detrimentally increasing water velocities.

13.08. Implementation

Initially, a design memorandum would be prepared that would address the design criteria for the rockfill weirs and navigation lock modifications. During the preparation of the document, fisheries agencies would participate in a review of the design criteria information. Model studies would also be conducted during this time period to determine data needed for final design of the weir system and the navigation lock discharge structure extension. This process is anticipated to take about 12 months. Following review and approval of the design memorandum, final engineering and design would be initiated, and contract documents would be prepared. Preparation of the contract documents is anticipated to take an additional 12 months. The contract documents would then be advertised, and a contractor would b selected. Construction would begin after the selected contractor received the notice to proceed. The contractor would need approximately 6 months to mobilize. During the mobilization process, material for cofferdams would be acquired, and gravel and stone material would be stockpiled. Installation of the cofferdams and weir placement would begin at the first in-water work window. Placement of rockfill in water is limited to the months of December through March and possibly August through September (fall Chinook). The total estimated time required to perform the actual construction of the navigation lock discharge structure modification and installation of the three-weir system is about 2 years at Lower Granite Dam. The construction of the two-weir system would take about the same amount of time as the three-weir system. The five-weir system may require an additional year of construction time. The total time required from initiation of the design memorandum until completion of construction is estimated to be about 4½ years. If any unforeseen problems developed during the design or construction phases, additional time could be required to identify acceptable solutions. This implementation schedule also assumes that resources would be available when required.

If the rockfill weir system is determined to be acceptable, the time required to fully implement alternative 13 for a four-reservoir drawdown could potentially be reduced from 14 years to about 10 years.

13.09. Costs

Construction of a weir system at Lower Granite Dam is estimated to cost between $56 million and $68 million, depending on the weir system selected. These values are based on a 1 October 1992 price level and include contingencies, planning, engineering and design, construction management, and inflation to the estimated mid-point of construction. If drawdown alternative 13 were selected for implementation at Lower Granite Dam and the three-weir system was selected to replace modification of the adult ladder collection system and spillway drumgates, the estimated construction cost savings would be about $98 million.

13.10. Evaluation of Weir Systems

a. Impacts

(1) Adult Fish Systems

Based on the analysis assumptions, all of the weir systems appear to achieve adequate tailwater control for the adult fish system operation, at lowered pool levels and at discharges greater than 46,000 cfs. The adult fish collection channel is designed to operate effectively between water surface elevations 633 to 642 fmsl. Under normal operating pool levels, these elevations correspond to river discharges from 0 to 225,000 cfs. With any of the weir systems in place, the maximum discharge under which the adult system would satisfactorily function would be reduced from 225,000 cfs to as low as 170,000 cfs. About 6 percent of the daily flows are higher than 170,000 cfs during the 15 April to 15 June time period.

(2) Adult Fish Passage

The passage of adult fish past the weirs when pools are operating at a drawdown level may be of concern with any of the weir systems. Adult fish passage problems would be related to high water surface differentials and associated high water velocities across the weirs.

(3) Juvenile Fish

Rockfill weir systems may create predator habitat that could have an adverse impact on migratory juvenile fish survival.

(4) Navigation Effects

The public laws that authorized the construction of the lower Snake River locks and dams also specified the minimum navigable channel requirements of 250 feet width and 14 feet depth. In general, navigation clearances will be less than the required 14 feet with a minimum normal operating pool, but they will be adequate at the maximum normal pool. The number of weirs also affects minimum clearance through the navigation channel, with clearances decreasing as the number of weirs increases. Operating the pool at maximum levels for navigation would conflict with current fish passage minimum operating pool restrictions. The weirs will significantly increase the maximum water velocities in the tailwater reach compared to existing conditions. Increased velocities would be a concern for both commercial tug/barge traffic and adult fish passage.

Each of the weir options also requires relocation of the lock discharge structure to a point below the first weir. This requirement is based on locating the first weir an assumed minimum distance from the spillway, to prevent erosion and structural failure. Additional information from physical hydraulic models will be required to assess the minimum required distance. It may be possible to install the first weir upstream from the existing lock discharge structure, or reduce the length of the lock discharge extension.

Construction of the navigation lock modifications would interrupt navigation for approximately 1 year.

(5) Spillway Operation

The effects of the weir concept on spillway operation were evaluated for the two-weir system. Normally, all river flows at Lower Granite Dam are passed through the powerhouse exclusively for river discharges up to powerhouse capacity. Once river flows exceed about 130,000 cfs, the spillway is then operated to pass excess flows. Spillway flip-lips were designed to produce a stable skimming flow, thereby minimizing dissolved gasses. According to the Hydraulic Model Investigation, Technical Report No. 121-1, Lower Granite Dam, under normal operations with resulting normal tailwater elevations, the flip-lips will provide stable skimming flows up to a discharge of 23,000 cfs per spillway bay. This corresponds to a total river discharge of about 314,000 cfs. The flip-lip operation between 23,000 and 36,000 cfs per spillway bay produces unstable flow in and blow the stilling basin. The unstable flow is undesirable because the energy is not adequately dissipated within the stilling basin, and erosion can occur below the end sill of the basin. Beyond 36,000 cfs per spillway bay, the flip-lip action is overridden and stable plunging flows occur that allow the stilling basin to adequately and safely dissipate the energy associated with high flood flows (refer to charts 19 and 20).

The installation of the two-weir system would create higher tailwater conditions and shift the zone of unstable flow operation. The unstable operation would begin at approximately 28,000 cfs per day, corresponding to a total river discharge of 354,000 cfs, and extend beyond the spill per bay required to pass the standard project flood of 420,000 cfs. The flow per bay at which stable plunging flows would occur is unknown. Flows beyond the standard project flood were not evaluated in the original model study of flip-lip actions.

The effects of the three-weir and five-weir systems on the Lower Granite spillway operation were not evaluated, but are expected to produce results similar to the two-weir system.

(6) Project Effects

The two-weir system increases tailwater elevations at normal operating pool levels. At standard project flood flows of 420,000 cfs, tailwater elevations are projected to increase by about 3 feet with the two-weir system in place. The powerhouse tailrace deck level would still be above the projected tailwater elevation, but the freeboard provided for wave action would be reduced. The increased tailwater elevations created by the two-weir system would result in a reduction in head available for associated power generation. Power generation would decrease about 5 percent at minimum operating pool and a discharge of 160,000 cfs. The decrease would be less than 1 percent at low flows. The three-weir and five-weir systems would produce similar results.

b. Uncertainties

The development of tailwater rating curves for this analysis was based on assumed standard values for contraction and expansion coefficients across the rockfill weir systems. A sensitivity analysis was performed using higher coefficients. The sensitivity analysis shows that, as the computed head losses over the weirs increase, the differentials in the water surface elevations across the weirs also increase. To a large extent, this effect can be compensated for by lowering the weir crest elevations. At normal discharges above the index flow of 46,000 cfs, the computed tailwater elevations at Lower Granite Dam increase slightly, but velocities over the weirs decrease and navigation clearances increase. At the standard project flood discharge of 420,000 cfs, the increase in the computed tailwater elevation for all downstream reservoir conditions is in the range of 2.7 to 3.0 feet.

The HEC-2 analysis conducted for the proposed weir systems is a reconnaissance-level study. The current condition models were calibrated using both physical model test data and actual project data. The Lower Granite tailwater elevations presented in this study are representative of water surface elevations outside of the influence of the spillway and powerhouse. The effects of these two features increase as the discharges increase. If the weir options are considered in a feasibility or design study, physical model studies should b conducted to better define the effects of the proposed weirs on the project.

The ability to seal the weirs limiting leakage is also a key assumption. If an adequate seal cannot be made, compensating additional weir height would be required that could adversely effect the results presented. The weir heights and corresponding computed hydraulic performance data would also be affected if a design discharge of less than 46,000 cfs is used.

Spillway operation will be affected by any of the weir installations, especially during high flood flow situations. Project safety is of primary concern since current information suggests that flows over the spillway will be unstable during the standard project flood. Adjustments to spillway flip-lips to compensate for this condition may be possible but, if rockfill weirs were to fail during high flows, the tailwater conditions that would be experienced would not be predictable. If weir structures are pursued, it may be necessary to design the structures with materials that will provide a high assurance of stability up to the standard project flood for safe project operation. Based on available information, the rockfill weir structures described in this report should be stable for the 46,000- to 160,000-cfs flow range. Structural stability with flows above the 160,000 cfs is uncertain. Additional information will be required to assess the effect of higher river flows on the weir structures. It is not known how much annual maintenance would be required.

It was assumed that the lock discharge structure extension would be acceptable and would have little or no impact on navigation lock operation or tailrace conditions. Additional information will be necessary to confirm this assumption.

This analysis suggests that the weirs will cause the tailwater to encroach on the freeboard, thus protecting the powerhouse at high flows. If different assumptions are used, tailwater elevations could reach that of the tailrace deck and lead to powerhouse flooding. It may be necessary to provide some mitigative measures to protect the powerhouse.

It is assumed that tug/barges can negotiate the increased water velocities over the weirs when pools are returned to normal maximum operating levels. Additional information will be required to confirm this assumption.

13.11. General

Based on the assumptions and preliminary analysis presented in this report, it appears possible to control tailwater at Lower Granite Dam during drawdown operations with rockfill-type weir structures installed in the downstream river channel. Water surface differentials across the weirs in the two-weir system exceed criteria normally used in the design of adult fish passage facilities. The differentials with the three-weir and five-weir systems are less than those of the two-weir system, and may provide more acceptable fish passage conditions for upstream migrants. However, velocities across the weirs are quite high for all of the weir systems.

The costs for the three- and five-weir systems are greater than the two-weir system, and will require longer construction times. However, the installation of downstream weir systems would replace the need for modifying the adult ladder collection and spillway drumgate systems. This is anticipated to reduce the time required for the implementation of drawdown alternative 13 from 14 years to about 10 years. For other drawdown alternatives, a similar reduction in implementation time would be anticipated. Comparing construction costs for the three-weir system (including the navigation lock modifications and adult ladder exit modifications) against the construction costs of installing the spillway drumgates and modifying the adult collection system at Lower Granite Dam, the three-weir system could possibly provide a construction cost savings up to about $98 million. This comparison is based on the 1 October 1992 price level, and utilizes construction costs only.

Project operational changes will be required to provide barge and tug passage with any of the weir systems in place. During non-drawdown time periods, it will be necessary to operate Little Goose Dam (controlling tailwater at Lower Granite Dam) at normal maximum pool elevations to provide adequate clearances for barges and tugs across the weir system. Operating the pool at maximum levels for navigation will conflict with current fish passage minimum operating pool restrictions. Permanent changes in tailwater rating curves will reduce the available head for power production.

If any of the drawdown alternatives are carried into further detailed studies (feasibility phase), additional information on downstream rockfill weirs should be obtained to further explore their potential. Information such as location, spacing, heights, hydraulic performance, stability, seal blankets, spillway operational effects, and navigation can be examined in detail by using physical hydraulic models. This type of information can also be used to develop more confidence in construction costs, methods, and construction duration.

Section 14 - Juvenile Collection Design Flow

14.01. General

Under normal operating conditions, existing fishery bypass systems at each lower Snake River dam can operate effectively up to a 10-year flood event of 225,000 cfs. The modifications to accommodate the drawdown alternatives discussed in section 5 of this technical report were designed so that drawdown could occur each year during the spring outmigration of juvenile fish, and provide effective fish bypass operations up to the 10-year flood event. This design criteria determines the acceptable reservoir elevations for the drawdown alternatives. By changing this design criteria, the elevation of the pools can also be changed. Regional interests have requested that the design river flow be reduced from 225,000 cfs to 160,000 cfs, thereby allowing lower reservoir pool elevations. Reduction of the design criteria to 160,000 cfs is somewhat arbitrary, and additional study (beyond this analysis) of the risks and benefits should be undertaken before adopting any reduced flow design criteria. The Drawdown Committee requested the corps to prepare a sensitivity analysis on the effects of utilizing a reduced-flow design criteria. For the purposes of this analysis, 160,000 cfs was utilized. This section presents the requested analysis, and discusses the pros and cons of the suggested criteria change. For this analysis, drawdown alternative number 13 was used for comparative purposes.

14.02. Operation

For the purpose of this analysis, it is assumed that the drawdown of reservoir pools would be initiated each year to target drawdown elevations, and maintained within set limits similar to alternative 13 for all river flows up to the design river flow of 160,000 cfs. If river flows begin to exceed 160,000 cfs, refill of the reservoirs would be initiated.

a. Drawdown

The four lower Snake River projects will begin drafting no later than March 25 in order to reach the target drawdown elevations by April 15 each year. The target drawdown pool levels must be achieved prior to the arrival of large numbers of juvenile fish, since the low-level bypass systems will not be operational until drawdown pool levels are reached. The date computed to begin the drawdown assumes full pools initially, and a drawdown rate of 2 feet per day. The average project discharge above inflows required at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor is 6,700 cfs, 15,300 cfs, 20,500 cfs, and 26,000 cfs, respectively. The discharges will be highest at the beginning of the drawdown period. Peak discharges above inflows at the four projects would be 8,400 cfs, 18,300 cfs, 27,000 cfs, and 35,300 cfs, respectively. The total reservoir system storage that will be evacuated, from full pool elevations to the drawdown elevations, is estimated to be 1,067,200 AF.

b. Refill

If reservoir elevations are maintained at their drawdown levels during the April 15 to June 15 time period, refill of the reservoirs will take approximately 7 days (with average inflows of 95,000 cfs). Given the maximum inflows of record (190,000 cfs), the refill time will be reduced to 4 days. However, the refill time will increase dramatically in low water years. Given the 1992 inflows after mid-June (averaging 21,000 cfs), refill of the reservoirs will take about 57 days. During this transitional refill period, juvenile bypass systems will be inoperable until normal pool levels are reached. If reservoirs are maintained at their drawdown levels from April 15 to after Labor Day, refill of the reservoirs will begin around September 5, and will take approximately 30 days (provided average inflows of 30,000 cfs are achieved). The time for refill will vary, depending on inflows. Given maximum inflows of record (40,000 cfs), refill will take approximately 19 days. During low water years, when average inflows can drop to around 20,000 cfs, refill will take up to 64 days. Shorter refill times can be achieved by drafting upstream storage, but a large portion of the September inflows into Lower Granite Reservoir usually come from drafts of Dworshak Reservoir. These computations assume minimum project releases of 11,500 cfs during the refill period.

14.03. Project Modifications--Comparison to Alternative 13

a. General

By lowering the design flow from 225,000 cfs to 160,000 cfs, the reservoir pools at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams could be operated at the following levels:

Project	Normal Operating Range (fmsl)	Drawdown Operating Range at 225,000 cfs Design Flow (Alternative 13)	Drawdown Operating Range at 160,000 cfs Design Flow	Elevation Difference in Design Levels (feet)
Lower Granite	738-733	705-700	697-692	8
Little Goose	638-633	605-600	597-592	8
Lower Monumental	540-537	507-502	499-494	8
Ice Harbor	440-437	415-410	408-403	7

By designing facilities to be operable up to 160,000 cfs rather than 225,000 cfs, the reservoir pools can be operated at about 7 to 8 feet lower than that proposed by alternative 13 (for flows less than 160,000 cfs).

b. Low-Level Juvenile Bypass System

The same design of the juvenile bypass system presented in alternative 13 can be used under the lowered pool levels. The only difference is the elevation at which the low-level system is constructed.

c. Adult Facilities

Adult facility modifications would be the same as for alternative 13, except for the secondary low-level adult ladder exit that would be constructed 7 to 8 feet lower than that proposed by alternative 13.

d. Existing Spillway/Stilling Basin Modifications

The modification to these facilities would be identical to those proposed by alternative 13.

e. Miscellaneous Modifications

All of the modifications described in alternative 13 will be required except that the modifications will need to be designed to accommodate lower pool levels (7 to 8 feet lower) than those proposed by alternative 13.

f. Embankment Protection

Additional bank protection will be required above that required for alternative 13, since reservoir pools will be lower and additional bank surface area will be exposed.

14.05. Implementation

The implementation (design and construction) schedule is expected to be identical to alternative 13, taking approximately 14 years to fully implement from the date authorization and appropriation are received.

14.06. Cost Estimate

Reducing the design flow (allowing reservoir pool levels to decrease) will slightly increase costs over those shown for alternative 13. Since water levels will be lower, additional embankment protection will be required. In addition, modifications to miscellaneous features (i.e., the floating navigation lock guide walls, debris shear boom, adult ladder at Lyons Ferry Hatchery, culvert outfalls, and the water quality siphons on the Lewiston Levees) will require a wider operational range, and this will also increase costs. Alternative 13 was previously estimated at $1.3 billion.

14.07. Hydrology and Hydraulic Effects

a. General

According to the frequency curve on plate 57, the design discharge of 160,000 is equaled or exceeded 54 percent of the time. This means that the design discharge of 160,000 cfs has slightly less than an average return period of 2 years, as compared to 10 years for the design discharge of 225,000 cfs.

b. Water Travel Time

For alternative 13, the water travel time from the confluence of the Snake and Clearwater Rivers to the mouth of the Snake River ranges from 379 hours to 65 hours, for flows ranging from 25,000 to 160,000 cfs, respectively. Travel time through the remaining pools after drawdown ranges from 372 hours to 62 hours for the above flow range. Reducing the pool by designing to a lesser peak discharge of 160,000 cfs will provide travel times from the confluence of the Snake and Clearwater Rivers to the mouth of the Snake River that range from 334 hours to 59 hours for flows ranging from 25,000 to 160,000 cfs, respectively. Travel time through the remaining pools after drawdown ranges from 324 hours to 54 hours for the above flow range.

14.08. Summary

By lowering the river flow used for design of juvenile bypass systems from 225,000 cfs to 160,000 cfs, the reservoir pools at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams could be operated at 7 to 8 feet lower than those proposed by alternative 13. Similar modifications would be required, but the time necessary for implementation would be the same. The cost will be slightly higher, primarily due to the increased embankment protection required.

The time required to evacuate the lower Snake River reservoirs to achieve the target drawdown pool levels would increase by 4 days over that required by alternative 13.

By lowering target drawdown pool levels an additional 7 to 8 feet; water travel time would decrease by about 45 hours for flows of 25,000 cfs, and 8 hours for a river flow of 160,000 cfs over the drawdown pool levels proposed by alternative 13.The effect of this change on juvenile fish travel time and survival is unknown.

Preliminary information from the Lower Granite three-bay sectional fish guidance efficiency model indicates that the fish guiding efficiency of existing STS's will decrease with lowered pool levels. It is anticipated that the intake screening would be less efficient with pools lowered an additional 7 to 8 feet, as compared to the screen efficiency associated with the proposed pool levels of alternative 13. As intake screen efficiencies decrease, more juvenile fish will pass through operating turbines. Turbines are also less efficient in their operation at lower pool levels. This may increase juvenile fish mortality for those fish that pass through operating turbines.

Section 15 - Simultaneous Implementation Plan

15.01. General

The Drawdown Committee requested that an implementation schedule illustrating simultaneous modification of the lower Snake River dams be discussed and compared to the previously described implementation schedules. For the purposes of this discussion, alternative 13 (described in section 5) was selected as a representative drawdown alternative to use for comparative purposes. This section describes the simultaneous construction schedule, and compares it to the proposed construction schedule presented in section 5 of this report. The effect of the changed implementation plan on costs is also presented in the following paragraphs.

15.02. Schedule

Plate 70 illustrates a simultaneous implementation plan for alternative 13. Assuming that funds and resources are available when required, it is estimated that it will take about 10.5 years to simultaneously implement alternative 13 at all four lower Snake River dams from the date authority and appropriation are received.

If this schedule could be achieved, it would save about 4 years over the proposed staggered implementation schedule presented on plate 17.1.

Design memorandums (DM's) will be required for features such as adult fishway modifications and new low-level juvenile bypass systems. The DM's will identify and satisfy engineering data requirements (i.e., design criteria and survey information). In addition, coordination with fishery agencies, concerning adult fishway modifications and the new low-level juvenile fish bypass systems, will be carried out during this process. Hydraulic models of each of the four lower Snake River projects will be used to identify the strategic placement of cofferdams for modifications to the adult collection system. Construction cofferdams will be placed to achieve the best available hydraulic conditions for continued adult fishway operations during construction. In addition, the models will be used to identify the most acceptable location for the juvenile fish bypass release points. Sectional hydraulic models of the spillways will be used to analyze the proposed stilling basin modifications.

Construction work on stilling basins will be offset from adult fishway modifications to avoid reducing flow capacities through the powerhouse and spillway simultaneously. In addition, construction activities on existing stilling basins will be phased to minimize the reduction of spillway capacities. Construction will only be allowed during annual low water periods (from August through March). Contractors will be required to have all cofferdams removed and all spillway bays operational during the typical April through July runoff period.

15.03. Costs

The estimated cost for modifications using the proposed implementation plan as illustrated on plate 17.1, is $1.29 billion. For the simultaneous implementation of alternative 13 to all four lower Snake River dams, the estimated cost is $1.26 billion. The simultaneous implementation appears to save only about 2.3 percent of the total estimated costs. In essence, the estimated cost for either implementation plan is considered to be the same.

15.04. Summary

Biological testing of the drawdown concept would not be conducted until all structural changes have been completed if the simultaneous implementation plan is pursued. The proposed staggered plan shown on plate 17.1 allows for testing and evaluation after the first two dams have been modified. This evaluation would allow the identification of problem areas in designs or construction that could be remedied prior to, or during, construction of the modifications for the next two dams. It is highly probable that limitations on manpower, money, and materials will extend the simultaneous implementation plan. Also, if additional study or research (hydraulic model or prototype studies) identifies any unforeseen technical problems, more time may be required to obtain acceptable solutions.

Section 16 - Surface Flow Collection System

16.01. General

A surface flow collection system has been suggested as a means to improve juvenile fish guidance during drawdown operations at the lower Snake River dams. The suggestion for an improved fish collection system was based on preliminary information from the Lower Granite 3-Bay Sectional physical hydraulic model, which indicated that fish guiding efficiencies of existing intake screening devices may decrease under drawdown operations.

A surface-collection system in the forebay would attempt to take advantage of the behavioral tendency of juvenile fish to swim in the upper levels of the reservoir pool. Water flowing into a surface collection system, located above and in front of existing turbine intakes, would provide migrating juvenile fish with another passage route around operating turbines.

A surface flow collection system could be operated independently or in combination with existing collection systems. Existing collection systems with a surface collector may collect fish that pass below the surface collection system. Also, flow into the surface collection system may cause fish to stay higher in the water column, enabling existing collection systems to gather fish that might otherwise pass below the existing diversion screens. A surface collection system in the forebay may also reduce the time that juvenile fish spend in the forebay area close to the dam structure.

A surface fish collection system located near the water surface in the forebay has also been suggested, without consideration to drawdown operations, as a means to improve juvenile fish passage around existing lower Snake River dams (see SCS Technical Report Appendix E, Existing System Improvements). The present juvenile fish collection systems were developed around existing intake structures of dams. These systems, although effective in diverting and collecting large numbers of fish, subject fish to turbulent flows as well as velocity and pressure changes. Conditions in the existing collection systems may stress and injure the fish. Therefore, developing a new surface fish collection system in the forebay may increase the numbers of fish diverted and collected plus reduce fish stress and injury.

This section discusses the concept of a surface-oriented collection system in the forebay for migrating juvenile fish at Lower Granite Dam. Design assumptions, concept descriptions, cost estimates, and preliminary implementation schedules are presented. For the purposes of this concept investigation, drawdown alternative 13 was used to demonstrate the application of such a system to drawdown operations. A version of this same concept could be used at other lower Snake River projects.

16.02. Design Concepts and Key Assumptions

a. Basic Concepts

Two design concepts that were considered in this report based on existing projects using surface-oriented types of designs to divert and/or collect juvenile fish include:

(1) Vertical Juvenile Fish Entrance Slots

This concept is based in part on a system presently used at Wells Dam (Public Utility District Number 1 of Douglas County, Washington) on the mid-Columbia River. Wells Dam, being a hydrocombine design (spillways located directly above the powerhouse intakes) is significantly different than the lower Snake River dams. Due to its design, conventional intake screening and diversion systems would be ineffective at Wells Dam. To allow the guidance of juvenile fish, vertical-slot fish entrances were placed in the intake gate slots in front of the spillways. The vertical-slot fish entrances divert fish away from turbines, and discharge them through spillways.

The vertical slots (16 feet wide) extend from the forebay surface to a depth of 70 feet. For an application of this concept at Lower Granite Dam, vertical-slot juvenile fish entrances (roughly 60 feet deep at normal forebay elevations) could be used to lead juvenile fish into a collection channel and related features. One entrance per generating unit (for a total of six) could be located across the face of the powerhouse. Vertical slots would create areas of higher flows and velocities, in conjunction with deep fishway entrances, to attract downstream migrating fish into a fish collection and bypass system.

(2) Skimmer Weirs or Orifices

This concept is based on a portion of a system that has been used at Ice Harbor Dam on the lower Snake River. The Ice Harbor system utilizes an existing ice-and-trash sluiceway located above the turbine intakes on the upstream face of the dam to attract fish swimming in the upper water column into a sluiceway that discharges fish and water directly to the tailrace. For Lower Granite Dam, a surface weir system similar to that at Ice Harbor Dam could be used to skim juvenile fish into a collection channel that would lead to collection or bypass facilities.

b. Selected Concept

A single concept design using a version of the Wells Dam fishway entrance, in conjunction with a collection/sample and bypass system, has been developed in this study to explore the feasibility of a surface flow collection system. Many of the same features would be common for both a Wells Dam and Ice Harbor Dam type of design, but a vertical-slot fishway entrance would make it easier to collect or bypass fish for both normal and drawdown operations.

c. Key Assumptions

The following main assumptions were used in developing the design:

- The surface collection system will be used as a supplement to the existing turbine fish collection and bypass system.
- Full dewatering of fish collection and transport flows will be required during both normal and drawdown operations to allow sampling of fish.
- The system will function over the following operating ranges:
- Juvenile fish collection/sampling/transport, or bypass/sampling operations during normal forebay elevations 733 to 738.
- Juvenile fish bypass/sampling operations during drawdown forebay elevations 700 to 705, as identified for drawdown alternative 13.
- Special juvenile fish bypass operations using, in part, the southernmost spillway bay during the transition phase (between forebay elevations 738 and 700) and during emergency operations when the main collection system is not functional. (Note: The drawdown transition phase will occur prior to the arrival of large numbers of juvenile fish. This portion of the system will not be designed to meet all optimal fishery criteria because of low fish numbers during this time period, and expected infrequent use of the emergency system.)
- The amount of flow required to attract juvenile fish into the vertical slots will equal 5 percent of the powerhouse flows (i.e., for normal operations, about 1100 cfs per unit or 6600 cfs total; for drawdown operations, about 717 cfs per unit or 4300 cfs total).
- Water velocities approaching dewatering screens will be limited to 5 fps or less. Water velocities perpendicular to screens will be limited to 0.4 to 0.5 fps.
- Fish and transportation water from the surface collection facility will connect to a new juvenile fish facility by using an open flume design instream of using the existing pressurized fish transport pipe system.
- Current state-of-the-art juvenile fish facility design criteria as it relates to pressure changes, fish transfer water velocities, etc., will be used for normal and drawdown operations. [Note: Emergency and transition operations (between normal and drawdown conditions) will not be designed to meet all optimal fishery criteria because of anticipated low usage of these features.]

16.03. Selected Concept Description

a. General Operations

Juvenile fish approaching Lower Granite Dam from its upstream side and following river currents leading towards the turbine units will have the following options:

- Entering into a new surface fish collection system;
- entering into the existing fish collection system after being diverted with intake screens into a gatewell and related features;
- going through the turbines; and
- swimming away from the turbine intakes back into the reservoir or to an alternate passage route (e.g., the spillway).

Fish and attraction water entering into the surface fish collection system will pass through deep vertical slots located across the front of the powerhouse and, from there, into a collection channel. The collection channel will lead fish and water to: 1) regular collection/;transport/sampling/bypass facilities during normal operations; 2) bypass and sampling facilities during drawdown operations; and 3) bypass/spill facilities during emergencies and during the transition between normal and drawdown operations. The main collection channel will have dewatering capabilities to reduce the amount of water handled within the system downstream of the main fish entrances. See plate 72 for a general plan of the system.

b. Normal Fishway Operations

(1) Surface Collection System Fish Transportation Channels

Fish swimming into the surface collection system from the forebay will pass through one of the six 16-foot-wide, 61-foot-deep slots [assuming pool elevation 738 (see plate 76, detail 2)] that connects to a 10-foot-wide fish collection channel that stretches across the width of the powerhouse. Average velocities through the slot openings will range between 1 and 2 fps, assuming 1100 cfs entrance flow per slot. Slot openings and depths can be reduced to optimize fish passage and hydraulic conditions by adding solid panels to the framework of the slot openings. Dewatering of entrance flows (see the following paragraphs) will be completed within the collection channel, and will keep channel flows across the powerhouse at about 1100 cfs. Average collection channel velocities across the powerhouse will range between 1 and 2 fps.

Fish and collection channel transportation flows (about 1100 cfs) reaching the south end of the powerhouse will then enter into a floor transition and additional dewatering sections. The floor invert will rise at about a 17-percent slop [about a 10-degree adverse angle (see plate 76)] until it reaches a floor dewatering section. The water depths and flow amounts in this transition channel will be reduced from about 61 feet of depth and 1100 cfs to about 8 feet of depth and about 250 cfs at the upstream end of the floor dewatering section. Water velocities throughout the transition and side dewatering will range between 1 and 2 fps. Velocities will gradually increase to approximately 5 fps at the upstream end of the floor dewatering.

Fish and transportation flows(reduced from about 250 cfs to 30 cfs in the floor dewatering section) will pass into a 36-inch-diameter conduit that flows 18 inches deep. This conduit with fish and water will continue until it is eventually combined with another flume system that is part of the existing collection system (refer to the following paragraphs). The combined flows will pass down a flume to collection, sampling, transport, and bypass facilities located downstream of the dam on the south shore.

(2) Extension of the Existing Fish Collection Gallery Within the Dam

The existing fish collection gallery located within the powerhouse that is used as part of the existing turbine intake screen system will be extended (mined--see plate 73) through the south end of the powerhouse. The existing downwell, pressure fish transportation pipeline, and related features that are currently used to carry fish and water to the existing holding and load facilities will be abandoned or demolished, as necessary. The new extended collection gallery, in addition to new dewatering and related features, will eventually combine (refer to the previous paragraph) with the new normal operation fish transportation flume coming from the surface collection system.

(3) Side Dewatering System

The majority of excess water from the surface collection channel will be removed by a side manifold dewatering system located at various locations across the length of the collection channel. This dewatering system, comparable in concept to a system currently under construction for the new McNary Juvenile Fish Facilities (see plates 74 and 75) that will remove excess water with velocities perpendicular to the screen equal to or less than 0.4 fps.

The manifold dewatering system will consist of a total of five stations across the powerhouse, and one station located in the normal operation collection channel floor transition area near the south shore. Each station will have ten conduits and control gates directing discharges to a common water withdrawal channel located between the manifold dewatering system and the upstream face of the original dam. A brush screen cleaning system will be used to periodically clean debris from the screens.

The water withdrawal channel that carries excess flows to the north end of the powerhouse will discharge into a large chamber separating, during normal operations, a single spillway bay from the forebay (see plates 72 and 77). This spillway gate in the isolated bay will be opened enough to discharge excess collection channel flows over the spillway.

During high river flow conditions, when all of the spillway bays are needed and fish collection and bypass operations are halted, a bulkhead will be installed at the north end of the water withdrawal channel. Bulkheads will be removed from the large chamber around the spillway gate to allow discharge from the forebay through the spillway.

(4) Floor Dewatering System

The floor dewatering system comparable in design to existing primary dewatering systems used at the Lower Monumental and Little Goose Juvenile Fish Facilities, will further reduce the channel flow remaining after the side dewatering (see plates 73 and 74). Water velocity perpendicular to the screen will be equal to or less than 0.4 fps. A brush screen cleaning system will be used to periodically clean debris from the screens.

c. Drawdown Fish Sampling or Bypass Operations

(1) Surface Collection System Fish Transportation Channels

The surface collection system fish transportation channels will operate in a manner similar to that previously described for normal operations, except that the effective slot depth will equal 28 feet [assuming a forebay elevation equal to 705 (see plate 76, detail 2)]. Average velocities through the slot openings will range between 1 and 2 fps, assuming 717 cfs entrance flow per slot. Slot openings and depths can be reduced to optimize fish passage and hydraulic conditions by adding solid panels to the framework of the slot openings. Dewatering of entrance flows (see the following paragraphs) will be completed within the collection channel that will keep channel flows across the powerhouse at about 717 cfs. Average collection channel velocities within the channel across the powerhouse will range between 1.5 and 2.5 fps.

Fish and collection channel transportation flows (about 717 cfs) reaching the south end of the powerhouse will then enter into a floor transition and additional dewatering sections. The floor invert will rise at about a 5-percent slope [about a 3-degree adverse angle (see plate 76)] until it is slightly higher than the invert of the new collection gallery within the dam that will extend (refer to the following paragraphs) beyond the south end of the powerhouse.

The water depths and flow amounts in this transition channel will be reduced from about 28 feet of depth and 717 cfs, to about 18 feet of depth and about 360 cfs (assuming a forebay elevation of 705). Water velocities throughout this transition will again range between 1.5 and 2.5 fps.

Fish and transportation flows (approximately 360 cfs) will then continue in the channel until the channel is eventually combined (after undergoing additional dewatering and channel transitions) with the extension of the new collection gallery from the dam. The combined collection channels will then lead to new bypass and sampling facilities by utilizing a small transportation flume with about 30 cfs flow.

(2) New Fish Collection Gallery Within the Dam

The new fish collection gallery located within the powerhouse, which would be used as part of the existing turbine intake screen system during drawdown conditions, would be extended (mined--see plate 73) through the south end of the powerhouse. The extension of the new collection gallery, in addition to new dewatering and related features, will combine (see the previous paragraph) with the drawdown operation fish collection channel coming from the surface collection system.

(3) Manifold Dewatering System

Excess water not required to transport fish through the surface collection channel will be dewatered primarily by the same side manifold dewatering system previously described for normal operations. The system will remove water with velocities through the gross screen area equal to about 0.5 fps. The manifold dewatering system will consist of a total of five stations across the powerhouse (same as that used for normal operations) and one station located in the drawdown operation collection channel floor transition area near the south shore.

The same water withdrawal channel and related systems used for normal operations will carry excess flows to the north end of the powerhouse for discharging over the spillway. As was the case for normal operations, during high river flow conditions when all of the spillway bays are needed, a bulkhead will be installed at the north end of the water withdrawal channel. Bulkheads will be removed from the large chamber around the spillway gate to allow discharge from the forebay through the spillway.

d. Transition and Emergency Fish Bypass Operations

It will be possible to use a portion of the surface collection system to divert fish in the upper reservoir water levels to the southernmost spillway bay as the pool is being lowered between normal and full drawdown operations. This same system could also be used for emergency operations during both normal and drawdown operations when portions of the main system become nonfunctional. Although this part of the system will be capable of passing fish directly to the tailrace from the surface collection system, it will not be designed to meet all optimal fishery criteria because of anticipated low usage of this system.

To implement this system, bulkheads will be installed in the normal and drawdown operation fish channels at the south end of the powerhouse. A bulkhead will be removed form the fish channel at the north end of the powerhouse. The manifold side dewatering system will be shut down, and a bulkhead will be installed at the north end of the water withdrawal channel.

Fish and transportation water entering the collection channel through the vertical slots across the powerhouse will move northward toward the nearest spillway bay, rather than southward towards regular facilities. Fish and water will then proceed into the large chamber at the north end of the powerhouse. Finally, fish will pass through the gated opening of the spillway to the tailrace.

Flow passing into the vertical entrance slots, and in the collection channel, will be controlled by the amount of water passing through the spillway gate. Slot openings and depths could be reduced to somewhat optimize fish passage and hydraulic conditions. As previously discussed, flow conditions during these operations will not meet the optimum fishery criteria. The harshest conditions (i.e., high velocities, etc.) will occur as fish pass through the spillway gate and over the spillway to reach the tailrace.

16.04. Construction Methods

a. General

The channel and dewatering system will be constructed of structural steel. This results in a channel that is much lighter than if it was constructed of concrete. Consequently, erection of the channels will be easier. All work can be performed without upstream cofferdams. Concrete corbels will be installed on the upstream face of the dam. The dewatering and fish channels can be supported on the corbels. Steel piling embedded into rock with steel framing will be used to create a dewatering chamber that allows water from the dewatering channel to pass over the southernmost spillway bay.

b. Concrete Corbels

Precast concrete corbels (see plates 74 and 75) will be attached to the pier nose on the upstream face of the powerhouse intake and erection bay structures. Prior to installing the corbels, reinforcing steel anchorage bars must be grouted into the existing structures. The drilling and grouting will be performed underwater. The bars will extend upstream of the powerhouse to receive the precast corbels. The precast concrete corbels will be fabricated on the shore, and will have blockouts to receive the anchorage bars. After the grout holding the anchorage bars in the dam has obtained adequate strength, the corbels will be loaded onto a barge with a barge-mounted crane and erected. The crane will lower the corbels into position, with the anchorage bars extending into the blockouts in the corbels. The blockouts will then be grouted underwater. The corbels will have to be held in place by a crane until the grout has obtained enough strength to support the corbels.

c. Channel Sections

Individual 30-foot-long structural steel channel sections, that include the fishway channels, dewatering manifolds and the water withdrawal channel, can be fabricated on shore just upstream of the dam. As much of the fabrication as possible will be performed on the shore to avoid underwater assembly that is far more difficult. Following fabrication on the shore, the structural steel sections will be loaded onto barges with barge-mounted cranes, and set on the corbels. Each channel section will be capable of spanning between adjacent corbels. Adjacent channel sections will be attached, both to each other and to the corbels. The steel may be protected from corrosion by use of an impressed current cathodic protection system.

The normal operation surface collector fish channel will extend downstream of the dam until it merges with the fish collection channel originating from the extension of the fish collection gallery within the dam. The channel will consist of a corrugated metal flume supported by steel towers, similar to that used for the Little Goose Juvenile Fish Facility.

A dewatering structure for the drawdown surface collection fish channel will be installed on the downstream face of the south nonoverflow monolith. It will be constructed of steel, and will be similar to the dewatering structure used for the Little Goose Juvenile Fish Facility. The surface collection fish channel will then merge with the flume leading from the drawdown fish channel extension. Steel towers extending to the ground, and supports attached to the downstream face of the nonoverflow monolith, will support the channel and dewatering units.

d. Channels Extending Through the Dam

Various channels are required to pass water through the dam. These channels will be mined out of existing concrete. Mining will probably consist of drilling, splitting, and then removing the concrete. A bulkhead and frame will be placed on the upstream side of the mined channel to hold back reservoir water during construction. Mined channels will be required as described below:

- The surface collection drawdown fish channel will extend westerly through the south nonoverflow monolith. The channel in the monolith will be created by mining approximately a 10-foot-wide by 21-foot-high opening.

- The normal operation fish channel will be mined through the erection bay and north nonoverflow monoliths. The channel will be 3 feet in diameter, and will extend between the existing access gallery and the proposed extension of the existing powerhouse collection gallery (see plate 74, section D).

e. Dewatering Chamber Adjacent to the Spillway

A chamber just upstream of the southernmost spillway bay (see plate 77) is required to allow water from the dewatering channel to pass over the spillway. The water level in this chamber will be lower than the reservoir. A structural steel frame with removable stoplogs will be required to isolate the reservoir water from the chamber. The stoplogs will be removed, when necessary, to spill reservoir waters over the southernmost spillway bay during extremely high river flows.

Large holes will be drilled into the rock at the bottom of the reservoir. Piling, consisting of large wide flange sections, will be welded together at a work area near the upstream shoreline. The piling will be loaded onto a barge with a barge-mounted crane. The piling will be moved by barge over the holes in the rock. The piling will then be set in the holes, and grouted in place with tremie concrete.

Following erection of the piling, a structural steel framework will be installed to connect the piling together, as well as to the upstream face of the spillway monolith. Some of the steel erection will be performed underwater with divers.

Steel stoplogs will be fabricated and installed in the stoplog slots located on both ends of each piling group. To allow access to the stoplog guides, a heavy platform will be constructed over the structural steel framework at the same elevation as the top of the dam. A tire-mounted crane could then remove or install the stoplogs as necessary.

16.05. Implementation

The total time to implement a surface collection system in the forebay at Lower Granite Dam (assuming the project has received authorization and appropriation) is estimated to be slightly more than 5 years. This time includes 2½ years for Feature Design Memorandums and Plans and Specifications preparation, and 2 3/4 years for construction. Additional time needed to complete fisheries research and hydraulic model studies related to this alternative is assumed to occur during Phase II of the Systems Configuration Study, and prior to the start of the Feature Design Memorandums. It should also be noted that the total project implementation time assumed the sufficient manpower and resources will be available during all phases of the project. Lengthy review processes, manpower shortages, and limited resources would extend the total estimated project time.

16.06. Cost Estimate

Cost data is based on conceptual-level designs, and are to be used for comparing various alternatives in the planning process. They are not of sufficient detail for project authorization or appropriation.

The concept-level, fully-funded project cost is estimated to be $145,922,000 for Lower Granite Dam. As discussed in paragraph 16.01., the surface collection system in this study will be used to supplement the existing turbine fish collection and bypass system. The total fully-funded cost would be in addition to the costs related to alternative 13 (see paragraph 5.05.e). Similar costs would be associated with constructing surface collection systems for other lower Snake River dams. Construction costs are based upon an October 1992 price level escalated to midpoint of construction. The required biological research, feasibility studies, hydraulic model studies, feature design memorandums, and engineering and design was estimated at 20 percent of the construction cost. Construction management was estimated at 11 percent of the construction cost. Contingencies used reflect the expected level of construction risk, unknowns, and the level of design detail available in this study.

16.07. Summary

a. General

A surface flow collection system has been suggested as a means to improve juvenile fish guidance during drawdown operations at the lower Snake River dams. (This system will be in addition to drawdown alternative 13.) The surface flow collection system in the forebay will attempt to take advantage of the behavioral tendency of juvenile fish to swim in the upper levels of the reservoir pool. The design uses deep vertical-slot fishway entrances connected to a collection channel and related features to direct fish to: 1) sampling and bypass facilities during drawdown operations; 2) fish collection/sampling/transport or sampling/bypass facilities during normal operations; and 3) bypass facilities during emergency operations and during transition operations between normal and drawdown procedures.

Total conceptual-level, fully-funded project costs to construct a surface flow collection system at Lower Granite Dam (not including other costs associated with alternative 13) will equal $145,922,000. Total time to implement a surface flow collection system at Lower Granite Dam, assuming all Phase II studies are complete and there are no manpower or resource restrictions, is estimated at slightly more than 5 years.

b. Unknowns and Future Studies

(1) Unknowns

Besides the unknowns previously identified for alternative 13, one of the biggest uncertainties associated with a surface collection system is how effective the system will be in collecting or bypassing fish. Also, it is not known if a surface collection system will enhance the performance of the present turbine intake systems by causing fish to swim higher in the water column and, therefore, make the existing turbine intake screens more effective in diverting fish.

(2) Future Studies

Additional hydraulic model studies using Lower Granite Dam general project and turbine intake sectional models, beyond what has previously identified for alternative 13, will be required to optimize the design of a surface collection system for the wide range of expected pool elevations. In addition, biological testing will be required to help judge the effectiveness of a surface collection system.

One method that might be used to help determine the fish collection/guidance efficiencies of a surface collection system, in conjunction with existing or new turbine intake systems, would be to use the Ice Harbor Dam project, with its existing ice-and-trash sluiceway [see paragraph 16.02.a.(2)], in combination with a new turbine intake system that is being added to the project. Biological research evaluating fish collection/guidance for both singular and combination weir surface collection and turbine intake systems might give an indication of the effectiveness of a surface collection system.

Appendix B - Other Studies

Lower Snake Reservoir Drawdown
Impact on Power Plant Operation

Ice Harbor
Lower Monumental
Little Goose
Lower Granite

February 1992

FEBRUARY 1992

LOWER SNAKE RESERVOIR DRAWDOWN IMPACT ON POWER PLANT OPERATION

ICE HARBOR
LOWER MONUMENTAL
LITTLE GOOSE
LOWER GRANITE

PREPARED BY:
HYDROELECTRIC DESIGN CENTER
NORTH PACIFIC DIVISION
PORTLAND, OREGON

DEPARTMENT OF THE ARMY
WALLA WALLA DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

FEBRUARY 1992

LOWER SNAKE RESERVOIR DRAWDOWN IMPACT ON POWER PLANT OPERATION

ICE HARBOR
LOWER MONUMENTAL
LITTLE GOOSE
LOWER GRANITE

By

CORPS OF ENGINEERS
HYDROELECTIC DESIGN CENTER
NORTH PACIFIC DIVISION
PORTLAND, OREGON

For

WALLA WALLA DISTRICT
CORPS OF ENGINEERS
WALLA WALLA, WASHINGTON

Prepared by: Brian Moentenich
Brian L. Moentenich
Mechanical Engineer, P.E.

Alan R. Christensen
Alan R. Christensen
Mechancial Engineer, P.E.

Impact on Power Plant Operation

1. General. Lowering the reservoir levels at one or more of the four projects on the lower Snake River will impact powerhouse operation. As levels are lowered, the net heads and tailwater elevations on the turbines are also lowered. This will reduce generation, unit efficiency, and increase the tendency of the turbine to cavitate. The greater the pools are lowered, the greater the impacts. There may be head and/or tailwater levels below which would shut down the powerhouse.

1.1 The existing turbines at the four lower Snake River projects are expected to be able to operate at lower than designed heads that will occur when the forebay elevation is lowered to levels approaching the spillway crests. No structural modifications are anticipated to be needed. This is based upon unit performance data (power output, discharge, and efficiency) contained in the model test reports for the respective turbines. Even though the model tests indicate the units can operate at these low heads, there may be other reasons which would prohibit them to do so. There is a possibility that unacceptable air entraining vortices may form on the water surface near the trash racks. The units may run rough with excessive noise and vibration. Also, the units may be prone to cavitate badly.

1.2 For a six-week period, beginning 1 March 1992, the Lower Granite and Little Goose forebay reservoir levels are planned to be lowered to elevations 703 and 617, respectively. During this test, the operation of Lower Granite's generating units will be monitored closely to verify if they can operate satisfactorily. Confirming Lower Granite's units to satisfactorily operate under lowered pool conditions would help verify that the generating units at the remaining lower Snake projects could do so as well.

2. Operation of Existing Units with Pools at Minimum Operating Pool and Spillway Crest. When the powerhouses are at minimum operating pool (MOP) the heads are all at about 100 feet. When the pools are lowered to the spillway crests, and the plants operate at a discharge of 20,000 cfs, the resulting heads range from 52.7 feet to 65 feet. Kaplan turbines commonly operate over head ranges exceeding 2:1. For example, the operating head range for the Bonneville Second Powerhouse turbines is 32.5 feet to 70 feet. Graphs numbered IH-1 thru IH-4 and LS-1 thru LS-4 represent the expected performance of the existing units when the units are operated at the best gate efficiency over the head range from the minimum operating pool elevation to the spillway crest elevation at a discharge of 20,000 cfs. The unit efficiencies decrease at the lower heads.

3. Options to Increase Efficiency. Operating existing turbine-generator units at low heads causes losses in operating efficiencies. This is because the turbines were designed and built to have peak efficiencies at or near the heads they would be operated at most of the time. Low efficiency operation due to lower heads can be mitigated wholly or in part by one of the following:

(1) Operating at a lower speed.

(2) Operating at variable speeds.

(3) Replacing the turbine runners.

3.1 Lower Speed. To operate the units at lower speeds, the generators would need to be replaced. If the full rated unit power output capacities are to be maintained, the shaft torque would increase. This means the shafts would have to be replace as well as installation of larger coupling bolts in the turbine runner hub. The operating characteristics of the units would be nearly the same as if new turbine runners were installed. Graphs IH-T1 through IH-T4 and LS-T1 through LS-T4 show these expected operating characteristics. Estimated costs for this option are $9.5 million per unit.

3.2 Variable Speed. There are essentially two ways to vary the speed of large alternating current (AC) generators. The power output of the unit or plant can be converted to direct current (DC) and then inverted back to AC. The high voltage DC intertie used to exchange power between the Pacific Northwest and Southern California is an example of this method. Alternatively, a direct AC frequency conversion can be made using cyclo converters or series resonant converters. Variable speed operation, however, provides the ability to operate continuously at the turbine's best efficiency point regardless of head. Graphs IH-1M through IH-4M and LS-1M through LS-4M show the expected operating characteristics of variable speed units. Estimated costs for this option are $10 million per unit.

3.3 Replacing the Turbine Runners. New turbine runners can be designed which operate at peak efficiency at a lower head. The numerical value of the peak efficiency would be expected to remain the same or increase slightly. The blades can be made of stainless steel and discharge ring overlaid with stainless steel, which would improve cavitation resistance. As mentioned in paragraph 3.1 above, the unit characteristics would be the same as if the speed was lowered. Thus, graphs IH-T1 through IH-T4 and LS-T1 through LS-T4 represent the expected performance for new turbine runners. Estimated costs for new runners are approximately $4 million per unit.

Appendix

Tables:

I. 1. Elevation at MOP and Spillway Crest
2. Comparison of Maximum Turbine Efficiency

II. Cost Estimate and Construction Schedule

Graphs of Ice Harbor Generating Unit Performance:

	Existing Units	Graph number
	Best gate water rate vs. head	IH-1
	Best gate turbine discharge vs. head	IH-2
	Best gate turbine efficiency vs. head	IH-3
	Best gate unit efficiency vs. head	IH-4

	Modified Units (Variable Speed)	
III.	Best gate water rate vs. head	IH-1M
	Best gate turbine discharge vs. head	IH-2M
	Best gate turbine efficiency vs. head	IH-3M
	Best gate unit efficiency vs. head	IH-4M

	Modified Units (New Turbines)	
	Best gate water rate vs. head	IH-T1
	Best gate turbine discharge vs. head	IH-T2
	Best gate turbine efficiency vs. head	IH-T3
	Best gate unit efficiency vs. head	IH-T4

Graphs of Lower Monumental, Little Goose, and Lower Granite Generating Unit Performance:

	Existing Units	
	Best gate water rate vs. head	LS-1
	Best gate turbine discharge vs. head	LS-2
	Best gate turbine efficiency vs. head	LS-3
	Best gate unit efficiency vs. head	LS-4

	Modified Units (Variable Speed)	
IV.	Best gate water rate vs. head	LS-1M
	Best gate turbine discharge vs. head	LS-2M
	Best gate turbine efficiency vs. head	LS-3M
	Best gate unit efficiency vs. head	LS-4M

	Modified Units (New Turbines)	
	Best gate water rate vs. head	LS-T1
	Best gate turbine discharge vs. head	LS-T2
	Best gate turbine efficiency vs. head	LS-T3
	Best gate unit efficiency vs. head	LS-T4

V. Meeting Minutes: Variable Speed Generation
Transverse Sections:
Ice Harbor
VI. Lower Monumental
Little Goose
Lower Granite

Table 1
Elevations at Minimum Operating Pool and Spillway Crest

Project	MOP El (Feet)	TW El at 20 kcfs	Head (Feet)	Spillway Crest El	TW EL at 20 kcfs	Head (Feet)
Ice Harbor	437.00	338.30	98.70	391.00	338.30	52.70
Lower Monumental	537.00	437.16	99.84	481.00	428.30	52.70
Little Goose	633.00	537.06	95.94	581.00	517.97	63.03
Lower Granite	733.00	633.11	99.89	681.00	616.00	65.00

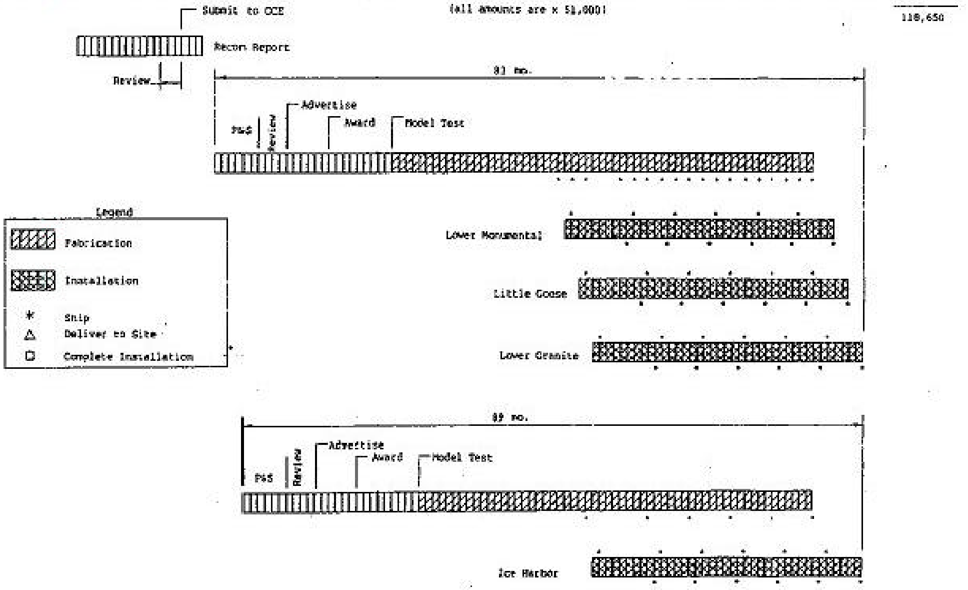
Table 2
Comparison of Maximum Turbine Efficiency (%)

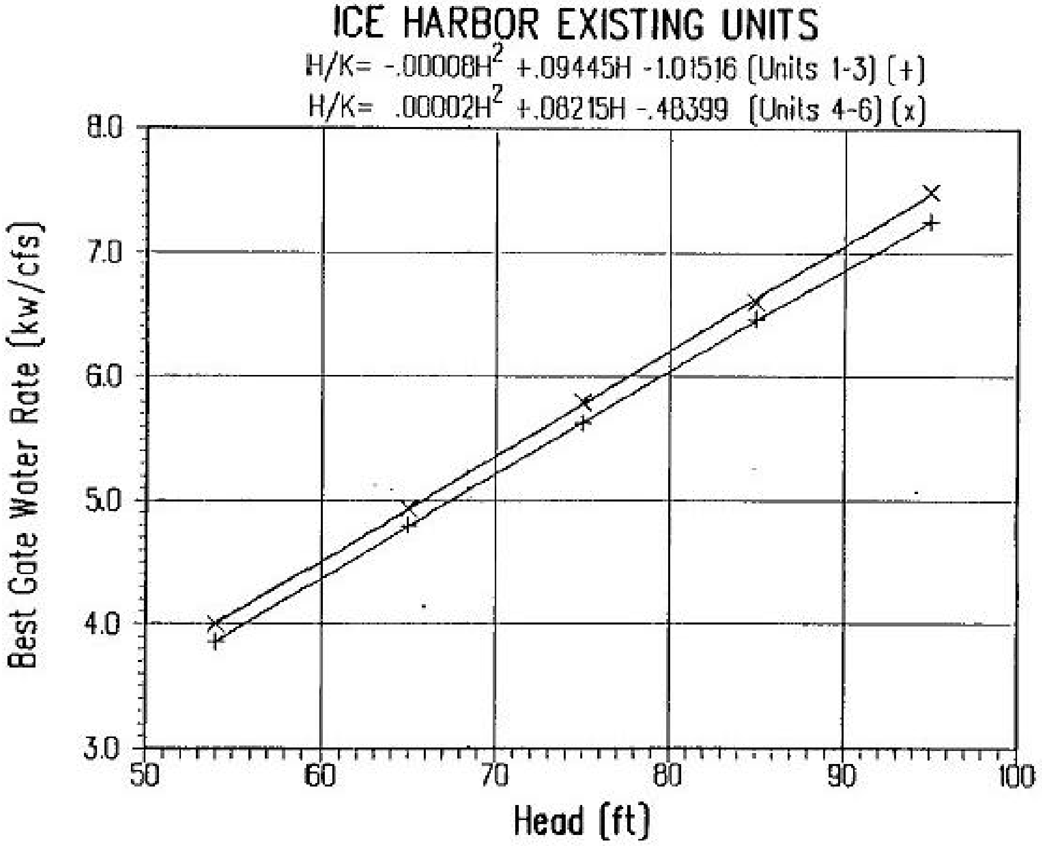
Project/Unit	Existing Units			Variable Speed DC Link			New Runner/Low Speed Generator		
	60'	80'	100'	60'	80'	100'	60'	80'	100'
I. Harbor 1-3	89.3	92.0	92.5	92.8	92.8	92.8	91.9	92.7	90.4
I. Harbor 4-6	90.7	93.6	95.0	95.2	95.2	95.2	93.4	95.0	93.5
L. Mon 1-3	83.1	89.2	90.0	91.6	91.6	91.6	88.8	91.8	90.0
L. Mon 4-6	88.2	92.0	93.0	93.7	93.7	93.7	91.3	93.5	93.0
L. Goose 1-3	83.1	89.2	90.0	91.6	91.6	91.6	88.8	91.8	90.0
L. Goose 4-6	88.2	92.0	93.0	93.7	93.7	93.7	91.3	93.5	93.0
Lower Gr. 1-3	83.1	89.2	90.0	91.6	91.6	91.6	88.8	91.8	90.0
Lower Gr. 1-3	88.2	92.0	93.0	93.7	93.7	93.7	91.3	93.5	93.0

COST ESTIMATE AND CONSTRUCTION SCHEDULE-TURBINE RUNNER REPLACEMENT

	FY-1	FY-2	FY-3	FY-4	FY-5	FY-6	FY-7	FY-8	FY-9	FY-10	TOTALS
CONSTRUCTION	0	0	0	2,000	8,000	15,500	18,500	22,600	22,600	15,700	104,900
PLANNING & Eng	750	400	1,200	1,400	650	550	550	550	550	400	7,000
CONST. MGT.	0	0	50	250	400	750	1,500	1,500	1,500	800	6,750
											118,650

(all amounts are x $1,000)

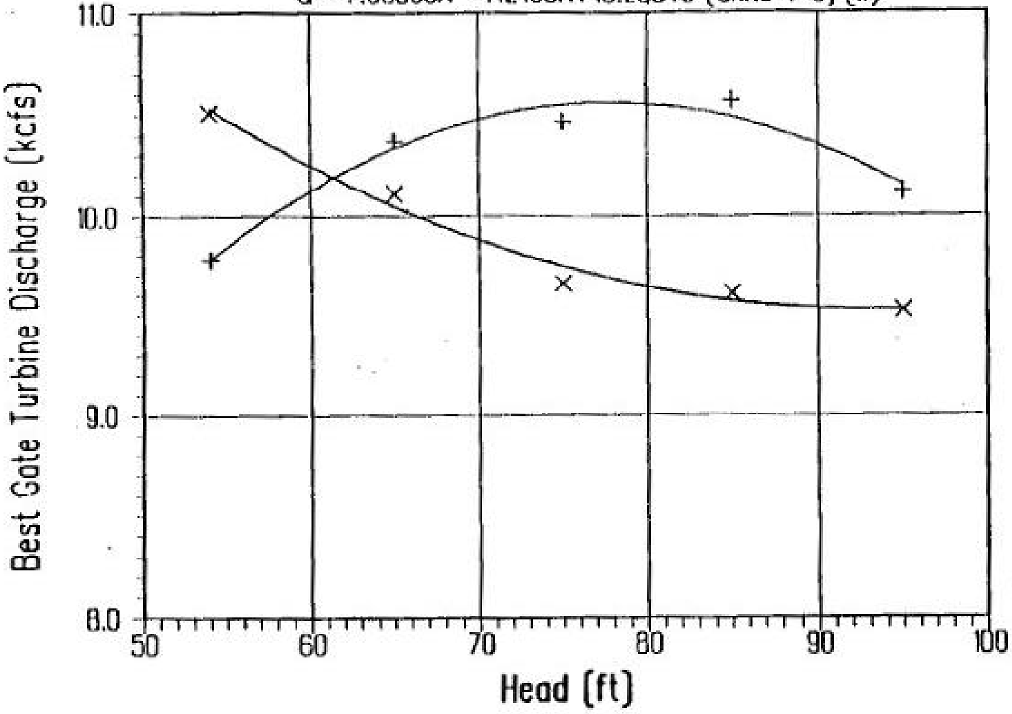




ICE HARBOR EXISTING UNITS

$Q= -.00139H^2 +.21531H+2.20014$ (Units 1-3) (+)

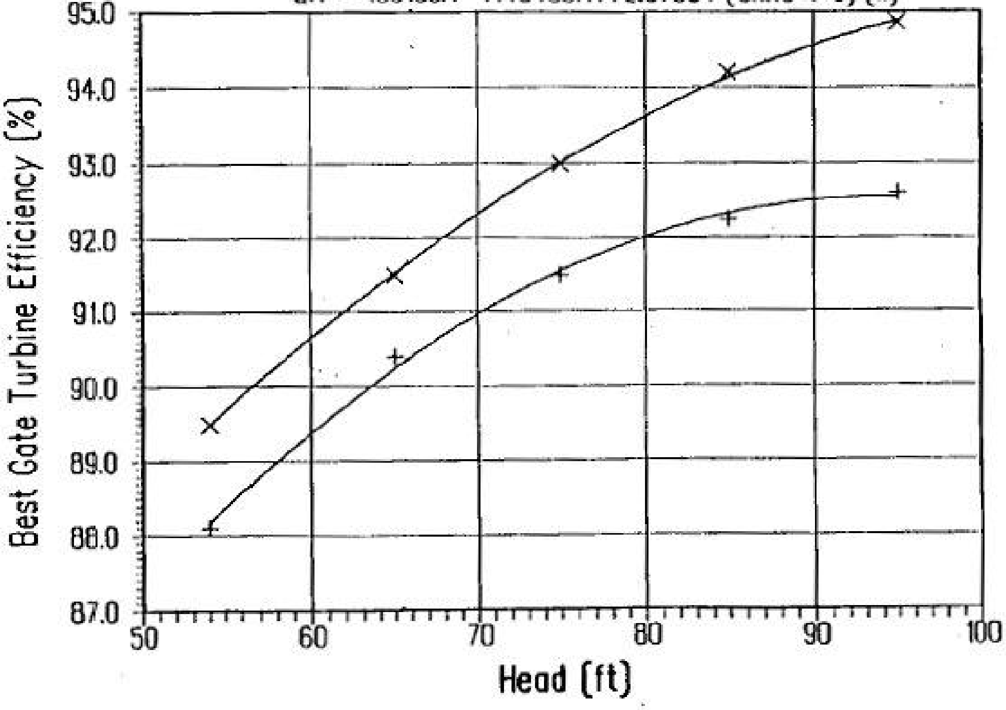
$Q= +.00066H^2 -.12195H+15.20343$ (Units 4-6) (x)

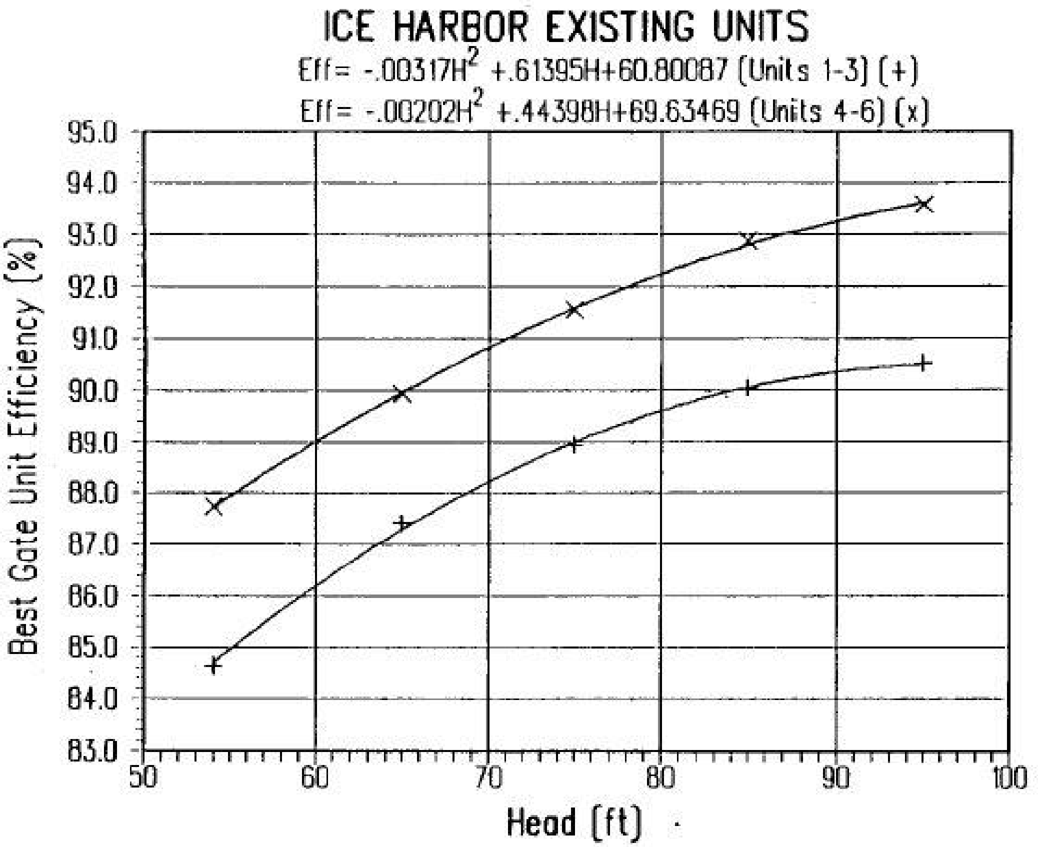


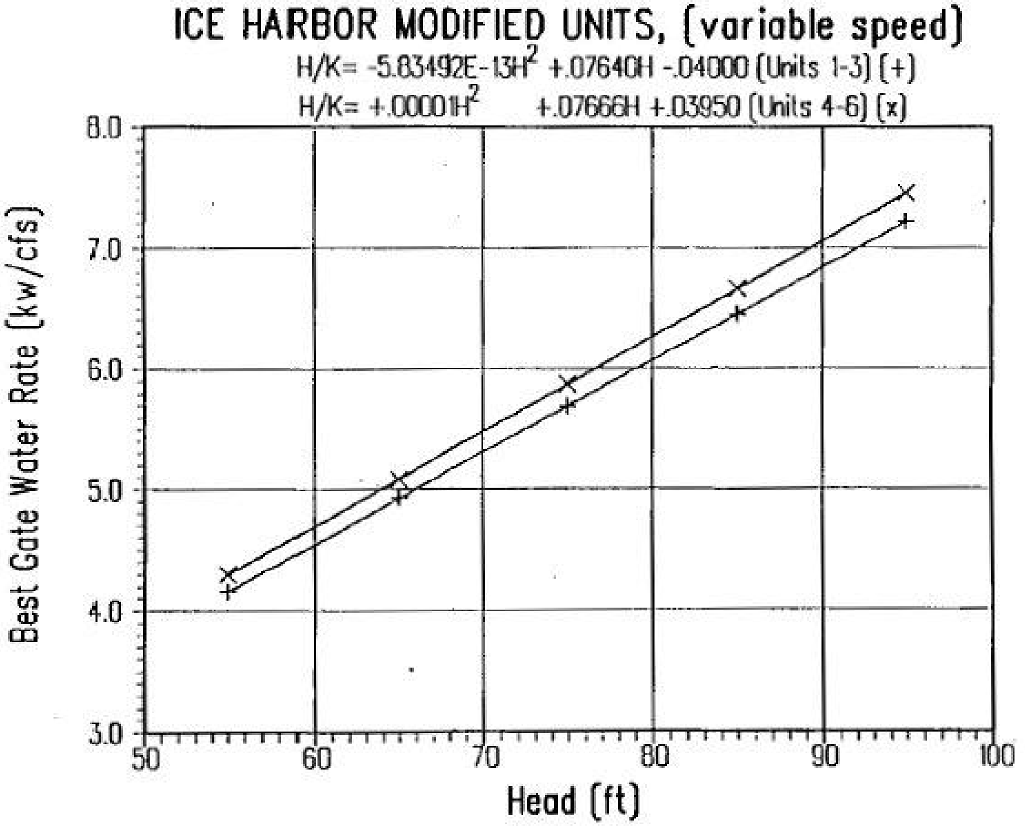
ICE HARBOR EXISTING UNITS

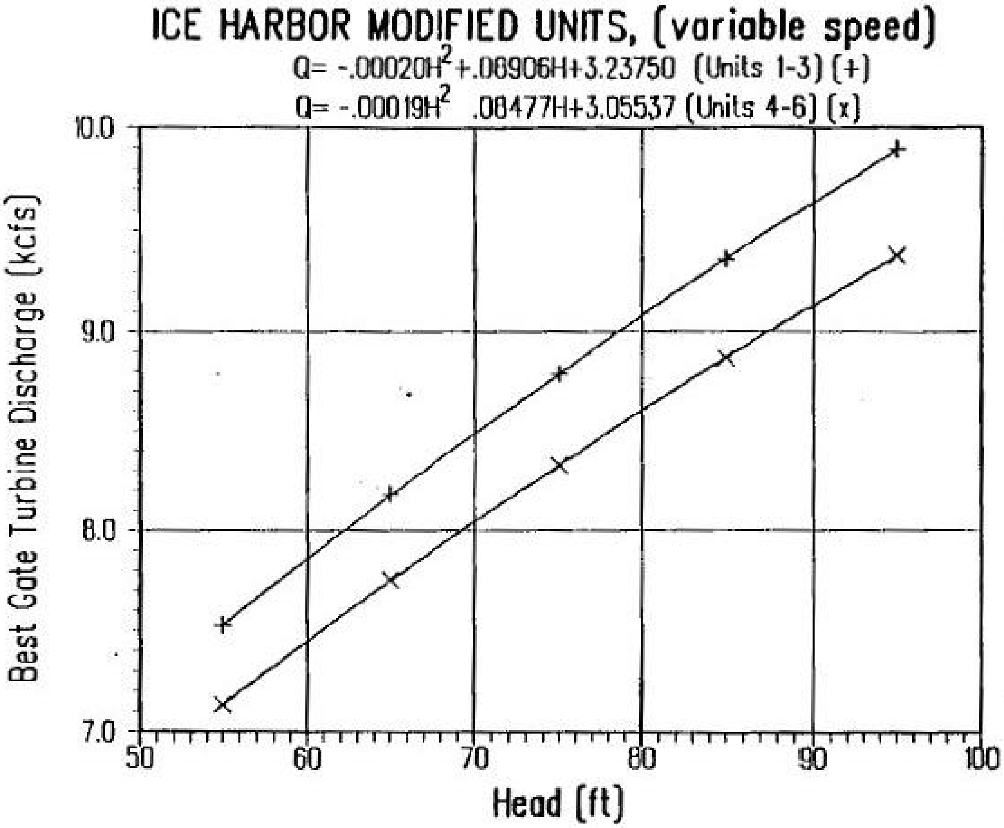
$Eff= -.00274H^2 +.51591H+68.30706$ (Units 1-3) (+)

$Eff= -.00183H^2 +.40455H+72.97034$ (Units 4-6) (x)



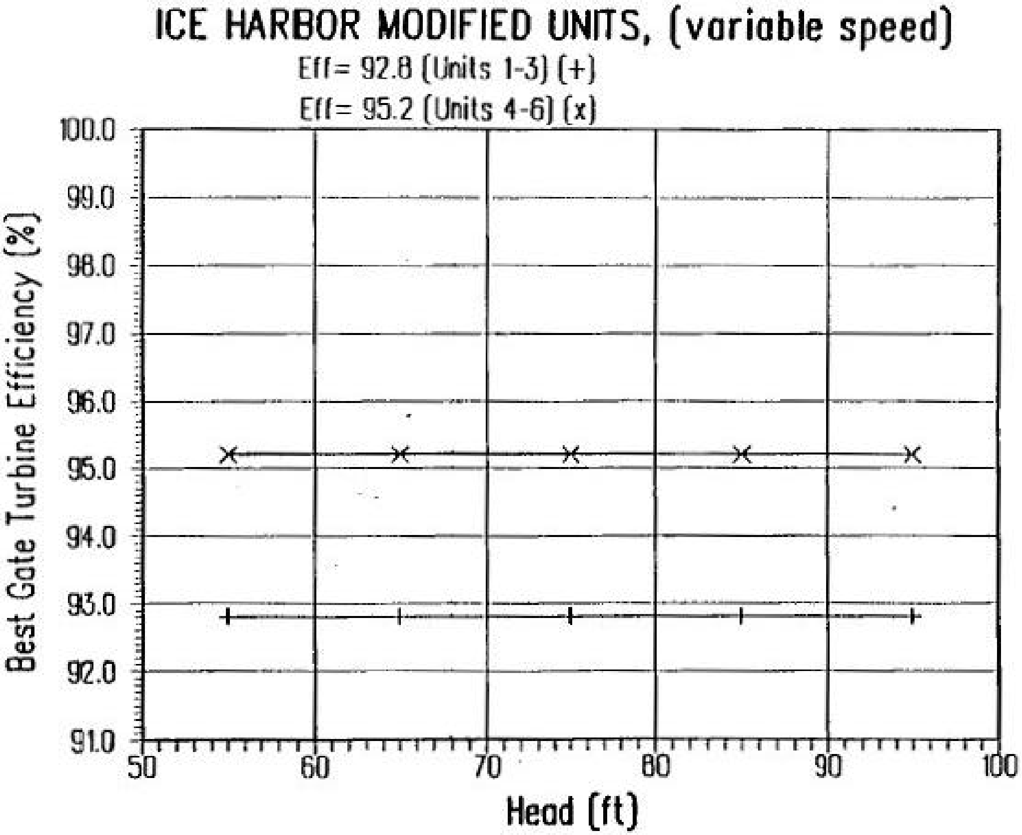

ICE HARBOR EXISTING UNITS
Eff= -.00317H^2 +.61395H+60.80087 (Units 1-3) (+)
Eff= -.00202H^2 +.44398H+69.63469 (Units 4-6) (x)
Best Gate Unit Efficiency (%)
95.0
94.0
93.0
92.0
91.0
90.0
89.0
88.0
87.0
86.0
85.0
84.0
83.0
50
60
70
80
90
100
Head (ft)


ICE HARBOR MODIFIED UNITS, (variable speed)
H/K= -5.83492E-13H^2 +.07640H -.04000 (Units 1-3) (+)
H/K= +.00001H^2 +.07666H +.03950 (Units 4-6) (x)
Best Gate Water Rate (kw/cfs)
8.0
7.0
6.0
5.0
4.0
3.0
50
60
70
80
90
100
Head (ft)


ICE HARBOR MODIFIED UNITS, (variable speed)

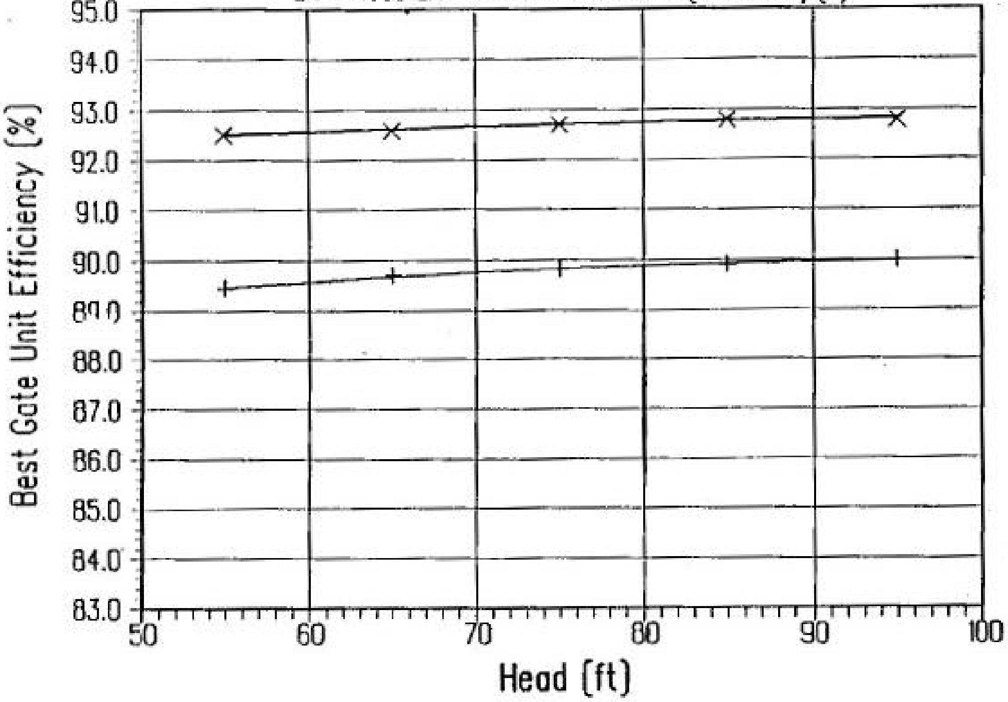
$Q= -.00020H^2+.08906H+3.23750$ (Units 1-3) (+)

$Q= -.00019H^2\ .08477H+3.05537$ (Units 4-6) (x)


ICE HARBOR MODIFIED UNITS, (variable speed)

Eff= 92.8 (Units 1-3) (+)

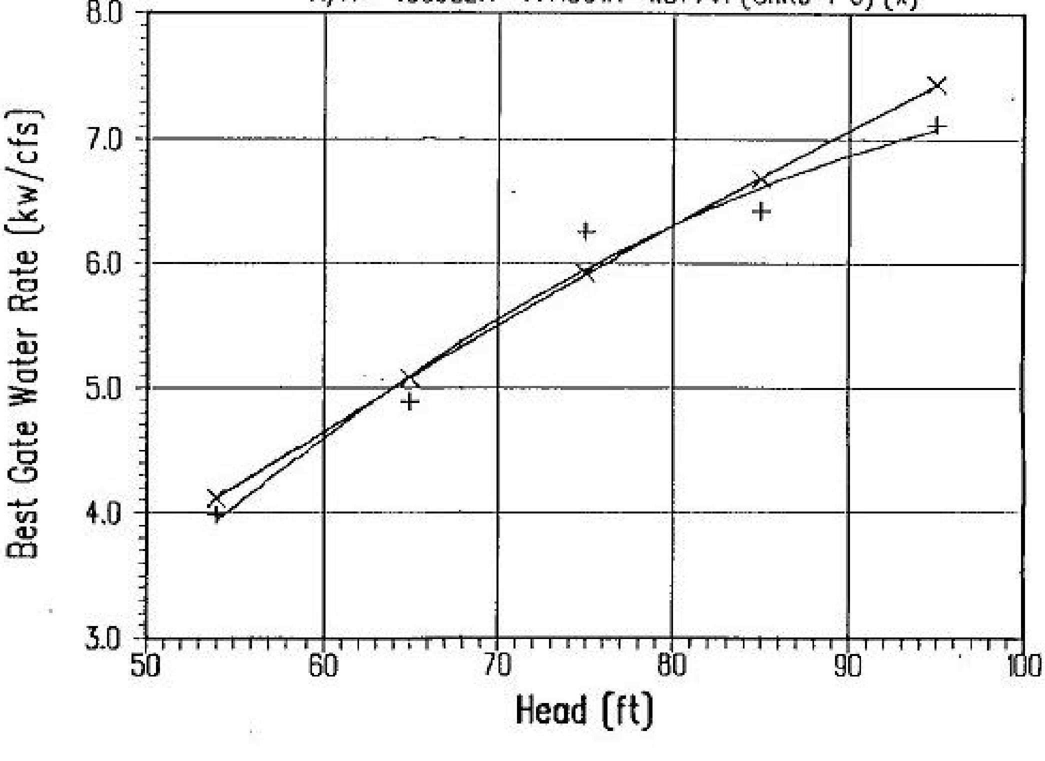
Eff= 95.2 (Units 4-6) (x)



ICE HARBOR MODIFIED UNITS, (variable speed)

Eff= -.00027H^2 +.05351H+87.33950 (Units 1-3) (+)

Eff= -.00012H^2 +.02571H+91.45475 (Units 4-6) (x)



ICE HARBOR MODIFIED UNITS (turbine)

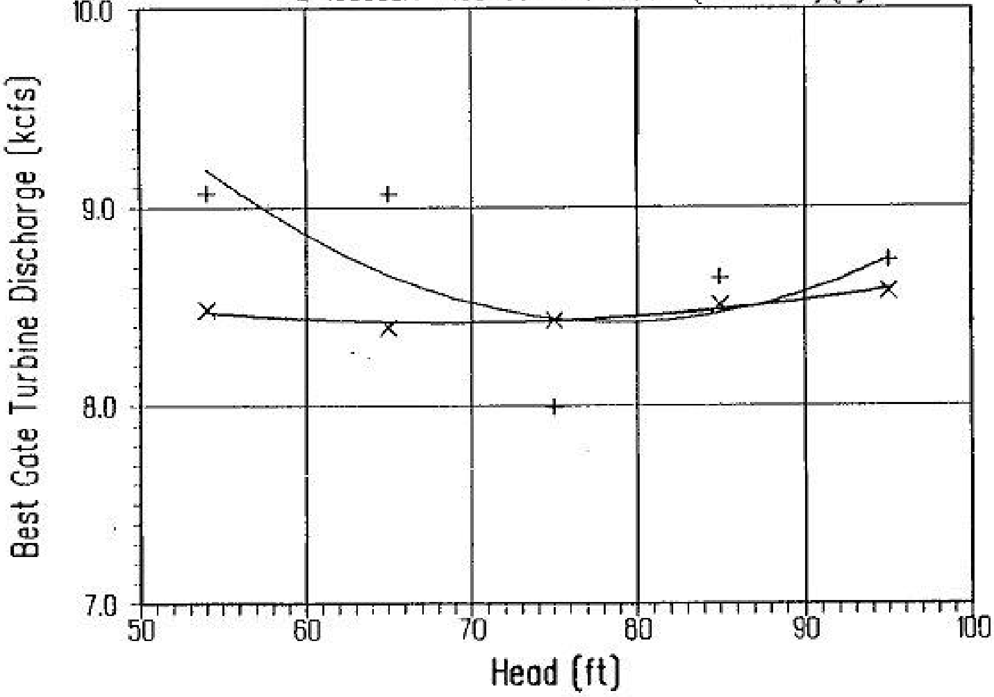
H/K= -.00097H^2 +.22163H -5.19785 (Units 1-3) (+)

H/K= -.00022H^2 +.11361H -1.37711 (Units 4-6) (x)

ICE HARBOR MODIFIED UNITS (turbine)

$Q=.00124H^2 -.19601H +16.15504$ (Units 1-3) (+)

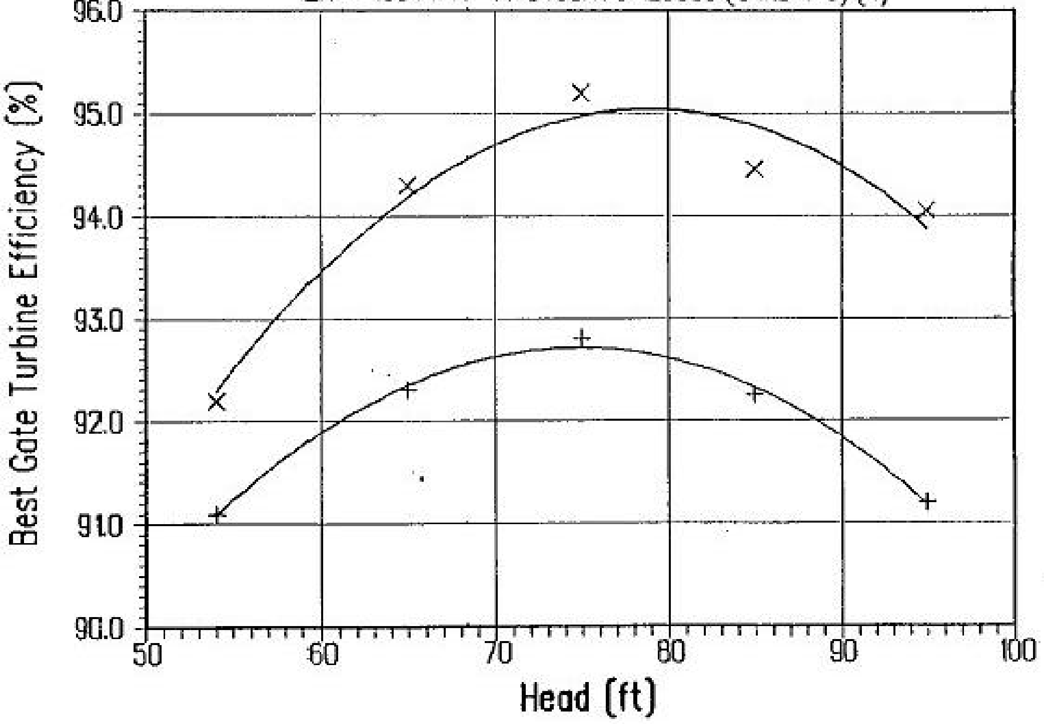
$Q=.00025H^2 -.03400H + 9.59034$ (Units 4-6) (x)



ICE HARBOR MODIFIED UNITS (turbine)

$Eff= -.00374H^2 +.56011H+71.76316$ (Units 1-3) (+)

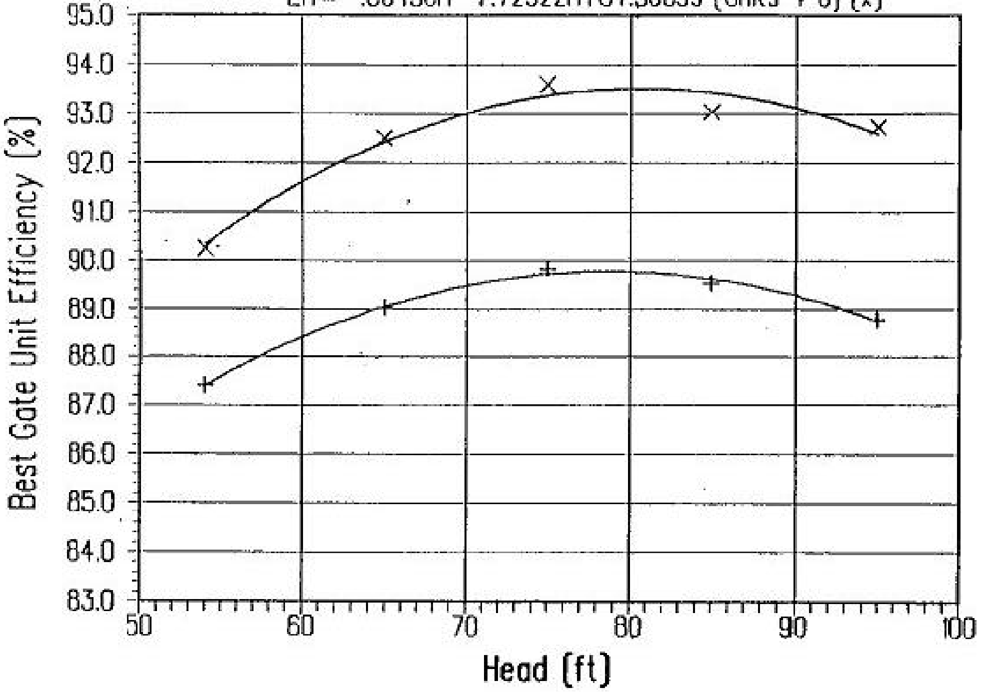
$Eff= -.00447H^2 +.70405H+67.29065$ (Units 4-6) (x)



ICE HARBOR MODIFIED UNITS (turbine)

$Eff = -.00389H^2 + .61298H + 65.66648$ (Units 1-3) (+)

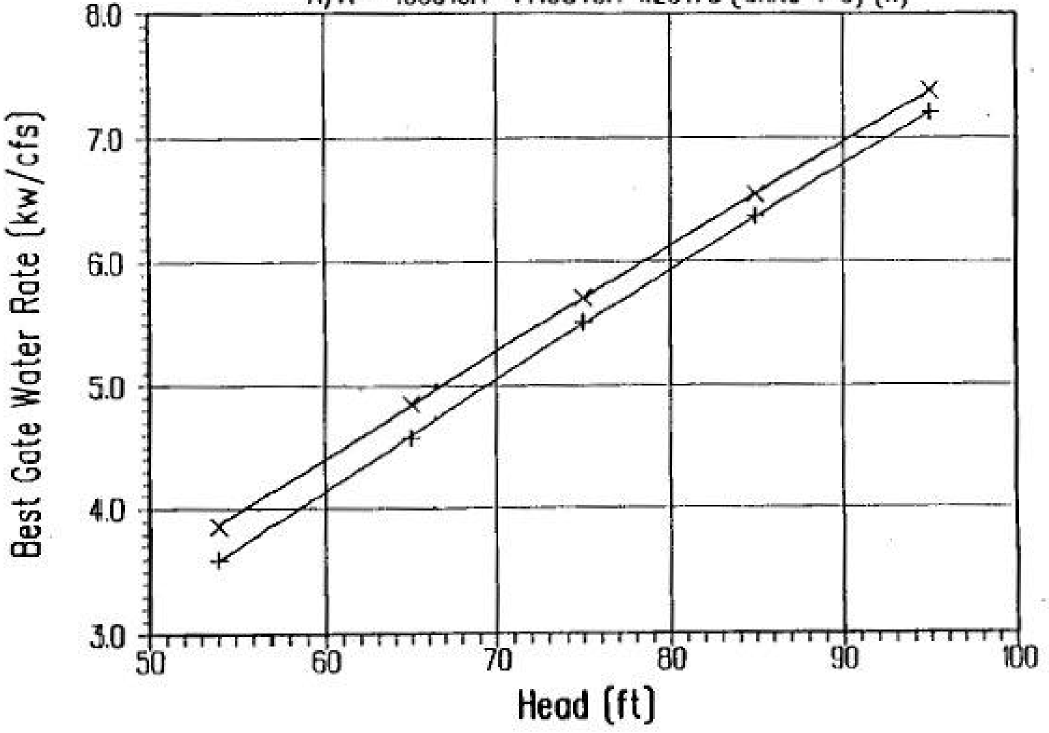
$Eff = -.00450H^2 + .72522H + 64.30099$ (Units 4-6) (x)



L.MON, L.GOOSE, & L.GRANITE EXISTING UNITS

$H/K = -.00014H^2 + .10950H - 1.91710$ (Units 1-3) (+)

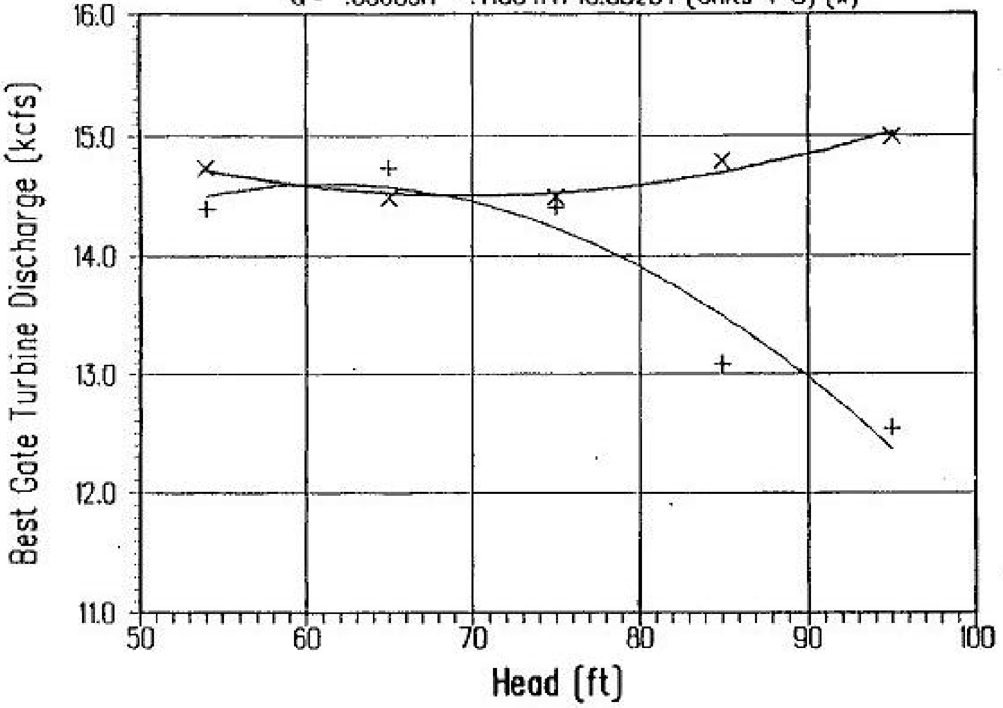
$H/K = -.00010H^2 + .10045H - 1.26178$ (Units 4-6) (x)



L.MON, L.GOOSE, & L.GRANITE EXISTING UNITS

$Q = -.00196H^2 + .23928H + 7.28555$ (Units 1-3) (+)

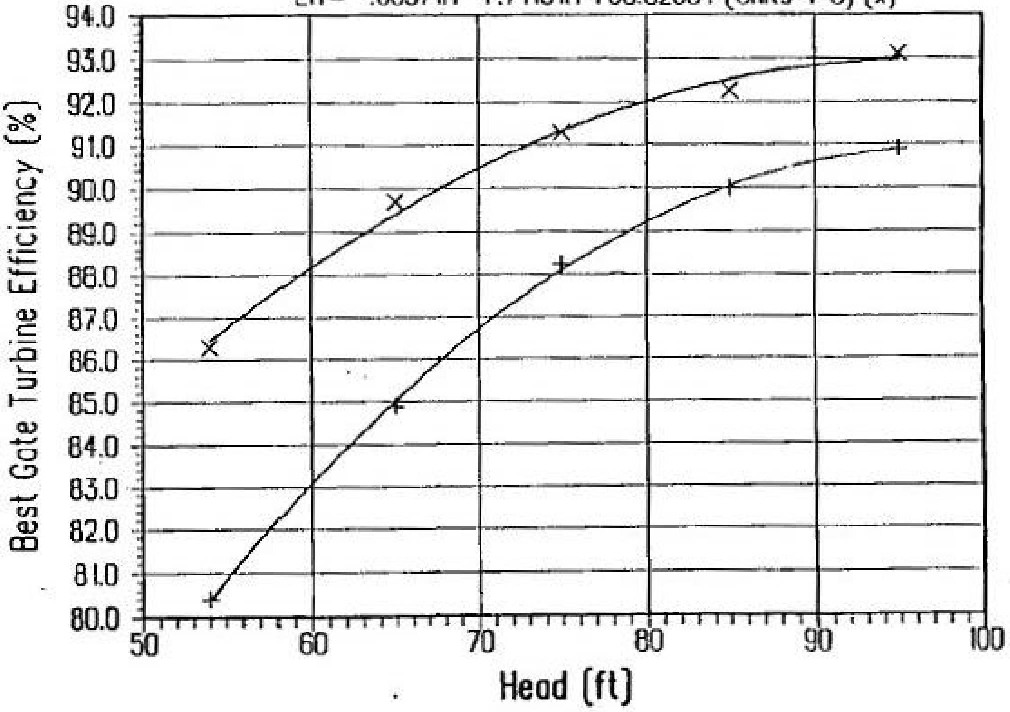
$Q = .00083H^2 - .11604H + 18.55254$ (Units 4-6) (x)

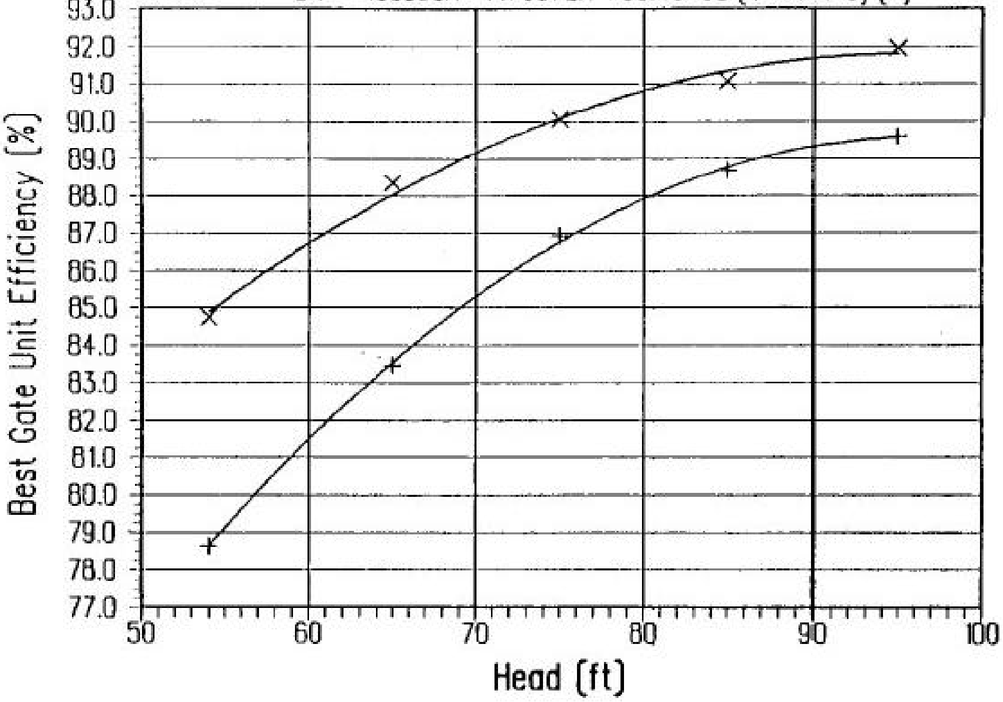


L. MON, L. GOOSE, & L. GRANITE EXISTING UNITS

$Eff = -.00559H^2 + 1.08954H + 37.82019$ (Units 1-3) (+)

$Eff = -.00371H^2 + .71151H + 58.82054$ (Units 4-6) (x)

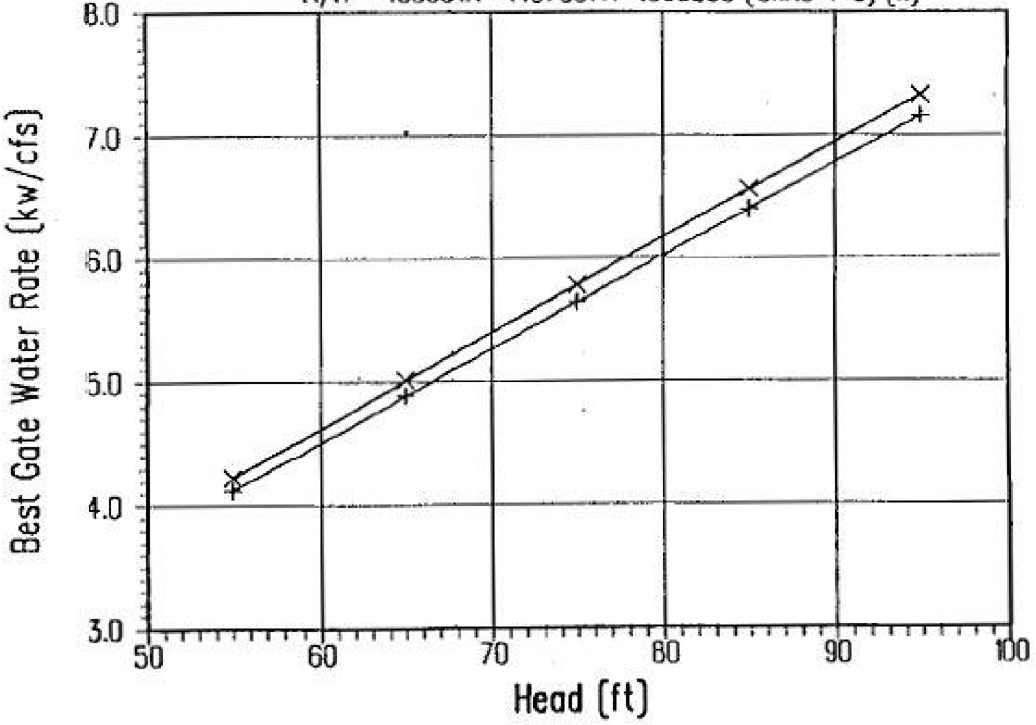




L. MON, L. GOOSE, & L. GRANITE EXISTING UNITS

Eff= $-.00605H^2 + 1.16873H + 33.16163$ (Units 1-3) (+)

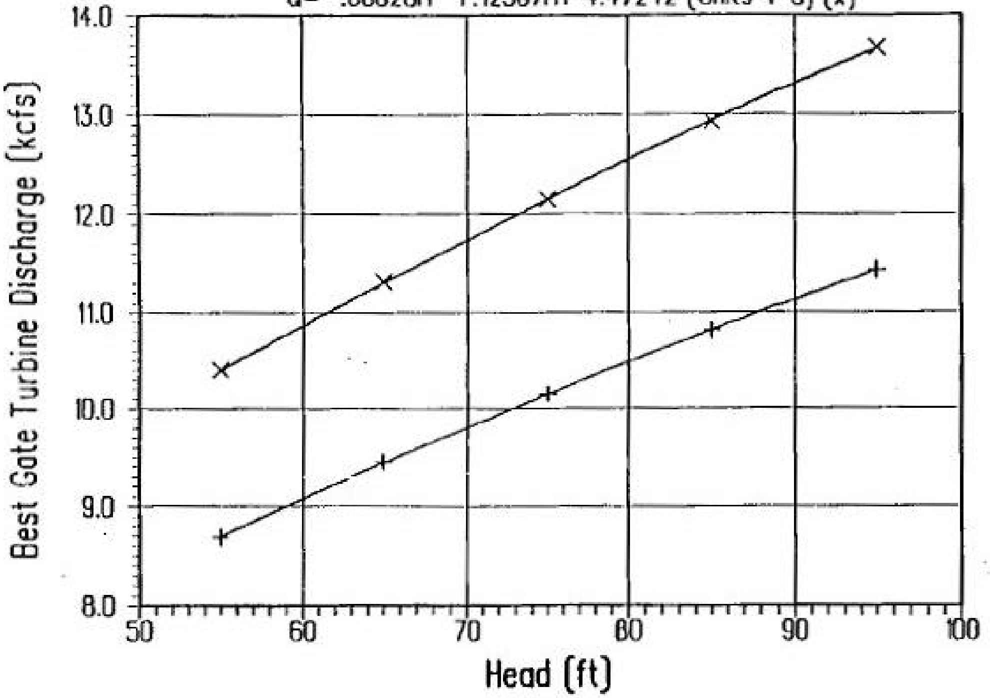
Eff= $-.00396H^2 + .75872H + 55.45782$ (Units 4-6) (x)



L.MON,L.GOO, & L.GRNT MODIFIED UNITS (var. speed)

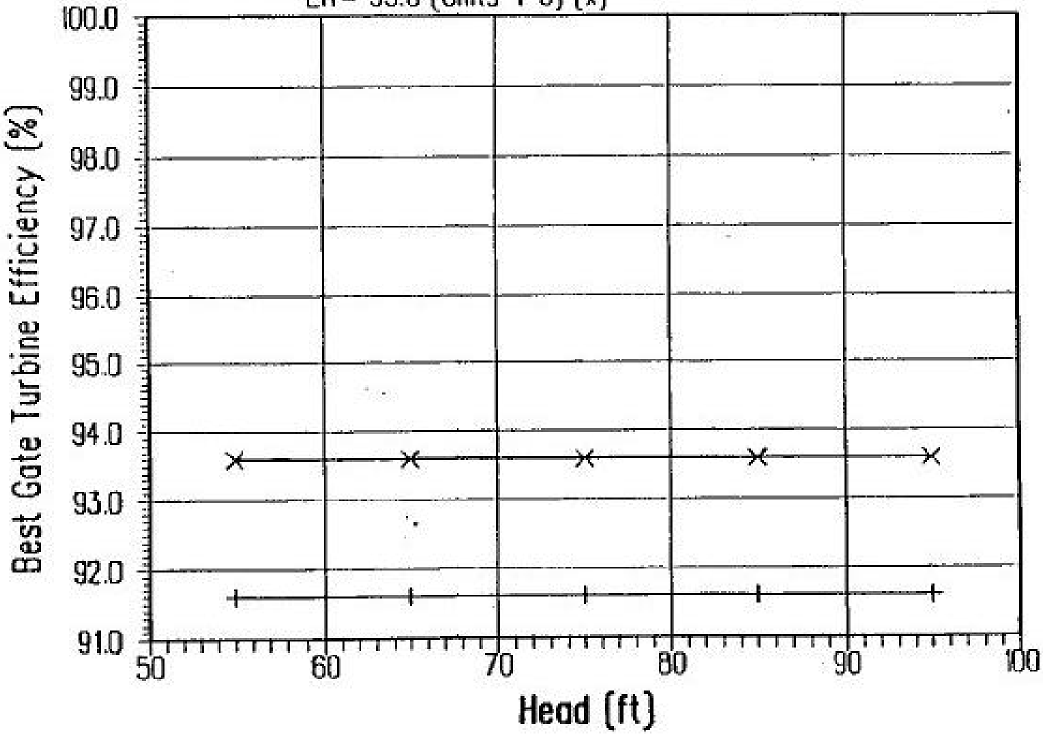
H/K= $.00001H^2 + .07463H + .005250$ (Units 1-3) (+)

H/K= $-.00001H^2 + .07857H - .069250$ (Units 4-6) (x)


L.MON, L.GOO, & L.GRNT MODIFIED UNITS (var. speed)

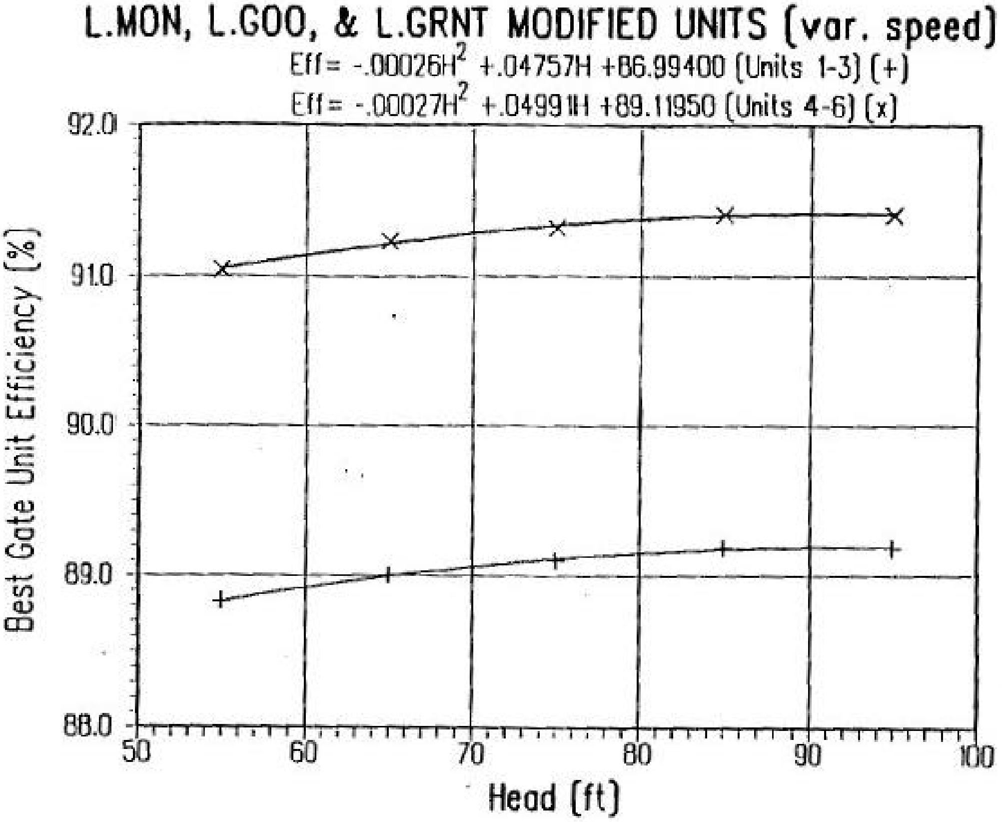
$Q = -.00023H^2 + .10305H + 3.73338$ (Units 1-3) (+)

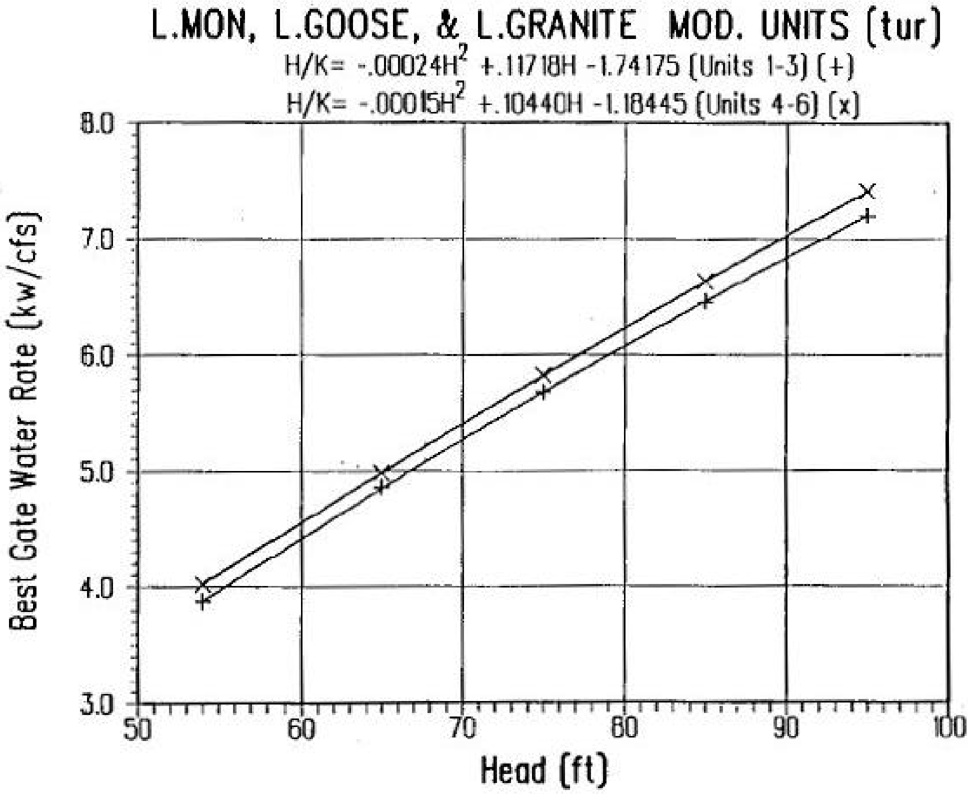
$Q = -.00028H^2 + .12307H + 4.47242$ (Units 4-6) (x)


L.MON, L.GOO, & L.GRNT MODIFIED UNITS (var. speed)

Eff= 91.6 (Units 1-3) (+)

Eff= 93.6 (Units 4-6) (x)


L.MON, L.GOO, & L.GRNT MODIFIED UNITS (var. speed)
Eff= -.00026H^2 +.04757H +86.99400 (Units 1-3) (+)
Eff= -.00027H^2 +.04991H +89.11950 (Units 4-6) (x)
92.0
91.0
90.0
89.0
88.0
Best Gate Unit Efficiency (%)
50
60
70
80
90
100
Head (ft)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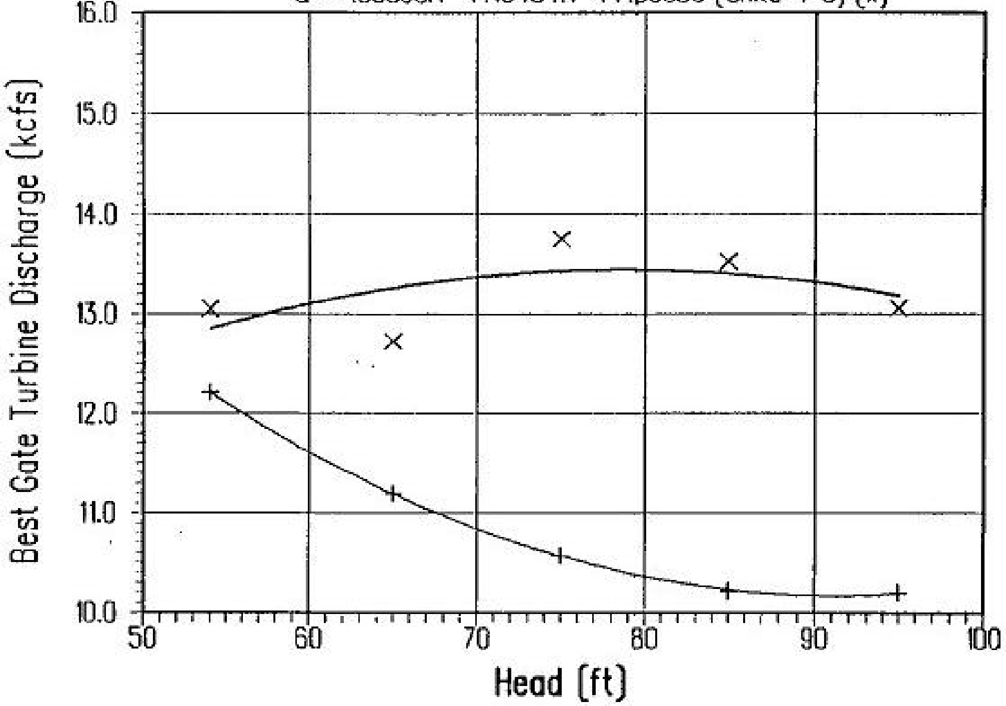
8.0
7.0
6.0
5.0
4.0
3.0
Best Gate Water Rate (kw/cfs)
50
60
70
80
90
100
Head (ft)



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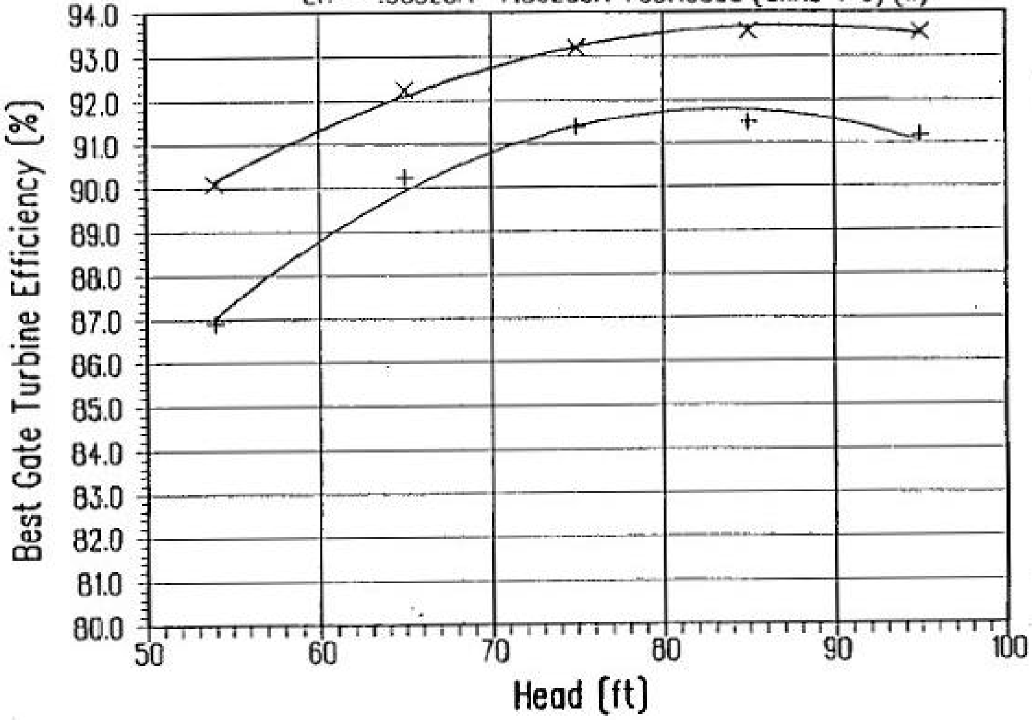

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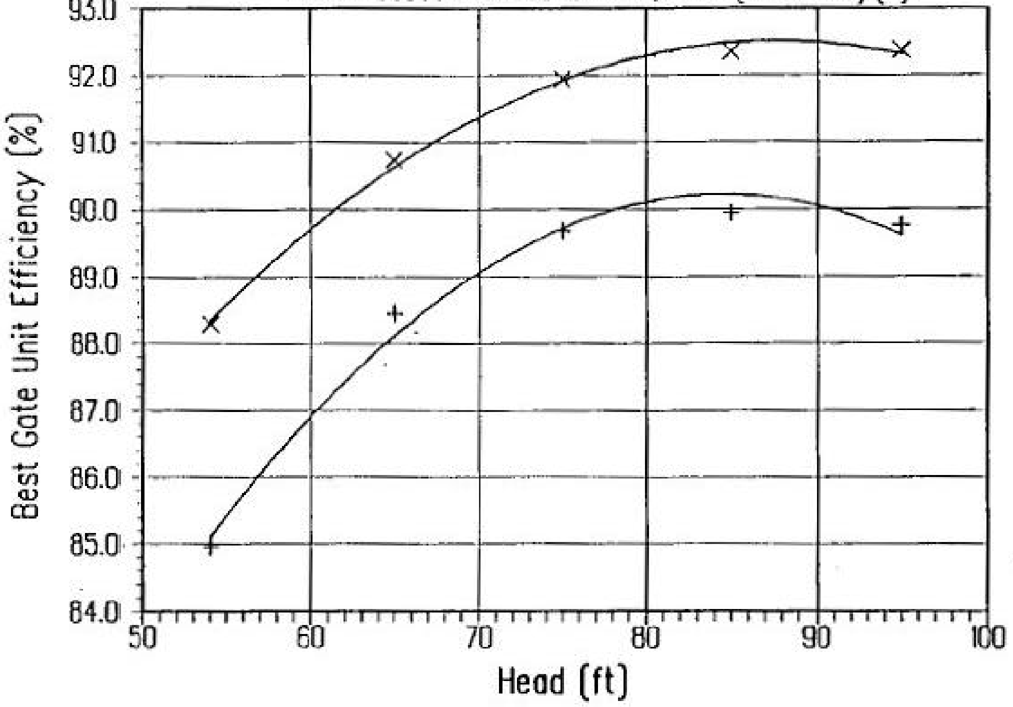

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$\text{Eff} = -.00368H^2 + .64511H + 64.24900$ (Units 4-6) (x)

DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION, CORPS OF ENGINEERS
P.O. BOX 2870
PORTLAND, OREGON 97208-2870

REPLY TO
ATTENTION OF:

CENPD-PE-HD (1110)

JAN 29 1992

Meeting Minutes

SUBJECT: Variable Speed Generation

1. A meeting was held on January 13, 1992 in the Division office to discuss the concept of variable speed generation (VSG). An agenda is attached. The purpose of the meeting was to discuss:

a. The reasons why VSG may be beneficial to the Corps.

b. The various types of VSG units available, their benefits and drawbacks.

c. The status of development of Electronic Power Conditioning's (EPC's) Series Resonant Converter (SRC) type of VSG.

d. What needs to be done to develop the technology to suit the Corps' needs.

2. Variable speed generation is one of the options available to the Corps in addressing the following specific action item in the Northwest Power Planning Council's 1991 Power Plan (Vol. II - Part I, Chapter 1, Page 9):

"Hydropower 4:
Assess ability to operate power system to serve the needs of salmon better.

> The Council will explore innovative ways to plan for and operate the region's entire power system so that it best serves the needs of salmon. The Council believes that the region's power system can be better adapted to the salmon's life cycle, and is committed to exploring the right balance between a cost-effective power supply and the survival of marginal salmon stocks. In the course of amending the Council's Columbia River Basin Fish and Wildlife Program in 1991 and 1992, the Council will explore these issues. The Council will continue to work with the Corps of Engineers, the Fish Passage Center and others, to monitor the effects on fish and wildlife of changes in river operations."

3. One of the options being considered by the Corps to assess the feasibility of implementing the intent of the "Hydropower 4" activity is lowering the reservoir levels at projects on the lower Snake River to assist downstream passage of endangered and other anadromous salmon species. This "lowered pool level"

operation is likely to occur during the 3-5 month period when juvenile salmon are migrating downstream in the spring during maximum flow conditions. Because the generating units operate at fixed speed, as the head drops, so too will turbine efficiency. For example, if the head drops from 99' to 65' at Lower Granite, the highest achievable turbine efficiency will drop by 6%. A chart showing the relationship of efficiency to head is attached.

4. Current biological evidence suggests that operation of turbines at peak efficiencies minimizes the mortality of juveniles which are not intercepted by existing screening systems and pass through the operating turbines. Biological tests which determined this data and relationship between mortality and turbine efficiency were conducted under normal pool operations. It is suspected, but not known for certain, that the same relationships will occur under lowered pool operations. Therefore, it is prudent to examine methods for modifying existing turbines to maximize efficiencies for both normal and drawdown operations.

5. Variable speed generation with the possibility of constant, maximum available efficiency operation is one of the options being considered to mitigate reduced efficiency. VSG operation could recover part of the generation lost due to reduced efficiency resulting from lowered reservoir levels, with the same, or potentially reduced fish mortality.

6. The only options readily available to mitigate this drop in efficiency are to:

a. modify or replace the turbines; or

b. operate the turbines at variable speed and constant, maximum available efficiency.

7. There are essentially three systems which can be used for/with variable speed/frequency turbine/generators:

a. High Voltage DC (HVDC) converters, similar to those used on long distance, bulk power transmission;

b. Cycloconverters (CC); and

c. Series Resonant Converters (SRC)

8. Presently, in the tens to hundreds of MW power conditioning capability class, only HVDC and CC systems are in commercial use. Both the HVDC and CC devices generate significant levels of

harmonics. "Harmonics" are undesirable characteristics of the wave forms of AC voltage and current. HVDC and CC devices may not be usable as VSG - transmission grid interface devices without very expensive tunable (variable over the full frequency range of the generator) low-order, e.g., 3rd, 5th, 7th, etc., harmonic filters. In addition, since these devices must handle the full MVA output of a machine (plus the losses in their own power electronics), they are likely to be quite expensive.

9. For example, a large manufacturer (ABB) has recently estimated the cost of a DC link converter rated at 135 MW to be $10 million per unit.

10. The SRC, by contrast, if used with a doubly-fed machine, needs to be sized only at about 20% of the machine rating. This is because it primarily supplies energy to the rotor and only part-time to the generator output. A conventional synchronous generator can be converted to a doubly-fed machine by rewinding the rotor to incorporate three-phase, ac windings. This should reduce the cost of the power electronics by at least 50%. However, the cost of modifying the generator rotor will tend to offset the reduced cost of the power electronics. In addition, the SRC operates at a very high link frequency. Thus, any additional filtering that might be needed can be done relatively inexpensively (the higher the frequency, the smaller the physical size and cost of the filter).

11. Prototype SRC devices (35 - 100 KVA) - without additional filters - have been tested in the laboratory. Both current and voltage harmonic content have been well within the ANSI/IEEE 519 standard of less that 5% total harmonic distortion. The SRC could also be used with a standard synchronous machine, but its rating would have to be somewhat higher than the generator to accommodate variable frequency operation and its own losses. Dallas Marckx of EPC estimates the projected cost for a 150 MW SRC converter to range between $3 million and $7.5 million.

12. Advanced prototype SRCs are presently available for applications up to about 300 KVA, 480 volt, three phase ac. Multiple SRC units could be paralleled for testing at higher capacities, up to about 5 MVA (with a doubly-fed machine). For higher voltage operation, a suitable transformer may need to be connected to the generator output. An intermediate design, fabrication, and test-demonstration step of 20-30 MVA would be needed before a working prototype of an SRC capable of being retrofitted to a 155 MVA machine could be developed. At 1.5 - 2 years per step, it is anticipated that a full-scale SRC R & D program would require 4.5 to 6 years to complete. This schedule might be shortened if no significant development problems occur.

13. BPA has been funding Series Resonant Converter research at Oregon State University and EPC since about 1985. They indicated they had sufficient funds and would be willing to underwrite a demonstration unit in the 1-3 MW range. CENPP-OP is going to see if they have any units they would be willing to do this to. It will require either modification or replacement of the rotor.

14. The Northwest Power Planning Council's amendments require the Corps to provide a Phase I report which defines, evaluates, and recommends potential long term actions for further development in Phase II. Phase I will screen measures which can increase the survival of juvenile anadromous fish through the eight Federal projects on the lower Columbia and Snake rivers. The Phase I report is due in November, 1992. The drawdown of the Lower Snake river reservoirs is one of the long range alternatives being considered. If this option is recommended, a detailed and in-depth assessment of the alternatives available to the Corps to enhance the operating efficiency of the turbines will be needed. It may be necessary to hire the services of those organizations (such as turbine manufacturers and EPC) who possess the critical information and capability necessary to perform the studies during Phase II.

15. The technology to design and build suitable variable speed generator control systems larger than 300 Kw does not exist. At the present time, it is unknown whether there are other owners of large generating units who would be motivated to develop high power SRC technology. Some of the large electrical equipment manufacturers, such as Toshiba and Hitachi, who are working on large, variable speed pumped storage machines in Japan (22; 85; & 395 MVA - 11/91 issue of International Water Power & Dam Construction), may have an interest, although they are presently only using cycloconverter technology. SRC development for units in the 150 MW range may benefit the Corps especially if pool lowering becomes a reality. It will take between 4.5 and 6 years to develop the technology if research and development funding continues to be available.

16. Copies furnished to the following personnel who attended the meeting:

Brian Moentenich	CENPD-PE-HD	(503)326-3840
John Ferguson	CENPP-PE-RR	(503)326-6482
Gary Johnson	CENPP-OP-PW	(503)326-6073
Dallas Marckx	EPC	(503)753-7220
Claus Weigand	EPC	(503)753-7220
Nick Butler	BPA	(503)230-4524
Hian (Yon) Lauw	EPC	(503)753-7220

(CF: Con't)

Lee Sheldon	BPA	(503)230-3448
Rick Emmert	CENPW-PL-PF	(509)522-6637
Mark Lindgren	CENPW-EN-DB-HY	(509)522-6518
Glenn Meloy	CENPD-PE-HD	(503)326-3835
Karl Bryan	CENPD-EO-OP	(503)326-3803
Michael Spence	CENPP-OP-PT	(503)326-3734
Don Campbell	CENPD-PE-HD	(503)326-7337

17. Subsequent to the meeting, Nick Butler indicated that BPA would be willing to fund a study by EPC (mentioned in Paragraph 14) if the Corps would manage it. EPC's preliminary estimate of the study cost is close to $100,000.

Brian L Moentenich
Brian Moentenich, P.E.
Head, Turbine Section

Encls:
Agenda
Turbine Performance Chart

CF:
See Paragraph 16 listing

AGENDA

MEETING AT CORPS OF ENGINEERS
JANUARY 13, 1992 AT 9:30 AM

Variable Speed Generation in Hydro Plants

General (Marckx, Moentenich)

Nature of variable-speed generation

Benefits

Methods for accomplishing VSG (Lauw, Weigand)

Power electronics--solid-state power conversion (Lauw)

Heart of any VSG system

Likely power electronics configurations

Primary limitations

Review of past research (Lauw)

Review of current and future research (Marckx, Weigand)

Primary issues in multi-megawatt hydro plants (Lauw, Moentenich)

Needed feasibility study--see attachment (everyone)

L. MON, L. GOOSE, & L. GRANITE EXISTING UNITS

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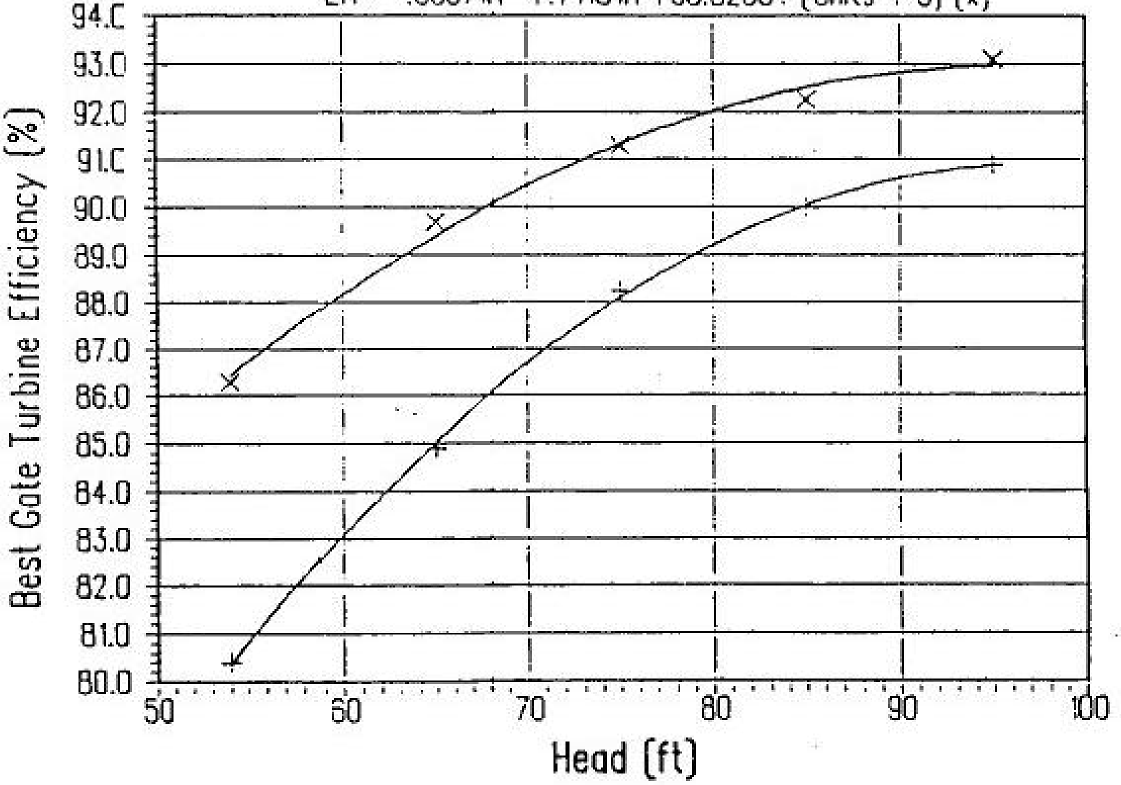
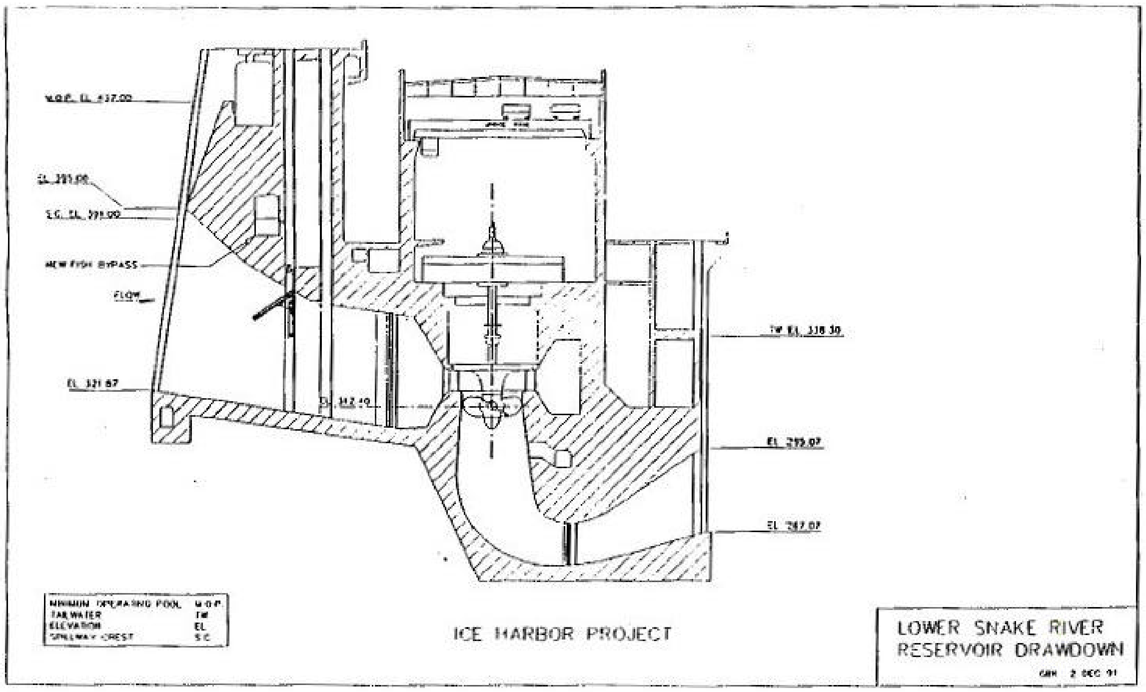
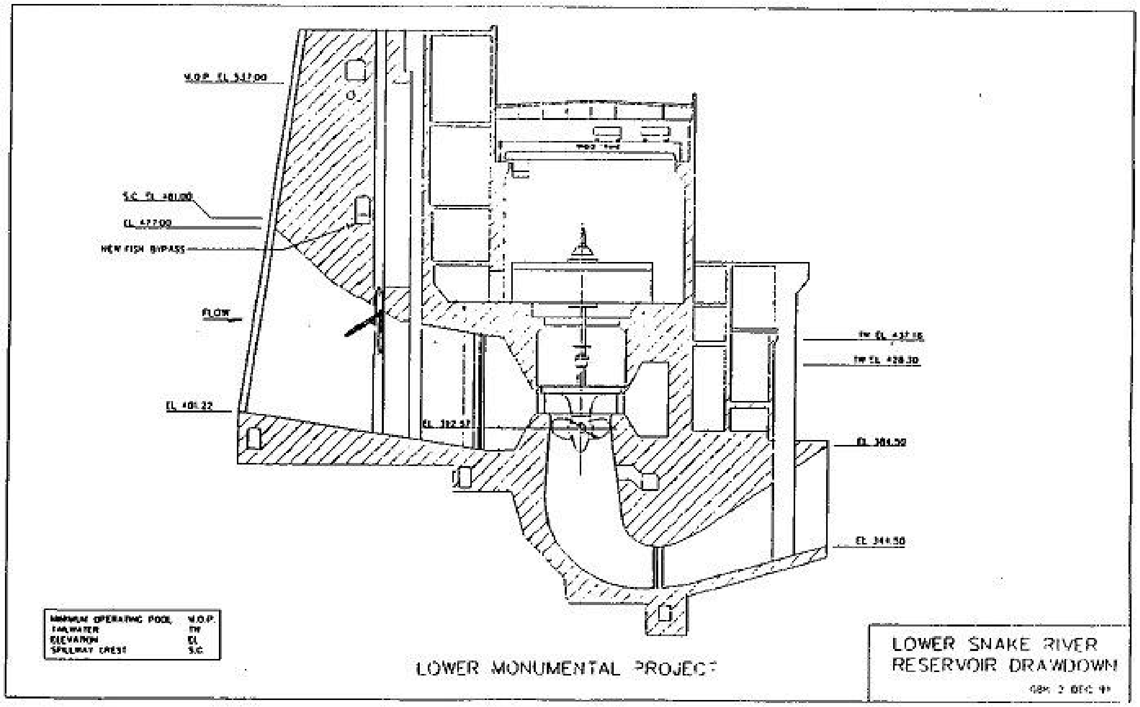




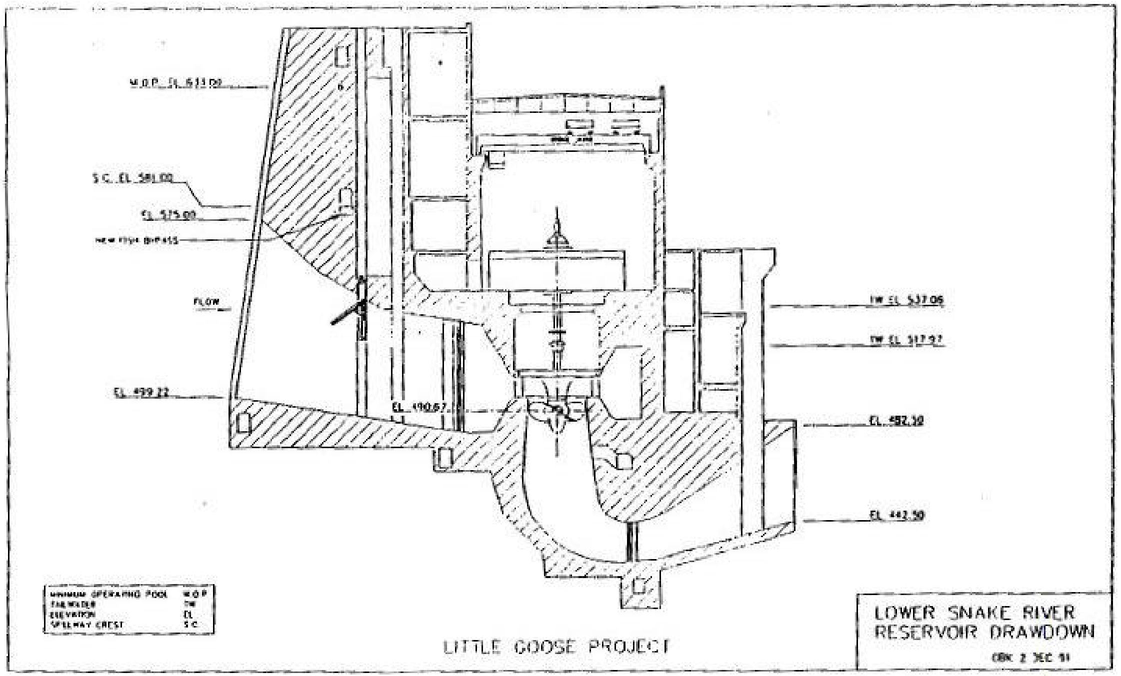
ICE HARBOR PROJECT

LOWER SNAKE RIVER
RESERVOIR DRAWDOWN

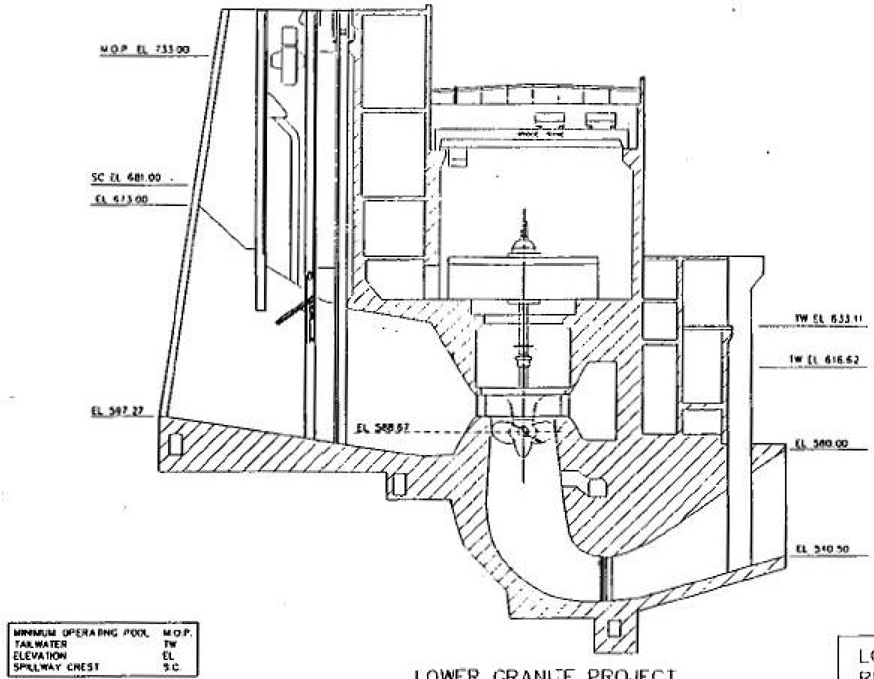
GRH 2 DEC 91



LOWER MONUMENTAL PROJECT



LITTLE GOOSE PROJECT



LOWER GRANITE PROJECT

LOWER SNAKE RIVER
RESERVOIR DRAWDOWN

Variable-Speed Generation Feasibility Study:

Electrical Options

Contract No.
DE-AC79-92BP34885

Final Report
October 1992

By: Dr. Hian K. Lauw (Principal Investigator)
Claus H. Weigand
Dallas A. Marckx

Electronic Power Conditioning Incorporated
1895 NW Ninth Street, Suite A
Corvallis, OR 97330
Tel: (503) 753-7220
Fax: (503) 758-3140

Prepared For

U.S. Department of Energy
Bonneville Power Administration
Portland, Oregon

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Acknowledgements

This study was a team effort. The authors of this report wish to acknowledge the contributions of the U.S. Army Corps of Engineers and Bonneville Power Administration in providing technical information and calculations, conducting tours of hydro plants and transmission facilities, and providing guidance at review meetings. General Electric Co., as joint contractor, contributed extensively in the area of HVDC. General Electric's work is summarized in its own report included here as Appendix B.

In addition, four major corporations, who represent highly qualified suppliers of the variable-speed generation hardware considered in this study, contributed significantly by providing extensive information and engineering time, and arranging for tours of relevant operating facilities. Those corporations include Asea Brown Boveri Inc. (ABB), Siemens Power Corporation, Toshiba Corporation, and Hitachi Ltd.

1. Summary

The preservation and enhancement of salon in the tributaries of the Columbia River has a high priority among the planning bodies of the Pacific Northwest. The causes for the declining salmon runs have been the subject of considerable study in recent years. One conclusion reached by many of those involved in this study is that the hydroelectric projects operated by the U.S. Army Corps of Engineers and the Bureau of Reclamation contribute to the decrease in certain species of salmon.

Various modifications to the hydro plant hardware and operating procedures are under consideration. The proposed modifications of the operating procedures include seasonal adjustments of the pool levels behind the dams to flush fish through the river system more rapidly. Of particular interest at this time is the effect of reducing substantially the pool levels at four hydro plants on the lower Snake River. These plants are Ice Harbor, Lower Monumental, Little Goose, and Lower Granite.

Setting the pool levels significantly below their normal levels will cause a loss in generating efficiency and an increase in fish mortality. Fish survival in turbines correlates strongly to efficiency since higher efficiency implies lower cavitation and other adverse hydraulic effects. One method of maximizing efficiency is through the use of variable-speed generation. With variable-speed generation, a turbine-generator can turn at different, adjustable speeds while producing constant frequency and constant voltage power that is compatible with the grid. If such a generation system were installed, the RPM could be set to maximize turbine efficiency and minimize fish kill in the turbines.

This study was commissioned by the Bonneville Power Administration to assess the cost, efficiency, and other operating implications of installing the necessary hardware to enable variable-speed generation at the four lower Snake River hydro plants. During this worldwide assessment, five hardware configurations were identified and studied in detail. Because of their technical complexity, they will not be described in this part of the report but, rather, in appendix A. General Electric Company studied two configurations that involved connection to a high voltage direct current (HVDC) system. Electronic Power Conditioning, Incorporated, studied the others.

All configurations are costly. For the Lower Granite project, which has a maximum capacity of 961 MVA, the lowest cost system would be about $47 million (without static Var unit), and the highest cost system would be about $198 million. The lowest cost configuration could be bypassed and would not reduce the generation efficiency at the normal pool level. It would increase the efficiency by 3.8 percentage points at the lowest anticipated pool level compared to the existing fixed-speed system. Another, but more costly configuration increases the generation efficiency by 0.3 percentage points at the normal pool level, and by 4.3 percentage points at the lowest anticipated pool level compared to the existing fixed-speed system. No one configuration is superior in all respects. However, overall fish kill in the turbines would probably decrease with any of the variable-speed configurations if substantially reduced pool levels were experienced every year.

All five configurations could be installed and operated on a practical basis. Several vendors for the hardware and design services appear qualified and interested in such a project. Technical risks are not viewed as great, and any increased maintenance burden would be acceptable.

This report has been limited to the study of electrical options. The preferred configuration of the five considered is not being identified here. The data gathered in this study will be factored into broader studies in the Pacific Northwest regarding methods to preserve and enhance salmon populations. The broader studies involve non-electrical options, such as other dam operating strategies and mechanical modifications, and can be expected to take into consideration the results of ongoing fish research.

The information gathered and conclusions reached in this study are highly site specific. Under no circumstances should they be extrapolated to any other hydro project without a thorough reexamination of all site-specific variables.

2. Introduction

For more than to decades, certain stocks of Pacific salmon in the Columbia River and its tributaries have been steadily declining. One of several key reasons identified as major contributors to this decline are the multi-purpose hydroelectric projects constructed on these rivers by the U.S. Army Corps of Engineers (Corps), the U.S. Bureau of Reclamation (Bureau), and publicly- and privately-owned utilities.

The Corps, working in cooperation with the Northwest Power Planning Council (Council) and other parties, is developing a plan of action to help restore the salmon runs. Fisheries biologists are devising strategies to assist downstream migration of juvenile salmon. One of the strategies involves lowering of the reservoir levels at several of the dams. this action is expected to reduce juvenile predation by reducing transit time through the reservoirs. Tests at two of the Lower Snake River Projects have been conducted to assess some of the impacts of this proposed new operating strategy.

One significant drawback associated with lowering the reservoirs is related to the operating characteristics of the conventional, fixed-speed Kaplan (adjustable-blade) hydroturbine-generators presently in use at the projects. Operating them at the proposed significantly lower reservoir levels would seriously reduce their efficiency to the point where an *increase* in fish mortality would be anticipated (fish mortality has been shown to be directly related to turbine efficiency - the lower the efficiency, the higher the mortality and vice versa). In order to resolve this dilemma, some means of varying the speed of the turbines must be found in order to maintain near-maximum efficiency as the level of the reservoir changes. If operation at near-maximum available efficiency can be achieved successful, fish kills will be kept to a minimum and the loss of electric power and energy due to operation at the lowered reservoir levels will also be minimized.

Bonneville Power Administration (BPA) is responsible for marketing the electric power and energy produced at the hydroelectric projects owned and operated by the Corps and Bureau, and developing and implementing plans to restore regional fisheries adversely affected by those hydroelectric projects. In addition, BPA has been conducting research into the potential benefits of variable-speed generation. Consequently, BPA offered to assist the Corps in evaluating applicable electrical options for variable-speed generation.

Several proven technologies are now available to accomplish variable-speed generation. This study identifies all of the applicable options, discusses their technical and economic aspects (planning level accuracy) and impacts, examines their power and energy production impacts, and recommends one or more of the options for further detailed study. How the various options would affect present operating and maintenance practices, and operating and maintenance personnel (and skill) level requirements is also addressed. The results of this study will be evaluated by the Corps when preparing their report to the Council regarding the Corps' part of the salmon run restoration plan for the Columbia Basin. The Corps' report is expected to be delivered to the Council in November 1992. Upon recommendation by the Council, the Corps will determine which corrective action will be taken in the future to restore the salmon runs.

3. Environmental and Hydraulic Requirements

3.1 Necessary Improvements for Downstream Migration of Juvenile Salmon

The requirements and current situation for juvenile salmon migration are as follows:

- During smolt outmigration, a minimum flow rate of water is needed in order for juvenile salmon migrating downstream to sense the downstream direction and travel quickly to the Pacific Ocean.
- The flow rate of the Columbia River and its tributaries has been significantly reduced with the construction of many hydroelectric projects and their associated reservoirs. The flow rate may have declined below the minimum value needed for many of the downstream-migrating fish to reach the ocean in a timely manner. Many fish are thought to remain in the reservoirs without a proper sense of direction, increasing their exposure to predators.
- Fish travel past the dams either through a bypass system, or through the spillways, or directly through the turbines.
- If turbines operate at peak efficiency, the survival rate of juvenile salmon traveling through the turbines can be more than 95%, according to a study commissioned by the Corps (1).
- If the turbine operates at lower than peak efficiency, either because the operating head differs from its design value, or power output is above or below the design value, then the amount of cavitation will be above a minimum level (cavitation occurs when local water pressure is suddenly reduced to a subatmospheric level)(2). Fish passing through this dynamically changing cavitation zone will either be fatally injured or killed due to the sudden change in pressure. As the amount of cavitation increases, the affected zone spreads over a larger percentage of the turbine's blade surface, increasing the likelihood of fish being killed if they travel through the turbine at that time.

Considering the factors indicated above, two essential requirements emerge, which, if implemented, are expected to increase the number of juvenile salmon reaching the Pacific Ocean:

1. During smolt outmigrations, the flow rate of water in the reservoirs behind dams located on rivers with migratory salmon runs must be increased.
2. During smolt outmigrations, turbines must be operated as close to peak efficiency as possible in order to minimize resultant fish kills.

3.2 Alternative Operating Strategy for the Hydro-Projects

With present reservoir levels, meeting requirement (1) of section 3.1 (*i.e.*, establishing downstream flow rate in the reservoirs during spring runoff) is not possible because of the required increase in water flow, the limited capacity of existing turbines to pass the increased volume of water (increasing spill could introduce nitrogen supersaturation which would kill more fish) (3), and the limited volume of water available in the storage reservoirs needed to meet the new flow requirements. One way of resolving this dilemma is to lower the reservoir levels, thus increasing the flow rate to levels approaching the previous, natural conditions.

The U.S. Army Corps of Engineers has performed a drawdown test at two of its Lower Snake River Projects during the 1992 spring runoff season. Based on the information gained from the test, they are performing computer simulations to identify an optimum relationship of reservoir level (head) as a function of time-of-year. Initial results indicate operation at two discrete reservoir levels [*i.e.*, high (normal) and low (spring runoff)], with 2-3 week transition periods between each level. Data for the exact low head-level, its duration, and timing are not yet available. Also, it is not certain whether the reservoir level during spring runoff should be constant. Present best estimates for the Lower Granite Project on the Snake River are:

	Head (feet)	**Duration (Approximate)**
High (normal)	99	7 months
Transition (high-low)	99 going to 57	2-3 weeks
Low (spring runoff)	57	4 months
Transition (low-high)	57 going to 99	2-3 weeks

3.3 Requirements for Future Turbine Operation

In order to meet requirement (2) of section 3.1. (*i.e.*, operation as close as possible to peak efficiency) during the "Transition" an "Low" periods identified above, normal operation of the turbines will have to be modified.

An evaluation of the performance curves of the fixed-speed Kaplan turbines in use at the lower Snake River projects reveals that, despite the relatively constant efficiency over a wide range of head conditions for this type of turbine, substantial loss of efficiency will occur at the proposed low head level. In addition, a substantial increase in cavitation is possible while operating the turbine under these low-head conditions at synchronous RPM.

An effective way to resolve this problem is to adjust the turbine speed (RPM) according to the following relationship:

$$\mathrm{RPM}/\mathrm{RPM}_{\mathrm{synchronous}} = (\mathrm{Head}/\mathrm{Head}_{\mathrm{design}})^{\&\mathrm{frac12;}}$$

The speed can be varied on a continuous basis or, an alternative, which achieves nearly the same results, is to operate the turbine at two discrete speeds, using best available efficiency at each speed.

An additional means to reduce cavitation on Kaplan turbines was pointed out by one of the engineers responsible for turbine design at a major equipment manufacturer. The type of cavitation identified is that occurring in the gap between the tip of the turbine blade and the turbine casing. They have found that this type of cavitation can be greatly reduced through a molded-in tip-vane with grooves on the surface facing the turbine case.

4. Comparison of Electrical Configurations Including Cost, and Operational and Maintenance Aspects

The main features of the five different variable-speed generation configurations are listed in Table 1. Table 2, as well as Figures 4.1 and 4.2, indicate how the different approaches affect turbine and generation unit efficiency. In Table 3, approximate cost estimates for the various approaches are broken out. An in-depth discussion of their important technical features can be found in sections A2 through A4.

From a cost-of-retrofit standpoint, it appears that a load-commutated inverter approach (including the HVDC back-to-back and HVDC transmission approaches) would be the favored solution. Of all the power conditioning approaches, the 40% rated HVDC back-to-back approach appears to have the lowest cost (approximately \$47 million without static Var-controller, \$54 million with static Var-controller). However, during the transition between pool levels, this approach allows variable-speed operation on only 4 of 6 generators per power house (Appendix B, Option B). If variable-speed operation of all generators is desired during this period, then the power conditioning approach at the generator (non HVDC) voltage level appears to be less costly (\$64 million without static Var-controller, \$71 million with static Var-controller).

With a power conditions, the existing synchronous generators remain untouched and can be operated for about seven months out of the year in their current fashion with the LCI bypassed. Though increased maintenance is small in any configuration, the power conditioner will be new to maintenance personnel. Some personal training will be required.

Possible interactions between the power conditioner and the generator on one side, and between the power conditioner and the grid on the other side must be thoroughly analyzed using a comprehensive system model. Due to the high power capacity of the LCI, any induced instabilities can have far-reaching effects which make system simulations more complex and difficult. Possible undesirable side effects, on the generator side, include vibration and harmonic heating; and on the grid side, harmonic oscillations and instability of generator sin distant power plants. Some unanticipated side effects might still occur after commissioning. Adequate engineering solutions are believed to be available to suppress any system instabilities.

From an operational and maintenance point of view, the 2-speed generator is more attractive in several aspects. It maintains the normal mode of generator operation over the full year while allowing the best efficiency during both the normal and the low-head periods. There are no new or previously unknown conditions to be dealt with. Overall system efficiency during the low-head period is slightly higher (0.3 percentage points) than for any other configuration. Currently the generators are operating at 90 RPM, which differs from the maximum efficiency RPM of the turbines at full head. If the decision is made to install pole-changing generators, this existing mismatch could be corrected at the same time, thereby increasing the overall efficiency at full head by 0.3%. Additional maintenance is minimal and limited to brush replacement. Also, the increased skill necessary to operate the 2-speed generator in an optimal fashion is minimal.

The 2-speed generator is considerably more costly, due to some degree to adverse foreign currency exchange rates. For the case where the replacement of an existing generator is already necessary, the cost of conversion to a pole-changing generator will be substantially reduced, and this configuration then would become the lowest in cost. However, the replacement of an entire generator is not anticipated at the four lower Snake River projects.

Many of the outstanding technical features of the doubly-fed configuration would be insufficiently exploited in this generation-only environment and, therefore, the cost-of-retrofit is not justifiable, unless the replacement of a generator is otherwise necessary. In a pumped-storage environment with widely varying head conditions, all benefits of this system can be fully used. Under these conditions, the doubly-fed system may be the system of choice [6, 7]. The stabilizing effect which the doubly-fed system adds to the grid to which it is connected may be of interest. Due to its spread-out interconnections, the BPA grid currently faces some stability problems. None of the other VSG configurations discussed in this report offers a stabilizing feature. These configurations, rather, tend to cause additional stability problems which require engineered solutions.

The efficiency of the doubly-fed turbine-generator at close to rated head levels is inferior to the efficiencies of all other systems due to the fact that the power electronic converter in the other configurations can be bypassed, leaving the synchronous generator to operate the way it currently does. Even though the power electronic converter in the doubly-fed configuration could be bypassed, some of the operational advantages of this configuration would then be lost. The efficiency penalty at full head is particularly significant due to the relatively flat efficiency versus head characteristic of the Kaplan turbine. No other turbine type has this flat efficiency versus head characteristic. The turbine-generator can be operated efficiently deviating up to 20 feet from the rated head without the need to interpose the LCI in any of the power conditioning approaches. At head levels below 80 feet, where the LCI would be in operation, the efficiency of the doubly-fed configuration compares well or even surpasses the efficiencies of all other variable-speed approaches.

The above discussion covers existing technology options that can be currently implemented. Several vendors of the necessary hardware and design services are available. Research and development is currently underway, particularly in the area of high power electronics, which might lead to different, more attractive results in the future.

Table 1
Comparison of Main Features of All Feasible VSG Configurations

Technical Features	**Variable Speed Generation System Configuration**				
	Power Conditioning Approach	**Pole-Changing Approach**	**Doubly-Fed Approach**	**HVDC Back-to-Back Approach**	**HVDC Transmission Approach**
Modifications to existing generator	none	replace generator	replace generator	none	none
Converter rating	~80% of generator rating	N/A	~40% of system rating	40% to 80% of powerhouse rating	40% to 80% of powerhouse rating
RPM-range	60 to 90 RPM	64.3 RPM and 85.7 RPM only	60 to 90 RPM	60 to 90 RPM	60 to 90 RPM
Sub-/super-synchronous operation	yes	N/A	yes	yes	yes
Plant reactive power control	with added static var cont.	yes	yes	with added static var cont.	with added static var cont.
Additional electrical losses	2.5% to 3.0%	-0.3% to 1.7%	<2.0%	2.5% to 3.0%	2.5% to 3.0%
VSG bypass	built-in	unnecessary	unnecessary	built-in	built-in
Largest installed system (MVA)	~80	~300	85 (400 under construction)	> 1,000	>1,000

Table 2
Comparison of Unit Efficiencies

	Unit Efficiency at Best Gate For 57 Ft (90 RPM)	**Unit Efficiency at Full Gate For 57 Ft (90 RPM)**	**Unit Efficiency at Best Gate For 100 Ft (90 RPM)**	**Unit Efficiency at Full Gate For 100 Ft (90 RPM)**
Existing Generator (Single Speed)				
?$_{T(urbine)}$	87.4%	86.7%	93.0%	90.2%
?$_{G(enerator)}$	97.6%	98.5%	98.6%	98.7%
?$_{Unit}$ = ?$_T$ * ?$_G$	85.3%	85.4%	91.7%	89.0%
Net Output (MW)	43.6	68.8	113.6	156.1
Pole-Changing Generator (Two Speed)				
?$_{T(urbine)}$	93.4%	90.4%	93.6%	91.3%
?$_{G(enerator)}$	95.9%	97.3%	98.3%	98.3%
?$_{Unit}$ = ?$_T$ * ?$_G$	89.6%	88.0%	92.0%	89.7%
Net Output (MW)	45.8	69.9	114.0	157.3
Existing Generator plus LCI Power Cond. (Variable Speed)				
?$_{T(urbine)}$	93.6%	90.4%	93.0%	90.2%
?$_{G(enerator)}$	97.7%	98.5%	98.6%	98.7%
?$_{L(CI)}$	97.4%	97.5%	100% (Bypassed)	100% (Bypassed)
?$_{Unit}$ = ?$_T$ * ?$_G$ * ?$_L$	89.1%	86.8%	91.7%	89.0%
Net Output (MW)	45.5	69.0	113.6	156.1

*Full gate not allowed

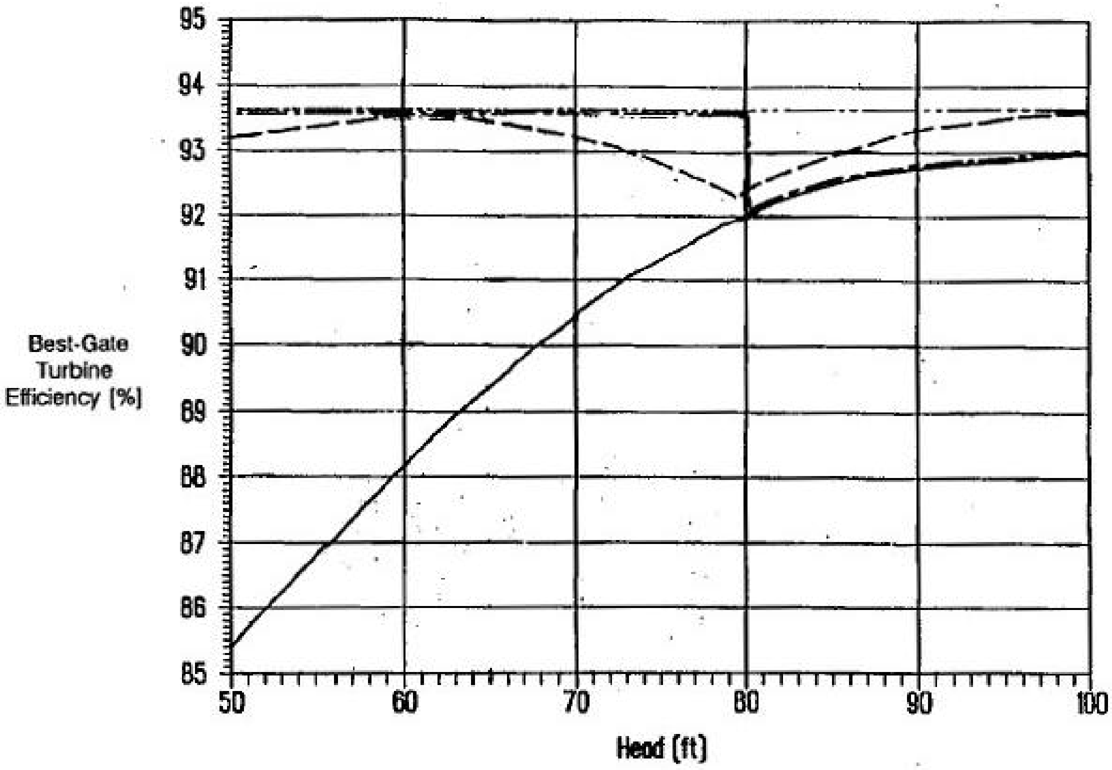

Figure 4.1: Comparison of Best-Gate Turbine Efficiencies for

- Existing Fixed-speed Approach (90 RPM) ———
- Pole-changing Approach (85.7/64.3 RPM) — — —
- Variable-speed Approach (with 80% rated LCI and bypass switch) --- - ---
- Variable-speed Approach (Doubly-fed Machine) —·-—

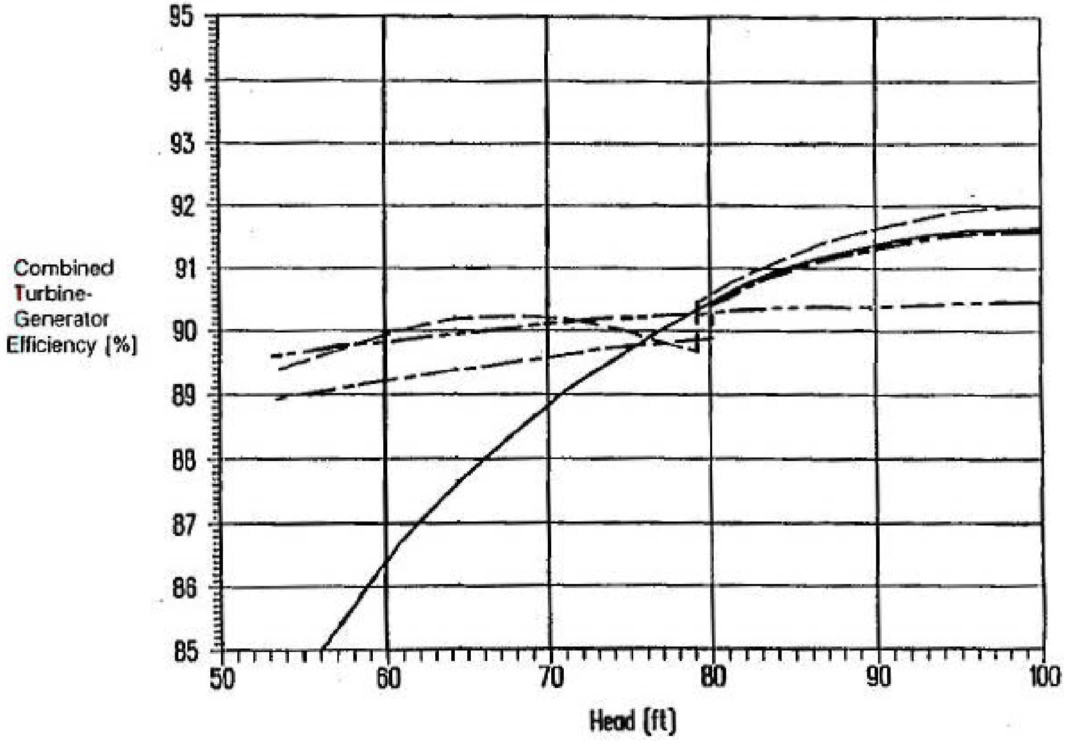

Figure 4.2: Comparison of Combined Turbine-Generator Efficiencies for

- Existing Fixed-speed Approach (90 RPM) ————
- Pole-changing Approach (85.7/64.3 RPM) — — — —
- Variable-speed Approach (with 80% rated LCI and bypass switch) —— - —— -
- Variable-speed Approach (Doubly-fed Machine) —·—

Table 3
Cost of Retrofit
(In Million $)

Cost Component	Power Conditioning (Generator Voltage)	Pole-Changing Generator (2-Speed)	Doubly-Fed Machine	HVDC Back-to-Back (BTB)	HVDC Transmission
Generator	not applicable	21.4/Unit	˜15.0/Unit	not applicable	not applicable
Generator Installation	not applicable	˜3.0/Unit	˜1.5/Unit	not applicable	not applicable
Converter	7.46/Unit	not applicable	˜15.0/Unit	44.0 to 88.0/powerhouse	52.8 to 105.6/powerhouse
Converter Installation	˜3.0/Unit	not applicable	˜1.5/Unit	included	included
Real Estate	not applicable	not applicable	not applicable	not included	not included
Line Installation	not applicable	not applicable	not applicable	not applicable	30.8
Installed Cost Per Unit	˜10.46	˜24.4	˜33.0	not applicable	not applicable
Auxiliary Power Supply Per Powerhouse	1.4	not applicable	not applicable	1.4	1.4
Static Var Compensation	7.25	not applicable	included	7.25	not available
Harmonic Filter	not included, to be determined	not applicable	included	not included, to be determined	not included, to be determined
Installed Cost Per Powerhouse	˜71.41	˜146.4	˜; 198.0	52.65 to 98.65	243.4 to 454.6 for 3 powerhouses and one inverter at Ashe

5. Conclusions and Recommendations

Five configurations for the implementation of variable speed generation at high power levels have been studied and discussed in detail; their features and cost of retrofit were compared in the previous chapter. Emphasis should be placed on the fact that the study covers only configurations and technologies which have been successfully implemented in the past.

Conclusions reached include the following:

- Any preference for a certain configuration is highly dependent on specific site requirements, hydraulic operating constraints, and existing equipment. For example, because the four lower Snake River projects are already in operation, retrofit considerations are particularly important. The replacement of an entire generator (two-speed and doubly-fed generator configurations) will be particularly costly. In addition, these four hydro projects will likely have a two-level hydraulic operating strategy, which lends itself well to the two-speed generator. The results and conclusions presented in this report must not be extrapolated to other plants without a thorough examination of all variables.

- Initially in this study, the reliability of high power electronics was a major concern. High power electronics are fundamental to VSG in all configurations, other than the two-speed generator. However, the high reliability record of high power electronic systems installed in the field eliminated this matter from further concern.

- The lower cost configurations involve power conditioning. If the power converter is installed at the generator voltage, VSG at the Lower Granite plant is estimated to cost about $71.4 million. If the power converter is installed at the high transmission voltage in the "back-to-back" configuration, the cost could be as low as $52.65 million if it is rated at 40 percent of the plant rating, and $98.65 million if rated at 80 percent of the plant rating. The lower cost would require near-certain predictability as to the pool drawdown level each year. As the best hydraulic operating strategy emerges, this HVDC option should be kept in mind.

- The best efficiency at all likely pool levels occurs with the 2-speed generator. Its high speed is matched to the best turbine efficiency at full head, which is even better than the existing fixed-speed generator. At full power, the two-speed generator will experience a 0.3 percentage point increase in efficiency, and the doubly-fed configuration will experience a 1.2 percentage point decrease in efficiency, compared to the existing fixed-speed system. Other configurations operate with the power electronic converters bypassed at higher head levels, so turbine efficiency is not impacted.

- All VSG configurations excel at the lowest anticipated pool levels. Here turbine-generator efficiencies increased by 3.8 to 4.3 percentage points with the VSG configurations considered.

- The amounts of increased energy generation and reduced fish kill in the turbines with VSG is, in general, a function of the specific hydraulic operating strategy--the more time spent at low pool levels, the greater the benefits of VSG. These amounts cannot be estimated until the precise hydraulic operating strategy is determined. The doubly-fed generator begins with compromised efficiency at full power, which must be offset by the benefits at lower pool levels. But the power conditioning configurations, which can be bypassed at or near full power, have no such compromise which must be offset.

- The two-speed generator appears to be the best in all categories except cost. The cost of implementing this approach and the doubly-fed approach might be reduced by reusing parts from the existing fixe-speed generators or replacing the generator at a time when it would normally be rewound. However, this cost reduction technique can not be expected to push the cost of the two-speed generator below the cost of the other approaches.

- Judging by the staffing at operating hydro plants and facilities containing high power electronics, the maintenance and operation of the VSG configurations do not appear to be a major consideration. While there would be a modest increase in number and skill level of the maintenance and operating personnel, there would be no fundamental change relative to trends already present (*e.g.*, increasing use of sophisticated electronic controls). Any actual installation should properly budget for this function, but it is not likely that the associated costs or training burdens would be important in a final selection of options.

- Potential system instabilities can occur when power electronic converters are inserted between one or several generators and the grid, as it is the case for the three different power conditioning approaches described in this report. The converter may cause mechanical and electrical oscillations on either the generator or grid side, or both. Due to the complexity of the overall utility grid, it may be difficult to model the total system sufficiently accurately to anticipate all possible resonant modes (see Appendix B, 4-10). It must be emphasized that over 3,000 MVA of power conditioning capacity might be installed if all four lower Snake River projects were retrofitted for VSG. The reliability of the results obtained from system simulations is related to the ratio of VSG capacity and grid short circuit capacity. The greater this ratio is the less reliable the simulation results will be, according to one equipment manufacturer. The grid short circuit capacity is about 15,555 MVA. Any analytical model used most cover all hardware impacted by the VSG installation. That hardware could be much more distant from the site than in cases where, for example, large (10 to 40 MVA) motor drives are installed. Adequate engineering solutions are undoubtedly available for any such instabilities, but great care must be taken in designing the DC link and other filter elements. These solutions are not anticipated to affect substantially either the performance or costs of the VSG alternatives.

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Appendix A - Electrical Topologies for Variable-Speed Generation

A.1 Existing Electrical System

A.1.1 Fixed-Speed Generator Specifications

The study focuses on the four lower Snake River hydroelectric projects, named "Lower Granite," "Little Goose," "Lower Monumental," and "Ice Harbor" (in descending order). The synchronous generators installed in the first three projects (6 in each) are all identical and have the following name-plate data:

rated power:	142.105 MVA
power factor:	0.95
service factor:	1.15
rated voltage:	13.8 kV
rated current:	5.95 kA
number of poles:	80
rated RPM:	90.0 RPM
manufacturer:	General Electric Co.

At the Ice Harbor hydroelectric project, generators with the following nameplate data are installed:

4 each of:

rated power:	116.8 MVA
power factor:	0.95
service factor:	1.15
rated voltage:	13.8 kV
rated current:	4.89 kA
number of poles:	84
rated RPM:	85.7 RPM
manufacturer:	General Electric Co.

and 2 each of:

rated power:	94.737 MVA
power factor:	0.95
service factor:	1.15
rated voltage:	13.8 kV
rated current:	3.96 kA
number of poles:	80
rated RPM:	90.0 RPM
manufacturer:	General Electric Co.

The main focus is on the 18 identical generator systems located at "Lower Granite," "Little Goose," and "Lower Monumental." No significantly different issues or results are expected from an investigation of the "Ice Harbor" hydroelectric installation.

Even though the 18 generators are identical, auxiliary equipment such as the exciters vary in age, technology, and manufacturer. Some of the generators are equipped with DC-exciters mounted on the main generator shaft; others have separate motor-generator sets providing DC-power, while newer units have controlled rectifier systems providing excitation power off the 4.16 kV station service supply. Also, these hydroelectric projects posses black-start capability for which a 500 kVA diesel-engine-driven generator set is provided at each location.

A service-factor of 1.15 was designed into the generators. This means the generators are able to operate continuously at an output power of 163 MVA. Considering a power factor of 0.95, this power level corresponds with the rated output power of the turbines (212 khp or 158 MW). The capability to operate above rated power has the economic advantage of eliminating the need to put a second unit on line at a very low output power setting or have two systems run only slightly above half rating, if this should be demanded by the momentary load situation. Most of the system maintenance (which is a major cost factor) has to be performed according to a schedule which is based on operating hours. Thus, it is relatively more expensive to operate generator systems at fractional output rating. The need to operate in such an undesirable mode can be avoided by using the service factor as a degree of operational freedom.

A.1.2 Electrical System Characteristics

As viewed from the utility grid, the presence of a variable-speed generation system must not adversely affect its management. In fact, stringent requirements, such as the following, have to be met by the VSG system at the point of interconnection with the utility grid. Otherwise its use may be limited or not at all acceptable.

Harmonic Distortion:

The harmonic distortion of voltage and current at the point of interconnection is limited by IEEE 519 specifications. Exceeding these limits could cause operational problems for sensitive loads connected to the grid. It also could cause overheating of transmission lines and transformers, and decrease efficiency.

Reactive Power Control:

The existing synchronous generators provide sufficient regulation capacity (±0.95) for reactive power on the utility grid. Installing a large number of systems which would not allow reactive power control on the grid could diminish this regulation capacity below acceptable levels. Given the fact that the existing transmission lines are operating close to capacity, the presence of large reactive current components would overload the utility lines and, therefore, can not be tolerated.

Grid Stability:

Short circuits, lightning strikes, load rejection of generators, and other faults can have a negative impact on grid stability. The presence of a VSG system must not aggravate the fault-triggered transient behavior of the grid. One VSG system (see chapter A.3.4 for detailed discussion) has proven to have a damping effect on the transient behavior of other synchronous generators connected to the same grid, this VSG system, therefore, enhances grid stability.

A.2 Power Conditioning Strategy

A.2.1 Generation System Description

The power conditions strategy is based on the principle that for a synchronous generator, the mechanical RPM is proportional to the electrical stator frequency. By inserting a variable-frequency, 3-phase power conditioner capable of processing more than 1,000 MVA between one (or several) of the generators and the 60 Hz utility grid, it is possible to operate the existing synchronous generators at variable RPM. A bypass switch is provided for the power conditioner allowing standard fixed-speed operation.

There are two basic approaches to implement the variable-speed option with power conditioners. The first approach is to install individual power conditioners for each of the six generators of each powerhouse. The second approach is to install one power conditioner for the entire powerhouse at the transmission voltage level. This approach is referred to as high-voltage DC (HVDC) option and was studied in detail by consultants of General Electric Company. The report of this study is incorporated into this report as Appendix B.

Figure A2.1 shows the general system layout for power conditioning at both the generator and transmission voltage level.

A.2.2 Selection of the Power Conditioner

A.2.2.1 Load-Commutated Inverter (LCI)

The most basic load-commutated inverter consists of a controlled inverter bridge, which is connected to the grid, and a controlled rectifier bridge, which is connected to the generator. The rectified and inverter bridges are connected by a DC-link inductance (see Figure A2.2 for the basin LCI diagram). This diagram applies in principle to both the approaches described above. Both the inverter bridge and the rectifier bridge are controlled according to phase-control schemes [4], in which the rectifier (connected to the generator) controls the DC-link voltage, whereas the inverter (connected to the grid) controls the DC-link current, which in effect controls generator RPM and thus frequency. The product of DC-link current and voltage determines the active power transferred from the generator to the grid. Usually, the DC-link voltage is maintained constant at its maximum, which allows maximum efficiency operation of the LCI (by doing so the DC-link current is minimized) and maximum power-factor operation of the LCI (the switch firing angle is as small as possible, which reduces the amount of reactive power drawn by the LCI). Consequently, active power is controlled with the DC-link current only. The RPM of the mechanical system and, therefore, the frequency at the rectifier will adjust itself based on the power balance inside the electro-mechanical energy conversion system (*i.e.* if the DC-link current is increased, mechanical RPM will drop, and vice versa). RPM adjustments thus require adjustments at both the LCI and the governor of the turbine.

The exciter of the generator has to be controlled such that constant flux is maintained in the generator. This control strategy will lead to reduced voltages on the generator output terminals at lower RPM. In order to maintain the desired constant voltage operation in the LCI (see Appendix B, 2-6), a tap-changing transformer between the LCI and the generator is necessary. If the maximum amount of reactive power supplied by the synchronous generator is insufficient for the commutation of the LCI rectifier, capacitors have to be added. Accordingly, the utility grid has to provide reactive power to the inverter bridge to allow commutation of its semiconductors. Filters which most likely have to be installed at the point of interconnection with the utility grid concurrently can correct for the lagging power factor of the inverter bridge.

Several modifications to the basic LCI set-up are possible and usually implemented, for one to optimize the inverter from a cost standpoint and second to reduce some of its undesirable side-effects, especially harmonic distortion at the input and output terminals.

At such high power levels, no single semiconductor switch can handle both full voltage and full current. Thus, multiple switches must be clustered in such a way that they operate as one switch. One way to optimize the LCI from a cost view is to choose the input and output operating voltages such that operation is possible with only series-connected semiconductor switches, as opposed to the use of parallel connected switches. Therefore, the internal operating voltages have to be chosen such that the DC-link current does not exceed about 4 kAmps. Due to the given design voltage of both the generator and the grid, input and output transformers will be required for the LCI. The transformer between the LCI and the generator has to operate at frequencies as low as 40 Hz; therefore, it must be derated accordingly. Another approach is to connect several LCIs in parallel to keep the DC-link current below 4 kAmps. The firing angles of the parallel connected LCIs are then offset, resulting in 12-, 18-, or even 24-pulse operation, which further minimizes harmonics in both the grid and the generator (Figure A2.3).

A LCI will inject a certain amount of voltage and current harmonics into both the grid and the generator. IEEE 519 specifications limit such harmonics on the grid side, whereas generator heating and generator vibration limit the harmonic content on the generator side. One common way to reduce harmonics in both frequency content and magnitude is to use 12-, 18-, or 24-pulse bridges. The necessary Y-Δ transformer can be combined with the voltage adjustment discussed above and tap-changers, to adjust for lower generator output voltage at lower RPM. Also, conservatively rated DC-filters will be necessary to sufficiently decouple the variable-frequency side from the grid side of the LCI. Otherwise, beat-frequency and subharmonic oscillations can occur (see Appendix B, 4-10), which adversely affect both the generator and the grid. Due to the fact that it is difficult to model the interaction between a VSG system of extremely high capacity (over 1,000 MVA) and the grid sufficiently accurately to simulate all possible operating scenarios, some adverse operating effects may not be detected until after commissioning of the VSG system. While sound, cost-effective solutions to these problems probably can be found, some design uncertainty remains.

Adequate remedies have to be found and implemented at this point. Also, the quality of the filtering effort is adversely affected by even minute frequency deviations on the 60 Hz grid (appendix B, 4-13), and by temperature- and/or age-related capacitance and inductance variations. An alternative to overly costly filtering efforts is avoidance of certain operating points (RPM). The operational problems related to the harmonic pollution caused by LCI's is independent of the operating voltage of the LCI (transmission voltage or generator voltage level).

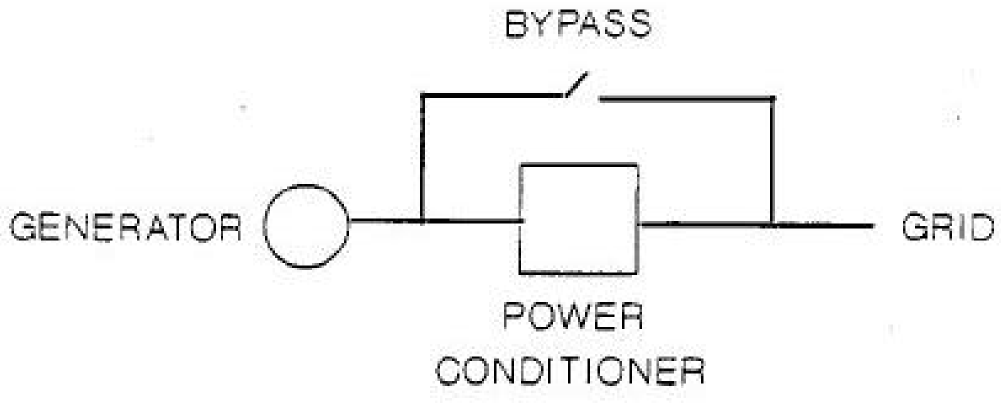


Figure A2.1: General System Layout for the Power Conditioning Strategy

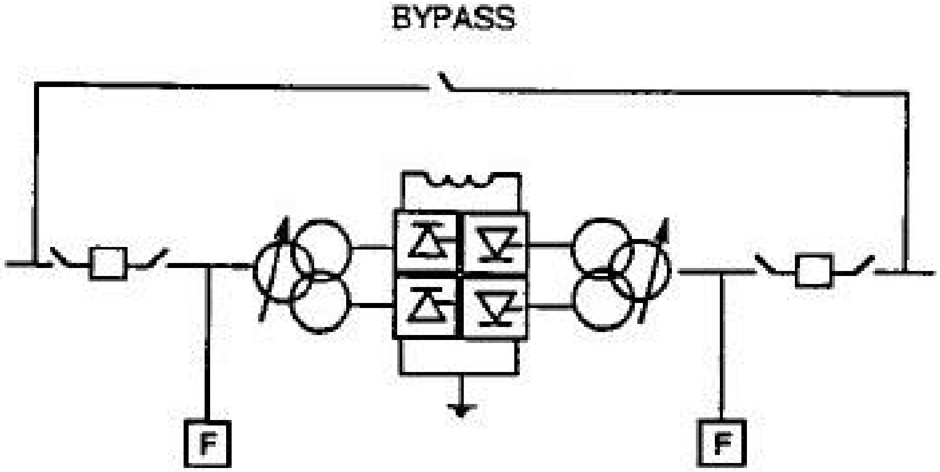


Figure A2.2: Basic LCI Diagram (Generator Voltage and HVDC Level)

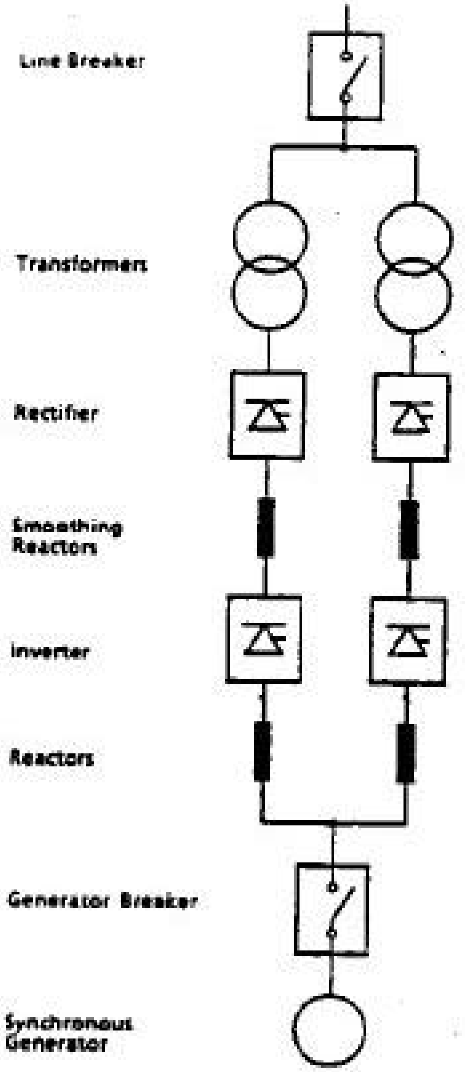


Figure A2.3: 2 LCIs in Parallel Connection (12-Pulse Operation)

A.2.3 Rating of the Power Condition

For the case where the power conditions is connected to and operates at the generator level, its rating has to be equal to about 80% of the generator rating. This results from the desire to operate the units in the fixed-speed mode until the pool-level is reduced to 80 feet. Also, the best-efficiency point of operation of the turbine occurs at partially closed gate. Best efficiency output power of the turbine will be only a fraction of its rated output power at the lowest intended operating head (57 feet). For this operating condition (which is where the system operates most of the time during variable-speed operation), the power conditioner will be considerably oversized.

Due to the extensive experience of the General Electric Company in the field of HVDC, they were commissioned to study this approach to variable speed generation. Conceptually, the use of HVDC is just another form of power conditioning, but at the high voltage of the transmission system.

According to the report of General Electric Company, the same rating analysis applies for the implementation of a HVDC back-to-back converter (referred to as Option A) which would be inserted between the high-voltage side of the powerhouse transformer and the transmission line, thus processing the output power of all six generators with one power conditioner. An option (referred to as HVDC Option B) which would utilize a HVDC back-to-back power conditioner at the transmission voltage level much more effectively (compared to HVDC Option A) was introduced in this report. This option suggests operating only four generators with the power conditioner during the short drawdown period, and then connecting the remaining generators to the power conditioner for the entire period while the pool remains at its lowest level. The power conditioner would operate during this period at its rated power level and, thus, best efficiency. The rating of the power condition in this event is only 40% to 80% of the powerhouse rating. However, this requires that the pools are drawn down to the same level every year, which may not be the case. The desired (minimum) pool level depends on a number of hydraulic conditions which can vary from year to year. This option should be kept in mind as the hydraulic operating plan is firmed up.

A.2.4 System Retrofit Scenario

Since the generators will remain unchanged in the power conditioning configuration, a major consideration is the physical placement of the power converter (and the static var-compensation system, if deemed necessary), as well as the bypass switch-gear and necessary filter hardware. Large galleries are located at each project behind the generator hall. They are approximately 25' wide, 50' high, and stretch almost the entire length (540') of the powerhouse. According to the opinions of two equipment suppliers, this space is sufficient to house 6 LCI power conditioners of sufficient rating, including input and output transformers. The HVDC-option would require placement of the LCI in the vicinity of the 500 kV switchyards. A static var-compensation system would be located there as well. Regardless of operating voltage level, the circuits of the LCI will be water-cooled, and will require a water-to-water heat-exchanger, which will not pose a problem because sufficient cooling water from the pools is available. The RPM-controller, as well as the controller for the static var-compensation system, will have to be integrated into the system controller.

A.2.5 System Performance and Operation

Performance and operation of a system using the power conditioning approach deviate significantly from the fixed-speed synchronous generator.

Efficiency:

The electrical efficiency of the LCI-connected synchronous generator(s) at rated load will be between 2.5% and 3.0% lower than the efficiency of the fixed-speed synchronous generator(s). lose to 2.5% are lost in the LCI and some additional power is lost in the generator due to harmonic losses. Additional losses would be incurred in a static var-compensation system, if implemented.

Reactive Power Control:

No reactive power control is inherently possible with a variable-speed generation system using a LCI as frequency converter, the LCI always draws reactive power from the grid. Any reactive power control desired would have to be accomplished using a static var-compensation system.

Harmonic Distortion:

Harmonic distortion output from the variable-speed generation system will be much increased compared to the fixed-speed synchronous generator. With the implementation of the 12-pulse inverter and additional filtering hardware, it is possible to limit harmonic distortion at the point of interconnection to within IEEE 519 specifications.

Generator System Operation:

Using the power conditioning strategy, it is possible to continuously adjust RPM to optimize turbine efficiency according to head-level and flow. Several systems of this type have been operating for years without any problems. An adaptive controller can be added, which continuously would optimize system performance.

A.2.6. System Maintenance

Differences in maintenance are mostly limited to the power conditioner. Internal system monitors alleviate a possible need for trouble-shooting considerably. Having experience with static excitation systems already operating at the sites, maintenance personnel should be able, after a training period, to independently do most of the troubleshooting for large power conditioning units. Usually, manufacturers provide customers with the necessary training to successfully troubleshoot the system. Annual maintenance is limited to checks of the cooling system, transformer oil levels (if oil-cooled transformers are used), and associated breakers. Due to increased vibration in the generator, more frequent inspections of the stator and windings are advisable.

A.2.7 System Cost

The $65,700/MVA cost estimate for system s operating at the generator voltage level, as supplied by potential vendors, is similar to well-known cost estimates for LCI-type power conditioners. Assuming that the LCI does not process more than 80% of the rated generator output (142 MVA), the cost per LCI would be about $7.46 million. Installation cost per LCI is about $3 million. Thus, installed cost per unit becomes $10.46 million and $62.76 million per powerhouse. In addition, due to the variable-frequency output of the generators, an internal powerhouse auxiliary power system becomes necessary at a cost of $1.4 million. Overall cost per powerhouse becomes $64.16 million for LCIs rated at 80% of rated output (excluding static Var units).

The installed cost of the LCI increases to about $125.7k/MVA for systems operating at the HVDC voltage level (excluding real estate cost). However, as can be seen from Option B of the General Electric Company study, considering the low total output power of the powerhouse at 57 feet of head, the LCI rating might be reduced to 40% of rated powerhouse output. Installed cost estimates for this configuration are $44.0 million per powerhouse, assuming that the hydraulic operating plan allows a uniform drawdown to 57 feet every year. Together with the auxiliary power supply (priced at $1.4 million), total cost per powerhouse becomes $45.4 million for the 40% option (excluding a static Var-controller).

If a static Var-compensation unit is required to provide the same range of reactive power control as the fixed-speed system did before (±48.4 MVar per generator), another $2.90 million for each generator (or $7.25 million for one powerhouse as a single unit) would have to be added. The cost/MVar of this system decreases nonlinearity with rating.

A.3 Pole-Changing Synchronous Generator

A.3.1 Generator Description

A pole-changing synchronous generator is a synchronous generator which is able to operate at several synchronous speeds and which differs from a single-speed synchronous generator mainly in the design of the stator winding and the rotor (5). The poles on the rotor of a pole-changing synchronous generator are subdivided into identical groups. Arranged symmetrically in each group there are large poles in the center and small poles at the outside. Through change in polarity of every pole in every second group, and by disconnecting one of the small poles in each group, the number of active poles on the rotor can be altered. Separate windings exist on the stator for each pole-setting. By using switches to alter the configuration on the rotor and change over to a different winding on the stator simultaneously, the different RPM-settings are realized. At very high power levels, the implementation of only two synchronous speeds, and then only certain combinations of speeds, are technically feasible.

A.3.2 Generator Retrofit Scenario

Because of the superior operating characteristics of the pole-changing synchronous generator, it may be worth studying further methods to reduce its cost. One method would be to reuse the parts and auxiliary equipment (such as the stator lamination, rotor spider, top and bottom shafts, slip-rings and the exciter) of the existing generator. To date, it has been determined that the stator lamination can not be used in the desired new pole-changing synchronous generator; that is, the entire generator must be replaced. All other existing auxiliary equipment (breaker, synchronizer, controls, *etc.*) can be used as is. The controls for the pole-changing logic would have to be integrated into the existing generator control logs.

A.3.3 Generator Performance and Operation

With few exceptions, the performance of the pole-changing synchronous generator is identical to that of the fixed-speed synchronous generator:

Efficiency:

The efficiency of a new pole-changing synchronous generator is at the most 1.7% lower than the efficiency of the existing fixed-speed synchronous generators. That reduction occurs at the lower of the two expected pool levels.

Reactive Power Control:

Reactive power at the stator terminals of a pole-changing synchronous generator is controlled with the magnitude of the DC-excitation current on the rotor. There is no difference in control compared with the reactive power control of a fixed-speed synchronous generator.

Total Harmonic Distortion:

Compared to the fixed-speed synchronous generator, the harmonic output at the stator terminals of the pole-changing synchronous generator is increased. However, having determined an optimal layout for the non-uniform rotor pole distribution (which causes the harmonic distortion), it is possible to keep the total harmonic distortion at the stator terminals within IEEE 519 specifications.

Generator Stability:

Due to the wide harmonic spectrum of the pole-field curve, there are characteristic subharmonic oscillations which cause forces on the stator core. It is possible to model this behavior with computer programs during the design stage to limit the forces to acceptable levels.

Generator Operation:

The largest pole-changing synchronous generator built to date has a rating of 305 MVA. Smaller units which are older than 20 years have excellent operating records which do not differ from those of single-speed synchronous generators. The desired operating RPM is set while the generator is off line. The generator is accelerated with the turbine to the desired RPM and then synchronized to the grid like a single-speed synchronous generator.

A.3.4 Generator Maintenance

The only difference in maintenance between a fixed-speed synchronous generator and a pole-changing synchronous generator is the number of slip-rings on the generator shaft to be maintained, and the number of brushes to be checked periodically and replaced according to the maintenance schedule. Pole-changing synchronous generators may have up to 5 slip-rings (instead of two for the fixed-speed synchronous generator) which are subject to the same wear and tear as the slip-rings of the fixed-speed synchronous generator. Inspection and maintenance of the switches which accomplish the task of pole-changing on rotor and stator have to be incorporated into the regular maintenance schedule as additional items.

A.3.5 Generator Cost

Subject to an official bid, a new pole-changing synchronous generator will cost about 28% more than a new fixed-speed synchronous generator of equal rating. The estimated cost for a new 142 MVA, 90 RPM, fixed-speed synchronous generator is \$16.86 million, thus the cost of a new pole-changing synchronous generator of the same rating would be about \$21.4 million, thus total plant cost (including \$3 million per unit for installation) would be about \$146.4 million. The unusually high equipment cost is partially due to the currently adverse exchange rate of the U.S dollar with respect to most major foreign currencies. This cost estimate was supplied by a foreign equipment manufacturer.

A.4 Doubly-Fed Generator

A.4.1 General System Description

A doubly-fed generator consists of a 3-phase wound-rotor generator with a variable-frequency AC/AC-converter connected to the rotor, and the stator connected to the utility grid. The rotational magnetic fields of both rotor and stator are in synchronism. The mechanical RPM can be found from:

$$\text{RPM} = 120 * (60\text{ Hz} - f_{\text{rotor}})/\text{number of poles}$$

If DC is applied to the rotor windings, the same RPM as for a synchronous generator would result. Figure A4.1 shows the block diagram of a doubly-fed generator.

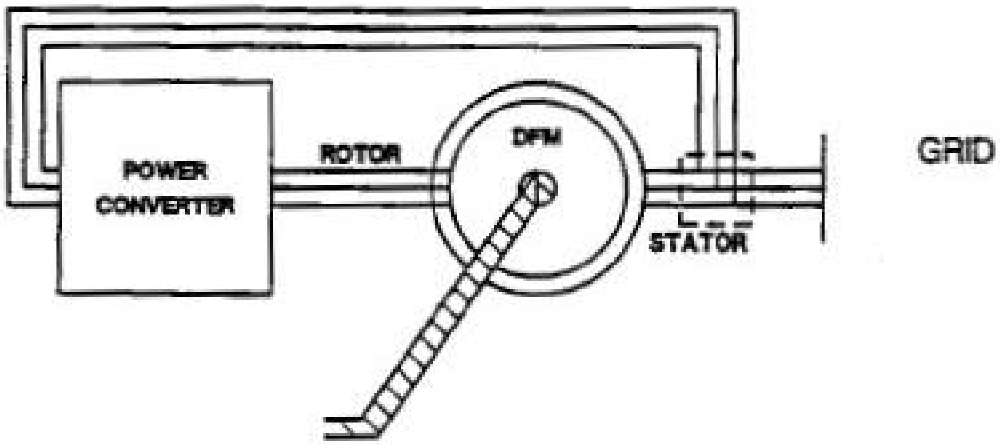


Figure A4.1: Block Diagram of a Doubly-Fed Generator

A.4.2 Design of the 3-Phase Wound Rotor

The successful design of a 3-phase wound rotor for a generator of high power rating and low RPM poses the main challenge for the implementation of this system. The size of the air-gap determines the reactive power to be supplied by the power converter in order to maintain sufficient generator excitation. Mechanical design constraints on the rotor assembly require a certain minimum size air-gap. In general, as the rotor diameter increases, the size of the air-gap has to increase disproportionally more. High reactive magnetization power leads directly to a more costly generator and converter. This effect is particularly pronounced for the 90 RPM generators with very large diameter rotors, which are the subject of this study.

The design of a smooth rotor lamination around the existing rotor frame is possible. When retrofitting an existing synchronous generator with a 3-phase wound rotor it is possible to reduce the size of the air-gap somewhat from the size with the salient-pole rotor. Proven solutions for other design problems have been found. They include:

- an acceptable trade-off between the number of turns per winding, maximum required rotor currents, and maximum rotor voltages
- mechanically reliable mounting of the rotor winding bars while allowing for their thermal expansion during operation, and
- adequate cooling of the rotor windings even at lowest RPM.

A.4.3 Converter for the 3-Phase AC=Excitation

One of the most appealing features of the doubly-fed system is the fact that the power converter in the rotor circuit needs to be rated only at a fraction of the total system rating. However, a number of electrical requirements have limited the choice of the type of frequency converter to cyclo-converters. Until now, the cyclo-converter is the only known converter type commissioned at high power levels which covers the frequency range between DC and about 10 Hz and is capable to transition from very low frequency AC to DC smoothly. This capability is required by the doubly-fed machine. On the other hand, continuous operation of the cyclo-converter at DC must be avoided due to possible overheating of certain semiconductors.

Some type of resonant converter could be an ideal replacement for the cyclo-converter, alleviating most of its disadvantages (*i.e.*, considerable harmonic content and poor power factor at the input), if it were not for its limited demonstrated output power at the current state of development.

A.4.4 System Retrofit Scenario

Even though the main difficulty appears to be with the design of the wound rotor, it is necessary to check for possible subharmonic oscillations in the existing stator, caused by interaction between the wound rotor and the stator. Changes to the stator are needed if these oscillations can occur. The generator stator has to be replaced at great cost if the synchronous RPM of the generator is not located close to the center of the desired RPM range. That is the case for the generators considered in this study. Thus, the entire generator must be replaced. The top shaft of the rotor has to be redesigned to accommodate the 3-phase slip-ring assembly. The cost of retrofit would be lower if the system is implemented at a point of time when an existing generator would need to be either rebuilt or totally replaced. The relative cost of retrofit would be even less if an upgrade of the existing exciter of the fixed-speed synchronous generator would be necessary at the same time.

Space in the gallery behind the generator floor is sufficient to accommodate the cyclo-converter. Transformers and filters could be placed there with all other switch-gear outside the powerhouse. The controls for the doubly-fed machine have to be integrated into the existing generator controls.

A.4.5 System Performance and Operation

The performance of the doubly-fed generation system resembles the behavior of a fixed-speed synchronous generator in many ways.

Efficiency:

Due to the higher excitation currents and present harmonics, the losses in the wound rotor will be higher than in the salient-pole DC-rotor. It is expected that the generator efficiency will therefore be about 1 percentage point (or less) lower than the fixed-speed generator. With a given efficiency of the cyclo-converter of about 97.5%, the electrical system efficiency should be about 1.2 percentage points lower than that of the fixed-speed synchronous generator.

Reactive Power Control:

Reactive power at the point of interconnection with the utility can be controlled with the amplitude of the rotor current, similar to the reactive power control of a fixed-speed synchronous machine. However, given the poor power factor (0.56) at the input of the cyclo-converter, it appears to be more efficient to make power factor corrections with a static Var-compensation system connected to the point of interconnection with the grid.

Harmonic Distortion:

Cyclo-converters are known to cause considerable harmonic distortion at their input terminals, which requires filtering in order to satisfy IEEE 519 specifications. Non-sinusoidal rotor currents from the cyclo-converter output induce harmonic currents in the stator which also have to be filtered out. However, due to the fractional rating of the cyclo-converter relative to the system rating, the filtering effort may be comparable to the effort necessary to limit the harmonics in other VSG configurations.

System Stability:

Tests with the doubly-fed generation system have shown that the presence of this system has a stabilizing effect on the utility grid. In the case of grid disturbances (lightning strike, short circuits), the oscillations observed on the other fixed-speed synchronous generators were dampened by the doubly-fed generator and disappeared faster than without the doubly-fed generator system.

Generator System Operation:

With the doubly-fed machine approach, it is possible to continuously adjust RPM over the specified range. If desired, operation above synchronous RPM is possible.

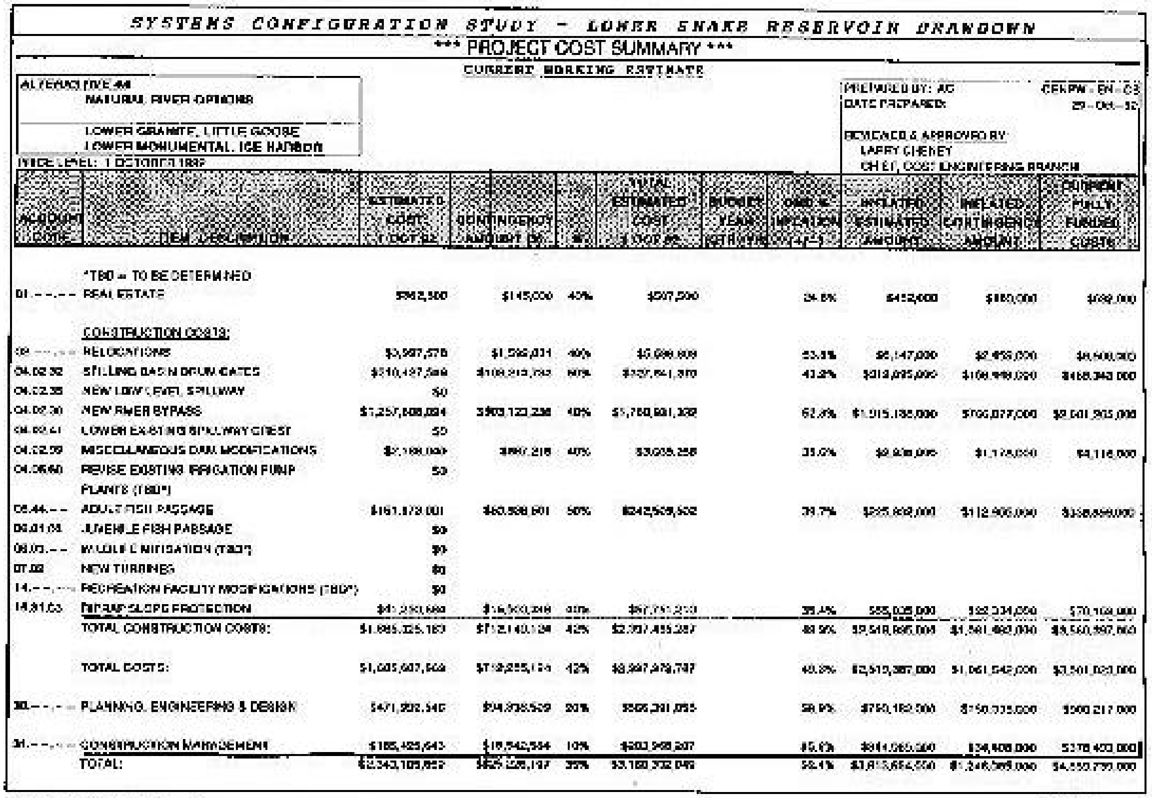
A.4.6 System Maintenance

Compared to the fixed-speed synchronous generator, the only additional maintenance items to be covered for the generator are the additional slip-ring(s) of the 3-phase rotor, with their associated brushes. The mechanical integrity of the rotor winding support requires annual checks. The liquid cooling system of the cyclo-converter requires periodic inspection. The maintenance experience with DC-output static exciters should enable maintenance personnel to troubleshoot the power circuit of the cyclo-converter as well. State-of-the-art protection electronics in the converter controller and manufacturer training provide maintenance personnel with the necessary support to handle almost all necessary repair work. The transformers of the cyclo-converter, as well as the high voltage switches and breakers, require periodic checking.

A.4.7 System Cost

The estimated equipment cost for a variable-speed generation system, using the doubly-fed machine approach, is $211k/MVA. Total system cost for the 142 MVA unit is $33 million (installed). This includes the replacement of the generator (including stator) with a 100-pole generator and the adequately rated cyclo-converter with associated filtering hardware. The unusually high equipment cost is partly due to the currently adverse exchange rate of the U.S. dollar with respect to most major foreign currencies. This cost estimate was supplied by a major foreign equipment manufacturer.

Appendix C - Cost Data



SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 4A
NATURAL RIVER OPTIONS
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AG — CENPW-EN-CS
DATE PREPARED: 29-Oct-92
REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR	OMB % INFLATION	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$3,897,570	$1,559,031	40%	$5,596,601		53.3%	$6,147,000	$2,459,000	$8,606,000
04.02.32	STILLING BASIN DRUM GATES	$218,427,586	$109,213,793	50%	$327,641,379		43.2%	$312,895,000	$156,448,000	$469,343,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.30	NEW RIVER BYPASS	$1,257,808,094	$503,123,238	40%	$1,760,931,332		62.8%	$1,915,185,000	$766,077,000	$2,681,263,000
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.59	MISCELLANEOUS DAM MODIFICATIONS	$2,168,040	$867,216	40%	$3,035,256		35.0%	$2,938,000	$1,178,000	$4,116,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
05.44.--.--	ADULT FISH PASSAGE	$161,673,001	$80,836,501	50%	$242,509,502		39.7%	$225,892,000	$112,946,000	$338,838,000
06.01.01	JUVENILE FISH PASSAGE	$0								
06.03.--.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
14.01.03	RIPRAP SLOPE PROTECTION	$41,250,600	$16,500,240	40%	$57,750,840		35.4%	$55,835,000	$22,334,000	$78,169,000
	TOTAL CONSTRUCTION COSTS:	$1,885,325,169	$712,140,124	42%	$2,597,465,287		48.9%	$2,518,892,000	$1,061,492,000	$3,580,387,000
	TOTAL COSTS:	$1,885,687,669	$712,285,124	42%	$2,597,972,787		48.9%	$2,519,347,000	$1,061,542,000	$3,581,023,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$471,992,540	$94,398,508	20%	$566,391,048		58.9%	$750,182,000	$150,035,000	$900,217,000
31.--.--	CONSTRUCTION MANAGEMENT	$185,425,643	$18,542,564	10%	$203,968,207		85.6%	$344,065,000	$34,408,000	$378,473,000
	TOTAL:	$2,543,105,852	$825,226,197	32%	$3,368,332,049		58.4%	$3,613,594,000	$1,246,085,000	$4,859,779,000

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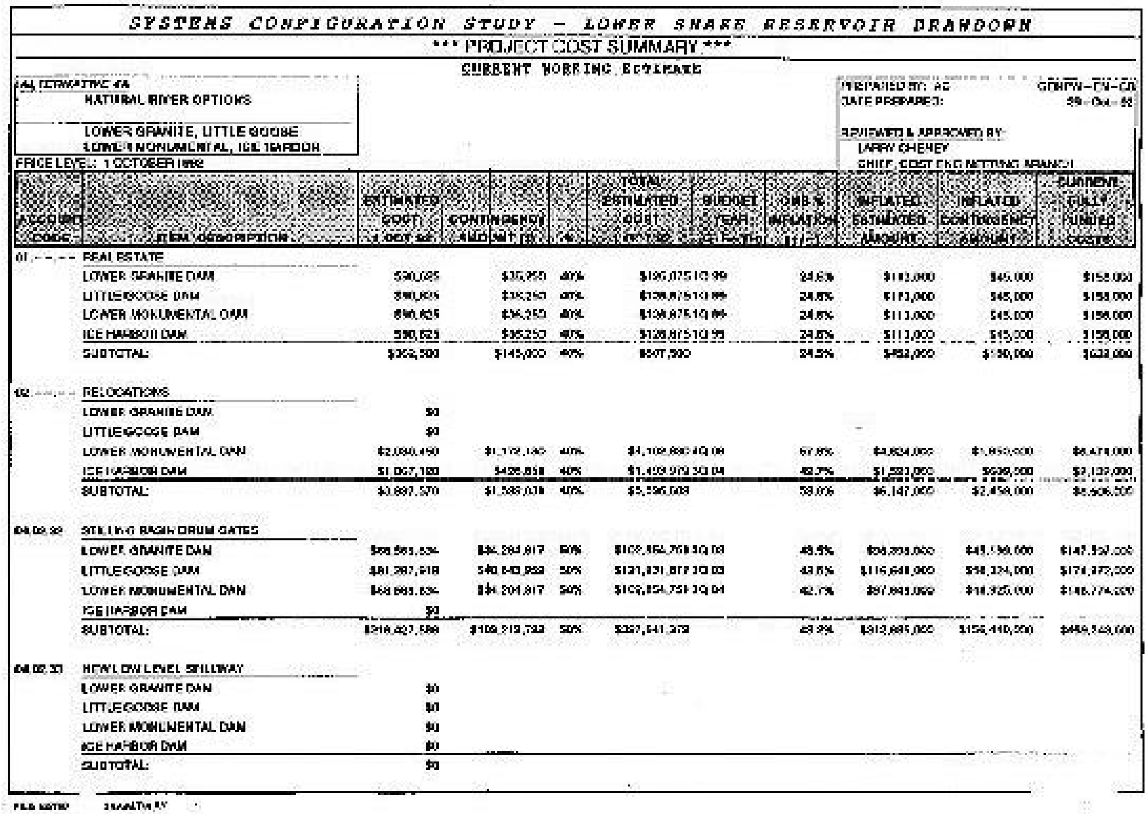

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 4A
NATURAL RIVER OPTIONS
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AG — CENPW-EN-CS
DATE PREPARED: 29-Oct-92
REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR	OMB % INFLATION	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.--.--	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.5%	$113,000	$45,000	$158,000
	LITTLE GOOSE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.5%	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.5%	$113,000	$45,000	$158,000
	ICE HARBOR DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.5%	$113,000	$45,000	$158,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
02.--.--	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$2,090,450	$1,172,180	40%	$4,102,880	4Q 08	67.8%	$4,824,000	$1,850,000	$6,474,000
	ICE HARBOR DAM	$1,807,120	$426,858	40%	$1,459,979	3Q 04	42.7%	$1,523,000	$609,000	$2,132,000
	SUBTOTAL:	$3,897,570	$1,559,031	40%	$5,596,603		53.0%	$6,147,000	$2,459,000	$8,606,000
04.02.32	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,634	$34,284,817	50%	$102,854,451	3Q 03	43.5%	$98,398,000	$49,199,000	$147,597,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	3Q 03	43.6%	$116,648,000	$58,324,000	$174,972,000
	LOWER MONUMENTAL DAM	$68,569,634	$34,284,817	50%	$102,854,451	3Q 04	42.7%	$97,849,000	$48,925,000	$146,774,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		43.2%	$312,895,000	$156,448,000	$469,343,000
04.02.35	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

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SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 4A
NATURAL RIVER OPTIONS

LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CD
DATE PREPARED: 29-OCT-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.38	NEW RIVER BYPASS									
	LOWER GRANITE DAM	$328,003,070	$131,401,220	40%	$459,404,290	3Q 01	34.0%	$439,452,000	$175,781,000	$615,233,000
	LITTLE GOOSE DAM	$305,983,328	$122,393,331	40%	$428,376,659	3Q 01	34.8%	$412,465,000	$164,987,000	$577,452,000
	LOWER MONUMENTAL DAM	$370,353,202	$148,141,281	40%	$518,494,483	3Q 08	69.9%	$629,230,000	$251,692,000	$880,922,000
	ICE HARBOR DAM	$255,465,563	$102,187,425	40%	$357,652,988	3Q 08	69.8%	$433,641,000	$173,517,000	$607,158,000
	SUBTOTAL:	$1,257,003,094	$503,123,278	40%	$1,760,031,332		52.7%	$1,915,155,000	$766,077,000	$2,681,289,000
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	2Q 97	16.8%	$544,000	$358,000	$902,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	2Q 97	16.8%	$544,000	$358,000	$902,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	3Q 05	52.3%	$825,000	$331,000	$1,156,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	3Q 06	52.3%	$825,000	$331,000	$1,156,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		35.8%	$2,738,000	$1,378,000	$4,116,000
04.08.96	REVISE EXISTING IRRIGATION PUMP PLANTS (*10D)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 4A
NATURAL RIVER OPTIONS

LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.44.--	ADULT FISH PASSAGE									
	LOWER GRANITE DAM	$55,717,939	$27,858,969	50%	$83,576,908	2Q 00	29.6%	$72,210,000	$36,105,000	$108,315,000
	LITTLE GOOSE DAM	$56,396,344	$28,198,172	50%	$84,594,516	2Q 00	29.6%	$73,090,000	$36,544,000	$109,634,000
	LOWER MONUMENTAL DAM	$46,708,915	$23,354,458	50%	$70,063,373	1Q 08	62.7%	$75,995,000	$37,998,000	$113,993,000
	ICE HARBOR DAM	$2,849,853	$1,424,927	50%	$4,274,780	1Q 08	62.7%	$4,637,000	$2,318,000	$6,955,000
	SUBTOTAL:	$161,673,051	$80,836,526	50%	$242,509,577		39.7%	$225,932,000	$112,966,000	$338,898,000
06.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
06.03.--	WILDLIFE MITIGATION (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 4A
NATURAL RIVER OPTIONS

LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COSTS 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.--.--	RECREATION FACILITY MODIFICATIONS (SBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
16.81.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$26,173,913	$10,470,365	40%	$36,646,278	2Q 99	25.6%	$32,977,000	$13,151,000	$46,228,000
	LITTLE GOOSE DAM	$2,993,352	$1,197,341	40%	$4,190,693	2Q 99	25.6%	$3,760,000	$1,504,000	$5,264,000
	LOWER MONUMENTAL DAM	$6,538,700	$2,615,481	40%	$9,154,181	1Q 07	58.9%	$10,390,000	$4,156,000	$14,546,000
	ICE HARBOR DAM	$5,542,598	$2,217,159	40%	$7,759,654	1Q 07	58.9%	$8,808,000	$3,523,000	$12,331,000
	SUBTOTAL:	$41,250,864	$16,500,346	40%	$57,751,210		35.4%	$55,935,000	$22,334,000	$78,163,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 4A
NATURAL RIVER OPTIONS

LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COSTS 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.--.--	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$133,587,815	$26,717,563	20%	$160,305,378	1Q 97	36.5%	$182,882,000	$36,576,000	$219,458,000
	LITTLE GOOSE DAM	$125,242,175	$25,048,435	20%	$150,290,610	1Q 97	30.9%	$171,457,000	$34,291,000	$205,748,000
	LOWER MONUMENTAL DAM	$138,805,447	$27,761,089	20%	$166,566,536	1Q 04	65.7%	$257,762,000	$51,552,000	$309,314,000
	ICE HARBOR DAM	$74,357,108	$14,871,422	20%	$89,228,530	1Q 04	85.7%	$138,091,000	$27,618,000	$165,697,000
	SUBTOTAL:	$471,992,546	$94,398,509	20%	$566,391,055		58.9%	$750,192,000	$150,035,000	$900,217,000
31.--.--	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$52,480,939	$5,248,093	10%	$57,729,030	2Q 01	66.1%	$87,171,000	$8,717,000	$95,888,000
	LITTLE GOOSE DAM	$49,203,283	$4,920,228	10%	$54,123,511	2Q 01	69.1%	$91,725,000	$9,172,000	$99,897,000
	LOWER MONUMENTAL DAM	$54,590,711	$5,459,071	10%	$59,960,782	2Q 07	108.8%	$114,070,000	$11,406,000	$125,405,000
	ICE HARBOR DAM	$29,211,721	$2,921,172	10%	$32,132,893	2Q 07	109.2%	$61,111,000	$6,111,000	$67,222,000
	SUBTOTAL:	$185,425,649	$18,542,564	10%	$203,968,207		85.0%	$345,005,000	$34,450,000	$378,492,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 4A
NATURAL RIVER OPTIONS

LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW - EN - CB
DATE PREPARED: 27 - Oct - 92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COSTS 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-FY)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$477,009,716	$203,232,259	43%	$680,240,975		35.0%	$643,581,000	$274,495,000	$918,076,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$133,587,815	$26,717,563	20%	$160,305,378	1Q 97	36.9%	$182,882,000	$36,570,000	$219,450,000
31.--.--	CONSTRUCTION MANAGEMENT	$52,480,928	$5,248,093	10%	$57,729,020	2Q 01	66.1%	$87,171,000	$8,717,000	$95,888,000
	SUBTOTAL:	$663,169,084	$235,234,165	35%	$898,403,249			$913,747,000	$319,433,000	$1,233,580,000
	LITTLE GOOSE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$447,202,857	$192,649,569	43%	$639,852,426		35.7%	$606,607,000	$261,617,000	$868,224,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$125,243,675	$25,048,735	20%	$150,292,410	1Q 97	36.5%	$171,497,000	$34,291,000	$205,748,000
31.--.--	CONSTRUCTION MANAGEMENT	$49,202,283	$4,920,228	10%	$54,122,511	2Q 01	66.1%	$81,795,000	$8,172,000	$89,967,000
	SUBTOTAL:	$621,737,940	$222,654,452	36%	$844,392,422			$869,802,000	$304,125,000	$1,164,027,000
	LOWER MONUMENTAL DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$495,733,739	$209,821,371	42%	$705,555,110		65.0%	$810,026,000	$344,057,000	$1,164,083,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$138,805,447	$27,761,089	20%	$166,566,536	1Q 04	85.7%	$257,762,000	$51,552,000	$309,314,000
31.--.--	CONSTRUCTION MANAGEMENT	$54,530,718	$5,453,071	10%	$59,983,789	2Q 07	109.2%	$114,070,000	$11,406,000	$125,476,000
	SUBTOTAL:	$689,069,907	$243,035,531	35%	$932,105,428			$1,180,858,000	$407,857,000	$1,588,828,000
	ICE HARBOR DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$265,961,101	$106,509,426	40%	$372,470,527		66.4%	$440,547,000	$180,443,000	$620,990,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$74,957,108	$14,271,422	20%	$89,228,530	1Q 04	85.7%	$130,001,000	$27,016,000	$155,017,000
31.--.--	CONSTRUCTION MANAGEMENT	$29,211,721	$2,921,172	10%	$32,132,893	2Q 07	109.2%	$61,111,000	$6,111,000	$67,222,000
	SUBTOTAL:	$369,129,930	$124,302,019	34%	$493,431,950			$649,199,000	$214,170,000	$863,932,000
	TOTAL PROJECT:	$2,343,105,852	$825,226,197	35%	$3,168,335,049		53.4%	$3,613,854,000	$1,245,055,000	$4,857,730,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 4A
NATURAL RIVER OPTIONS

LOWER GRANITE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW - EN - CB
DATE PREPARED: 21 - Oct - 92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COSTS 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-FY)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,369,834	$34,184,917	50%	$102,554,751	3Q 99	41.5%	$98,380,000	$49,193,000	$147,590,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS	$326,003,070	$130,401,228	40%	$456,404,298	3Q 01	34.0%	$439,452,000	$175,781,000	$615,233,000
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 97	18.8%	$644,000	$258,000	$902,000
04.06.90	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.14.--	ADULT FISH PASSAGE	$55,717,889	$27,858,945	50%	$83,576,834	2Q 00	29.6%	$72,210,000	$36,106,000	$108,316,000
06.01.03	JUVENILE FISH PASSAGE	$0								
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$26,175,913	$10,470,365	40%	$36,646,278	2Q 99	25.6%	$32,817,000	$13,151,000	$45,968,000
	TOTAL CONSTRUCTION COSTS:	$477,009,716	$203,232,259	43%	$680,240,975		35.0%	$643,581,000	$274,495,000	$918,076,000
	TOTAL COSTS:	$477,099,341	$203,268,509	43%	$680,367,850		35.0%	$643,694,000	$274,540,000	$918,234,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$133,587,815	$26,717,563	20%	$160,305,378	1Q 97	36.9%	$182,882,000	$36,570,000	$219,450,000
31.--.--	CONSTRUCTION MANAGEMENT	$52,480,928	$5,248,093	10%	$57,729,020	2Q 01	66.1%	$87,171,000	$8,717,000	$95,888,000
	TOTAL:	$663,169,084	$235,234,165	35%	$898,403,249		37.3%	$913,747,000	$319,433,000	$1,233,580,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE #4
NATURAL RIVER OPTIONS

LITTLE GOOSE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,287,918	$40,643,959	50%	$121,931,877	3Q 03	43.5%	$116,648,000	$58,324,000	$174,972,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS	$305,983,233	$122,393,293	40%	$428,376,526	3Q 01	34.8%	$412,465,000	$164,987,000	$577,452,000
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 97	18.9%	$644,000	$258,000	$902,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$56,396,344	$28,198,172	50%	$84,594,516	2Q 00	29.6%	$73,090,000	$36,544,000	$109,634,000
06.01.03	JUVENILE FISH PASSAGE	$0								
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$2,993,352	$1,197,341	40%	$4,190,693	2Q 99	25.6%	$3,760,000	$1,504,000	$5,264,000
	TOTAL CONSTRUCTION COSTS:	$447,202,857	$192,649,569	43%	$639,852,426		35.7%	$606,607,000	$261,617,000	$868,224,000
	TOTAL COSTS:	$447,293,482	$192,685,819	43%	$639,979,301		35.7%	$606,720,000	$261,662,000	$868,382,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$125,242,175	$25,048,435	20%	$150,290,610	1Q 97	36.9%	$171,457,000	$34,291,000	$205,748,000
31.--.--	CONSTRUCTION MANAGEMENT	$49,202,283	$4,920,228	10%	$54,122,511	2Q 01	66.1%	$81,725,000	$8,172,000	$89,897,000
	TOTAL:	$621,737,940	$222,654,482	36%	$844,392,422		37.9%	$859,902,000	$304,125,000	$1,164,027,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE #4
NATURAL RIVER OPTIONS

LOWER MONUMENTAL DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR. YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$2,930,450	$1,172,180	40%	$4,102,630	4Q 08	57.6%	$4,624,000	$1,850,000	$6,474,000
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	3Q 08	42.7%	$97,849,000	$48,925,000	$146,774,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS	$370,353,202	$148,141,281	40%	$518,494,483	3Q 08	69.9%	$629,230,000	$251,692,000	$880,922,000
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 05	52.3%	$825,000	$331,000	$1,156,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$46,708,915	$23,354,458	50%	$70,063,373	1Q 08	62.7%	$75,996,000	$37,998,000	$113,993,000
06.01.03	JUVENILE FISH PASSAGE	$0								
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$6,538,703	$2,615,481	40%	$9,154,184	1Q 07	58.8%	$10,389,000	$4,156,000	$14,545,000
	TOTAL CONSTRUCTION COSTS:	$495,643,114	$209,785,121	42%	$705,428,235		65.0%	$818,913,000	$344,952,000	$1,163,885,000
	TOTAL COSTS:	$495,733,739	$209,821,371	42%	$705,555,110		66.0%	$819,026,000	$344,997,000	$1,164,023,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$138,805,447	$27,761,089	20%	$166,566,536	1Q 06	85.7%	$257,762,000	$51,552,000	$309,314,000
31.--.--	CONSTRUCTION MANAGEMENT	$54,530,711	$5,453,071	10%	$59,983,782	2Q 07	109.2%	$114,078,000	$11,408,000	$125,486,000
	TOTAL:	$689,069,897	$243,035,531	35%	$932,105,428		71.6%	$1,190,866,000	$407,957,000	$1,598,823,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 4A
NATURAL RIVER OPTIONS

ICE HARBOR DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD – TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$150,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$1,087,128	$429,851	40%	$1,498,979	3Q 04	42.7%	$1,523,000	$609,000	$2,132,000
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS	$255,468,589	$102,187,436	40%	$357,656,025	3Q 09	69.9%	$434,041,000	$173,617,000	$607,658,000
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 05	52.3%	$825,000	$331,000	$1,156,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$2,849,853	$1,424,927	50%	$4,274,780	1Q 09	62.7%	$4,637,000	$2,318,000	$6,955,000
06.01.03	JUVENILE FISH PASSAGE	$0								
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$5,542,896	$2,217,158	40%	$7,760,054	1Q 07	58.8%	$8,808,000	$3,523,000	$12,331,000
	TOTAL CONSTRUCTION COSTS:	$265,470,476	$106,473,176	40%	$371,943,652		69.4%	$449,834,000	$180,198,000	$630,232,000
	TOTAL COSTS:	$265,561,101	$106,509,426	40%	$372,070,527		69.4%	$449,947,000	$180,443,000	$630,390,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$74,357,108	$14,871,422	20%	$89,228,530	1Q 04	85.7%	$138,081,000	$27,616,000	$165,697,000
31.--.--	CONSTRUCTION MANAGEMENT	$29,211,721	$2,921,172	10%	$32,132,893	2Q 07	108.2%	$61,111,000	$6,111,000	$67,222,000
	TOTAL:	$369,129,930	$124,302,019	34%	$493,431,950		76.0%	$649,139,000	$214,170,000	$863,309,000

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SHEET 2

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$218,427,586	$109,213,793	50%	$327,641,379		44.3%	$315,231,000	$157,617,000	$472,848,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$2,168,040	$867,216	40%	$3,035,256		41.6%	$3,068,000	$1,228,000	$4,296,000
04.06.90	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$168,160,907	$84,080,454	50%	$252,241,361		38.7%	$233,301,000	$116,650,000	$349,951,000
06.01.03	JUVENILE FISH PASSAGE	$43,847,148	$17,538,859	40%	$61,386,007		33.7%	$58,622,000	$23,452,000	$82,074,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$43,433,445	$17,373,378	40%	$60,806,823		40.2%	$60,896,000	$24,359,000	$85,255,000
	TOTAL CONSTRUCTION COSTS:	$476,037,126	$229,073,700	48%	$705,110,826		41.0%	$671,118,000	$323,306,000	$994,424,000
	TOTAL COSTS:	$476,399,626	$229,218,700	48%	$705,618,326		41.0%	$671,570,000	$323,486,000	$995,056,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$133,391,895	$26,678,379	20%	$160,070,274		49.1%	$198,907,000	$39,782,000	$238,689,000
31.--.--	CONSTRUCTION MANAGEMENT	$52,403,959	$5,240,396	10%	$57,644,355		78.3%	$93,428,000	$9,342,000	$102,770,000
	TOTAL:	$662,195,480	$261,137,475	39%	$923,332,955		44.7%	$963,905,000	$372,610,000	$1,336,515,000

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SHEET 1

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 28–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR – YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.––.––	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LITTLE GOOSE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	ICE HARBOR DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		24.6%	$452,000	$180,000	$632,000
02.––.––	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.32	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,834	$34,284,917	50%	$102,854,751	1Q 04	45.7%	$99,906,000	$49,953,000	$149,859,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	1Q 04	45.7%	$118,436,000	$59,218,000	$177,655,000
	LOWER MONUMENTAL DAM	$68,569,834	$34,284,917	50%	$102,854,751	1Q 03	41.3%	$96,889,000	$48,445,000	$145,334,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		44.3%	$315,231,000	$157,617,000	$472,848,000
04.02.30	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 28–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST OCT 92	BUDGET YEAR (QTR – YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.36	NEW RIVER BYPASS SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	1Q 00	28.6%	$697,000	$279,000	$976,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	1Q 00	28.6%	$697,000	$279,000	$976,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		41.5%	$3,068,000	$1,228,000	$4,296,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (*TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

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SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PREPARED BY: AC
CENPW – EN – CB
DATE PREPARED: 28 – Oct – 92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

PRICE LEVEL: 1 OCTOBER 1992

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR – YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
09.44.– –	ADULT FISH PASSAGE									
	LOWER GRANITE DAM	$58,173,695	$29,106,398	50%	$87,280,093	3Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
	LITTLE GOOSE DAM	$58,008,585	$29,004,493	50%	$87,013,478	3Q 00	30.7%	$75,818,000	$37,909,000	$113,727,000
	LOWER MONUMENTAL DAM	$46,708,915	$23,354,458	50%	$70,063,373	3Q 06	58.7%	$73,153,000	$36,556,000	$109,709,000
	ICE HARBOR DAM	$5,269,012	$2,634,506	50%	$7,903,518	3Q 06	58.7%	$8,257,000	$4,129,000	$12,386,000
	SUBTOTAL:	$168,160,907	$84,080,454	50%	$252,241,361		38.7%	$233,301,000	$116,650,000	$349,954,000
09.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$10,961,787	$4,384,715	40%	$15,346,502	2Q 98	21.7%	$13,340,000	$5,337,000	$18,677,000
	LITTLE GOOSE DAM	$10,961,787	$4,384,715	40%	$15,346,502	2Q 98	21.7%	$13,340,000	$5,337,000	$18,677,000
	LOWER MONUMENTAL DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
	ICE HARBOR DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
	SUBTOTAL:	$43,847,148	$17,538,859	40%	$61,386,007		33.7%	$58,622,000	$23,452,000	$82,074,000
06.00.– –	WILDLIFE MITIGATION (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PREPARED BY: AC
CENPW – EN – CB
DATE PREPARED: 28 – Oct – 92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

PRICE LEVEL: 1 OCTOBER 1992

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR – YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.– – – –	RECREATION FACILITY MODIFICATIONS (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
16.81.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$20,623,350	$8,249,340	40%	$28,872,690	3Q 01	34.0%	$27,790,000	$11,130,000	$38,920,000
	LITTLE GOOSE DAM	$13,881,285	$5,552,514	40%	$19,433,799	3Q 01	34.8%	$18,712,000	$7,485,000	$26,197,000
	LOWER MONUMENTAL DAM	$5,296,995	$2,118,798	40%	$7,415,793	3Q 07	61.1%	$8,533,000	$3,414,000	$11,947,000
	ICE HARBOR DAM	$3,631,815	$1,452,726	40%	$5,084,541	3Q 07	61.1%	$5,851,000	$2,340,000	$8,191,000
	SUBTOTAL:	$43,433,445	$17,373,378	40%	$60,806,823		40.2%	$60,886,000	$24,369,000	$85,255,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 23–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.––.––	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$44,483,873	$8,896,775	20%	$53,380,648	2Q 97	38.7%	$61,699,000	$12,340,000	$74,039,000
	LITTLE GOOSE DAM	$46,110,956	$9,222,191	20%	$55,333,147	2Q 97	38.7%	$63,956,000	$12,791,000	$76,747,000
	LOWER MONUMENTAL DAM	$36,982,271	$7,396,454	20%	$44,378,726	1Q 02	71.2%	$63,314,000	$12,662,000	$75,976,000
	ICE HARBOR DAM	$5,713,295	$1,142,659	20%	$6,855,954	1Q 02	71.2%	$9,781,000	$1,956,000	$11,737,000
	SUBTOTAL:	$133,290,395	$26,658,079	20%	$159,948,474		49.1%	$198,750,000	$39,749,000	$238,499,000
31.––.––	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$17,475,807	$1,747,581	10%	$19,223,388	4Q 01	69.5%	$29,621,000	$2,963,000	$32,584,000
	LITTLE GOOSE DAM	$18,115,018	$1,811,502	10%	$19,926,520	4Q 01	69.5%	$30,705,000	$3,070,000	$33,775,000
	LOWER MONUMENTAL DAM	$14,528,750	$1,452,875	10%	$15,981,624	3Q 06	96.9%	$28,607,000	$2,861,000	$31,468,000
	ICE HARBOR DAM	$2,244,509	$224,451	10%	$2,468,960	3Q 05	96.9%	$4,419,000	$442,000	$4,861,000
	SUBTOTAL:	$52,364,084	$5,236,409	10%	$57,600,402		78.0%	$93,352,000	$9,336,000	$102,688,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$150,870,976	$84,222,773	$0	$235,093,748	$0	$0	$217,778,000	$104,706,000	$322,482,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$44,509,248	$8,901,850	20%	$53,411,098	2Q 97	38.7%	$61,734,000	$12,347,000	$74,081,000
31.––.––	CONSTRUCTION MANAGEMENT	$17,485,778	$1,748,578	10%	$19,234,354	4Q 01	69.5%	$29,638,000	$2,964,000	$32,602,000
	SUBTOTAL:	$220,956,625	$96,509,451	44%	$307,866,076			$309,201,000	$120,062,000	$429,323,000
	LITTLE GOOSE DAM									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$164,681,965	$79,802,484	48%	$244,484,460		37.9%	$227,003,000	$110,329,000	$337,232,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$46,136,331	$9,227,266	20%	$55,363,597	2Q 97	38.7%	$63,991,000	$12,790,000	$76,759,000
31.––.––	CONSTRUCTION MANAGEMENT	$18,124,987	$1,812,499	10%	$19,937,486	4Q 01	69.5%	$30,722,000	$3,072,000	$33,794,000
	SUBTOTAL:	$229,033,928	$90,878,499	40%	$319,912,427			$321,829,000	$126,144,000	$447,973,000
	LOWER MONUMENTAL DAM									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$132,079,541	$64,359,691	49%	$196,429,232		47.8%	$195,423,000	$95,179,000	$290,602,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$37,007,646	$7,401,529	20%	$44,409,176	1Q 02	71.2%	$63,357,000	$12,672,000	$76,029,000
31.––.––	CONSTRUCTION MANAGEMENT	$14,538,718	$1,453,872	10%	$15,992,590	3Q 06	96.9%	$28,627,000	$2,862,000	$31,489,000
	SUBTOTAL:	$183,716,531	$73,251,342	40%	$256,967,873			$287,520,000	$110,758,000	$398,278,000
	ICE HARBOR DAM									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$20,404,624	$8,688,751	43%	$29,093,375		51.6%	$30,916,000	$13,192,000	$44,106,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$5,738,670	$1,147,734	20%	$6,886,404	1Q 02	71.2%	$9,825,000	$1,965,000	$11,790,000
31.––.––	CONSTRUCTION MANAGEMENT	$2,254,477	$225,448	10%	$2,479,925	3Q 05	96.9%	$4,439,000	$444,000	$4,883,000
	SUBTOTAL:	$28,488,396	$10,098,183	35%	$38,586,579			$45,293,000	$15,646,000	$60,939,000
	TOTAL PROJECT:	$662,195,480	$261,137,475	39%	$923,332,955		44.7%	$963,903,000	$372,610,000	$1,336,513,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY

LOWER GRANITE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	<u>CONSTRUCTION COSTS:</u>									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	1Q 04	45.7%	$99,906,000	$49,953,000	$149,859,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 00	28.6%	$697,000	$279,000	$976,000
04.06.50	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,173,995	$29,086,998	50%	$87,260,993	2Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	2Q 98	21.7%	$13,340,000	$5,337,000	$18,677,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.61.03	RIPRAP SLOPE PROTECTION	$20,623,350	$8,249,340	40%	$28,872,690	2Q 01	34.8%	$27,800,000	$11,120,000	$38,920,000
	TOTAL CONSTRUCTION COSTS:	$158,870,976	$70,222,773	40%	$229,093,749		37.1%	$217,776,000	$104,706,000	$322,482,000
	TOTAL COSTS:	$158,961,601	$70,259,023	40%	$229,220,624		37.1%	$217,889,000	$104,751,000	$322,640,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$44,509,240	$8,901,850	20%	$53,411,090	2Q 97	38.7%	$61,734,000	$12,347,000	$74,081,000
31.--.--	CONSTRUCTION MANAGEMENT	$17,485,776	$1,748,578	10%	$19,234,354	4Q 01	69.5%	$29,638,000	$2,964,000	$32,602,000
	TOTAL:	$220,956,617	$80,909,451	37%	$301,866,068		40.0%	$309,261,000	$120,062,000	$429,323,000

FILE NAME: [illegible]

SET 3

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 - VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY

LITTLE GOOSE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (±)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,287,918	$40,643,959	50%	$121,931,877	1Q 04	45.7%	$118,436,000	$59,219,000	$177,655,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 00	28.6%	$697,000	$279,000	$976,000
04.06.50	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,008,985	$29,004,493	50%	$87,013,478	3Q 00	30.7%	$75,818,000	$37,909,000	$113,727,000
06.81.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	2Q 98	21.7%	$13,340,000	$5,337,000	$18,677,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$13,881,285	$5,552,514	40%	$19,433,799	3Q 01	34.8%	$18,712,000	$7,485,000	$26,197,000
	TOTAL CONSTRUCTION COSTS	$164,681,985	$79,802,484	48%	$244,484,469		37.9%	$227,003,000	$110,229,000	$337,232,000
	TOTAL COSTS:	$164,772,610	$79,838,734	48%	$244,611,344		37.8%	$227,116,000	$110,274,000	$337,390,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$46,136,331	$9,227,266	20%	$55,363,597	2Q 97	38.7%	$63,991,000	$12,798,000	$76,789,000
31.--.--	CONSTRUCTION MANAGEMENT	$18,124,987	$1,812,499	10%	$19,937,486	4Q 01	69.5%	$30,722,000	$3,072,000	$33,794,000
	TOTAL:	$229,033,928	$90,878,499	40%	$319,912,427		40.5%	$321,829,000	$126,144,000	$447,973,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY

LOWER MONUMENTAL DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CO
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	1Q 03	41.7%	$96,889,000	$48,445,000	$145,334,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
04.06.00	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$46,708,915	$23,354,458	50%	$70,063,373	3Q 06	56.7%	$73,190,000	$36,596,000	$109,709,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$5,296,995	$2,118,798	40%	$7,415,793	3Q 07	81.1%	$9,593,000	$3,414,000	$11,847,000
	TOTAL CONSTRUCTION COSTS:	$132,079,541	$64,359,691	49%	$196,439,232		47.8%	$195,423,000	$95,179,000	$290,602,000
	TOTAL COSTS:	$132,170,166	$64,395,941	49%	$196,566,107		47.8%	$195,536,000	$95,224,000	$290,760,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$37,007,646	$7,401,529	20%	$44,409,175	1Q 02	71.2%	$63,357,000	$12,672,000	$76,029,000
31.--.--	CONSTRUCTION MANAGEMENT	$14,538,718	$1,453,872	10%	$15,992,590	3Q 05	96.9%	$28,627,000	$2,862,000	$31,489,000
	TOTAL:	$183,716,591	$73,251,342	40%	$256,967,873		55.0%	$287,520,000	$110,758,000	$398,278,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 5 – VARIABLE POOL
EXISTING POWERHOUSE
WITH EXISTING SPILLWAY

ICE HARBOR DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CO
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
04.06.00	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$5,269,012	$2,634,506	50%	$7,903,518	3Q 06	56.7%	$8,257,000	$4,128,000	$12,385,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$3,631,815	$1,452,726	40%	$5,084,541	3Q 07	81.1%	$5,851,000	$2,340,000	$8,191,000
	TOTAL CONSTRUCTION COSTS:	$20,404,624	$8,688,751	43%	$29,093,375		51.6%	$30,915,000	$13,192,000	$44,108,000
	TOTAL COSTS:	$20,495,249	$8,725,001	43%	$29,220,250		51.5%	$31,028,000	$13,237,000	$44,265,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$5,738,670	$1,147,734	20%	$6,886,404	1Q 02	71.2%	$9,825,000	$1,965,000	$11,790,000
31.--.--	CONSTRUCTION MANAGEMENT	$2,254,477	$225,448	10%	$2,479,925	3Q 05	96.9%	$4,439,000	$444,000	$4,883,000
	TOTAL:	$28,488,396	$10,098,182	35%	$38,586,578		57.9%	$45,292,000	$15,646,000	$60,938,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 8 – VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AG CENPW–EN–CR
DATE PREPARED: 20–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$218,427,586	$109,213,793	50%	$327,641,379		42.7%	$311,698,000	$155,817,000	$467,453,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.90	MISCELLANEOUS DAM MODIFICATIONS	$2,168,045	$867,218	40%	$3,035,263		37.6%	$2,982,000	$1,194,000	$4,176,000
04.06.80	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.04.--	ADULT FISH PASSAGE	$168,160,907	$84,080,454	50%	$252,241,361		34.7%	$229,901,000	$118,950,000	$348,851,000
06.01.03	JUVENILE FISH PASSAGE	$43,647,145	$17,458,858	40%	$61,106,003		35.2%	$59,304,000	$23,720,000	$83,024,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$151,960,000	$60,784,000	40%	$212,744,000		29.6%	$196,940,000	$78,770,000	$275,710,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.51.00	RIPRAP SLOPE PROTECTION	$43,459,845	$17,373,378	40%	$60,826,823		32.3%	$57,443,000	$22,976,000	$80,419,000
	TOTAL CONSTRUCTION COSTS:	$627,857,126	$289,057,706	46%	$916,854,825		37.4%	$861,606,000	$389,133,000	$1,250,739,000
	TOTAL COSTS:	$628,219,626	$289,202,706	46%	$918,362,325		37.4%	$862,058,000	$389,313,000	$1,251,371,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$175,940,695	$35,188,139	20%	$211,128,834		51.7%	$266,851,000	$53,371,000	$320,222,000
31.--.--	CONSTRUCTION MANAGEMENT	$69,119,559	$6,911,956	10%	$76,031,515		79.6%	$124,237,000	$12,427,000	$136,664,000
	TOTAL:	$873,419,880	$332,102,795	38%	$1,205,522,675		42.5%	$1,253,166,000	$465,111,000	$1,718,277,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 8 – VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AG CENPW–EN–CR
DATE PREPARED: 20–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.--.--	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LITTLE GOOSE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	ICE HARBOR DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
02.--.--	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.35	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,834	$34,284,917	50%	$102,854,751	3Q 03	43.5%	$98,261,000	$49,130,000	$147,391,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	3Q 03	43.9%	$116,486,000	$58,242,000	$174,728,000
	LOWER MONUMENTAL DAM	$68,569,834	$34,284,917	50%	$102,854,751	1Q 03	41.3%	$96,889,000	$48,445,000	$145,334,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		42.7%	$311,638,000	$155,817,000	$467,453,000
04.02.33	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 9 – VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CS
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-FY)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.20	NEW RIVER BYPASS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	1Q 08	54.5%	$837,000	$335,000	$1,172,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	1Q 08	54.5%	$837,000	$335,000	$1,172,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		37.6%	$2,982,000	$1,194,000	$4,176,000
04.09.90	REVISE EXISTING IRRIGATION PUMP PLANTS (*TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 9 – VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CS
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-FY)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.11.--	ADULT FISH PASSAGE									
	LOWER GRANITE DAM	$53,173,995	$29,085,960	55%	$87,262,293	2Q 00	39.7%	$75,035,000	$30,017,000	$114,050,000
	LITTLE GOOSE DAM	$53,008,385	$29,054,493	55%	$87,013,478	2Q 00	39.7%	$75,816,000	$37,909,000	$113,727,000
	LOWER MONUMENTAL DAM	$48,706,315	$20,354,458	55%	$70,063,873	2Q 08	56.7%	$71,196,000	$30,990,000	$109,703,000
	ICE HARBOR DAM	$5,280,012	$2,634,505	55%	$7,003,515	2Q 05	55.7%	$8,257,000	$4,128,000	$12,385,000
	SUBTOTAL:	$168,160,807	$84,080,454	55%	$252,241,261		39.7%	$233,391,000	$116,050,000	$349,351,000
06.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
	LITTLE GOOSE DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
	LOWER MONUMENTAL DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 05	49.6%	$16,421,000	$6,568,000	$22,989,000
	ICE HARBOR DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 05	49.6%	$16,421,000	$6,568,000	$22,989,000
	SUBTOTAL:	$43,847,148	$17,538,859	40%	$61,386,007		35.2%	$59,304,000	$23,720,000	$83,024,000
06.03.--	WILDLIFE MITIGATION (TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	LITTLE GOOSE DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	LOWER MONUMENTAL DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	ICE HARBOR DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	SUBTOTAL:	$151,960,000	$60,784,000	40%	$212,744,000		29.6%	$196,940,000	$78,776,000	$275,716,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 3 – VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CE
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB'S INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
15.01.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$20,623,350	$8,249,340	40%	$28,872,690	3Q 99	26.0%	$26,109,000	$10,444,000	$36,553,000
	LITTLE GOOSE DAM	$13,081,285	$5,232,514	40%	$18,313,799	3Q 99	36.6%	$17,574,000	$7,029,000	$24,603,000
	LOWER MONUMENTAL DAM	$5,296,988	$2,118,795	40%	$7,415,783	1Q 06	54.1%	$8,503,000	$3,315,000	$11,818,000
	ICE HARBOR DAM	$3,631,815	$1,452,726	40%	$5,084,541	1Q 06	54.1%	$5,597,000	$2,238,000	$7,835,000
	SUBTOTAL:	$43,433,445	$17,373,378	40%	$60,806,823		32.9%	$57,443,000	$22,976,000	$80,419,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 3 – VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CE
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB'S INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.--.--	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$55,146,443	$11,029,290	20%	$66,175,733	3Q 97	40.5%	$77,401,000	$15,480,000	$92,881,000
	LITTLE GOOSE DAM	$56,773,531	$11,354,706	20%	$68,128,237	3Q 97	40.5%	$79,767,000	$15,953,000	$95,720,000
	LOWER MONUMENTAL DAM	$47,644,846	$9,528,969	20%	$57,173,815	1Q 02	71.2%	$81,568,000	$16,314,000	$97,882,000
	ICE HARBOR DAM	$16,375,870	$3,275,174	20%	$19,651,044	1Q 02	71.2%	$28,035,000	$5,608,000	$33,643,000
	SUBTOTAL:	$175,940,690	$35,188,139	20%	$211,128,829		51.7%	$266,851,000	$53,371,000	$320,222,000
31.--.--	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$21,404,679	$2,140,468	10%	$23,545,147	2Q 01	67.8%	$36,253,000	$3,626,000	$39,879,000
	LITTLE GOOSE DAM	$22,303,887	$2,230,389	10%	$24,534,276	2Q 01	67.0%	$37,425,000	$3,743,000	$41,168,000
	LOWER MONUMENTAL DAM	$18,717,618	$1,871,762	10%	$20,589,380	1Q 08	100.7%	$37,566,000	$3,757,000	$41,323,000
	ICE HARBOR DAM	$6,433,377	$643,338	10%	$7,076,715	1Q 08	100.7%	$12,912,000	$1,291,000	$14,203,000
	SUBTOTAL:	$69,119,559	$6,911,956	10%	$76,031,515		79.8%	$124,257,000	$12,427,000	$136,684,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 2 - VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$196,951,601	$91,455,023	46%	$288,406,624		34.0%	$263,636,000	$122,884,000	$386,520,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$56,146,449	$11,029,290	20%	$68,175,738	3Q 97	40.5%	$77,441,000	$15,435,000	$92,877,000
31.--.--	CONSTRUCTION MANAGEMENT	$21,664,678	$2,166,468	10%	$23,831,144	3Q 01	67.5%	$36,353,000	$3,635,000	$39,989,000
	SUBTOTAL:	$273,762,725	$104,650,781	38%	$378,413,506			$377,470,000	$142,015,000	$519,485,000
	LITTLE GOOSE DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$202,762,610	$95,034,734	47%	$297,797,344		31.3%	$273,111,000	$128,473,000	$401,584,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$56,773,531	$11,354,706	20%	$68,128,237	3Q 97	40.5%	$79,767,000	$15,953,000	$95,720,000
31.--.--	CONSTRUCTION MANAGEMENT	$22,303,887	$2,230,389	10%	$24,534,276	3Q 01	67.0%	$37,426,000	$3,743,000	$41,169,000
	SUBTOTAL:	$281,840,028	$108,619,829	39%	$390,459,857			$390,304,000	$148,169,000	$538,473,000
	LOWER MONUMENTAL DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$170,160,166	$76,591,941	47%	$246,752,107		44.1%	$244,851,000	$114,946,000	$359,796,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$47,644,340	$9,528,868	20%	$57,173,208	1Q 99	71.2%	$81,500,000	$16,214,000	$97,669,000
31.--.--	CONSTRUCTION MANAGEMENT	$18,717,618	$1,871,762	10%	$20,589,380	1Q 06	100.7%	$37,999,000	$3,757,000	$41,328,000
	SUBTOTAL:	$236,522,631	$88,002,573	38%	$327,515,203			$363,985,000	$135,013,000	$499,004,000
	ICE HARBOR DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$58,485,249	$23,921,001	41%	$82,406,250		37.7%	$80,400,500	$33,000,000	$113,402,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$16,376,870	$3,275,174	20%	$19,651,044	1Q 02	71.2%	$29,005,500	$5,800,000	$35,643,000
31.--.--	CONSTRUCTION MANAGEMENT	$6,433,377	$643,338	10%	$7,076,715	1Q 06	100.7%	$12,912,000	$1,291,000	$14,203,000
	SUBTOTAL:	$81,294,496	$27,839,512	34%	$109,134,008			$121,417,500	$39,901,000	$161,314,000
	TOTAL PROJECT:	$873,419,880	$332,142,795	38%	$1,205,562,675		42.6%	$1,253,185,500	$465,111,000	[illegible]

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 2 - VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY

LOWER GRANITE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$89,625	$35,850	40%	$125,475	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	3Q 00	43.3%	$98,251,000	$49,130,000	$147,381,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 99	20.7%	$654,000	$262,000	$916,000
04.06.50	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
05.44.--	ADULT FISH PASSAGE	$58,173,995	$29,086,998	50%	$87,260,993	3Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
06.01.53	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$20,623,350	$8,249,340	40%	$28,872,690	3Q 99	26.8%	$26,153,000	$10,461,000	$36,614,000
	TOTAL CONSTRUCTION COSTS:	$196,860,976	$91,419,774	46%	$288,279,740		34.0%	$263,523,000	$122,839,000	$386,362,000
	TOTAL COSTS:	$196,951,601	$91,455,025	46%	$288,406,624		34.0%	$263,636,000	$122,884,000	$386,520,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$56,146,440	$11,029,290	20%	$68,175,736	3Q 97	40.5%	$77,441,000	$15,435,000	$92,877,000
31.--.--	CONSTRUCTION MANAGEMENT	$21,664,676	$2,166,468	10%	$23,831,144	3Q 01	67.5%	$36,353,000	$3,635,000	$39,989,000
	TOTAL:	$273,762,725	$104,650,781	38%	$378,413,506		37.3%	$377,475,000	$142,015,000	$519,490,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 3 - VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY

LITTLE GOOSE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.4%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.22	STILLING BASIN DRUM GATES	$81,987,918	$40,943,959	50%	$121,881,877	3Q 98	41.8%	$116,486,000	$58,242,000	$174,728,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
04.08.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,009,686	$29,004,843	50%	$87,014,529	3Q 00	30.7%	$75,818,000	$37,909,000	$113,727,000
06.01.08	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$13,881,285	$5,552,514	40%	$19,433,799	2Q 99	26.6%	$17,574,000	$7,029,000	$24,603,000
	TOTAL CONSTRUCTION COSTS:	$202,671,985	$94,998,484	47%	$297,670,469		34.8%	$272,998,000	$128,430,000	$401,428,000
	TOTAL COSTS:	$202,762,610	$95,034,734	47%	$297,797,344		34.5%	$273,111,000	$128,473,000	$401,584,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$56,773,591	$11,354,700	20%	$68,128,287	3Q 97	40.5%	$79,767,000	$15,958,000	$95,725,000
31.--.--	CONSTRUCTION MANAGEMENT	$22,303,987	$2,230,399	10%	$24,534,386	3Q 01	67.8%	$37,426,000	$3,743,000	$41,169,000
	TOTAL:	$281,840,088	$108,619,833	39%	$390,459,857		37.9%	$390,304,000	$148,169,000	$538,473,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 3 - VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY

LOWER MONUMENTAL DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.8%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.22	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	1Q 99	41.9%	$97,888,000	$48,446,000	$146,334,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 06	54.6%	$837,000	$335,000	$1,172,000
04.08.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$46,708,915	$23,354,458	50%	$70,063,373	3Q 06	56.7%	$73,190,000	$36,595,000	$109,785,000
06.01.08	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 05	49.8%	$16,421,000	$6,568,000	$22,989,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$5,296,926	$2,118,769	40%	$7,415,695	1Q 06	54.1%	$8,163,000	$3,265,000	$11,428,000
	TOTAL CONSTRUCTION COSTS:	$170,069,541	$79,555,691	47%	$249,625,232		44.1%	$244,738,000	$114,903,000	$359,641,000
	TOTAL COSTS:	$170,160,166	$79,591,941	47%	$249,752,107		44.1%	$244,851,000	$114,948,000	$359,799,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$47,644,848	$9,528,969	20%	$57,173,818	1Q 02	73.3%	$82,573,000	$16,310,000	$98,883,000
31.--.--	CONSTRUCTION MANAGEMENT	$18,717,818	$1,871,782	10%	$20,589,600	1Q 06	100.7%	$37,565,000	$3,757,000	$41,322,000
	TOTAL:	$236,522,831	$90,992,692	38%	$327,515,523		52.4%	$364,989,000	$135,015,000	$500,004,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 2 – VARIABLE POOL
MODIFY POWERHOUSE
WITH EXISTING SPILLWAY

ICE HARBOR DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CR
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 98	21.6%	$112,000	$15,000	$154,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$540,010	$216,004	40%	$756,014	1Q 00	54.5%	$837,000	$335,000	$1,172,000
04.06.85	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$5,269,012	$2,634,506	50%	$7,903,518	3Q 06	56.7%	$8,257,000	$4,128,000	$12,385,000
08.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 05	49.4%	$16,471,000	$6,588,000	$22,959,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	23.6%	$46,235,000	$18,494,000	$65,320,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$3,631,815	$1,452,726	40%	$5,084,541	1Q 08	64.1%	$5,957,000	$2,238,000	$7,845,000
	TOTAL CONSTRUCTION COSTS:	$58,394,624	$23,884,751	41%	$82,279,375		37.7%	$80,347,000	$32,963,000	$113,310,000
	TOTAL COSTS:	$58,485,249	$23,921,001	41%	$82,406,250		37.7%	$80,459,000	$33,000,000	$113,459,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$16,375,870	$3,275,174	20%	$19,651,044	1Q 09	71.2%	$28,035,000	$5,608,000	$33,643,000
31.--.--	CONSTRUCTION MANAGEMENT	$6,433,377	$643,338	10%	$7,076,715	1Q 06	100.7%	$12,912,000	$1,291,000	$14,203,000
	TOTAL:	$81,294,496	$27,839,513	34%	$109,134,009		47.6%	$121,407,000	$39,907,000	$161,314,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE A3 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CR
DATE PREPARED: 05-Nov-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	$0	$507,500	$0	$0	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$218,427,538	$109,213,769	50%	$327,641,307		44.3%	$315,301,000	$157,617,000	$472,918,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$2,158,040	$863,216	40%	$3,021,256		37.8%	$2,982,000	$1,194,000	$4,176,000
04.06.85	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$168,160,907	$84,080,454	50%	$252,241,361		38.4%	$232,728,000	$116,365,000	$349,094,000
08.01.03	JUVENILE FISH PASSAGE	$43,847,148	$17,538,859	40%	$61,386,007		33.2%	$58,404,000	$23,362,000	$81,766,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$32,198,265	$12,879,306	40%	$45,077,571		33.0%	$42,807,000	$17,123,000	$60,100,000
	TOTAL CONSTRUCTION COSTS:	$464,831,946	$224,579,629	48%	$689,391,579		40.4%	$662,393,000	$315,731,000	$978,124,000
	TOTAL COSTS:	$465,194,446	$224,724,629	48%	$689,899,074		40.4%	$662,705,000	$315,911,000	$980,696,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$130,240,045	$26,048,209	20%	$156,288,254		38.9%	$191,000,000	$38,201,000	$229,201,000
31.--.--	CONSTRUCTION MANAGEMENT	$51,169,089	$5,116,909	10%	$56,285,998		67.0%	$86,147,000	$8,615,000	$94,762,000
	TOTAL:	$646,579,580	$255,890,846	40%	$902,469,226		43.2%	$929,932,000	$362,727,000	$1,292,659,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 2 -- CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 05-Nov-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

PRICE LEVEL: 1 OCTOBER 1992

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.--.--	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.0%	$113,000	$45,000	$150,000
	LITTLE GOOSE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	ICE HARBOR DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
02.--.--	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.32	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,834	$34,284,917	50%	$102,854,751	1Q 04	45.7%	$99,906,000	$49,953,000	$149,859,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	1Q 04	45.7%	$118,436,000	$59,219,000	$177,655,000
	LOWER MONUMENTAL DAM	$68,569,834	$34,284,917	50%	$102,854,751	1Q 00	41.3%	$96,866,000	$48,443,000	$145,309,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		44.3%	$315,231,000	$157,617,000	$472,848,000
04.02.35	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 2 -- CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 05-Nov-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

PRICE LEVEL: 1 OCTOBER 1992

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.38	NEW RIVER BYPASS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		37.6%	$2,982,000	$1,194,000	$4,176,000
04.06.69	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE A3 - CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CS
DATE PREPARED: 06-Nov-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.44.--	ADULT FISH PASSAGE									
	LOWER GRANITE DAM	$58,173,935	$29,086,960	50%	$87,260,895	3Q 09	33.7%	$76,052,000	$38,017,000	$114,069,000
	LITTLE GOOSE DAM	$56,008,985	$28,004,493	50%	$84,013,478	3Q 09	33.7%	$75,886,000	$37,509,000	$113,727,000
	LOWER MONUMENTAL DAM	$46,708,915	$23,354,458	50%	$70,063,373	2Q 06	55.6%	$72,675,000	$36,340,000	$109,015,000
	ICE HARBOR DAM	$5,269,012	$2,634,506	50%	$7,903,518	2Q 06	55.6%	$8,199,000	$4,099,000	$12,298,000
	SUBTOTAL:	$166,160,847	$83,080,424	50%	$249,241,271		38.4%	$232,724,000	$116,365,000	$349,089,000
06.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
	LITTLE GOOSE DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
	LOWER MONUMENTAL DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
	ICE HARBOR DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
	SUBTOTAL:	$43,847,148	$17,538,860	40%	$61,386,007		33.2%	$58,404,000	$23,362,000	$81,766,000
06.03.--	WILDLIFE MITIGATION (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE A3 - CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CS
DATE PREPARED: 06-Nov-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
19.81.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$20,623,350	$8,249,340	40%	$28,872,690	2Q 99	25.9%	$25,964,000	$10,386,000	$36,349,000
	LITTLE GOOSE DAM	$2,646,105	$1,058,442	40%	$3,704,547	2Q 99	25.6%	$3,324,000	$1,329,000	$4,653,000
	LOWER MONUMENTAL DAM	$5,296,995	$2,118,798	40%	$7,415,793	1Q 06	54.1%	$8,163,000	$3,265,000	$11,428,000
	ICE HARBOR DAM	$3,631,815	$1,452,726	40%	$5,084,541	1Q 06	54.1%	$5,597,000	$2,238,000	$7,835,000
	SUBTOTAL:	$32,198,265	$12,879,306	40%	$45,077,571		33.5%	$42,967,000	$17,183,000	$60,150,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 -- CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 06-Nov-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.--.--	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$44,509,240	$8,901,850	20%	$53,411,088	1Q 97	36.9%	$60,933,000	$12,187,000	$73,120,000
	LITTLE GOOSE DAM	$42,990,480	$8,598,096	20%	$51,588,576	1Q 97	36.9%	$58,854,000	$11,771,000	$70,625,000
	LOWER MONUMENTAL DAM	$37,007,640	$7,401,528	20%	$44,409,176	1Q 02	71.2%	$63,357,000	$12,672,000	$76,029,000
	ICE HARBOR DAM	$5,738,670	$1,147,734	20%	$6,886,404	1Q 97	36.9%	$7,856,000	$1,571,000	$9,427,000
	SUBTOTAL:	$130,246,030	$26,049,208	20%	$156,295,254		46.8%	$191,000,000	$38,201,000	$229,201,000
31.--.--	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$17,485,776	$1,748,578	10%	$19,234,354	3Q 01	67.8%	$29,341,000	$2,934,000	$32,275,000
	LITTLE GOOSE DAM	$16,889,117	$1,688,912	10%	$18,578,029	4Q 01	68.5%	$28,627,000	$2,863,000	$31,490,000
	LOWER MONUMENTAL DAM	$14,538,718	$1,453,872	10%	$15,992,590	3Q 04	67.8%	$24,396,000	$2,440,000	$26,836,000
	ICE HARBOR DAM	$2,254,477	$225,448	10%	$2,479,925	3Q 01	67.8%	$3,783,000	$378,000	$4,161,000
	SUBTOTAL:	$51,168,088	$5,116,809	10%	$56,284,898		60.4%	$86,147,000	$8,615,000	$94,762,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 -- CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 06-Nov-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$157,970,976	$76,322,773	48%	$234,293,749		36.0%	$215,727,000	$103,885,000	$319,612,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$44,509,240	$8,901,850	20%	$53,411,088	1Q 97	36.9%	$60,933,000	$12,187,000	$73,120,000
31.--.--	CONSTRUCTION MANAGEMENT	$17,485,776	$1,748,578	10%	$19,234,354	3Q 01	67.8%	$29,341,000	$2,934,000	$32,275,000
	SUBTOTAL:	$220,056,625	$87,009,451	40%	$307,066,076			$306,114,000	$119,051,000	$425,165,000
	LITTLE GOOSE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$153,446,845	$75,308,412	49%	$228,755,257		37.8%	$211,463,000	$104,011,000	$315,474,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$42,990,480	$8,598,096	20%	$51,588,576	1Q 97	36.9%	$58,854,000	$11,771,000	$70,625,000
31.--.--	CONSTRUCTION MANAGEMENT	$16,889,117	$1,688,912	10%	$18,578,029	4Q 01	68.5%	$28,627,000	$2,863,000	$31,490,000
	SUBTOTAL:	$213,417,067	$85,631,670	40%	$299,048,737			$299,057,000	$118,690,000	$417,747,000
	LOWER MONUMENTAL DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$132,079,541	$64,359,691	49%	$196,439,232		47.3%	$184,538,000	$95,774,000	$280,312,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$37,007,640	$7,401,528	20%	$44,409,176	1Q 02	71.2%	$63,357,000	$12,672,000	$76,029,000
31.--.--	CONSTRUCTION MANAGEMENT	$14,538,718	$1,453,872	10%	$15,992,590	3Q 04	67.8%	$24,396,000	$2,440,000	$26,836,000
	SUBTOTAL:	$183,716,531	$73,251,342	40%	$256,967,873			$272,404,000	$110,931,000	$383,335,000
	ICE HARBOR DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$20,404,624	$8,688,751	43%	$29,093,375		60.1%	$29,794,000	$13,871,000	$43,665,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$5,738,670	$1,147,734	20%	$6,886,404	1Q 97	36.9%	$7,856,000	$1,571,000	$9,427,000
31.--.--	CONSTRUCTION MANAGEMENT	$2,254,477	$225,448	10%	$2,479,925	3Q 01	67.8%	$3,783,000	$378,000	$4,161,000
	SUBTOTAL:	$28,488,396	$10,098,182	35%	$38,586,579			$41,546,000	$15,865,000	$57,411,000
	TOTAL PROJECT	$645,678,566	$255,990,640	40%	$901,669,206		42.9%	$929,932,000	$369,727,000	$1,299,659,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 12 - CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

LOWER GRANITE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED 08-Nov-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 93	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,034	$34,284,517	50%	$102,853,551	1Q 04	45.7%	$99,906,000	$49,953,000	$149,859,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$537,510	$215,004	40%	$752,514	1Q 96	20.7%	$654,000	$262,000	$916,000
04.06.65	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
05.44.--	ADULT FISH PASSAGE	$58,178,996	$29,089,498	50%	$87,268,494	3Q 00	30.7%	$76,037,000	$38,017,000	$114,054,000
05.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 96	20.7%	$13,231,000	$5,292,000	$18,523,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$20,624,250	$8,249,700	40%	$28,873,950	2Q 99	25.6%	$25,903,000	$10,361,000	$36,264,000
	TOTAL CONSTRUCTION COSTS	$158,870,076	$76,222,773	48%	$235,090,749		36.0%	$215,727,000	$103,885,000	$319,612,000
	TOTAL COSTS:	$158,961,501	$76,259,023	48%	$235,220,524		35.9%	$215,840,000	$103,930,000	$319,770,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$44,508,216	$8,901,680	20%	$53,411,298	1Q 97	36.9%	$60,933,000	$12,187,000	$73,120,000
31.--.--	CONSTRUCTION MANAGEMENT	$17,485,776	$1,748,578	10%	$19,234,354	3Q 01	57.6%	$29,341,000	$2,934,000	$32,275,000
	TOTAL:	$220,955,625	$86,909,451	39%	$307,865,076		39.1%	$306,114,000	$119,051,000	$425,165,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 12 - CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

LITTLE GOOSE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED 08-Nov-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 93	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,297,818	$40,649,259	50%	$121,991,077	1Q 04	45.7%	$118,486,000	$59,213,000	$177,055,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$537,510	$215,004	40%	$752,514	1Q 96	20.7%	$654,000	$262,000	$916,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
05.44.--	ADULT FISH PASSAGE	$58,008,905	$29,004,453	50%	$87,013,358	3Q 00	30.7%	$75,818,000	$37,909,000	$113,727,000
05.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 96	20.7%	$13,231,000	$5,292,000	$18,523,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.04	RIPRAP SLOPE PROTECTION	$2,646,105	$1,058,442	40%	$3,704,547	2Q 99	25.6%	$3,324,000	$1,329,000	$4,653,000
	TOTAL CONSTRUCTION COSTS:	$153,446,605	$76,309,613	49%	$229,756,217		37.8%	$211,463,000	$104,011,000	$315,474,000
	TOTAL COSTS:	$153,537,400	$75,344,632	49%	$228,882,032		37.9%	$211,576,000	$104,256,000	$315,832,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$42,930,480	$8,586,096	20%	$51,516,576	1Q 97	36.7%	$58,654,000	$11,771,000	$70,425,000
31.--.--	CONSTRUCTION MANAGEMENT	$16,983,117	$1,698,312	10%	$18,679,429	4Q 01	68.5%	$28,627,000	$2,803,000	$31,430,000
	TOTAL:	$213,417,028	$85,631,040	40%	$299,048,448		38.7%	$298,857,000	$118,830,000	$417,687,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 — CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

LOWER MONUMENTAL DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW - EN - CB
DATE PREPARED: 05 - Nov - 92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR—YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED:									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.0%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,567,834	$34,283,917	50%	$102,851,751	1Q 03	41.3%	$96,809,000	$48,445,000	$145,254,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.36	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
04.06.80	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$46,706,915	$23,354,460	50%	$70,060,373	2Q 06	55.6%	$72,679,000	$36,340,000	$109,019,000
08.01.08	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.08	RIPRAP SLOPE PROTECTION	$5,296,995	$2,118,798	40%	$7,415,793	1Q 06	54.1%	$8,163,000	$3,265,000	$11,428,000
	TOTAL CONSTRUCTION COSTS:	$132,079,541	$64,359,891	49%	$196,439,432		47.3%	$194,535,000	$94,774,000	$289,310,000
	TOTAL COSTS:	$132,170,166	$64,395,941	49%	$196,566,107		47.3%	$194,652,000	$94,819,000	$289,471,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$37,007,646	$7,401,529	20%	$44,409,175	1Q 02	71.2%	$63,357,000	$12,672,000	$76,029,000
31.--.--	CONSTRUCTION MANAGEMENT	$14,530,713	$1,453,072	10%	$15,983,785	3Q 04	67.6%	$24,396,000	$2,440,000	$26,836,000
	TOTAL:	$183,716,531	$73,251,342	40%	$256,967,873		52.7%	$282,405,000	$109,931,000	$392,336,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 — CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

ICE HARBOR DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW - EN - CB
DATE PREPARED: 05 - Nov - 92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR—YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.0%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.36	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
04.06.80	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$5,269,012	$2,634,506	50%	$7,903,518	2Q 06	55.6%	$8,199,000	$4,099,000	$12,298,000
08.01.08	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.08	RIPRAP SLOPE PROTECTION	$3,631,815	$1,452,726	40%	$5,084,541	1Q 06	54.1%	$5,597,000	$2,239,000	$7,836,000
	TOTAL CONSTRUCTION COSTS:	$20,404,624	$8,688,751	43%	$29,093,375		50.0%	$30,604,000	$13,061,000	$43,665,000
	TOTAL COSTS:	$20,495,249	$8,725,001	43%	$29,220,250		50.0%	$30,717,000	$13,106,000	$43,823,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$5,735,670	$1,147,134	20%	$6,882,804	1Q 97	[illegible]	$7,856,000	$1,571,000	$9,427,000
31.--.--	CONSTRUCTION MANAGEMENT	$2,254,477	$225,448	10%	$2,479,925	3Q 01	67.8%	$3,783,000	$378,000	$4,161,000
	TOTAL:	$28,485,396	$10,097,583	35%	$38,582,979		[illegible]	$42,356,000	$15,055,000	$57,411,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 – CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AG — CENPW-EN-CE
DATE PREPARED: 20-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR - Yr)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$218,427,586	$109,213,793	50%	$327,641,379		42.5%	$311,181,000	$155,590,000	$466,771,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$415,313,096	$166,125,238	40%	$581,438,334		41.8%	$589,122,000	$235,648,000	$824,770,000
04.02.89	MISCELLANEOUS DAM MODIFICATIONS	$2,168,046	$867,218	40%	$3,035,264		33.3%	$2,890,000	$1,162,000	$4,052,000
04.06.80	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
05.40.--	ADULT FISH PASSAGE	$168,160,801	$84,080,400	50%	$252,241,201		37.6%	$231,451,000	$115,725,000	$347,176,000
05.01.03	JUVENILE FISH PASSAGE	$43,847,148	$17,538,859	40%	$61,386,007		33.7%	$58,629,000	$23,476,000	$82,105,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$35,739,644	$14,295,858	40%	$50,035,502		32.6%	$47,401,000	$18,962,000	$66,363,000
	TOTAL CONSTRUCTION COSTS:	$883,656,421	$392,121,418	44%	$1,275,777,839		40.4%	$1,240,725,000	$550,552,000	$1,791,277,000
	TOTAL COSTS:	$884,018,921	$392,266,418	44%	$1,276,285,339		40.4%	$1,241,177,000	$550,732,000	$1,791,909,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$247,525,298	$49,505,060	20%	$297,030,357		51.6%	$375,422,000	$75,164,000	$450,586,000
31.--.--	CONSTRUCTION MANAGEMENT	$97,242,004	$11,053,962	10%	$108,295,848		72.6%	$168,476,000	$19,081,000	$187,557,000
	TOTAL:	$1,228,768,305	$452,065,038	37%	$1,681,051,339			$1,785,075,000	$644,977,000	$2,430,052,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 – CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AG — CENPW-EN-CE
DATE PREPARED: 20-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR - YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.--.--	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.5%	$113,000	$45,000	$158,000
	LITTLE GOOSE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.5%	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.5%	$113,000	$45,000	$158,000
	ICE HARBOR DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.5%	$113,000	$45,000	$158,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
02.--.--	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.32	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,834	$34,284,917	50%	$102,854,751	4Q 03	43.5%	$98,398,000	$49,199,000	$147,597,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	4Q 03	43.5%	$116,648,000	$58,324,000	$174,972,000
	LOWER MONUMENTAL DAM	$68,569,834	$34,284,917	50%	$102,854,751	4Q 02	40.2%	$96,135,000	$48,067,000	$144,202,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		42.5%	$311,181,000	$155,590,000	$466,771,000
04.02.35	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW-EN-CE
DATE PREPARED: 28-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.33	NEW RIVER BYPASS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$103,828,274	$41,531,310	40%	$145,359,584	4Q 03	43.5%	$148,994,000	$59,597,000	$208,591,000
	LITTLE GOOSE DAM	$103,828,274	$41,531,310	40%	$145,359,584	4Q 03	43.5%	$148,994,000	$59,597,000	$208,591,000
	LOWER MONUMENTAL DAM	$103,828,274	$41,531,310	40%	$145,359,584	4Q 02	40.2%	$145,567,000	$58,227,000	$203,794,000
	ICE HARBOR DAM	$103,828,274	$41,531,310	40%	$145,359,584	4Q 02	40.2%	$145,567,000	$58,227,000	$203,794,000
	SUBTOTAL:	$415,313,096	$166,125,238	40%	$581,438,334		41.8%	$589,122,000	$235,648,000	$824,770,000
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	3Q 97	18.8%	$644,000	$258,000	$902,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	2Q 04	46.8%	$796,000	$318,000	$1,114,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	2Q 04	46.8%	$796,000	$318,000	$1,114,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	2Q 04	46.8%	$796,000	$318,000	$1,114,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		39.8%	$3,032,000	$1,212,000	$4,244,000
04.06.00	REVISE EXISTING IRRIGATION PUMP PLANTS (*TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW-EN-CE
DATE PREPARED: 28-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.44.--	ADULT FISH PASSAGE									
	LOWER GRANITE DAM	$58,173,995	$29,086,998	50%	$87,260,993	2Q 03	29.6%	$75,393,000	$37,697,000	$113,090,000
	LITTLE GOOSE DAM	$58,008,985	$29,004,493	50%	$87,013,478	2Q 05	29.6%	$75,180,000	$37,590,000	$112,769,000
	LOWER MONUMENTAL DAM	$46,708,915	$23,354,458	50%	$70,063,373	2Q 06	55.6%	$72,679,000	$36,340,000	$109,019,000
	ICE HARBOR DAM	$5,269,012	$2,634,506	50%	$7,903,518	2Q 06	55.6%	$8,199,000	$4,099,000	$12,298,000
	SUBTOTAL:	$168,160,907	$84,080,454	50%	$252,241,361		37.6%	$231,451,000	$115,725,000	$347,176,000
06.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
	LITTLE GOOSE DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
	LOWER MONUMENTAL DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	47.9%	$16,212,000	$6,485,000	$22,697,000
	ICE HARBOR DAM	$10,961,787	$4,384,715	40%	$15,346,502	2Q 04	49.7%	$16,410,000	$6,564,000	$22,974,000
	SUBTOTAL:	$43,847,148	$17,538,859	40%	$61,386,007		33.9%	$58,690,000	$23,475,000	$82,165,000
06.03.--	WILDLIFE MITIGATION (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 – CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR - YR)	OMB % INFLATION (1)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.-- .--	RECREATION FACILITY MODIFICATIONS (TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
10.01.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$22,709,610	$9,083,844	40%	$31,793,454	1Q 99	24.6%	$28,296,000	$11,319,000	$39,615,000
	LITTLE GOOSE DAM	$3,430,845	$1,372,338	40%	$4,803,183	1Q 99	24.6%	$4,275,000	$1,710,000	$5,985,000
	LOWER MONUMENTAL DAM	$5,804,205	$2,321,682	40%	$8,125,887	1Q 06	54.5%	$8,967,000	$3,587,000	$12,554,000
	ICE HARBOR DAM	$3,794,984	$1,517,994	40%	$5,312,978	1Q 06	54.5%	$5,863,000	$2,345,000	$8,208,000
	SUBTOTAL:	$35,739,644	$14,295,858	40%	$50,035,502		32.6%	$47,401,000	$18,961,000	$66,362,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 – CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR - YR)	OMB % INFLATION (1)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.-- .--	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$74,165,317	$14,833,064	20%	$88,998,381	1Q 99	44.1%	$106,872,000	$21,375,000	$128,247,000
	LITTLE GOOSE DAM	$72,282,124	$14,456,425	20%	$86,738,549	1Q 99	44.1%	$104,159,000	$20,831,000	$124,990,000
	LOWER MONUMENTAL DAM	$66,221,580	$13,244,316	20%	$79,465,896	2Q 02	73.0%	$114,563,000	$22,913,000	$137,476,000
	ICE HARBOR DAM	$34,856,274	$6,971,255	20%	$41,827,529	1Q 99	44.1%	$50,228,000	$10,045,000	$60,273,000
	SUBTOTAL:	$247,525,298	$49,505,060	20%	$297,030,357		51.8%	$375,822,000	$75,164,000	$450,986,000
31.-- .--	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$29,136,375	$2,913,637	10%	$32,050,012	2Q 01	66.1%	$48,396,000	$4,839,000	$53,235,000
	LITTLE GOOSE DAM	$28,396,549	$2,839,655	10%	$31,236,204	2Q 01	66.1%	$47,167,000	$4,716,000	$51,883,000
	LOWER MONUMENTAL DAM	$26,015,622	$2,601,562	10%	$28,617,184	4Q 04	91.3%	$49,768,000	$4,977,000	$54,745,000
	ICE HARBOR DAM	$13,693,535	$2,738,707	20%	$16,432,242	2Q 01	66.1%	$22,745,000	$4,549,000	$27,294,000
	SUBTOTAL:	$97,242,081	$11,093,561	10%	$108,335,642		72.8%	$168,076,000	$19,081,000	$187,157,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 28-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$264,785,510	$118,568,587	45%	$383,374,097		37.7%	$364,750,000	$163,283,000	$528,042,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$74,165,316	$14,833,064	20%	$88,998,381	1Q 99	44.1%	$106,872,000	$21,375,000	$128,247,000
31.--.--	CONSTRUCTION MANAGEMENT	$29,136,375	$2,913,637	10%	$32,050,012	2Q 01	66.1%	$48,396,000	$4,839,000	$53,235,000
	SUBTOTAL:	$368,177,826	$136,371,538	37%	$504,549,364		40.7%	$520,140,000	$189,542,000	$709,682,000
	LITTLE GOOSE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$258,050,619	$117,153,618	45%	$375,213,437		38.0%	$350,775,000	$162,031,000	$521,400,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$72,252,124	$14,450,425	20%	$86,702,549	1Q 99	44.1%	$104,169,000	$20,841,000	$124,980,000
31.--.--	CONSTRUCTION MANAGEMENT	$28,396,549	$2,839,655	10%	$31,236,204	2Q 01	66.1%	$47,107,000	$4,716,000	$51,823,000
	SUBTOTAL:	$358,829,117	$134,405,940	37%	$493,315,065		41.0%	$510,214,000	$190,913,000	$698,497,000
	LOWER MONUMENTAL DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$236,415,025	$106,093,895	45%	$342,508,919		44.0%	$340,356,000	$153,024,000	$493,380,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$65,221,582	$12,244,316	20%	$77,465,898	2Q 02	73.0%	$114,569,000	$22,913,000	$137,476,000
31.--.--	CONSTRUCTION MANAGEMENT	$26,016,622	$2,601,562	10%	$28,617,184	4Q 04	91.2%	$49,760,000	$4,977,000	$54,745,000
	SUBTOTAL:	$325,742,854	$121,976,013	37%	$450,718,867		52.1%	$504,800,000	$180,879,000	$685,759,000
	ICE HARBOR DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$124,296,067	$50,285,320	40%	$174,581,395		42.2%	$176,895,000	$71,554,000	$248,449,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$34,856,874	$6,971,255	20%	$41,827,129	1Q 98	44.1%	$50,228,000	$10,045,000	$60,273,000
31.--.--	CONSTRUCTION MANAGEMENT	$11,693,536	$2,738,707	20%	$14,432,243	2Q 01	66.1%	$22,745,000	$4,543,000	$27,284,000
	SUBTOTAL:	$171,036,502	$60,031,540	35%	$231,068,042		44.2%	$249,981,000	$86,183,000	$336,114,000
	TOTAL PROJECT:	$1,225,786,300	$452,865,091	37%	$1,681,651,391		44.6%	$1,785,075,000	$644,077,000	$2,429,052,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY

LOWER GRANITE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 28-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COSTS 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$66,550,834	$39,503,917	60%	$106,054,751	4Q 03	43.5%	$98,338,000	$49,153,000	$147,497,000
04.02.33	NEW LOW LEVEL SPILLWAY	$0								
04.02.35	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$103,829,274	$41,531,315	40%	$145,360,584	4Q 03	43.5%	$148,294,000	$59,657,000	$208,891,000
04.02.89	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 97	10.9%	$544,000	$256,000	$800,000
04.06.50	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,173,695	$29,086,798	50%	$87,260,493	2Q 00	29.6%	$75,393,000	$37,697,000	$113,090,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	10.9%	$13,036,000	$5,213,000	$18,247,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$22,702,610	$9,083,044	40%	$31,783,654	1Q 99	24.6%	$28,296,000	$11,319,000	$39,615,000
	TOTAL CONSTRUCTION COSTS	$264,785,510	$118,568,587	45%	$383,374,097		37.7%	$364,750,000	$163,283,000	$528,043,000
	TOTAL COSTS	$264,876,135	$118,604,837	45%	$383,500,972		37.7%	$364,872,000	$163,328,000	$528,200,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$74,165,316	$14,833,064	20%	$88,998,381	1Q 99	44.1%	$106,872,000	$21,376,000	$128,247,000
31.--.--	CONSTRUCTION MANAGEMENT	$29,136,375	$2,913,637	10%	$32,050,012	2Q 01	66.1%	$48,396,000	$4,839,000	$53,235,000
	TOTAL:	$368,177,826	$136,371,538	37%	$504,549,364		40.7%	$520,140,000	$189,542,000	$709,682,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY

LITTLE GOOSE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.8%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,237,918	$40,648,959	50%	$121,881,877	4Q 03	43.5%	$115,640,000	$58,334,000	$174,372,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$103,968,274	$41,591,310	40%	$145,559,584	4Q 03	43.3%	$145,204,000	$58,507,000	$203,591,000
04.02.89	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 97	18.9%	$644,000	$258,000	$902,000
04.06.80	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,008,955	$29,004,489	50%	$87,013,475	2Q 00	29.6%	$75,400,000	$37,580,000	$112,980,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$3,430,845	$1,372,338	40%	$4,803,183	1Q 99	24.8%	$4,275,000	$1,710,000	$5,985,000
	TOTAL CONSTRUCTION COSTS:	$258,059,819	$117,156,618	45%	$375,213,437		39.0%	$355,775,000	$162,683,000	$521,458,000
	TOTAL COSTS:	$258,150,444	$117,189,858	45%	$375,340,312		39.0%	$358,888,000	$162,726,000	$521,624,000
30.--.--	PLANNING ENGINEERING & DESIGN	$72,282,124	$14,456,425	20%	$86,738,549	1Q 98	44.1%	$104,159,000	$20,831,000	$124,990,000
31.--.--	CONSTRUCTION MANAGEMENT	$28,396,549	$2,839,655	10%	$31,236,204	3Q 01	66.1%	$47,167,000	$4,716,000	$51,883,000
	TOTAL:	$358,858,117	$134,485,948	37%	$493,315,065		41.6%	$510,214,000	$188,243,000	$698,457,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY

LOWER MONUMENTAL DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 98	24.4%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$83,569,834	$36,284,917	50%	$109,854,751	4Q 02	45.2%	$96,135,000	$48,067,000	$144,202,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$103,968,274	$41,591,310	40%	$145,359,584	4Q 02	40.2%	$145,067,000	$56,227,000	$201,294,000
04.02.89	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	2Q 04	45.6%	$796,000	$318,000	$1,114,000
04.06.80	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$48,708,715	$24,354,498	50%	$73,063,373	2Q 05	55.6%	$72,679,000	$36,340,000	$109,019,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	47.9%	$16,212,000	$6,485,000	$22,697,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$5,804,205	$2,321,682	40%	$8,125,887	1Q 05	54.5%	$9,367,000	$3,587,000	$12,554,000
	TOTAL CONSTRUCTION COSTS	$236,415,025	$106,093,885	45%	$342,508,910		44.0%	$340,396,000	$153,074,000	$493,380,000
	TOTAL COSTS:	$236,505,650	$106,130,135	45%	$342,635,785		44.0%	$340,469,000	$153,069,000	$493,538,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$66,221,892	$13,244,316	20%	$79,466,868	2Q 02	73.0%	$114,589,000	$22,919,000	$137,478,000
31.--.--	CONSTRUCTION MANAGEMENT	$26,015,622	$2,601,562	10%	$28,617,184	4Q 04	91.3%	$49,769,000	$4,977,000	$54,745,000
	TOTAL:	$328,742,964	$121,976,013	37%	$450,718,867		62.5%	$504,800,000	$180,958,000	$685,755,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 14 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH MODIFICATION OF SPILLWAY

ICE HARBOR DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 21-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.8%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$103,828,274	$41,531,310	40%	$145,359,584	4Q 02	40.2%	$145,567,000	$58,227,000	$203,794,000
04.05.93	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	2Q 04	46.8%	$796,000	$318,000	$1,114,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$5,266,012	$2,634,506	50%	$7,900,510	2Q 06	55.0%	$8,159,000	$4,049,000	$12,208,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	2Q 04	49.7%	$16,410,000	$6,564,000	$22,974,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$3,794,934	$1,517,974	40%	$5,312,908	1Q 05	54.5%	$5,863,000	$2,346,000	$8,209,000
	TOTAL CONSTRUCTION COSTS:	$124,396,037	$50,165,320	40%	$174,561,355		42.8%	$176,835,000	$71,264,000	$248,099,000
	TOTAL COSTS:	$124,486,662	$50,201,570	40%	$174,688,270		42.2%	$176,948,000	$71,599,000	$248,547,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$34,856,274	$6,971,255	20%	$41,827,529	1Q 98	44.1%	$50,225,000	$10,048,000	$60,273,000
31.--.--	CONSTRUCTION MANAGEMENT	$13,693,536	$2,738,707	20%	$16,432,243	2Q 01	66.1%	$22,745,000	$4,549,000	$27,294,000
	TOTAL:	$173,036,502	$60,031,540	35%	$233,068,042		44.2%	$249,921,000	$86,193,000	$336,114,000
	TOTAL:	$173,036,502	$60,031,540	35%	$233,068,042		44.2%	$249,921,000	$86,193,000	$336,114,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 15 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 20-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	40%	$507,500		24.8%	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$8,068,703	$3,227,481	40%	$11,296,184		50.4%	$12,086,000	$5,155,000	$15,041,000
04.02.32	STILLING BASIN DRUM GATES	$218,427,586	$109,213,793	50%	$327,641,379		46.0%	$318,863,000	$159,432,000	$478,295,000
04.02.35	NEW LOW LEVEL SPILLWAY	$683,656,292	$273,462,517	40%	$957,118,809		47.4%	$1,007,773,000	$403,110,000	$1,410,883,000
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.05.93	MISCELLANEOUS DAM MODIFICATIONS	$2,168,045	$867,218	40%	$3,035,263		34.2%	$2,909,000	$1,165,000	$4,074,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$168,180,907	$84,090,454	50%	$252,271,361		38.1%	$232,267,000	$116,078,000	$348,345,000
06.01.03	JUVENILE FISH PASSAGE	$43,847,148	$17,538,859	40%	$61,386,007		35.8%	$59,577,000	$23,832,000	$83,409,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$37,312,950	$14,925,180	40%	$52,238,130		32.4%	$49,391,000	$19,757,000	$69,148,000
	TOTAL CONSTRUCTION COSTS:	$1,162,141,626	$503,515,500	43%	$1,665,657,126		46.6%	$1,693,596,000	$726,510,000	$2,419,006,000
	TOTAL COSTS:	$1,162,504,126	$503,660,500	43%	$1,666,164,626		46.6%	$1,694,048,000	$726,710,000	$2,420,758,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$325,501,155	$65,100,231	20%	$390,601,386		68.3%	$547,578,000	$109,516,000	$657,094,000
31.--.--	CONSTRUCTION MANAGEMENT	$127,675,454	$12,767,545	10%	$140,442,999		81.8%	$232,456,000	$23,248,000	$255,704,000
	TOTAL:	$1,615,680,735	$581,528,276	36%	$2,197,209,011		49.7%	$2,474,082,000	$859,474,000	$3,333,556,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE #5 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.--.--	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LITTLE GOOSE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	ICE HARBOR DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		24.6%	$452,000	$180,000	$632,000
02.--.--	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$2,426,576	$970,630	40%	$3,397,206	3Q 05	56.7%	$3,802,000	$1,521,000	$5,323,000
	ICE HARBOR DAM	$6,142,128	$2,456,851	40%	$8,598,979	3Q 04	47.6%	$9,066,000	$3,634,000	$12,700,000
	SUBTOTAL:	$8,568,704	$3,427,481	40%	$11,996,185		50.4%	$12,868,000	$5,155,000	$18,023,000
04.02.32	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,834	$34,284,917	50%	$102,854,751	4Q 00	44.6%	$99,152,000	$49,576,000	$148,728,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	4Q 03	44.6%	$117,542,000	$58,771,000	$176,313,000
	LOWER MONUMENTAL DAM	$68,569,834	$34,284,917	50%	$102,854,751	4Q 04	49.0%	$102,169,000	$51,085,000	$153,254,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		46.0%	$318,863,000	$159,432,000	$478,295,000
04.02.35	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$142,661,248	$57,064,499	40%	$199,725,747	3Q 01	34.5%	$192,847,000	$75,923,000	$268,290,000
	LITTLE GOOSE DAM	$147,366,382	$58,946,553	40%	$206,312,835	3Q 01	34.5%	$199,660,000	$79,460,000	$278,110,000
	LOWER MONUMENTAL DAM	$183,685,229	$73,474,092	40%	$257,159,321	3Q 04	56.7%	$287,835,000	$115,134,000	$402,969,000
	ICE HARBOR DAM	$202,242,433	$80,897,373	40%	$283,139,806	3Q 03	50.7%	$330,261,000	$131,593,000	$460,574,000
	SUBTOTAL:	$683,656,292	$273,460,517	40%	$957,116,809		47.4%	$1,002,773,000	$408,110,000	$1,410,843,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE #5 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.36	NEW FIFER BYPASS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	3Q 97	18.9%	$644,000	$258,000	$902,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	3Q 97	18.9%	$644,000	$258,000	$902,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	3Q 05	56.7%	$849,000	$340,000	$1,189,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	3Q 03	42.4%	$772,000	$309,000	$1,081,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		34.2%	$2,909,000	$1,165,000	$4,074,000
04.06.80	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 15 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PREPARED BY: AG CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

PRICE LEVEL: 1 OCTOBER 1992

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.A-.--	MULTIFISH PASSAGE									
	LOWER GRANITE DAM	$58,173,995	$29,086,998	50%	$87,260,993	3Q 99	30.7%	$76,035,000	$38,017,000	$114,052,000
	LITTLE GOOSE DAM	$58,008,986	$29,004,493	50%	$87,013,479	3Q 99	30.7%	$75,810,000	$37,903,000	$113,727,000
	LOWER MONUMENTAL DAM	$46,706,916	$23,354,458	50%	$70,061,373	1Q 06	54.5%	$72,165,000	$36,083,000	$108,248,000
	ICE HARBOR DAM	$5,269,012	$2,634,506	50%	$7,903,518	1Q 06	54.5%	$8,151,000	$4,073,000	$12,231,000
	SUBTOTAL:	$168,160,907	$84,080,454	50%	$252,241,361		38.1%	$232,157,000	$116,076,000	$348,233,000
06.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$10,961,787	$4,384,715	40%	$15,346,502	4Q 01	35.9%	$14,897,000	$5,959,000	$20,856,000
	LITTLE GOOSE DAM	$10,961,787	$4,384,715	40%	$15,346,502	4Q 01	35.9%	$14,897,000	$5,959,000	$20,856,000
	LOWER MONUMENTAL DAM	$10,961,787	$4,384,715	40%	$15,346,502	4Q 01	35.9%	$14,897,000	$5,959,000	$20,856,000
	ICE HARBOR DAM	$10,961,787	$4,384,715	40%	$15,346,502	4Q 01	35.8%	$14,886,000	$5,955,000	$20,841,000
	SUBTOTAL:	$43,847,148	$17,538,860	40%	$61,386,008		35.9%	$59,577,000	$23,832,000	$83,409,000
06.03.--	WILDLIFE MITIGATION (TBD')									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 15 - CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PREPARED BY: AG CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

PRICE LEVEL: 1 OCTOBER 1992

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD')									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
16.01.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$23,796,284	$9,518,514	40%	$33,314,798	3Q 99	25.0%	$29,660,000	$11,883,000	$41,543,000
	LITTLE GOOSE DAM	$2,721,030	$1,088,412	40%	$3,809,442	3Q 99	25.6%	$3,418,000	$1,367,000	$4,785,000
	LOWER MONUMENTAL DAM	$5,761,140	$2,304,456	40%	$8,065,596	4Q 04	49.0%	$8,584,000	$3,434,000	$12,018,000
	ICE HARBOR DAM	$5,034,296	$2,013,718	40%	$7,048,014	4Q 04	49.0%	$7,501,000	$3,001,000	$10,502,000
	SUBTOTAL:	$37,312,750	$14,925,100	40%	$52,237,850		33.4%	$49,591,000	$19,757,000	$69,348,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 15 -- CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.--.--	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$85,342,818	$17,068,564	20%	$102,411,383	1Q 97	36.9%	$116,834,000	$23,367,000	$140,201,000
	LITTLE GOOSE DAM	$84,274,102	$16,854,820	20%	$101,128,923	1Q 97	36.9%	$115,371,000	$23,074,000	$138,445,000
	LOWER MONUMENTAL DAM	$89,248,812	$17,849,762	20%	$107,098,575	1Q 02	71.2%	$152,794,000	$30,559,000	$183,353,000
	ICE HARBOR DAM	$66,635,321	$13,327,064	20%	$79,962,385	1Q 02	71.2%	$114,080,000	$22,816,000	$136,896,000
	SUBTOTAL:	$325,501,056	$65,100,210	20%	$390,601,266		53.3%	$499,079,000	$99,816,000	$598,895,000
31.--.--	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$33,527,536	$3,352,754	10%	$36,880,290	1Q 01	64.4%	$55,119,000	$5,512,000	$60,631,000
	LITTLE GOOSE DAM	$33,107,683	$3,310,768	10%	$36,418,451	1Q 01	64.4%	$54,429,000	$5,443,000	$59,872,000
	LOWER MONUMENTAL DAM	$35,062,073	$3,506,207	10%	$38,568,280	1Q 06	100.7%	$70,370,000	$7,037,000	$77,407,000
	ICE HARBOR DAM	$26,176,162	$2,617,616	10%	$28,793,778	1Q 06	100.7%	$52,540,000	$5,254,000	$57,794,000
	SUBTOTAL:	$127,873,454	$12,787,345	10%	$140,660,799		81.8%	$232,458,000	$23,246,000	$255,704,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 15 -- CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CE
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.8%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$304,705,158	$134,558,446	44%	$439,263,604		35.5%	$412,921,000	$182,688,000	$595,609,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$85,342,818	$17,068,564	20%	$102,411,383	1Q 97	36.9%	$116,834,000	$23,367,000	$140,201,000
31.--.--	CONSTRUCTION MANAGEMENT	$33,527,536	$3,352,754	10%	$36,880,290	1Q 01	64.4%	$55,119,000	$5,512,000	$60,631,000
	SUBTOTAL:	$423,666,137	$155,016,014	37%	$578,682,151			$584,987,000	$211,612,000	$796,599,000
	LITTLE GOOSE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.8%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$300,888,312	$134,285,015	45%	$435,173,327		36.6%	$410,969,000	$183,724,000	$594,693,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$84,274,102	$16,854,820	20%	$101,128,923	1Q 97	36.9%	$115,371,000	$23,074,000	$138,445,000
31.--.--	CONSTRUCTION MANAGEMENT	$33,107,683	$3,310,768	10%	$36,418,451	1Q 01	64.4%	$54,429,000	$5,443,000	$59,872,000
	SUBTOTAL:	$418,360,722	$154,486,853	37%	$572,847,575			$580,882,000	$212,286,000	$793,168,000
	LOWER MONUMENTAL DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 98	24.8%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$318,625,490	$138,220,071	44%	$457,045,561		53.8%	$490,301,000	$213,556,000	$703,857,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$89,248,812	$17,849,762	20%	$107,098,575	1Q 02	71.2%	$152,794,000	$30,559,000	$183,353,000
31.--.--	CONSTRUCTION MANAGEMENT	$35,062,073	$3,506,207	10%	$38,568,280	1Q 06	100.7%	$70,370,000	$7,037,000	$77,407,000
	SUBTOTAL:	$443,067,100	$160,352,311	36%	$603,438,480			$713,576,000	$251,197,000	$964,775,000
	ICE HARBOR DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 98	24.8%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$237,894,666	$95,684,168	40%	$333,578,834		51	$369,965,000	$147,562,000	$517,527,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$66,635,321	$13,327,064	20%	$79,962,385	1Q 02	71.2%	$114,080,000	$22,816,000	$136,896,000
31.--.--	CONSTRUCTION MANAGEMENT	$26,176,162	$2,617,616	10%	$28,793,778	1Q 06	100.7%	$52,540,000	$5,254,000	$57,794,000
	SUBTOTAL:	$330,796,774	$111,665,099	34%	$442,461,873			$536,698,000	$175,677,000	$712,375,000
	TOTAL PROJECT:	$1,615,880,735	$581,548,276	36%	$2,197,429,011		41.7%	$2,415,545,000	$851,772,000	$3,267,317,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT_WORKING_ESTIMATE

ALTERNATIVE 1B – CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY

LOWER GRANITE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CS
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.8%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	4Q 03	44.8%	$99,182,000	$49,578,000	$148,760,000
04.02.35	NEW LOW LEVEL SPILLWAY	$142,661,246	$57,064,498	40%	$199,725,744	2Q 01	24.8%	$182,207,000	$76,923,000	$259,230,000
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.59	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 97	16.9%	$644,000	$258,000	$902,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
05.44.--	ADULT FISH PASSAGE	$58,173,995	$29,086,998	50%	$87,260,993	3Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
05.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	4Q 01	35.8%	$14,897,000	$5,959,000	$20,856,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.51.03	RIPRAP SLOPE PROTECTION	$23,796,284	$9,518,514	40%	$33,314,798	2Q 99	25.0%	$29,608,000	$11,855,000	$41,843,000
	TOTAL CONSTRUCTION COSTS:	$304,705,150	$134,526,446	44%	$439,231,596		35.6%	$412,991,000	$182,638,000	$595,629,000
	TOTAL COSTS:	$304,795,775	$134,562,696	44%	$439,358,479		35.6%	$413,034,000	$182,733,000	$595,767,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$85,342,613	$17,068,684	20%	$102,411,289	1Q 97	36.9%	$116,834,000	$23,367,000	$140,201,000
31.--.--	CONSTRUCTION MANAGEMENT	$33,527,536	$3,352,754	10%	$36,880,290	1Q 01	64.4%	$55,119,000	$5,512,000	$60,631,000
	TOTAL:	$423,666,130	$155,014,016	37%	$578,680,162		37.7%	$584,987,000	$211,612,000	$796,599,000

SHEET 3

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT_WORKING_ESTIMATE

ALTERNATIVE 1B – CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY

LITTLE GOOSE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CS
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.8%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,287,918	$40,643,959	50%	$121,931,877	4Q 03	44.0%	$117,542,000	$58,771,000	$176,313,000
04.02.35	NEW LOW LEVEL SPILLWAY	$147,356,382	$58,946,553	40%	$206,302,935	3Q 01	24.8%	$198,650,000	$79,460,000	$278,110,000
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.59	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 97	16.9%	$644,000	$258,000	$902,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
05.44.--	ADULT FISH PASSAGE	$58,008,986	$29,004,493	50%	$87,013,479	3Q 00	30.7%	$75,818,000	$37,909,000	$113,727,000
05.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	4Q 01	35.8%	$14,897,000	$5,959,000	$20,856,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.51.03	RIPRAP SLOPE PROTECTION	$2,721,230	$1,088,492	40%	$3,809,722	2Q 99	25.8%	$3,418,000	$1,367,000	$4,785,000
	TOTAL CONSTRUCTION COSTS:	$300,888,312	$134,285,015	45%	$435,173,327		36.7%	$410,365,000	$183,724,000	$594,089,000
	TOTAL COSTS:	$300,978,937	$134,321,265	45%	$435,300,202		36.7%	$411,082,000	$183,769,000	$594,851,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$84,274,102	$16,854,820	20%	$101,128,922	1Q 97	36.8%	$115,371,000	$23,074,000	$138,445,000
31.--.--	CONSTRUCTION MANAGEMENT	$33,107,683	$3,310,768	10%	$36,418,451	1Q 01	64.4%	$54,429,000	$5,443,000	$59,872,000
	TOTAL:	$418,360,722	$154,486,854	37%	$572,847,576		36.5%	$580,882,000	$212,286,000	$793,168,000

SHEET 4

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 15 – CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY

LOWER MONUMENTAL DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AG CENPW–EN–CB
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COSTS 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,825	$36,250	40%	$127,075	1Q 99	24.6%	$113,000	$45,000	$150,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$2,426,575	$970,630	40%	$3,397,205	3Q 06	56.7%	$3,800,000	$1,521,000	$5,321,000
04.02.32	STILLING BASIN DRUM GATES	$68,509,834	$34,254,917	50%	$102,764,751	4Q 04	49.0%	$102,169,000	$51,085,000	$153,254,000
04.02.35	NEW LOW LEVEL SPILLWAY	$183,686,229	$73,474,492	40%	$257,160,721	3Q 06	56.7%	$287,836,000	$115,134,000	$402,970,000
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 06	56.7%	$849,000	$340,000	$1,189,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
05.44.--	ADULT FISH PASSAGE	$46,708,915	$23,354,458	50%	$70,063,373	1Q 06	54.6%	$72,165,000	$36,083,000	$108,248,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	4Q 01	35.9%	$14,897,000	$5,959,000	$20,856,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$5,761,140	$2,304,456	40%	$8,065,596	4Q 04	49.0%	$8,584,000	$3,434,000	$12,018,000
	TOTAL CONSTRUCTION COSTS:	$318,596,490	$138,960,071	44%	$457,556,561		53.0%	$490,331,000	$213,556,000	$703,887,000
	TOTAL COSTS:	$318,746,115	$139,026,321	44%	$457,772,436		53.0%	$490,414,000	$213,601,000	$704,015,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$89,248,012	$17,849,602	20%	$107,097,614	1Q 02	71.2%	$152,784,000	$30,579,000	$183,363,000
31.--.--	CONSTRUCTION MANAGEMENT	$35,062,073	$3,506,207	10%	$38,568,280	1Q 06	100.7%	$70,370,000	$7,037,000	$77,407,000
	TOTAL:	$443,057,100	$160,382,311	36%	$603,439,419		69.8%	$713,578,000	$251,197,000	$964,775,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 15 – CONTINUOUS POOL
EXISTING POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY

ICE HARBOR DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AG CENPW–EN–CB
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COSTS 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.0%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$6,142,129	$2,456,851	40%	$8,598,980	3Q 04	47.8%	$9,084,000	$3,634,000	$12,718,000
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$209,943,433	$83,977,373	40%	$293,920,806	3Q 06	56.7%	$328,981,000	$131,593,000	$460,574,000
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	2Q 03	42.4%	$772,000	$309,000	$1,081,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
05.44.--	ADULT FISH PASSAGE	$5,269,012	$2,634,506	50%	$7,903,518	1Q 06	54.5%	$8,141,000	$4,070,000	$12,211,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	4Q 01	35.8%	$14,886,000	$5,955,000	$20,841,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$5,034,296	$2,013,718	40%	$7,048,014	4Q 04	49.0%	$7,501,000	$3,001,000	$10,502,000
	TOTAL CONSTRUCTION COSTS:	$237,892,668	$95,683,966	40%	$333,576,634		55.2%	$369,365,000	$148,562,000	$517,927,000
	TOTAL COSTS:	$237,983,291	$95,720,216	40%	$333,703,509		55.3%	$369,478,000	$148,607,000	$518,085,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$66,635,321	$13,327,064	20%	$79,962,386	1Q 02	71.2%	$114,080,000	$22,816,000	$136,896,000
31.--.--	CONSTRUCTION MANAGEMENT	$26,178,162	$2,617,816	10%	$28,795,978	1Q 06	100.7%	$52,545,000	$5,254,000	$57,799,000
	TOTAL:	$330,796,774	$111,665,096	34%	$442,461,873		61.8%	$536,098,000	$176,677,000	$712,775,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 – CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD – TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$216,427,586	$109,213,793	50%	$327,641,379		44.3%	$315,231,000	$157,617,000	$472,848,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$2,168,040	$867,216	40%	$3,035,256		37.6%	$2,982,000	$1,194,000	$4,176,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$168,160,907	$84,080,454	50%	$252,241,361		38.4%	$232,729,000	$116,365,000	$349,094,000
06.01.03	JUVENILE FISH PASSAGE	$43,847,148	$17,538,859	40%	$61,386,007		33.2%	$58,404,000	$23,362,000	$81,766,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$151,960,000	$60,784,000	40%	$212,744,000		29.6%	$196,940,000	$78,776,000	$275,716,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.61.03	RIPRAP SLOPE PROTECTION	$32,198,265	$12,879,306	40%	$45,077,571		33.5%	$42,987,000	$17,193,000	$60,180,000
	TOTAL CONSTRUCTION COSTS:	$616,761,946	$285,363,628	46%	$902,125,574		37.9%	$849,273,000	$394,507,000	$1,243,780,000
	TOTAL COSTS:	$617,124,446	$285,508,628	46%	$902,633,074		37.9%	$849,725,000	$394,687,000	$1,244,412,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$172,794,845	$34,558,969	20%	$207,353,814		49.6%	$258,514,000	$51,706,000	$310,220,000
31.--.--	CONSTRUCTION MANAGEMENT	$67,683,669	$6,798,369	10%	$74,672,058		77.9%	$120,749,000	$12,076,000	$132,825,000
	TOTAL:	$857,602,960	$329,855,966	38%	$1,184,658,946		42.4%	$1,228,988,000	$458,469,000	$1,687,457,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 – CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.--.--	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LITTLE GOOSE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	ICE HARBOR DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
02.--.--	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.32	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,834	$34,284,917	50%	$102,854,751	1Q 04	45.7%	$99,906,000	$49,953,000	$149,859,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	1Q 04	45.7%	$118,436,000	$59,219,000	$177,655,000
	LOWER MONUMENTAL DAM	$68,569,834	$34,284,917	50%	$102,854,751	1Q 03	41.3%	$96,889,000	$48,445,000	$145,334,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		44.3%	$315,231,000	$157,617,000	$472,848,000
04.02.35	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 - CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.38	NEW RIVER BYPASS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		37.6%	$2,982,000	$1,194,000	$4,176,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (*TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 - CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.44.--	ADULT FISH PASSAGE									
	LOWER GRANITE DAM	$58,173,995	$29,086,998	50%	$87,260,993	3Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
	LITTLE GOOSE DAM	$58,008,985	$29,004,493	50%	$87,013,478	3Q 00	30.7%	$75,818,000	$37,909,000	$113,727,000
	LOWER MONUMENTAL DAM	$46,708,915	$23,354,458	50%	$70,063,373	2Q 06	55.6%	$72,679,000	$36,340,000	$109,019,000
	ICE HARBOR DAM	$5,269,012	$2,634,506	50%	$7,903,518	2Q 06	55.6%	$8,199,000	$4,099,000	$12,298,000
	SUBTOTAL:	$168,160,907	$84,080,454	50%	$252,241,361		38.4%	$232,729,000	$116,365,000	$349,094,000
06.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
	LITTLE GOOSE DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
	LOWER MONUMENTAL DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
	ICE HARBOR DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
	SUBTOTAL:	$43,847,148	$17,538,859	40%	$61,386,007		33.2%	$58,404,000	$23,362,000	$81,766,000
06.03.--	WILDLIFE MITIGATION (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	LITTLE GOOSE DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	LOWER MONUMENTAL DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	ICE HARBOR DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	SUBTOTAL:	$151,960,000	$60,784,000	40%	$212,744,000		29.6%	$196,940,000	$78,776,000	$275,716,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 - CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
16.81.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$20,623,350	$8,249,340	40%	$28,872,690	2Q 99	25.6%	$25,903,000	$10,361,000	$36,264,000
	LITTLE GOOSE DAM	$2,646,105	$1,058,442	40%	$3,704,547	2Q 99	25.6%	$3,324,000	$1,329,000	$4,653,000
	LOWER MONUMENTAL DAM	$5,296,995	$2,118,798	40%	$7,415,793	1Q 06	54.1%	$8,163,000	$3,265,000	$11,428,000
	ICE HARBOR DAM	$3,631,815	$1,452,726	40%	$5,084,541	1Q 06	54.1%	$5,597,000	$2,238,000	$7,835,000
	SUBTOTAL:	$32,198,265	$12,879,306	40%	$45,077,571		33.5%	$42,987,000	$17,193,000	$60,180,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 - CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.--.--	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$55,146,448	$11,029,290	20%	$66,175,738	1Q 97	36.9%	$75,495,000	$15,100,000	$90,595,000
	LITTLE GOOSE DAM	$53,627,680	$10,725,536	20%	$64,353,216	1Q 97	36.9%	$73,416,000	$14,684,000	$88,100,000
	LOWER MONUMENTAL DAM	$47,644,846	$9,528,969	20%	$57,173,816	1Q 02	71.2%	$81,568,000	$16,314,000	$97,882,000
	ICE HARBOR DAM	$16,375,870	$3,275,174	20%	$19,651,044	1Q 02	71.2%	$28,035,000	$5,608,000	$33,643,000
	SUBTOTAL:	$172,794,845	$34,558,969	20%	$207,353,814		49.6%	$258,514,000	$51,706,000	$310,220,000
31.--.--	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$21,664,676	$2,166,468	10%	$23,831,144	3Q 01	67.8%	$36,353,000	$3,636,000	$39,989,000
	LITTLE GOOSE DAM	$21,068,017	$2,106,802	10%	$23,174,819	3Q 01	67.8%	$35,352,000	$3,535,000	$38,887,000
	LOWER MONUMENTAL DAM	$18,717,618	$1,871,762	10%	$20,589,380	2Q 05	95.0%	$36,499,000	$3,650,000	$40,149,000
	ICE HARBOR DAM	$6,433,377	$643,338	10%	$7,076,715	2Q 05	95.0%	$12,545,000	$1,255,000	$13,800,000
	SUBTOTAL:	$67,883,689	$6,788,369	10%	$74,672,058		77.9%	$120,749,000	$12,076,000	$132,825,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 – CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$196,951,601	$91,455,023	46%	$288,406,624		34.8%	$265,075,000	$123,624,000	$388,699,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$55,146,448	$11,029,290	20%	$66,175,738	1Q 97	36.9%	$75,495,000	$15,100,000	$90,595,000
31.--.--	CONSTRUCTION MANAGEMENT	$21,664,676	$2,166,468	10%	$23,831,144	3Q 01	67.8%	$36,353,000	$3,636,000	$39,989,000
	SUBTOTAL:	$273,762,725	$104,650,781	38%	$378,413,506			$376,923,000	$142,360,000	$519,283,000
	LITTLE GOOSE DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$191,527,430	$90,540,662	47%	$282,068,092		36.3%	$260,811,000	$123,750,000	$384,561,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$53,627,680	$10,725,536	20%	$64,353,216	1Q 97	36.9%	$73,416,000	$14,684,000	$88,100,000
31.--.--	CONSTRUCTION MANAGEMENT	$21,068,017	$2,106,802	10%	$23,174,819	3Q 01	67.8%	$35,352,000	$3,535,000	$38,887,000
	SUBTOTAL:	$266,223,128	$103,373,000	39%	$369,596,128			$369,579,000	$141,969,000	$511,548,000
	LOWER MONUMENTAL DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$170,160,166	$79,591,941	47%	$249,752,107		43.5%	$243,887,000	$114,513,000	$358,400,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$47,644,846	$9,528,969	20%	$57,173,816	1Q 02	71.2%	$81,568,000	$16,314,000	$97,882,000
31.--.--	CONSTRUCTION MANAGEMENT	$18,717,618	$1,871,762	10%	$20,589,380	2Q 05	95.0%	$36,499,000	$3,650,000	$40,149,000
	SUBTOTAL:	$236,522,631	$90,992,672	38%	$327,515,303			$361,954,000	$134,477,000	$496,431,000
	ICE HARBOR DAM									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS	$58,485,249	$23,921,001	41%	$82,406,250		36.8%	$79,952,000	$32,800,000	$112,752,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$16,375,870	$3,275,174	20%	$19,651,044	1Q 02	71.2%	$28,035,000	$5,608,000	$33,643,000
31.--.--	CONSTRUCTION MANAGEMENT	$6,433,377	$643,338	10%	$7,076,715	2Q 05	95.0%	$12,545,000	$1,255,000	$13,800,000
	SUBTOTAL:	$81,294,496	$27,839,512	34%	$109,134,009			$120,532,000	$39,663,000	$160,195,000
	TOTAL PROJECT:	$857,802,980	$326,855,966	38%	$1,184,658,946		42.4%	$1,228,988,000	$458,469,000	$1,687,457,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 – CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY

LOWER GRANITE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	1Q 04	45.7%	$99,906,000	$49,953,000	$149,859,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.36	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
04.06.80	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,173,995	$29,086,998	50%	$87,260,993	3Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$20,623,350	$8,249,340	40%	$28,872,690	2Q 99	25.6%	$25,903,000	$10,361,000	$36,264,000
	TOTAL CONSTRUCTION COSTS:	$196,860,976	$91,418,773	46%	$288,279,749		34.8%	$264,962,000	$123,579,000	$388,541,000
	TOTAL COSTS:	$196,951,601	$91,455,023	46%	$288,406,624		34.8%	$265,075,000	$123,624,000	$388,699,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$55,146,448	$11,029,290	20%	$66,175,738	1Q 97	36.9%	$75,495,000	$15,100,000	$90,595,000
31.--.--	CONSTRUCTION MANAGEMENT	$21,664,676	$2,166,468	10%	$23,831,144	3Q 01	67.8%	$36,353,000	$3,636,000	$39,989,000
	TOTAL:	$273,762,725	$104,650,781	38%	$378,413,506		37.2%	$376,923,000	$142,360,000	$519,283,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 – CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY

LITTLE GOOSE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD – TO BE DETERMINED									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.––.––	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,287,918	$40,643,959	50%	$121,931,877	1Q 04	45.7%	$118,436,000	$59,219,000	$177,655,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.––	ADULT FISH PASSAGE	$58,008,985	$29,004,493	50%	$87,013,478	3Q 00	30.7%	$75,818,000	$37,909,000	$113,727,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 98	20.7%	$13,231,000	$5,292,000	$18,523,000
06.03.––	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.––.––	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.B1.03	RIPRAP SLOPE PROTECTION	$2,646,105	$1,058,442	40%	$3,704,547	2Q 93	25.6%	$3,324,000	$1,329,000	$4,653,000
	TOTAL CONSTRUCTION COSTS:	$191,436,805	$90,504,412	47%	$281,941,217		36.3%	$260,698,000	$123,705,000	$384,403,000
	TOTAL COSTS:	$191,527,430	$90,540,662	47%	$282,068,092		36.3%	$260,811,000	$123,750,000	$384,561,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$53,627,680	$10,725,536	20%	$64,353,216	1Q 97	36.9%	$73,416,000	$14,684,000	$88,100,000
31.––.––	CONSTRUCTION MANAGEMENT	$21,068,017	$2,106,802	10%	$23,174,819	3Q 01	67.8%	$35,352,000	$3,535,000	$38,887,000
	TOTAL:	$266,223,128	$103,373,000	39%	$369,596,128		38.4%	$369,570,000	$141,969,000	$511,548,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 – CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY

LOWER MONUMENTAL DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD – TO BE DETERMINED									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.––.––	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	1Q 03	41.3%	$96,889,000	$48,445,000	$145,334,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.––	ADULT FISH PASSAGE	$46,708,915	$23,354,458	50%	$70,063,373	2Q 06	55.6%	$72,679,000	$36,340,000	$109,019,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
06.03.––	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.––.––	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.B1.03	RIPRAP SLOPE PROTECTION	$5,296,995	$2,118,798	40%	$7,415,793	1Q 06	54.1%	$8,163,000	$3,265,000	$11,428,000
	TOTAL CONSTRUCTION COSTS:	$170,069,541	$79,555,691	47%	$249,625,232		43.5%	$243,774,000	$114,468,000	$358,242,000
	TOTAL COSTS:	$170,160,166	$79,591,941	47%	$249,752,107		43.5%	$243,887,000	$114,513,000	$358,400,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$47,644,846	$9,528,969	20%	$57,173,816	1Q 02	71.2%	$81,568,000	$16,314,000	$97,882,000
31.––.––	CONSTRUCTION MANAGEMENT	$18,717,618	$1,871,762	10%	$20,589,380	2Q 05	95.0%	$36,499,000	$3,650,000	$40,149,000
	TOTAL:	$236,522,631	$90,992,672	38%	$327,515,303		51.6%	$361,954,000	$134,477,000	$496,431,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 17 - CONTINUOUS POOL
MODIFICATION OF POWERHOUSE
WITH EXISTING SPILLWAY

ICE HARBOR DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY;
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q 06	54.5%	$837,000	$335,000	$1,172,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$5,269,012	$2,634,506	50%	$7,903,518	2Q 06	55.6%	$8,199,000	$4,099,000	$12,298,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$3,631,815	$1,452,726	40%	$5,084,541	1Q 06	54.1%	$5,597,000	$2,238,000	$7,835,000
	TOTAL CONSTRUCTION COSTS:	$58,394,624	$23,884,751	41%	$82,279,375		36.8%	$79,839,000	$32,755,000	$112,594,000
	TOTAL COSTS:	$58,485,249	$23,921,001	41%	$82,406,250		36.8%	$79,952,000	$32,800,000	$112,752,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$16,375,870	$3,275,174	20%	$19,651,044	1Q 02	71.2%	$28,035,000	$5,608,000	$33,643,000
31.--.--	CONSTRUCTION MANAGEMENT	$6,433,377	$643,338	10%	$7,076,715	2Q 05	95.0%	$12,545,000	$1,255,000	$13,800,000
	TOTAL:	$81,294,496	$27,839,512	34%	$109,134,009		46.8%	$120,532,000	$39,663,000	$160,195,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 - CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATIO (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$146,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$216,427,586	$108,213,793	50%	$324,641,379		42.5%	$311,181,000	$155,590,000	$466,771,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$415,313,096	$166,125,238	40%	$581,438,334		41.8%	$589,122,000	$235,648,000	$824,770,000
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$2,150,040	$887,216	40%	$3,035,956		32.6%	$2,880,000	$1,152,000	$4,032,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$168,160,907	$84,080,454	50%	$252,241,361		37.6%	$231,451,000	$115,725,000	$347,178,000
06.01.03	JUVENILE FISH PASSAGE	$43,847,148	$17,538,859	40%	$61,386,007		32.1%	$57,944,000	$23,177,000	$81,121,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$151,960,000	$60,784,000	40%	$212,744,000		29.8%	$196,940,000	$78,776,000	$275,716,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$35,739,644	$14,295,859	40%	$50,035,502		33.4%	$47,050,000	$19,065,000	$66,723,000
	TOTAL CONSTRUCTION COSTS:	$1,035,616,421	$452,905,418	44%	$1,488,521,839		38.8%	$1,437,176,000	$629,133,000	$2,066,309,000
	TOTAL COSTS:	$1,035,978,921	$453,050,418	44%	$1,489,029,339		38.8%	$1,437,628,000	$629,313,000	$2,066,941,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$290,074,098	$58,014,820	20%	$348,088,917		55.6%	$451,288,000	$90,258,000	$541,546,000
31.--.--	CONSTRUCTION MANAGEMENT	$113,957,681	$11,395,768	10%	$125,353,449		76.7%	$201,397,000	$20,139,000	$221,536,000
	TOTAL:	$1,440,010,700	$522,461,006	36%	$1,962,471,706		44.2%	$2,090,313,000	$739,710,000	$2,830,023,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.--.--	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	$0	$126,875	1Q 99	$0	$113,000	$45,000	$158,000
	LITTLE GOOSE DAM	$90,625	$36,250	$0	$126,875	1Q 99	$0	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	$0	$126,875	1Q 99	$0	$113,000	$45,000	$158,000
	ICE HARBOR DAM	$90,625	$36,250	$0	$126,875	1Q 99	$0	$113,000	$45,000	$158,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
02.--.--	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.32	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,834	$34,284,917	50%	$102,854,751	3Q 03	$0	$98,398,000	$49,199,000	$147,597,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	3Q 03	$0	$116,648,000	$58,324,000	$174,572,000
	LOWER MONUMENTAL DAM	$68,569,834	$34,284,917	50%	$102,854,751	4Q 02	$0	$96,135,000	$48,067,000	$144,202,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		42.5%	$311,181,000	$155,590,000	$466,771,000
04.02.33	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.38	NEW RIVER BYPASS SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$103,828,274	$41,531,310	40%	$145,359,584	3Q 03	43.5%	$149,094,000	$59,597,000	$208,591,000
	LITTLE GOOSE DAM	$103,828,274	$41,531,310	40%	$145,359,584	3Q 03	43.5%	$149,094,000	$59,597,000	$208,591,000
	LOWER MONUMENTAL DAM	$103,828,274	$41,531,310	40%	$145,359,584	4Q 02	43.2%	$145,567,000	$58,227,000	$203,794,000
	ICE HARBOR DAM	$103,828,274	$41,531,310	40%	$145,359,584	4Q 02	43.2%	$145,567,000	$58,227,000	$203,794,000
	SUBTOTAL:	$415,313,096	$166,125,238	40%	$581,438,334		41.8%	$589,122,000	$235,648,000	$824,770,000
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	3Q 97	18.9%	$644,000	$258,000	$902,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	3Q 97	18.9%	$644,000	$258,000	$902,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	2Q 04	46.8%	$796,000	$318,000	$1,114,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	2Q 04	46.8%	$796,000	$318,000	$1,114,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		32.8%	$2,880,000	$1,152,000	$4,032,000
04.06.80	REVISE EXISTING IRRIGATION PUMP PLANTS (*TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

PRICE LEVEL: 1 OCTOBER 1992

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.44.– –	ADULT FISH PASSAGE									
	LOWER GRANITE DAM	$58,173,995	$29,086,998	50%	$87,260,993	2Q 00	29.6%	$75,393,000	$37,697,000	$113,090,000
	LITTLE GOOSE DAM	$58,008,985	$29,004,493	50%	$87,013,478	2Q 00	29.6%	$75,180,000	$37,589,000	$112,769,000
	LOWER MONUMENTAL DAM	$46,708,915	$23,354,458	50%	$70,063,373	2Q 08	55.8%	$72,679,000	$36,340,000	$109,019,000
	ICE HARBOR DAM	$5,269,012	$2,634,506	50%	$7,903,518	2Q 06	55.6%	$8,199,000	$4,099,000	$12,298,000
	SUBTOTAL:	$168,160,907	$84,080,454	50%	$252,241,361		37.6%	$231,451,000	$115,725,000	$347,176,000
06.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
	LITTLE GOOSE DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
	LOWER MONUMENTAL DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	47.9%	$16,212,000	$6,485,000	$22,697,000
	ICE HARBOR DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	42.9%	$15,664,000	$6,266,000	$21,930,000
	SUBTOTAL:	$43,847,148	$17,538,859	40%	$61,386,007		32.1%	$57,944,000	$23,177,000	$81,121,000
06.03.– –	WILDLIFE MITIGATION (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	LITTLE GOOSE DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	LOWER MONUMENTAL DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	ICE HARBOR DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	SUBTOTAL:	$151,960,000	$60,784,000	40%	$212,744,000		29.6%	$196,940,000	$78,776,000	$275,716,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

PRICE LEVEL: 1 OCTOBER 1992

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.– –.– –	RECREATION FACILITY MODIFICATIONS (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
16.01.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$22,709,610	$9,083,844	40%	$31,793,454	2Q 99	25.6%	$28,523,000	$11,410,000	$39,933,000
	LITTLE GOOSE DAM	$3,430,845	$1,372,338	40%	$4,803,183	2Q 99	25.6%	$4,309,000	$1,724,000	$6,033,000
	LOWER MONUMENTAL DAM	$5,804,205	$2,321,682	40%	$8,125,887	1Q 04	54.5%	$8,967,000	$3,587,000	$12,554,000
	ICE HARBOR DAM	$3,794,984	$1,517,994	40%	$5,312,978	1Q 06	54.4%	$5,859,000	$2,344,000	$8,203,000
	SUBTOTAL:	$35,739,644	$14,295,858	40%	$50,035,502		33.4%	$47,658,000	$19,065,000	$66,723,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 - CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.--.--	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$84,802,518	$16,960,504	20%	$101,763,021	3Q 98	47.9%	$125,423,000	$25,085,000	$150,508,000
	LITTLE GOOSE DAM	$82,919,324	$16,583,865	20%	$99,503,189	3Q 98	47.9%	$122,638,000	$24,527,000	$147,165,000
	LOWER MONUMENTAL DAM	$76,858,782	$15,371,756	20%	$92,230,538	2Q 01	66.1%	$127,662,000	$25,533,000	$153,195,000
	ICE HARBOR DAM	$45,493,474	$9,098,695	20%	$54,592,169	2Q 01	66.1%	$75,585,000	$15,113,000	$90,678,000
	SUBTOTAL:	$290,074,098	$58,014,820	20%	$348,088,917		55.6%	$451,308,000	$90,258,000	$541,546,000
31.--.--	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$33,315,275	$3,331,527	10%	$36,646,802	2Q 01	66.1%	$55,337,000	$5,533,000	$60,870,000
	LITTLE GOOSE DAM	$32,575,449	$3,257,545	10%	$35,832,994	2Q 01	66.1%	$54,108,000	$5,411,000	$59,519,000
	LOWER MONUMENTAL DAM	$30,194,522	$3,019,452	10%	$33,213,974	4Q 04	91.3%	$57,762,000	$5,776,000	$63,538,000
	ICE HARBOR DAM	$17,872,436	$1,787,244	10%	$19,659,680	4Q 04	91.3%	$34,190,000	$3,419,000	$37,609,000
	SUBTOTAL:	$113,957,682	$11,395,768	10%	$125,353,449		76.7%	$201,397,000	$20,139,000	$221,536,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 - CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$302,775,510	$133,784,567	44%	$436,560,097		36.8%	$414,221,000	$183,068,000	$597,289,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$84,802,518	$16,960,504	20%	$101,763,021	3Q 98	47.9%	$125,423,000	$25,085,000	$150,508,000
31.--.--	CONSTRUCTION MANAGEMENT	$33,315,275	$3,331,527	10%	$36,646,802	2Q 01	66.1%	$55,337,000	$5,533,000	$60,870,000
	SUBTOTAL:	$420,983,928	$154,112,868	37%	$575,096,796			$595,094,000	$213,731,000	$808,825,000
	LITTLE GOOSE DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$296,049,819	$132,349,618	45%	$428,399,437		37.8%	$408,044,000	$182,399,000	$590,443,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$82,919,324	$16,583,865	20%	$99,503,189	3Q 98	47.9%	$122,638,000	$24,527,000	$147,165,000
31.--.--	CONSTRUCTION MANAGEMENT	$32,575,449	$3,257,545	10%	$35,832,994	2Q 01	66.1%	$54,108,000	$5,411,000	$59,519,000
	SUBTOTAL:	$411,635,217	$152,227,278	37%	$563,862,495			$584,903,000	$212,382,000	$797,285,000
	LOWER MONUMENTAL DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$274,405,025	$121,289,885	44%	$395,694,910		42.1%	$389,591,000	$172,718,000	$562,309,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$76,858,782	$15,371,756	20%	$92,230,538	2Q 01	66.1%	$127,662,000	$25,533,000	$153,195,000
31.--.--	CONSTRUCTION MANAGEMENT	$30,194,522	$3,019,452	10%	$33,213,974	4Q 04	91.3%	$57,762,000	$5,776,000	$63,538,000
	SUBTOTAL:	$381,548,954	$139,717,343	37%	$521,266,297			$575,128,000	$204,072,000	$779,200,000
	ICE HARBOR DAM									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$162,386,067	$65,481,328	40%	$227,867,395		38.8%	$225,300,000	$90,968,000	$316,268,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$45,493,474	$9,098,695	20%	$54,592,169	2Q 01	66.1%	$75,585,000	$15,113,000	$90,678,000
31.--.--	CONSTRUCTION MANAGEMENT	$17,872,436	$1,787,244	10%	$19,659,680	4Q 04	91.3%	$34,190,000	$3,419,000	$37,609,000
	SUBTOTAL:	$225,842,602	$76,403,516	34%	$302,246,118			$335,188,000	$109,525,000	$444,713,000
	TOTAL PROJECT:	$1,440,010,700	$522,461,005	36%	$1,962,471,706		44.2%	$2,090,313,000	$739,710,000	$2,830,023,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 - CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY

LOWER GRANITE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	3Q 03	43.5%	$98,398,000	$49,199,000	$147,597,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$103,828,274	$41,531,310	40%	$145,359,584	3Q 03	43.5%	$148,994,000	$59,597,000	$208,591,000
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 97	18.9%	$644,000	$258,000	$902,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,173,996	$29,086,998	50%	$87,260,993	2Q 00	29.6%	$75,393,000	$37,697,000	$113,090,000
05.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$22,709,610	$9,083,844	40%	$31,793,454	2Q 99	25.6%	$28,523,000	$11,410,000	$39,933,000
	TOTAL CONSTRUCTION COSTS:	$302,775,510	$133,784,587	44%	$436,560,097		38.8%	$414,221,000	$183,068,000	$597,289,000
	TOTAL COSTS:	$302,866,135	$133,820,837	44%	$436,686,972		38.8%	$414,334,000	$183,113,000	$597,447,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$84,802,518	$16,960,504	20%	$101,763,021	3Q 98	47.9%	$125,423,000	$25,085,000	$150,508,000
31.--.--	CONSTRUCTION MANAGEMENT	$33,315,275	$3,331,527	10%	$36,646,802	2Q 01	66.1%	$55,337,000	$5,533,000	$60,870,000
	TOTAL:	$420,983,928	$154,112,868	37%	$575,096,796		40.6%	$595,094,000	$213,731,000	$808,825,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 - CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY

LITTLE GOOSE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,287,918	$40,643,959	50%	$121,931,877	3Q 03	43.5%	$116,648,000	$58,324,000	$174,972,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$103,828,274	$41,531,310	40%	$145,359,584	3Q 03	43.5%	$148,994,000	$59,597,000	$208,591,000
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 97	18.9%	$644,000	$258,000	$902,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,008,985	$29,004,493	50%	$87,013,478	2Q 00	29.6%	$75,180,000	$37,589,000	$112,769,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.01.03	RIPRAP SLOPE PROTECTION	$3,430,845	$1,372,338	40%	$4,803,183	2Q 99	25.6%	$4,309,000	$1,724,000	$6,033,000
	TOTAL CONSTRUCTION COSTS:	$295,049,819	$132,349,618	45%	$428,399,437		37.8%	$408,044,000	$182,399,000	$590,443,000
	TOTAL COSTS:	$296,140,444	$132,385,868	45%	$428,526,312		37.8%	$408,157,000	$182,444,000	$590,601,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$82,919,324	$16,583,865	20%	$99,503,189	3Q 98	47.9%	$122,638,000	$24,527,000	$147,165,000
31.--.--	CONSTRUCTION MANAGEMENT	$32,575,449	$3,257,545	10%	$35,832,994	2Q 01	66.1%	$54,108,000	$5,411,000	$59,519,000
	TOTAL:	$411,635,217	$152,227,278	37%	$563,862,495		41.4%	$584,903,000	$212,382,000	$797,285,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY

LOWER MONUMENTAL DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	4Q 02	40.2%	$96,135,000	$48,067,000	$144,202,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$103,828,274	$41,531,310	40%	$145,359,584	4Q 02	40.2%	$145,567,000	$58,227,000	$203,794,000
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	2Q 04	46.8%	$796,000	$318,000	$1,114,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$46,708,915	$23,354,458	50%	$70,063,373	2Q 06	55.6%	$72,679,000	$36,340,000	$109,019,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	47.9%	$16,212,000	$6,485,000	$22,697,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$5,804,205	$2,321,682	40%	$8,125,887	1Q 06	54.5%	$8,967,000	$3,587,000	$12,554,000
	TOTAL CONSTRUCTION COSTS:	$274,405,025	$121,289,685	44%	$395,694,910		42.1%	$389,591,000	$172,718,000	$562,309,000
	TOTAL COSTS:	$274,495,650	$121,326,135	44%	$395,821,785		42.1%	$389,704,000	$172,763,000	$562,467,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$76,858,782	$15,371,756	20%	$92,230,538	2Q 01	66.1%	$127,662,000	$25,533,000	$153,195,000
31.--.--	CONSTRUCTION MANAGEMENT	$30,194,522	$3,019,452	10%	$33,213,974	4Q 04	91.3%	$57,762,000	$5,776,000	$63,538,000
	TOTAL:	$381,548,954	$139,717,343	37%	$521,266,297		49.5%	$575,126,000	$204,072,000	$779,200,000

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SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 18 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH MODIFICATION TO SPILLWAY

ICE HARBOR DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD - TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$103,828,274	$41,531,310	40%	$145,359,584	4Q 02	40.2%	$145,567,000	$58,227,000	$203,794,000
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	2Q 04	46.8%	$796,000	$318,000	$1,114,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$5,269,012	$2,634,506	50%	$7,903,518	2Q 06	55.6%	$8,199,000	$4,099,000	$12,298,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	42.9%	$15,664,000	$6,266,000	$21,930,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$3,794,984	$1,517,994	40%	$5,312,978	1Q 06	54.4%	$5,859,000	$2,344,000	$8,203,000
	TOTAL CONSTRUCTION COSTS:	$162,386,067	$65,481,329	40%	$227,867,395		38.8%	$225,320,000	$90,948,000	$316,268,000
	TOTAL COSTS:	$162,476,692	$65,517,578	40%	$227,994,270		38.8%	$225,433,000	$90,993,000	$316,426,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$45,493,474	$9,098,695	20%	$54,592,169	2Q 01	66.1%	$75,565,000	$15,113,000	$90,678,000
31.--.--	CONSTRUCTION MANAGEMENT	$17,872,436	$1,787,244	10%	$19,659,680	4Q 04	91.3%	$34,190,000	$3,419,000	$37,609,000
	TOTAL:	$225,842,602	$76,403,516	34%	$302,246,118		47.1%	$335,188,000	$109,525,000	$444,713,000

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SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATIO (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	40%	$507,500		41.5%	$514,000	$204,000	$718,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$8,568,703	$3,427,481	40%	$11,996,184		45.7%	$12,485,000	$4,994,000	$17,479,000
04.02.32	STILLING BASIN DRUM GATES	$218,427,586	$109,213,793	50%	$327,641,379		46.7%	$320,511,000	$160,257,000	$480,768,000
04.02.35	NEW LOW LEVEL SPILLWAY	$683,656,292	$273,462,517	40%	$957,118,809		55.7%	$1,064,498,000	$425,797,000	$1,490,295,000
04.02.38	NEW RIVER BYPASS	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$2,168,040	$867,216	40%	$3,035,256		31.1%	$2,842,000	$1,138,000	$3,980,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$168,160,907	$84,080,454	50%	$252,241,361		40.6%	$236,731,000	$118,365,000	$355,096,000
06.01.03	JUVENILE FISH PASSAGE	$43,847,148	$17,538,859	40%	$61,386,007		33.3%	$58,450,000	$23,378,000	$81,828,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$151,960,000	$60,784,000	40%	$212,744,000		26.9%	$192,875,000	$77,150,000	$270,025,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$37,312,953	$14,925,181	40%	$52,238,134		31.7%	$49,126,000	$19,651,000	$68,777,000
	TOTAL CONSTRUCTION COSTS:	$1,314,101,629	$564,299,501	43%	$1,878,401,130		47.4%	$1,937,518,000	$830,730,000	$2,768,248,000
	TOTAL COSTS:	$1,314,464,129	$564,444,501	43%	$1,878,908,630		47.4%	$1,938,032,000	$830,934,000	$2,768,966,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$368,049,956	$73,609,991	20%	$441,659,947		58.6%	$583,760,000	$116,750,000	$700,510,000
31.--.--	CONSTRUCTION MANAGEMENT	$144,591,054	$14,459,105	10%	$159,050,160		84.3%	$266,473,000	$26,648,000	$293,121,000
	TOTAL:	$1,827,105,139	$652,513,598	36%	$2,479,618,737		51.7%	$2,788,265,000	$974,332,000	$3,762,597,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.--.--	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LITTLE GOOSE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	40%	$126,875	1Q 07	58.4%	$144,000	$57,000	$201,000
	ICE HARBOR DAM	$90,625	$36,250	40%	$126,875	1Q 07	58.4%	$144,000	$57,000	$201,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		41.5%	$514,000	$204,000	$718,000
02.--.--	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$2,426,575	$970,630	40%	$3,397,205	2Q 94	45.7%	$3,536,000	$1,414,000	$4,950,000
	ICE HARBOR DAM	$6,142,128	$2,456,851	40%	$8,598,979	2Q 94	45.7%	$8,949,000	$3,580,000	$12,529,000
	SUBTOTAL:	$8,568,703	$3,427,481	40%	$11,996,184		45.7%	$12,485,000	$4,994,000	$17,479,000
04.02.32	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,834	$34,284,917	50%	$102,854,751	1Q 04	45.7%	$99,906,000	$49,953,000	$149,859,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	1Q 04	45.7%	$118,436,000	$59,219,000	$177,655,000
	LOWER MONUMENTAL DAM	$68,569,834	$34,284,917	50%	$102,854,751	4Q 04	49.0%	$102,169,000	$51,085,000	$153,254,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		46.7%	$320,511,000	$160,257,000	$480,768,000
04.02.35	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$142,661,248	$57,064,499	40%	$199,725,747	4Q 01	35.9%	$193,877,000	$77,550,000	$271,427,000
	LITTLE GOOSE DAM	$147,366,382	$58,946,553	40%	$206,312,935	4Q 01	35.9%	$200,271,000	$80,108,000	$280,379,000
	LOWER MONUMENTAL DAM	$183,685,229	$73,474,092	40%	$257,159,321	3Q 09	70.3%	$312,816,000	$125,126,000	$437,942,000
	ICE HARBOR DAM	$209,943,433	$83,977,373	40%	$293,920,806	3Q 09	70.3%	$357,534,000	$143,013,000	$500,547,000
	SUBTOTAL:	$683,656,292	$273,462,517	40%	$957,118,809		55.7%	$1,064,498,000	$425,797,000	$1,490,295,000

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.38	NEW RIVER BYPASS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	4Q 97	19.8%	$649,000	$260,000	$909,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	4Q 97	19.8%	$649,000	$260,000	$909,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	2Q 03	42.5%	$772,000	$309,000	$1,081,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	2Q 03	42.5%	$772,000	$309,000	$1,081,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		31.1%	$2,842,000	$1,138,000	$3,980,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (*TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY – LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.44.--	ADULT FISH PASSAGE									
	LOWER GRANITE DAM	$58,173,995	$29,086,998	50%	$87,260,993	3Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
	LITTLE GOOSE DAM	$58,008,985	$29,004,493	50%	$87,013,478	3Q 00	30.7%	$75,818,000	$37,909,000	$113,727,000
	LOWER MONUMENTAL DAM	$46,708,915	$23,354,458	50%	$70,063,373	1Q 08	63.3%	$76,276,000	$38,137,000	$114,413,000
	ICE HARBOR DAM	$5,269,012	$2,634,506	50%	$7,903,518	1Q 08	63.3%	$8,604,000	$4,302,000	$12,906,000
	SUBTOTAL:	$168,160,907	$84,080,454	50%	$252,241,361		40.8%	$236,731,000	$118,365,000	$355,096,000
06.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
	LITTLE GOOSE DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
	LOWER MONUMENTAL DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	47.7%	$16,191,000	$6,476,000	$22,667,000
	ICE HARBOR DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	47.7%	$16,191,000	$6,476,000	$22,667,000
	SUBTOTAL:	$43,847,148	$17,539,059	40%	$61,386,007		33.3%	$58,450,000	$23,378,000	$81,828,000
06.03.--	WILDLIFE MITIGATION (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	LITTLE GOOSE DAM	$37,990,000	$15,196,000	40%	$53,186,000	3Q 97	18.9%	$45,170,000	$18,066,000	$63,236,000
	LOWER MONUMENTAL DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	ICE HARBOR DAM	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
	SUBTOTAL:	$151,960,000	$60,784,000	40%	$212,744,000		26.9%	$192,875,000	$77,150,000	$270,025,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
16.81.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$23,796,284	$9,518,514	40%	$33,314,798	1Q 99	24.6%	$29,650,000	$11,860,000	$41,510,000
	LITTLE GOOSE DAM	$2,721,230	$1,088,492	40%	$3,809,722	1Q 99	24.6%	$3,391,000	$1,356,000	$4,747,000
	LOWER MONUMENTAL DAM	$5,761,140	$2,304,456	40%	$8,065,596	4Q 04	49.0%	$8,584,000	$3,434,000	$12,018,000
	ICE HARBOR DAM	$5,034,299	$2,013,720	40%	$7,048,019	4Q 04	49.0%	$7,501,000	$3,001,000	$10,502,000
	SUBTOTAL:	$37,312,953	$14,925,181	40%	$52,238,134		31.7%	$49,126,000	$19,651,000	$68,777,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.--.--	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$95,980,019	$19,196,004	20%	$115,176,023	1Q 97	36.9%	$131,397,000	$26,279,000	$157,676,000
	LITTLE GOOSE DAM	$94,911,302	$18,982,260	20%	$113,893,563	1Q 97	36.9%	$129,934,000	$25,986,000	$155,920,000
	LOWER MONUMENTAL DAM	$99,886,112	$19,977,222	20%	$119,863,335	3Q 03	82.0%	$181,793,000	$36,358,000	$218,151,000
	ICE HARBOR DAM	$77,272,522	$15,454,504	20%	$92,727,027	3Q 03	82.0%	$140,636,000	$28,127,000	$168,763,000
	SUBTOTAL:	$368,049,956	$73,609,991	20%	$441,659,947		58.6%	$583,760,000	$116,750,000	$700,510,000
31.--.--	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$37,706,436	$3,770,644	10%	$41,477,080	2Q 01	66.1%	$62,630,000	$6,263,000	$68,893,000
	LITTLE GOOSE DAM	$37,286,583	$3,728,658	10%	$41,015,241	2Q 01	66.1%	$61,933,000	$6,193,000	$68,126,000
	LOWER MONUMENTAL DAM	$39,240,973	$3,924,097	10%	$43,165,070	3Q 06	103.9%	$80,012,000	$8,002,000	$88,014,000
	ICE HARBOR DAM	$30,357,062	$3,035,706	10%	$33,392,769	3Q 06	103.9%	$61,898,000	$6,190,000	$68,088,000
	SUBTOTAL:	$144,591,054	$14,459,105	10%	$159,050,160		84.3%	$266,473,000	$26,646,000	$293,121,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$342,695,158	$149,752,446	44%	$492,447,604		35.0%	$462,384,000	$202,547,000	$664,931,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$95,980,019	$19,196,004	20%	$115,176,023	1Q 97	36.9%	$131,397,000	$26,279,000	$157,676,000
31.––.––	CONSTRUCTION MANAGEMENT	$37,706,436	$3,770,644	10%	$41,477,080	2Q 01	66.1%	$62,630,000	$6,263,000	$68,893,000
	SUBTOTAL:	$476,472,238	$172,755,344	36%	$649,227,582		37.3%	$656,524,000	$235,134,000	$891,658,000
	LITTLE GOOSE DAM									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$338,878,312	$149,481,015	44%	$488,359,327		34.9%	$456,769,000	$202,133,000	$658,902,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$94,911,302	$18,982,260	20%	$113,893,563	1Q 97	36.8%	$129,934,000	$25,986,000	$155,920,000
31.––.––	CONSTRUCTION MANAGEMENT	$37,206,583	$3,728,658	10%	$41,015,241	2Q 01	66.1%	$61,933,000	$6,193,000	$68,126,000
	SUBTOTAL:	$471,166,822	$172,228,184	37%	$643,395,006			$648,749,000	$234,357,000	$883,106,000
	LOWER MONUMENTAL DAM									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 07	58.4%	$144,000	$57,000	$201,000
	CONSTRUCTION COSTS	$356,645,490	$154,186,071	43%	$510,831,561		59.6%	$569,579,000	$245,675,000	$815,254,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$99,886,112	$19,977,222	20%	$119,863,335	3Q 03	82.0%	$181,793,000	$36,358,000	$218,151,000
31.––.––	CONSTRUCTION MANAGEMENT	$39,240,973	$3,924,097	10%	$43,165,070	3Q 05	103.9%	$80,012,000	$8,002,000	$88,014,000
	SUBTOTAL:	$495,863,200	$178,123,641	36%	$673,986,840		66.4%	$831,528,000	$290,092,000	$1,121,620,000
	ICE HARBOR DAM									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 07	58.4%	$144,000	$57,000	$201,000
	CONSTRUCTION COSTS	$275,882,669	$110,879,969	40%	$386,762,638		62.7%	$448,786,000	$180,375,000	$629,161,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$77,272,522	$15,454,504	20%	$92,727,027	3Q 03	82.0%	$140,636,000	$28,127,000	$168,763,000
31.––.––	CONSTRUCTION MANAGEMENT	$30,357,062	$3,035,706	10%	$33,392,769	3Q 06	103.9%	$61,898,000	$6,190,000	$68,088,000
	SUBTOTAL:	$383,602,879	$129,406,429	34%	$513,009,308		69.8%	$651,454,000	$214,749,000	$866,213,000
	TOTAL PROJECT:	$1,827,105,139	$652,513,598	36%	$2,479,618,737		51.7%	$2,798,265,000	$974,332,000	$3,762,597,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY

LOWER GRANITE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW–EN–CB
DATE PREPARED: 29–Oct–92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR–YR)	OMB % INFLATION (+/–)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.––.––	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.––.––	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	1Q 04	45.7%	$99,906,000	$49,953,000	$149,859,000
04.02.35	NEW LOW LEVEL SPILLWAY	$142,661,248	$57,064,499	40%	$199,725,747	4Q 01	35.9%	$193,877,000	$77,550,000	$271,427,000
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	4Q 97	19.8%	$649,000	$260,000	$909,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.––	ADULT FISH PASSAGE	$58,173,995	$29,086,998	50%	$87,260,993	3Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
06.03.––	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.––.––	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$23,796,284	$9,518,514	40%	$33,314,798	1Q 99	24.6%	$29,650,000	$11,860,000	$41,510,000
	TOTAL CONSTRUCTION COSTS:	$342,695,158	$149,752,446	44%	$492,447,604		35.0%	$462,384,000	$202,547,000	$664,931,000
	TOTAL COSTS:	$342,785,783	$149,788,696	44%	$492,574,479		35.0%	$462,497,000	$202,592,000	$665,089,000
30.––.––	PLANNING, ENGINEERING & DESIGN	$95,980,019	$19,196,004	20%	$115,176,023	1Q 97	36.9%	$131,397,000	$26,279,000	$157,676,000
31.––.––	CONSTRUCTION MANAGEMENT	$37,706,436	$3,770,644	10%	$41,477,080	2Q 01	66.1%	$62,630,000	$6,263,000	$68,893,000
	TOTAL:	$476,472,238	$172,755,344	36%	$649,227,582		37.3%	$656,524,000	$235,134,000	$891,658,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY

LITTLE GOOSE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,287,918	$40,643,959	50%	$121,931,877	1Q 04	45.7%	$118,436,000	$59,219,000	$177,655,000
04.02.35	NEW LOW LEVEL SPILLWAY	$147,366,382	$58,946,553	40%	$206,312,935	4Q 01	35.9%	$200,271,000	$80,108,000	$280,379,000
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	4Q 97	19.6%	$649,000	$260,000	$909,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,008,985	$29,004,493	50%	$87,013,478	3Q 00	30.7%	$75,818,000	$37,909,000	$113,727,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 97	18.9%	$13,034,000	$5,213,000	$18,247,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	3Q 97	18.9%	$45,170,000	$18,068,000	$63,238,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$2,721,230	$1,088,492	40%	$3,809,722	1Q 99	24.6%	$3,391,000	$1,356,000	$4,747,000
	TOTAL CONSTRUCTION COSTS:	$338,878,312	$149,481,015	44%	$488,359,327		34.9%	$456,769,000	$202,133,000	$658,902,000
	TOTAL COSTS:	$338,968,937	$149,517,265	44%	$488,486,202		34.8%	$456,882,000	$202,178,000	$659,060,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$94,911,302	$18,982,260	20%	$113,893,563	1Q 97	36.9%	$129,934,000	$25,986,000	$155,920,000
31.--.--	CONSTRUCTION MANAGEMENT	$37,286,583	$3,728,658	10%	$41,015,241	2Q 01	66.1%	$61,933,000	$6,193,000	$68,126,000
	TOTAL:	$471,166,822	$172,228,184	37%	$843,395,006		37.3%	$648,749,000	$234,357,000	$883,106,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 – CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY

LOWER MONUMENTAL DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 07	58.4%	$144,000	$57,000	$201,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$2,426,575	$970,630	40%	$3,397,205	2Q 94	45.7%	$3,536,000	$1,414,000	$4,950,000
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	4Q 04	49.0%	$102,168,000	$51,085,000	$153,254,000
04.02.35	NEW LOW LEVEL SPILLWAY	$183,685,229	$73,474,092	40%	$257,159,321	3Q 09	70.3%	$312,816,000	$125,126,000	$437,942,000
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	2Q 03	42.5%	$772,000	$309,000	$1,081,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$46,708,915	$23,354,458	50%	$70,063,373	1Q 08	63.3%	$76,276,000	$38,137,000	$114,413,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	47.7%	$16,191,000	$6,476,000	$22,667,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$5,761,140	$2,304,456	40%	$8,065,596	4Q 04	49.0%	$8,584,000	$3,434,000	$12,018,000
	TOTAL CONSTRUCTION COSTS:	$356,645,490	$154,186,071	43%	$510,831,561		59.6%	$569,579,000	$245,675,000	$815,254,000
	TOTAL COSTS:	$356,736,115	$154,222,321	43%	$510,958,436		59.6%	$569,723,000	$245,732,000	$815,455,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$99,886,112	$19,977,222	20%	$119,863,335	3Q 03	82.0%	$181,793,000	$36,358,000	$218,151,000
31.--.--	CONSTRUCTION MANAGEMENT	$39,240,973	$3,924,097	10%	$43,165,070	3Q 06	103.9%	$80,012,000	$8,002,000	$88,014,000
	TOTAL:	$495,863,200	$178,123,641	36%	$673,986,840		66.4%	$831,528,000	$290,092,000	$1,121,620,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 19 -- CONTINUOUS POOL
MODIFY POWERHOUSE
WITH NEW LOW LEVEL SPILLWAY

ICE HARBOR DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CS
DATE PREPARED: 29-Oct-92

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 07	58.4%	$144,000	$57,000	$201,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$6,142,128	$2,456,851	40%	$8,598,979	2Q 94	45.7%	$8,949,000	$3,580,000	$12,529,000
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$209,943,433	$83,977,373	40%	$293,920,806	3Q 09	70.3%	$357,534,000	$143,013,000	$500,547,000
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	2Q 03	42.5%	$772,000	$309,000	$1,081,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$5,269,012	$2,634,506	50%	$7,903,518	1Q 08	63.3%	$8,604,000	$4,302,000	$12,906,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 04	47.7%	$16,191,000	$6,476,000	$22,667,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$37,990,000	$15,196,000	40%	$53,186,000	2Q 00	29.6%	$49,235,000	$19,694,000	$68,929,000
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.61.03	RIPRAP SLOPE PROTECTION	$5,034,299	$2,013,720	40%	$7,048,019	4Q 04	49.0%	$7,501,000	$3,001,000	$10,502,000
	TOTAL CONSTRUCTION COSTS:	$275,882,669	$110,879,969	40%	$386,762,638		62.7%	$448,786,000	$180,375,000	$629,161,000
	TOTAL COSTS:	$275,973,294	$110,916,219	40%	$386,889,513		62.7%	$448,930,000	$180,432,000	$629,362,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$77,272,522	$15,454,504	20%	$92,727,027	3Q 03	82.0%	$140,636,000	$28,127,000	$168,763,000
31.--.--	CONSTRUCTION MANAGEMENT	$30,357,062	$3,035,706	10%	$33,392,769	3Q 06	103.9%	$61,898,000	$6,190,000	$68,088,000
	TOTAL:	$383,602,879	$129,406,429	34%	$513,009,308		66.8%	$651,464,000	$214,749,000	$866,213,000

SYSCONFIG\CRSUMALT19.XY SHEET 6

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 -- CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

SUMMARY
PRICE LEVEL: 1 OCTOBER 1992

IDAHO PLAN
FIRST STEP IMPLEMENTATION PLAN

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 19 AUG 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$218,427,586	$109,213,793	50%	$327,641,379		53.8%	$335,847,000	$167,924,000	$503,771,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$2,168,040	$867,216	40%	$3,035,256		41.0%	$3,076,000	$1,228,000	$4,304,000
04.06.60	REVISE EXISTING IRRIGATION PUMP	$0								
	PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$168,160,907	$84,080,454	50%	$252,241,361		54.0%	$258,970,000	$129,485,000	$388,455,000
06.01.03	JUVENILE FISH PASSAGE	$43,847,148	$17,538,859	40%	$61,386,007		34.9%	$59,160,000	$23,665,000	$82,825,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.61.03	RIPRAP SLOPE PROTECTION	$32,198,265	$12,879,306	40%	$45,077,571		36.4%	$43,913,000	$17,566,000	$61,479,000
	TOTAL CONSTRUCTION COSTS:	$464,801,946	$224,579,628	48%	$689,381,574		51.0%	$700,966,000	$339,868,000	$1,040,834,000
	TOTAL COSTS:	$465,164,446	$224,724,628	48%	$689,889,074		51.0%	$701,418,000	$340,048,000	$1,041,466,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$130,246,045	$26,049,209	20%	$156,295,254		77.8%	$231,555,000	$46,312,000	$277,867,000
31.--.--	CONSTRUCTION MANAGEMENT	$51,168,089	$5,116,809	10%	$56,284,898		101.6%	$103,132,000	$10,313,000	$113,445,000
	TOTAL:	$646,578,580	$255,890,648	40%	$902,469,226		58.8%	$1,036,105,800	$396,673,000	$1,432,778,000

SYSCONFIG\CRSUMALT\IDAHO

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
INITIAL PHASE
LOWER GRANITE DAM
PRICE LEVEL: 1 OCTOBER 1992

IDAHO PLAN
FIRST STEP IMPLEMENTATION PLAN

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 19 AUG 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q99	24.6%	$113,000	$45,000	$158,000
	<u>CONSTRUCTION COSTS:</u>									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	4Q98	23.6%	$670,000	$268,000	$938,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE – INITIAL	$3,742,817	$1,871,409	50%	$5,614,226	1Q99	24.6%	$4,664,000	$2,331,000	$6,995,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q99	27.6%	$13,987,000	$5,595,000	$19,582,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$20,623,350	$8,249,340	40%	$28,872,690	2Q99	25.6%	$25,903,000	$10,361,000	$36,264,000
	TOTAL CONSTRUCTION COSTS:	$35,869,964	$14,722,267	41%	$50,592,231		26.1%	$45,224,000	$18,555,000	$63,779,000
	TOTAL COSTS:	$35,960,589	$14,758,517	41%	$50,719,106		26.1%	$45,337,000	$18,600,000	$63,937,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$10,068,965	$2,013,793	20%	$12,082,758	2Q97	38.7%	$13,966,000	$2,793,000	$16,759,000
31.--.--	CONSTRUCTION MANAGEMENT	$3,955,665	$395,566	10%	$4,351,231	4Q98	49.7%	$5,922,000	$592,000	$6,514,000
	TOTAL:	$49,985,219	$17,167,877	34%	$67,153,095		29.9%	$65,225,000	$21,985,000	$87,210,000

X/SYSCONFG/ 'ALIIDAHO

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
REMAINING PHASE
LOWER GRANITE DAM
PRICE LEVEL: 1 OCTOBER 1992

IDAHO PLAN
FIRST STEP IMPLEMENTATION PLAN

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 19 AUG 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$0								
	<u>CONSTRUCTION COSTS:</u>									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	2Q07	60.0%	$109,712,000	$54,856,000	$164,568,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$0								
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE – REMAINING	$54,431,178	$27,215,589	50%	$81,646,767	1Q04	45.7%	$79,306,000	$39,653,000	$118,959,000
06.01.03	JUVENILE FISH PASSAGE	$0								
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$0								
	TOTAL CONSTRUCTION COSTS:	$123,001,012	$61,500,506	50%	$184,501,518		53.7%	$189,018,000	$94,509,000	$283,527,000
	TOTAL COSTS:	$123,001,012	$61,500,506	50%	$184,501,518		53.7%	$189,018,000	$94,509,000	$283,527,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$34,440,283	$6,888,057	20%	$41,328,340	4Q01	69.5%	$58,376,000	$11,676,000	$70,052,000
31.--.--	CONSTRUCTION MANAGEMENT	$13,530,111	$1,353,011	10%	$14,883,122	1Q05	93.2%	$26,140,000	$2,614,000	$28,754,000
	TOTAL:	$170,971,407	$69,741,574	41%	$240,712,980		58.8%	$273,534,000	$108,799,000	$382,333,000

H/SYSCONF/CRSMAL/ALIIDAHO

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

LITTLE GOOSE DAM

PRICE LEVEL: 1 OCTOBER 1992

IDAHO PLAN
FIRST STEP IMPLEMENTATION PLAN

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 19 AUG 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD – TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.5%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,287,918	$40,643,959	50%	$121,931,877	2Q 05	50.9%	$122,663,000	$61,332,000	$183,995,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 04	47.9%	$802,000	$320,000	$1,122,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,008,985	$29,004,493	50%	$87,013,478	1Q 06	58.9%	$92,176,000	$46,088,000	$138,264,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	20.7%	$13,231,000	$5,292,000	$18,523,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$2,646,105	$1,058,442	40%	$3,704,547	2Q 06	55.8%	$4,117,000	$1,647,000	$5,764,000
	TOTAL CONSTRUCTION COSTS:	$153,446,805	$75,308,412	49%	$228,755,217		52.0%	$232,989,000	$114,679,000	$347,668,000
	TOTAL COSTS:	$153,537,430	$75,344,662	49%	$228,882,092		52.0%	$233,102,000	$114,724,000	$347,826,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$42,990,480	$8,598,096	20%	$51,588,576	1Q 04	85.7%	$79,833,000	$15,967,000	$95,800,000
31.--.--	CONSTRUCTION MANAGEMENT	$16,887,117	$1,688,912	10%	$18,576,029	3Q 07	111.0%	$35,636,000	$3,564,000	$39,200,000
	TOTAL:	$213,417,028	$85,631,870	40%	$299,048,898		61.5%	$348,571,000	$134,255,000	$482,826,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

LOWER MONUMENTAL DAM

PRICE LEVEL: 1 OCTOBER 1992

IDAHO PLAN
FIRST STEP IMPLEMENTATION PLAN

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 19 AUG 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	2Q 05	50.9%	$103,472,000	$51,736,000	$155,208,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 04	47.9%	$802,000	$320,000	$1,122,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$46,708,915	$23,354,458	50%	$70,063,373	1Q 06	58.9%	$74,220,000	$37,111,000	$111,331,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$5,296,995	$2,118,798	40%	$7,415,793	2Q 06	55.6%	$8,242,000	$3,297,000	$11,539,000
	TOTAL CONSTRUCTION COSTS:	$132,079,541	$64,359,691	49%	$196,439,232		53.5%	$202,707,000	$98,853,000	$301,560,000
	TOTAL COSTS:	$132,170,166	$64,395,941	49%	$196,566,107		53.5%	$202,820,000	$98,898,000	$301,718,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$37,007,646	$7,401,529	20%	$44,409,176	1Q 04	85.7%	$68,723,000	$13,745,000	$82,468,000
31.--.--	CONSTRUCTION MANAGEMENT	$14,538,718	$1,453,872	10%	$15,992,590	3Q 07	111.0%	$30,677,000	$3,067,000	$33,744,000
	TOTAL:	$183,716,531	$73,251,342	40%	$256,967,873		62.8%	$302,220,000	$115,710,000	$417,930,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 -- CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

ICE HARBOR DAM
PRICE LEVEL: 1 OCTOBER 1992

IDAHO PLAN
FIRST STEP IMPLEMENTATION PLAN

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 19 AUG 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	3Q 04	47.9%	$802,000	$320,000	$1,122,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$5,269,012	$2,634,506	50%	$7,903,518	1Q 08	63.3%	$8,604,000	$4,302,000	$12,906,000
08.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q 04	45.7%	$15,971,000	$6,389,000	$22,360,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$3,631,815	$1,452,726	40%	$5,084,541	2Q 06	55.6%	$5,651,000	$2,261,000	$7,912,000
	TOTAL CONSTRUCTION COSTS:	$20,404,624	$8,688,751	43%	$29,093,375		52.3%	$31,028,000	$13,272,000	$44,300,000
	TOTAL COSTS:	$20,495,249	$8,725,001	43%	$29,220,250		52.1%	$31,141,000	$13,317,000	$44,458,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$5,738,670	$1,147,734	20%	$6,886,404	1Q 04	85.7%	$10,657,000	$2,131,000	$12,788,000
31.--.--	CONSTRUCTION MANAGEMENT	$2,254,477	$225,448	10%	$2,479,925	3Q 07	111.0%	$4,757,000	$476,000	$5,233,000
	TOTAL:	$28,488,396	$10,098,182	35%	$38,586,579		61.9%	$46,555,000	$15,924,000	$62,479,000

K/SYSCONFO/ A13IDAHO

SYSTEMS CONFIGURATION STUDY - JQ

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

MODIFY EXISTING SPILLWAY

LOWER GRANITE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 21 July 1993

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$103,828,274	$41,531,310	40%	$145,359,584	4Q 03	43.5%	$148,994,000	$59,597,000	$208,591,000
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$0								
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$0								
08.01.03	JUVENILE FISH PASSAGE	$0								
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$0								
	TOTAL CONSTRUCTION COSTS:	$103,828,274	$41,531,310	40%	$145,359,584		43.5%	$148,994,000	$59,597,000	$208,591,000
	TOTAL COSTS:	$103,828,274	$41,531,310	40%	$145,359,584		43.5%	$148,994,000	$59,597,000	$208,591,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$29,071,917	$5,814,383	20%	$34,886,300	1Q 98	44.1%	$41,893,000	$8,378,000	$50,271,000
31.--.--	CONSTRUCTION MANAGEMENT	$11,421,110	$1,142,111	10%	$12,563,221	2Q 01	66.1%	$18,970,000	$1,898,000	$20,868,000
	TOTAL:	$144,321,301	$48,487,804	34%	$192,809,105		45.1%	$209,857,000	$69,873,000	$279,730,000

K/SYSCONFO/CRMASPILLWAY

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

SIDE CHANNEL SPILLWAY CONCEPT

LOWER GRANITE DAM

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC
CENPW-EN-CB
DATE PREPARED:
21 July 1993

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$0								
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	NEW CHANNEL SPILLWAY CREST	$314,544,027	$125,817,611	40%	$440,361,638	4Q03	43.5%	$451,371,000	$180,548,000	$631,919,000
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$0								
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$0								
06.01.03	JUVENILE FISH PASSAGE	$0								
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$0								
	TOTAL CONSTRUCTION COSTS:	$314,544,027	$125,817,611	40%	$440,361,638		43.5%	$451,371,000	$180,548,000	$631,919,000
	TOTAL COSTS:	$314,544,027	$125,817,611	40%	$440,361,638		43.5%	$451,371,000	$180,548,000	$631,919,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$88,072,328	$17,614,466	20%	$105,686,793	1Q98	44.1%	$126,912,000	$25,383,000	$152,295,000
31.--.--	CONSTRUCTION MANAGEMENT	$34,599,843	$3,459,984	10%	$38,059,827	2Q01	66.1%	$57,470,000	$5,747,000	$63,217,000
	TOTAL:	$437,216,198	$146,892,061	34%	$584,108,258		45.1%	$635,753,000	$211,678,000	$847,431,000

[illegible] SPILLWAY

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 - CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC
CENPW-EN-CB
DATE PREPARED:
4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$362,500	$145,000	$0	$507,500	$0	$0	$452,000	$180,000	$632,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$218,427,586	$109,213,793	50%	$327,641,379		39.8%	$305,430,000	$152,714,000	$458,144,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$2,168,040	$867,216	40%	$3,035,256		21.2%	$2,628,000	$1,050,000	$3,678,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$168,160,907	$84,080,454	50%	$252,241,361		33.6%	$224,732,000	$112,367,000	$337,099,000
06.01.03	JUVENILE FISH PASSAGE	$43,847,148	$17,538,859	40%	$61,386,007		29.8%	$56,914,000	$22,764,000	$79,678,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$32,198,265	$12,879,306	40%	$45,077,571		31.4%	$42,318,000	$16,927,000	$59,245,000
	TOTAL CONSTRUCTION COSTS:	$464,801,946	$224,579,628	48%	$689,381,574		36.0%	$632,022,000	$305,822,000	$937,844,000
	TOTAL COSTS:	$465,164,446	$224,724,628	48%	$689,889,074		36.0%	$632,474,000	$306,002,000	$938,476,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$130,246,045	$26,049,209	20%	$156,295,254		36.9%	$186,928,000	$37,387,000	$224,315,000
31.--.--	CONSTRUCTION MANAGEMENT	$51,168,089	$5,116,809	10%	$56,284,898		67.8%	$85,335,000	$8,535,000	$93,870,000
	TOTAL:	$646,578,580	$255,890,646	40%	$902,469,226		39.2%	$904,737,000	$351,924,000	$1,256,661,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
01.--.--	REAL ESTATE									
	LOWER GRANITE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LITTLE GOOSE DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	LOWER MONUMENTAL DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	ICE HARBOR DAM	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	SUBTOTAL:	$362,500	$145,000	40%	$507,500		24.5%	$452,000	$180,000	$632,000
02.--.--	RELOCATIONS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.32	STILLING BASIN DRUM GATES									
	LOWER GRANITE DAM	$68,569,834	$34,284,917	50%	$102,854,751	2Q 04	46.8%	$100,661,000	$50,330,000	$150,991,000
	LITTLE GOOSE DAM	$81,287,918	$40,643,959	50%	$121,931,877	2Q 04	46.8%	$119,331,000	$59,665,000	$178,996,000
	LOWER MONUMENTAL DAM	$68,569,834	$34,284,917	50%	$102,854,751	1Q 99	24.5%	$85,438,000	$42,719,000	$128,157,000
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$218,427,586	$109,213,793	50%	$327,641,379		39.8%	$305,430,000	$152,714,000	$458,144,000
04.02.35	NEW LOW LEVEL SPILLWAY									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR

PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
04.02.38	NEW RIVER BYPASS									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS									
	LOWER GRANITE DAM	$542,010	$216,804	40%	$758,814	2Q 98	21.7%	$660,000	$263,000	$923,000
	LITTLE GOOSE DAM	$542,010	$216,804	40%	$758,814	2Q 98	21.7%	$660,000	$263,000	$923,000
	LOWER MONUMENTAL DAM	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
	ICE HARBOR DAM	$542,010	$216,804	40%	$758,814	1Q 98	20.7%	$654,000	$262,000	$916,000
	SUBTOTAL:	$2,168,040	$867,216	40%	$3,035,256		21.2%	$2,628,000	$1,050,000	$3,678,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (*TBD)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 - CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW-EN-CB
DATE PREPARED: 4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.44.--	ADULT FISH PASSAGE									
	LOWER GRANITE DAM	$58,173,995	$29,086,998	50%	$87,260,993	4Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
	LITTLE GOOSE DAM	$58,008,985	$29,004,493	50%	$87,013,478	4Q 00	31.7%	$76,398,000	$38,199,000	$114,597,000
	LOWER MONUMENTAL DAM	$46,708,915	$23,354,458	50%	$70,063,373	3Q 02	39.1%	$64,972,000	$32,486,000	$97,458,000
	ICE HARBOR DAM	$5,269,012	$2,634,506	50%	$7,903,518	2Q 02	39.1%	$7,329,000	$3,665,000	$10,994,000
	SUBTOTAL:	$168,160,907	$84,080,454	50%	$252,241,361		33.6%	$224,732,000	$112,367,000	$337,099,000
06.01.03	JUVENILE FISH PASSAGE									
	LOWER GRANITE DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 98	22.7%	$13,450,000	$5,380,000	$18,830,000
	LITTLE GOOSE DAM	$10,961,787	$4,384,715	40%	$15,346,502	3Q 98	22.7%	$13,450,000	$5,380,000	$18,830,000
	LOWER MONUMENTAL DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 02	36.9%	$15,007,000	$6,002,000	$21,009,000
	ICE HARBOR DAM	$10,961,787	$4,384,715	40%	$15,346,502	1Q 02	36.9%	$15,007,000	$6,002,000	$21,009,000
	SUBTOTAL:	$43,847,148	$17,538,859	40%	$61,386,007		29.8%	$56,914,000	$22,764,000	$79,678,000
06.03.--	WILDLIFE MITIGATION (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
07.02	NEW TURBINES									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 - CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC — CENPW-EN-CB
DATE PREPARED: 4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)									
	LOWER GRANITE DAM	$0								
	LITTLE GOOSE DAM	$0								
	LOWER MONUMENTAL DAM	$0								
	ICE HARBOR DAM	$0								
	SUBTOTAL:	$0								
16.81.03	RIPRAP SLOPE PROTECTION									
	LOWER GRANITE DAM	$20,623,350	$8,249,340	40%	$28,872,690	3Q 99	26.6%	$26,109,000	$10,444,000	$36,553,000
	LITTLE GOOSE DAM	$2,646,105	$1,058,442	40%	$3,704,547	3Q 99	26.6%	$3,350,000	$1,340,000	$4,690,000
	LOWER MONUMENTAL DAM	$5,296,995	$2,118,798	40%	$7,415,793	4Q 99	37.1%	$7,262,000	$2,905,000	$10,167,000
	ICE HARBOR DAM	$3,631,815	$1,452,726	40%	$5,084,541	1Q 06	54.1%	$5,597,000	$2,238,000	$7,835,000
	SUBTOTAL:	$32,198,265	$12,879,306	40%	$45,077,571		31.4%	$42,318,000	$16,527,000	$59,245,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 - CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
30.--,--	PLANNING, ENGINEERING & DESIGN									
	LOWER GRANITE DAM	$44,509,248	$8,901,850	20%	$53,411,098	3Q 97	40.5%	$62,535,000	$12,508,000	$75,043,000
	LITTLE GOOSE DAM	$42,990,480	$8,598,096	20%	$51,588,576	3Q 97	40.5%	$60,402,000	$12,080,000	$72,482,000
	LOWER MONUMENTAL DAM	$37,007,646	$7,401,529	20%	$44,409,176	4Q 98	49.7%	$55,400,000	$11,081,000	$66,481,000
	ICE HARBOR DAM	$5,738,670	$1,147,734	20%	$6,886,404	4Q 98	49.7%	$8,591,000	$1,718,000	$10,309,000
	SUBTOTAL:	$130,246,045	$26,049,209	20%	$156,295,254		43.5%	$186,928,000	$37,387,000	$224,315,000
31.--,--	CONSTRUCTION MANAGEMENT									
	LOWER GRANITE DAM	$17,485,776	$1,748,578	10%	$19,234,354	4Q 01	69.5%	$29,638,000	$2,964,000	$32,602,000
	LITTLE GOOSE DAM	$16,889,117	$1,688,912	10%	$18,578,029	4Q 01	69.5%	$28,627,000	$2,863,000	$31,490,000
	LOWER MONUMENTAL DAM	$14,538,718	$1,453,872	10%	$15,992,590	3Q 00	61.2%	$23,436,000	$2,344,000	$25,780,000
	ICE HARBOR DAM	$2,254,477	$225,448	10%	$2,479,925	3Q 00	61.2%	$3,634,000	$364,000	$3,998,000
	SUBTOTAL:	$51,168,089	$5,116,809	10%	$56,284,898		66.8%	$85,335,000	$8,535,000	$93,870,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 - CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY
LOWER GRANITE, LITTLE GOOSE
LOWER MONUMENTAL, ICE HARBOR
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC CENPW-EN-CB
DATE PREPARED: 4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	LOWER GRANITE DAM									
01.--,--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$158,870,976	$76,222,773	48%	$235,093,749		35.7%	$216,913,000	$104,434,000	$321,347,000
30.--,--	PLANNING, ENGINEERING & DESIGN	$44,509,248	$8,901,850	20%	$53,411,098	3Q 97	40.5%	$62,535,000	$12,508,000	$75,043,000
31.--,--	CONSTRUCTION MANAGEMENT	$17,485,776	$1,748,578	10%	$19,234,354	4Q 01	69.5%	$29,638,000	$2,964,000	$32,602,000
	SUBTOTAL:	$220,956,625	$86,909,451	39%	$307,866,076			$309,199,000	$119,951,000	$429,150,000
	LITTLE GOOSE DAM									
01.--,--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$153,446,805	$75,308,412	49%	$228,755,217		39.0%	$213,189,000	$104,847,000	$318,036,000
30.--,--	PLANNING, ENGINEERING & DESIGN	$42,990,480	$8,598,096	20%	$51,588,576	3Q 97	40.5%	$60,402,000	$12,080,000	$72,482,000
31.--,--	CONSTRUCTION MANAGEMENT	$16,889,117	$1,688,912	10%	$18,578,029	4Q 01	69.5%	$28,627,000	$2,863,000	$31,490,000
	SUBTOTAL:	$213,417,028	$85,631,670	40%	$299,048,698			$302,331,000	$119,835,000	$422,166,000
	LOWER MONUMENTAL DAM									
01.--,--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$132,079,541	$64,359,691	49%	$196,439,232		31.2%	$173,333,000	$84,374,000	$257,707,000
30.--,--	PLANNING, ENGINEERING & DESIGN	$37,007,646	$7,401,529	20%	$44,409,176	4Q 98	49.7%	$55,400,000	$11,081,000	$66,481,000
31.--,--	CONSTRUCTION MANAGEMENT	$14,538,718	$1,453,872	10%	$15,992,590	3Q 00	61.2%	$23,436,000	$2,344,000	$25,780,000
	SUBTOTAL:	$183,716,531	$73,251,342	40%	$256,967,873			$252,282,000	$97,844,000	$350,126,000
	ICE HARBOR DAM									
01.--,--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS	$20,404,624	$8,688,751	43%	$29,093,375		40.1%	$28,587,000	$12,167,000	$40,754,000
30.--,--	PLANNING, ENGINEERING & DESIGN	$5,738,670	$1,147,734	20%	$6,886,404	4Q 98	49.7%	$8,591,000	$1,718,000	$10,309,000
31.--,--	CONSTRUCTION MANAGEMENT	$2,254,477	$225,448	10%	$2,479,925	3Q 00	61.2%	$3,634,000	$364,000	$3,998,000
	SUBTOTAL:	$28,488,396	$10,098,182	35%	$38,586,579			$40,925,000	$14,294,000	$55,219,000
	TOTAL PROJECT:	$646,578,580	$255,890,646	40%	$902,469,226		39.2%	$904,737,000	$351,924,000	$1,256,661,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

LOWER GRANITE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC
DATE PREPARED:
CENPW-EN-CB
4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST: 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	2Q 04	46.8%	$100,661,000	$50,330,000	$150,991,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	2Q 98	21.7%	$660,000	$263,000	$923,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,173,985	$29,086,993	50%	$87,260,978	4Q 00	30.7%	$76,033,000	$38,017,000	$114,050,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 98	22.7%	$13,450,000	$5,380,000	$18,830,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$20,623,250	$8,249,300	40%	$28,872,550	3Q 99	26.6%	$26,109,000	$10,444,000	$36,553,000
	TOTAL CONSTRUCTION COSTS:	$158,870,876	$76,222,773	48%	$235,093,749		36.7%	$216,813,000	$104,494,000	$321,307,000
	TOTAL COSTS:	$158,961,501	$76,259,023	48%	$235,220,624		36.7%	$217,026,000	$104,479,000	$321,505,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$44,509,248	$8,901,850	20%	$53,411,098	3Q 97	40.5%	$62,535,000	$12,508,000	$75,043,000
31.--.--	CONSTRUCTION MANAGEMENT	$17,485,778	$1,748,578	10%	$19,234,354	4Q 01	69.5%	$29,638,000	$2,964,000	$32,602,000
	TOTAL:	$220,956,525	$86,909,451	39%	$307,866,076		39.4%	[illegible]	$118,951,000	$420,750,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

LITTLE GOOSE DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC
DATE PREPARED:
CENPW-EN-CB
4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST: 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD = TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q 99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$81,287,918	$40,643,959	50%	$121,931,877	2Q 04	46.8%	$119,331,000	$59,665,000	$178,996,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	2Q 98	21.7%	$660,000	$263,000	$923,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$58,008,985	$29,004,493	50%	$87,013,478	4Q 00	31.7%	$76,398,000	$38,199,000	$114,597,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	3Q 98	22.7%	$13,450,000	$5,380,000	$18,830,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$2,646,105	$1,058,442	40%	$3,704,547	3Q 99	26.6%	$3,350,000	$1,340,000	$4,690,000
	TOTAL CONSTRUCTION COSTS:	$153,446,805	$75,308,412	49%	$228,755,217		39.0%	$213,189,000	$104,847,000	$318,036,000
	TOTAL COSTS:	$153,537,430	$75,344,662	49%	$228,882,092		39.0%	$213,302,000	$104,892,000	$318,194,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$42,990,480	$8,598,096	20%	$51,588,576	3Q 97	40.5%	$60,402,000	$12,080,000	$72,482,000
31.--.--	CONSTRUCTION MANAGEMENT	$16,889,117	$1,688,912	10%	$18,578,029	4Q 01	69.5%	$28,627,000	$2,863,000	$31,490,000
	TOTAL:	$213,417,028	$85,631,670	40%	$299,048,698		41.2%	$302,331,000	$119,835,000	$422,166,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

LOWER MONUMENTAL DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC
DATE PREPARED:
CENPW-EN-CB
4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD – TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$68,569,834	$34,284,917	50%	$102,854,751	1Q99	24.6%	$85,438,000	$42,719,000	$128,157,000
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q98	20.7%	$654,000	$262,000	$916,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$46,708,915	$23,354,458	50%	$70,063,373	3Q02	39.1%	$64,972,000	$32,486,000	$97,458,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q02	36.9%	$15,007,000	$6,002,000	$21,009,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$5,296,995	$2,118,798	40%	$7,415,793	4Q99	37.1%	$7,262,000	$2,905,000	$10,167,000
	TOTAL CONSTRUCTION COSTS:	$132,079,541	$64,359,691	49%	$196,439,232		31.2%	$173,333,000	$84,374,000	$257,707,000
	TOTAL COSTS:	$132,170,166	$64,395,941	49%	$196,566,107		31.2%	$173,446,000	$84,419,000	$257,865,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$37,007,646	$7,401,529	20%	$44,409,176	4Q98	49.7%	$55,400,000	$11,081,000	$66,481,000
31.--.--	CONSTRUCTION MANAGEMENT	$14,538,718	$1,453,872	10%	$15,992,590	3Q00	61.2%	$23,436,000	$2,344,000	$25,780,000
	TOTAL:	$183,716,531	$73,251,342	40%	$256,967,873		36.3%	$252,282,000	$97,844,000	$350,126,000

SYSTEMS CONFIGURATION STUDY - LOWER SNAKE RESERVOIR DRAWDOWN

*** PROJECT COST SUMMARY ***

CURRENT WORKING ESTIMATE

ALTERNATIVE 13 – CONTINUOUS POOL
EXISTING POWERHOUSE WITH
EXISTING SPILLWAY

ICE HARBOR DAM
PRICE LEVEL: 1 OCTOBER 1992

PREPARED BY: AC
DATE PREPARED:
CENPW-EN-CB
4 May 93

REVIEWED & APPROVED BY:
LARRY CHENEY
CHIEF, COST ENGINEERING BRANCH

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
	*TBD – TO BE DETERMINED									
01.--.--	REAL ESTATE	$90,625	$36,250	40%	$126,875	1Q99	24.6%	$113,000	$45,000	$158,000
	CONSTRUCTION COSTS:									
02.--.--	RELOCATIONS	$0								
04.02.32	STILLING BASIN DRUM GATES	$0								
04.02.35	NEW LOW LEVEL SPILLWAY	$0								
04.02.38	NEW RIVER BYPASS SPILLWAY	$0								
04.02.41	LOWER EXISTING SPILLWAY CREST	$0								
04.02.99	MISCELLANEOUS DAM MODIFICATIONS	$542,010	$216,804	40%	$758,814	1Q98	20.7%	$654,000	$262,000	$916,000
04.06.60	REVISE EXISTING IRRIGATION PUMP PLANTS (TBD*)	$0								
06.44.--	ADULT FISH PASSAGE	$5,269,012	$2,634,506	50%	$7,903,518	2Q02	39.1%	$7,329,000	$3,665,000	$10,994,000
06.01.03	JUVENILE FISH PASSAGE	$10,961,787	$4,384,715	40%	$15,346,502	1Q02	36.9%	$15,007,000	$6,002,000	$21,009,000
06.03.--	WILDLIFE MITIGATION (TBD*)	$0								
07.02	NEW TURBINES	$0								
14.--.--	RECREATION FACILITY MODIFICATIONS (TBD*)	$0								
16.81.03	RIPRAP SLOPE PROTECTION	$3,631,815	$1,452,726	40%	$5,084,541	1Q06	54.1%	$5,597,000	$2,238,000	$7,835,000
	TOTAL CONSTRUCTION COSTS:	$20,404,624	$8,688,751	43%	$29,093,375		40.1%	$28,587,000	$12,167,000	$40,754,000
	TOTAL COSTS:	$20,495,249	$8,725,001	43%	$29,220,250		40.0%	$28,700,000	$12,212,000	$40,912,000
30.--.--	PLANNING, ENGINEERING & DESIGN	$5,738,670	$1,147,734	20%	$6,886,404	4Q98	49.7%	$8,591,000	$1,718,000	$10,309,000
31.--.--	CONSTRUCTION MANAGEMENT	$2,254,477	$225,448	10%	$2,479,925	3Q00	61.2%	$3,634,000	$364,000	$3,998,000
	TOTAL:	$28,488,396	$10,098,182	35%	$38,586,579		43.1%	$40,925,000	$14,294,000	$55,219,000

SYSTEMS CONFIGURATION STUDY

LOWER SNAKE RIVER DRAWDOWN

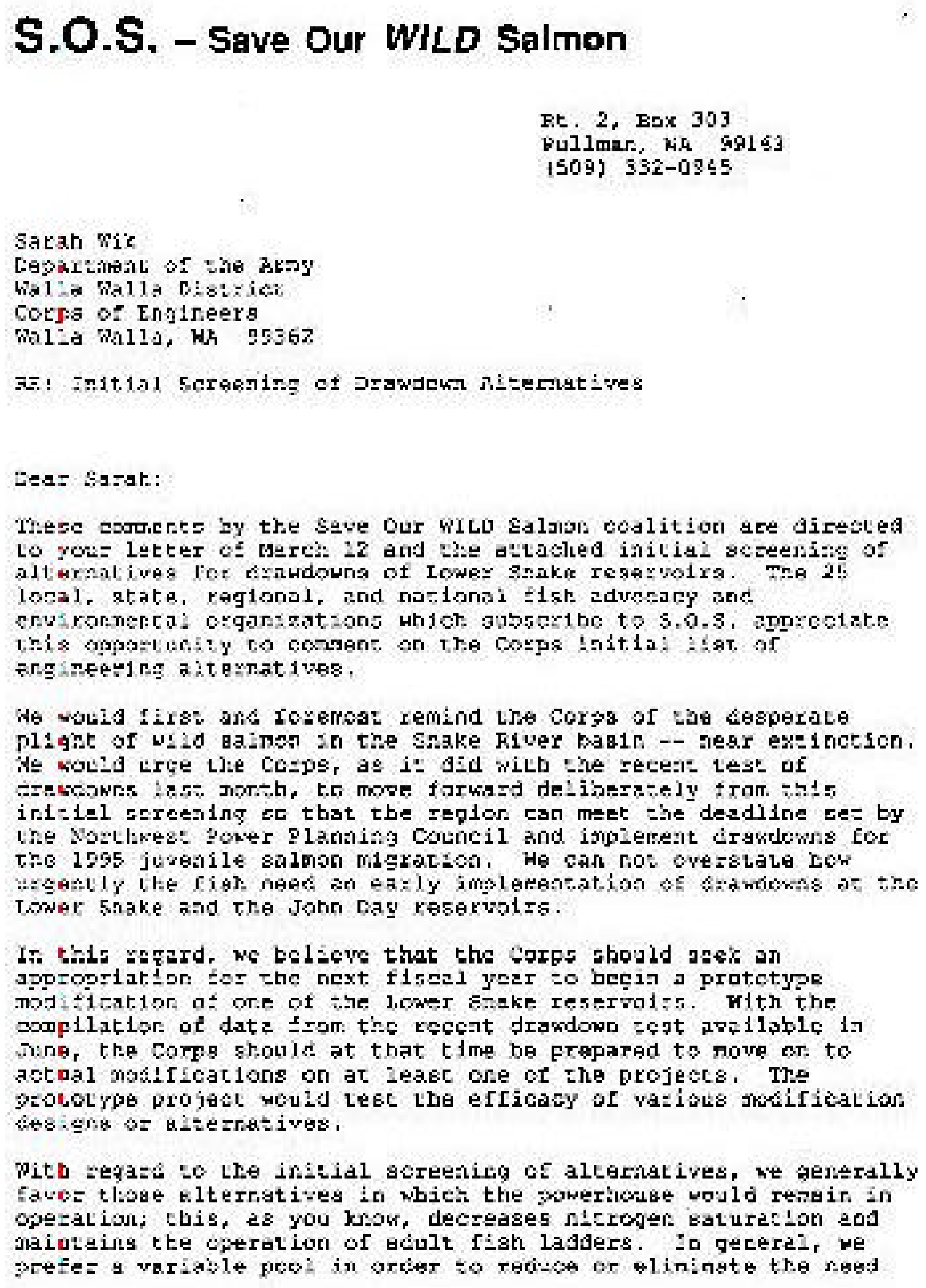
SURFACE FLOW COLLECTION SYSTEMS
LOWER GRANITE DAM

PRICE LEVEL: 1 OCTOBER 1992

ACCOUNT CODE	ITEM DESCRIPTION	ESTIMATED COST: 1 OCT 92	CONTINGENCY AMOUNT ($)	%	TOTAL ESTIMATED COST 1 OCT 92	BUDGET YEAR (QTR-YEAR)	OMB % INFLATION (+/-)	INFLATED ESTIMATED AMOUNT	INFLATED CONTINGENCY AMOUNT	CURRENT FULLY FUNDED COSTS
06.00.00	FISH & WILDLIFE FACILITIES									
06.01.00	FISH FACILITIES AT DAMS									
06.01.67	FISH COLLECTION FACILITIES									
	MOBILIZATON	$3,800,500	$1,520,000	40%	$5,320,500	3Q 00	30.7%	$4,867,000	$1,987,000	$6,854,000
	CONCRETE CORBELS	$2,995,500	$1,190,000	40%	$4,193,500	3Q 00	30.7%	$3,915,000	$1,566,000	$5,481,000
	CONCRETE WORK	$1,302,100	$521,000	40%	$1,823,100	3Q 00	30.7%	$1,702,000	$681,000	$2,383,000
	COLLECTION SYSTEM	$50,745,800	$20,298,000	40%	$71,043,800	3Q 00	30.7%	$66,325,000	$26,529,000	$92,854,000
	DOWNSTREAM FLUME AND DEWATER	$766,800	$307,000	40%	$1,073,800	3Q 00	30.7%	$1,002,000	$401,000	$1,403,000
	SUBTOTAL:	$59,610,700	$23,844,000	40%	$83,454,700			$77,911,000	$31,164,000	$109,075,000
30.00.00	PLANNING, ENGINEERING & DESIGN	$16,691,000	$3,338,000	20%	$20,029,000	1Q 97	36.9%	$22,850,000	$4,570,000	$27,420,000
31.00.00	CONSTRUCTION MANAGEMENT	$6,557,000	$656,000	10%	$7,213,000	3Q 00	30.7%	$8,570,000	$857,000	$9,427,000
	TOTAL COST:	$82,858,700	$27,838,000	34%	$110,696,700		31.8%	$109,331,000	$36,591,000	$145,922,000

FILE: [illegible]

Appendix D - Correspondence



S.O.S. – Save Our *WILD* Salmon

Rt. 2, Box 303
Pullman, WA 99163
(509) 332-0345

Sarah Wik
Department of the Army
Walla Walla District
Corps of Engineers
Walla Walla, WA 99362

RE: Initial Screening of Drawdown Alternatives

Dear Sarah:

These comments by the Save Our WILD Salmon coalition are directed to your letter of March 12 and the attached initial screening of alternatives for drawdowns of Lower Snake reservoirs. The 25 local, state, regional, and national fish advocacy and environmental organizations which subscribe to S.O.S. appreciate this opportunity to comment on the Corps initial list of engineering alternatives.

We would first and foremost remind the Corps of the desperate plight of wild salmon in the Snake River basin -- near extinction. We would urge the Corps, as it did with the recent test of drawdowns last month, to move forward deliberately from this initial screening so that the region can meet the deadline set by the Northwest Power Planning Council and implement drawdowns for the 1995 juvenile salmon migration. We can not overstate how urgently the fish need an early implementation of drawdowns at the Lower Snake and the John Day reservoirs.

In this regard, we believe that the Corps should seek an appropriation for the next fiscal year to begin a prototype modification of one of the Lower Snake reservoirs. With the compilation of data from the recent drawdown test available in June, the Corps should at that time be prepared to move on to actual modifications on at least one of the projects. The prototype project would test the efficacy of various modification designs or alternatives.

With regard to the initial screening of alternatives, we generally favor those alternatives in which the powerhouse would remain in operation; this, as you know, decreases nitrogen saturation and maintains the operation of adult fish ladders. In general, we prefer a variable pool in order to reduce or eliminate the need for flow augmentation during drawdown, and to protect against spilling large volumes of water, thereby preserving the structural integrity of the projects. However, we are deeply disturbed by the prospect of a pressurized juvenile collection channel and bypass, a measure which we hope the Corps will find some way to design out of the variable pool alternatives in the future.

Finally, we feel that the Corps can eliminate from further review the Auxiliary Regulating Outlet (ARO) alternatives. However, the proposals for river-level drawdowns brought forward by the Columbia Basin Fish and Wildlife Authority (CBFWA) have great merit and deserve careful investigation.

Thank you for this opportunity to comment. We urge the Corps to press forward aggressively with the design of drawdown modifications. If you have questions or need further information, please do not hesitate to call on me.

Sincerely,

James M Baker

James H. Baker

COLUMBIA
BASIN
FISH & WILDLIFE
AUTHORITY

April 23, 1992

Greg Graham, Study Manager
Corps of Engineers
Walla Walla District
Building 602, City-County Airport
Walla Walla, WA 99362-9265

Dear Mr. Graham:

Thank you for the opportunity to participate in the initial screening process and review of the Lower Snake River drawdown alternatives. The comments and alternative recommendations presented here are intended to aid the Corps of Engineers (COE) in expediting their System Configuration Study (Study). However, the Columbia Basin Fish and Wildlife Authority (CBFWA) reserves the option of submitting additional recommendations once the results of the 1992 Reservoir Drawdown Test are made available. CBFWA comments on long-term drawndown alternatives stem from review by our Fish Passage Advisory Committee (FPAC) and interaction with the COE's study team on April 9, 1992.

<u>General Objectives</u>

The objective of any Snake River reservoir drawdown is to significantly improve smolt travel time by increasing water particle travel time. Any alternative that fails to achieve a flow equivalent of 140 kcfs should be eliminated. Agency and tribal biologists also feel strongly about avoiding alternatives which proposed modifications using unproven technology or options which would require extended periods of research. In addition, ease of implementation should be treated as a peripheral factor, not something which directs the study. Even after preliminary review, it appears that some alternatives are better suited to specific projects, while others will be necessary to modify the remaining projects. The Study will need to clarify these dam-specific needs. We would also suggest that the COE develop a method for estimating refill times and volumes under the various drawdown options to help determine impacts to both juvenile and adult fish passage during the transition between "drawdown" passage facilities and "full" pool passage systems.

Proposed Design Criteria

Agency and tribal biologists attending the April 3 screening meeting commented on the following criteria:

1. Drawdown alternatives should look at two time periods: (a) 15 April - 15 June; and (b) 15 April - early September (Labor Day).

2. Using the PMF criteria of 860 kcfs for spillway capability seems totally unrealistic, especially in light of present Snake River discharge patterns.

3. The design criteria of 225 kcfs (ten-year flood) should be examined to see if this flow level is appropriate. A lower flow in the range of 180 kcfs seems more realistic. In years when runoff forecasts are significantly above average, drawdown won't be required to meet survival goals.

4. Larger orifices in JBS's would most likely injure fewer adult fallbacks. Some workers suggest a tapered orifice structure (24-18 inches reducing to 12 inches) might reduce the occurrence.

5. The juvenile transport channels for proposed modifications should be consistent with those being designed for Ice Harbor and the current system at John Day Dam. They should include facilities to sample fish.

6. The maximum transport velocity should be 4.0 feet per second and the minimum velocity 2.0 feet per second.

7. We suggest the inclusion of additional criteria for adult fish passage systems:

   a. Minimum flow depths of 8 feet at entrance of fish ladders.
   b. New ladders should have counting stations similar to existing facilities.
   c. New ladders should have appropriate design consideration for trapping and monitoring requirements.

Initial Screening Proposals

CBFWA biologists, as well as COE staff, felt that alternatives 1, 2, and 3 (Variable Pool - No Powerhouse Operation) should be removed since they do not meet the 140 kcfs equivalent and present both adult and juvenile passage concerns.

Alternatives 4, 8, 12, 16, and 20 should be removed since our experts consider the COE's proposed ARO (Auxiliary Regulating Outlet) alternative fraught with passage problems and requiring new, unproven technologies.

As a replacement for the ARO option, we strongly suggest that the COE adopt the Oregon Department of Fish and Wildlife's Natural River Option (NRO) as a non-overflow section option. Although only conceptual at this point, this alternative would return the river to conditions resembling a natural system, while allowing ponding of water during the non-migratory periods.

The remaining alternatives require modifications to either project spillways or powerhouse. Most agency and tribal representatives attending the April 3 meeting felt it unnecessary to modify existing spillways by lowering their ogee crests (to achieve 140 kcfs flow proposal equivalents). Since the equivalent flows could be attained in all but the most critical runoff years, the high cost of modification wouldn't justify the benefits. In addition, we can foresee considerable adult passage problems associated with reducing the reservoir levels below the existing spillway crests. Remove alternatives 7, 11, 15, and 19 for these reasons.

Alternatives 5 and 9 should be revised to indicate drawdowns ranging between 38 and 40 feet. Deeper drafts would render the existing vertical barrier screens (VBS) ineffective, or questionable at best. Alternatives 6 and 10 should show ranges of drawdown between 38 and 40 feet, again due to the concern of the existing VBS's. These two alternatives, at this drawdown, can then be considered constant pool alternatives. Alternatives 7 and 11 also indicate drawdowns much greater than 40 feet, and should also be rejected for similar VBS concerns.

The remaining alternatives (13, 14, 17, and 18) should be screened and evaluated as they currently stand using recommended design criteria.

We look forward to working with Study team members and other COE representatives to return mainstem passage corridors to systems that more closely resemble the natural hydrograph.

Sincerely,

John R. Donaldson

John R. Donaldson, PhD
Executive Director

PROPOSED ALTERNATIVE INITIAL SCREENING

Number	Description	Drawdown Level (feet) (Note 3)	WPTT Ranking (Note 1)	Implementation Ranking (Note 2)	Recommendation For Further Study
	VARIABLE POOL — NO POWERHOUSE OPERATION				
1	Existing Spillway Only	28 — 60	9	1	no
2	Modified Spillway Only	38 — 60	6	4	no
3	New Low Level Spillway Only	52 — 76	3	7	no
4	Auxiliary Regulating Outlet (ARO) Only	> 76	1	10	yes
	VARIABLE POOL WITH EXISTING POWERHOUSE				
⑤	Existing Powerhouse with Existing Spillway	28 — 57	9	2	yes
⑥	Existing Powerhouse with Modified Existing Spillway	38 — 60	6	5	yes ?
7	Existing Powerhouse with New Low Level Spillway	52 — 76	2	8	no
8	Existing Powerhouse with ARO	> 76	1	11	no
	VARIABLE POOL WITH MODIFIED POWERHOUSE				
⑨	Modified Powerhouse with Existing Spillway	28 — 57	8	3	yes ?
⑩	Modified Powerhouse with Modified Existing Spillway	38 — 60	5	6	yes ?
11	Modified Powerhouse with New Low Level Spillway	52 — 76	2	9	no
12	Modified Powerhouse with ARO	> 76	1	12	no
	CONSTANT POOL WITH EXISTING POWERHOUSE				
13	Existing Powerhouse with Existing Spillway	33	10	2	yes
14	Existing Powerhouse with Modified Existing Spillway	43	7	5	yes
15	Existing Powerhouse with New Low Level Spillway	57	4	8	yes
16	Existing Powerhouse with ARO	57	4	11	yes
	CONSTANT POOL WITH MODIFIED POWERHOUSE				
17	Modified Powerhouse with Existing Spillway	33	10	3	yes
18	Modified Powerhouse with Modified Existing Spillway	43	7	6	yes
19	Modified Powerhouse with New Low Level Spillway	57	4	9	yes
20	Modified Powerhouse with ARO	57	4	12	yes

Note 1. "1" represents most improved Water Particle Travel Time (WPTT)
Note 2. "1" represents most easily implemented alternative.
Note 3. For reference, a 57 foot drawdown represents an upstream pool at a level equal to the existing spillway crest at Lower Granite Dam.

Don Chapman Consultants, Inc

3180 Airport Way
Boise, Idaho 83706
[illegible]

Washington Branch
[illegible] 168th Ave. NE
Redmond, WA 98052
[illegible]

Ms. Sara Wik
U.S Army Corps of Engineers
Walla Walla District
Bldg. 603
Walla Walla WA 99362

7 April, 1992

Dear Ms. Wik:

I offer the following comments regarding the screening of the twenty alternative facility configurations.

The goal of any new dam configuration should be to impose no greater mortality on either smolts or adults than currently exists, and preferably to decrease net mortality associated with the redesigned structure. This involves balance among several mechanisms affecting mortality including: gas saturation associated with spill, changes in turbine effects, the effectiveness of any new smolt collection/bypass system, changes in juvenile mortality associated with spill passage, and impacts on adult passage in terms of delay of migration and fallback. Collectively, the configurations being considered will create conditions that can influence each of these mechanisms. Any forthcoming detailed biological assessment will have to attempt to quantify effects where possible, or at least characterize risk, as pertains to these mechanisms of mortality. This screening process does not involve that detailed assessment, rather it is a more subjective culling process to limit the scope of considerations.

General Comments:

Of the twenty proposed alternatives, any worth even considering involve major structural/technological changes or additions to adult and/or juvenile passage facilities. I am extremely skeptical about our ability to predict that this new set of proposed technological fixes will actually improve survival through to returning adult. Our experience with designing and constructing fish passage/bypass systems over the last two decades should have taught us that we will not, and probably cannot, get it right the first time, largely because we are not very adept at predicting fish behaviors or the side-effects of our fixes.

Undoubtedly, any new system, such as those contained in the alternatives, will require the same decades-long process of testing, tuning, and reconstruction as we are experiencing with our existing passage facilities. Even now, after more than twenty years, and all our efforts, we still don't even know how effective these systems are, nor specifically how to improve them. Ongoing COE passage research attests to this. Even our most affective systems, the adult passage facilities, are being questioned, examined and re-evaluated, the focus a massive radio-telemetry study. In my view there is considerable risk that new facilities, particularly complex ones as envisioned in the proposed alternatives, may not function as well as the ones currently in place.

My concerns aside, the evaluation process has to proceed and I offer the following comments.

I feel the variable pool alternatives are inherently more uncertain than the constant pool alternatives, because they afford less control over spill discharge patterns and will require complex adult and juvenile passage system designs relative to constant pool alternatives.

The subsequent detailed biological assessments of these alternatives will have to be placed in the context of the overall hydrosystem operations. The broader ecological consequences of the extreme dewatering cycles associated with any of the 20 proposed drawdown alternatives are a critical concern. The proposed operational window for reservoir drawdown may range from 2 to 5 months, April through August. This radical dewatering cycle is bound to alter productivity in the affected reservoirs. Apart from impacts resident fish, juvenile fall chinook and perhaps wild summer chinook that may be rearing in these locales could be at risk. It seems prudent that this issue receive attention early in the evaluation process. This issue may dictate research needs in 1993. For example, the temporal and spatial distribution, as well as food habits of both chinook races would be fundamental information.

I have no comments to offer regarding the proposed facility design criteria submitted by the COE. Specific comments regarding the various individual alternatives follow.

I. Variable Pools - No Powerhouse Operation (alternatives 1-4)

I concur with the COE's recommendation for this class of alternatives, i.e., only the Auxiliary Regulating Outlet (alternative #4) should be considered for further study. Without powerhouse operation, spill passage as required in alternatives 1-3 will create unacceptable gas saturation conditions. Also, the potential for substantial adult delay is pronounced. These alternatives(1-3) offer little in terms of benefits and impose high risk.

II. Variable Pool With Existing Powerhouse (alternatives 5-8)

By providing turbine operation in conjunction with spill under a variable pool, the ability to regulate gas saturation is afforded. The COE indicates that under very low pool conditions (alternatives 7 and 8) existing units will be inoperable, thus these alternatives do not warrant further consideration; I concur. I suggest that either, or both, alternatives 5 and 6 be considered for further study as recommended by the COE.

III. Variable Pool With Modified Powerhouse (alternatives 9-12)

This set of alternatives attempts to improve upon the previous alternatives by replacing existing generators with new devices, such as variable speed units, with the intention of reducing smolt mortality associated with turbine passage. The extent to which smolt mortality can actually be reduced is a critical uncertainty that will no doubt require ample empirical assessment prior to permanently adopting an alternative from this set. I recommend that either, or both, alternatives 9 and 10 be considered for further study.

IV. Constant Pool With Existing Powerhouse (alternatives 13-16)

Constant pool elevation alternatives offer several advantages over those with variable pool: adult ladder exit is simplified, spill patterns important to adult ladder entrance are easier to manipulate, and the juvenile collection and bypass systems are less complex. The COE recommends that all of the alternatives in this set should be studied further. They predict that the turbines will remain operable to the maximum drawdown level of 57 feet. If this is the case then I would concur with their suggestion. If however, existing turbines cannot operate at that head then I suggest only alternatives 13 and 14 receive further study. This years results from the drawdown experiment should provide guidance on this issue.

V. Constant Pool With Modified Powerhouse (alternatives 17-20)

I concur with the COE's suggestion to evaluate all of the alternatives in this category.

Sincerely,

Albert Giorgi

State of Idaho
DEPARTMENT OF WATER RESOURCES
1301 North Orchard Street, Statehouse Mail, Boise, Idaho 83720-9000
Phone: (208) 327-7900 FAX: (208) 327-7866

CECIL D. ANDRUS
GOVERNOR
R. KEITH HIGGINSON
DIRECTOR

March 24, 1992

Ms. Sarah Wik
Department of the Army
Walla Walla District, Corps of Engineers
Walla Walla, Washington 99362-9265

Dear Ms. Wik:

This department has reviewed the list of alternatives developed for the long-term Lower Snake Reservoir Drawdown as well as the proposed design and operation criteria presented in your March 12, 1992 letter and offer the following comments:

1. The objective of any reservoir drawdown in the Lower Snake River is to significantly improve water particle travel time by achieving a flow equivalent of 140 kcfs and thereby shortening the downstream travel time for salmon smolts. Therefore, the most important factor in evaluating the long-term alternatives for implementing the drawdown should be the amount of reduction in water particle travel time afforded by the proposals. Only those which show some promise of approaching the 140 kcfs flow equivalent should merit further consideration. Those which do not should be eliminated. Relative rankings of 1 through 10 really do not help us evaluate the predicted WPTT.

2. Ease of implementation should be treated only as a peripheral factor, not something which drives the decision process. If the proposal does not meet the flow objective it should be rejected, no matter how easy it is to implement.

3. In alternatives 1 through 11, one of the advantages listed is improved water particle travel time. Yet in the section on "unknowns" the affect of increased water particle travel time on juvenile migration is listed. This is very confusing, particularly since the impact of increased WPTT is well known and documented. There cannot be an improved WPTT <u>and</u> an increased WPTT in the same proposal.

4. It is not apparent which alternatives are being considered for which dam. Clearly, some are better suited to certain projects while others may not be implementable at any of them. For example, from the Morrison-Knudsen report we know that a low level outlet providing free-flow conditions is not feasible at Lower Monumental or Ice Harbor but could be appropriate at Lower Granite and Little Goose. Some clarification is needed.

5. According to the descriptions of the alternatives, Alternatives 11 and 12 do not merit further study because of limits to turbine operations. It seems possible that part of the powerhouse modification could be installation of more "fish-friendly" and efficient turbines in place of the existing turbines, and to install them so they can be operated under conditions of a variable pool.

6. In Alternative 3, adverse velocity currents below the spillway can be controlled by means of a downstream weir as suggested in the Morrison-Knudsen report mentioned in #4, above.

7. It is not necessary to modify project structures below the levels of the existing spillways to achieve the equivalent velocities of the CBFWA proposal. These flows can be attained in all except the lowest runoff years by operating the four lower Snake River projects down to the present spillway levels. The high costs of lowering spillway crests, and the fact that they would be needed only rarely to pass flows do not justify the construction costs. Therefore, the modifications in the alternatives here under consideration which allow drawdown levels below the 57 feet to spillway crest at Lower Granite are not warranted and need no longer be studied. Workable revisions to the fish bypass facilities designs should be considered instead.

Thank you for allowing us to comment on the alternatives under consideration. We look forward to further opportunities of working with you.

Sincerely,

Wayne Haas
Administrator
Policy and Planning Division

cc: Andy Brunelle

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
ENVIRONMENTAL & TECHNICAL SERVICES DIVISION
911 NE 11th Avenue - Room 620
PORTLAND, OREGON 97232
503/230-5400 FAX 503/230-5435

June 16, 1992 F/NWO1

MEMORANDUM FOR: Sarah Wik, CRSMA Study Manager
Walla Walla District COE

FROM: Bob Pearce, CRSMA Technical Advisory Group
Member

SUBJECT: Comments on System Configuration Alternatives
and Biological Plan Outline

This memo responds to your request for comments from the Columbia River Salmon Mitigation Analysis Technical Advisory Group (TAG) on (1) the reservoir drawdown and other system configuration alternatives, (2) a list of system improvements to be evaluated under the system configuration study, (3) the draft "Outline of Biological Plan", and (4) a list of tasks to be completed and incorporated into the plan, which were discussed at the May 27, 1992, TAG meeting. Comments are preliminary, due to the abbreviated time available for review. They do not represent a comprehensive listing of NMFS concerns, nor have they been coordinated with other fishery agencies or tribes with expertise in this area. These comments are provided to you at this time, and in this form, in accordance with your request for information in time to go into your presentation to the Northwest Power Planning Council's Drawdown Committee on June 26.

GENERAL COMMENTS:

1. As noted in the CBFWA letter of April 23, 1992, to Greg Graham of your office (copy enclosed), agency and tribal biologists feel strongly about avoiding drawdown alternatives that would require use of unproven technology or involve extended periods of research. In addition there should be strong concerns about alternatives to drawdown such as upstream juvenile collection facilities of a scale much larger than any used before, or a migratory canal or pipeline. Decades of research and development have been required to develop designs of adult and juvenile passage facilities that are moderately successfully. Alternatives that would require extending current criteria or technologies beyond the bounds within which we have a high level of confidence raise concerns. We have no objection to research on such alternatives, provided they are truly promising based on

realistic analysis. However, application of new concepts should be viewed with much caution since they can be expected to create new passage problems which may take decades more to solve. Experience shows every major passage facility, no matter how carefully designed and constructed initially, has required significant iterative modification and evaluation to obtain satisfactory performance. Therefore, alternatives that make use of proven types of fish passage facilities under conditions where they have been proven effective should be considered more acceptable than alternatives that require significant extrapolation of existing technology or development of new technology.

2. To expedite progress the CRSMA study must conclusively narrow down the number of alternatives being considered by the Power Planning Council and their Drawdown Committee as quickly as possible. Mitigation efforts should not be diffused by carrying forward passage concepts that have little or no promise of success. The potential for each alternative should be evaluated based on a realistic understanding of the engineering and biological problems associated with it, and the likelihood of successfully solving those problems in a reasonable time frame.

3. Before the Biological Plan can be developed in much detail, engineering development is needed of all alternatives to lay out the concepts and identify in some detail the types of facilities that are required. The engineering concept development should be guided by a small group of technically knowledgeable people. Review by the full TAG would be most beneficial after concept development has brought to light the advantages and disadvantages and technical problems that would be faced with each alternative.

SPECIFIC COMMENTS ON DRAWDOWN ALTERNATIVES, to supplement comments in previously referenced CBFWA letter of April 23, 1992:

1. Low tailwater elevations affect adult collection systems. Tailwater elevations at Lower Granite, Little Goose, and Lower Monumental, lower than approximately 1.0 foot below minimum operating pool of the next downstream project, and lower than 335 at Ice Harbor can be expected to have major impacts on the collection system effectiveness. Studies need to be done on how the systems might be modified, and what the impacts on passage would be.

2. Low powerhouse discharge in conjunction with high spill will adversely impact effectiveness of adult collection systems. This would tend to preclude alternatives with high spill and little or no powerhouse discharge.

3. Alternatives involving ungated spill through the existing spillway (gates full open) would not allow establishment of adult spill patterns (crowned operation) necessary for effective operation of adult collection systems. This tends to preclude such alternatives from further consideration.

4. Auxiliary regulating outlets (ARO's) proposed with some alternatives would create tailrace conditions unlike conditions at any existing spillway or powerhouse tailraces, raising concerns about whether the existing type of adult collection system would be effective. Also, depending on design/operation of ARO's, there may be potential for adults to be attracted up into the conduits, even though unable to pass completely through them to forebay. Potential would exist for injuries from high velocities. ARO's would have less submergence than conventional draft tubes, making them more available to upstream migrants. Juvenile mortalities that might occur with passage through ARO's are unknown. Also, potential exists for ARO tailrace conditions to be favorable for squawfish. This tends to preclude alternatives that include ARO,s.

5. Powerhouse juvenile bypass systems (JBS's) as currently designed, do not function well below minimum operating pool, and do not function at all at 3'to 4' or more below minimum operating pool. The acceptable range of submergence on collection system orifices to provide acceptable OPE was found to be approximately 4' to 18' from research done for the John Day JBS. This would limit pool fluctuation for a given orifice elevation to approximately 13', considering a 1' drawdown in the gate slot. For greater pool drawdowns, this indicates a separate collection system (orifices and conduit) would be required for each 13' of pool drawdown. The number of separate collection systems that could conceivably be installed would surely be limited by space and structural constraints. Needless to say, such systems would require more complex mechanical systems and operational adjustments. This raises concerns about the feasibility of alternatives that include powerhouse operation through large ranges of forebay elevation, and favors alternatives with relatively constant pool elevation. In any case, engineering and biological studies are needed to evaluate the feasibility of applying current JBS technology to various drawdown situations.

6. Existing JBS designs at the Lower Snake River dams use 70' to 75' high vertical barrier screens (VBS's). Lowering the orifice elevations to accommodate pool drawdowns would reduce the height (and area) of the VBS's correspondingly, and could significantly alter hydraulic conditions in the gate slot and impact orifice passage efficiency (OPE). With drawdown of the pools, complete redesign of the gatewell collection system would probably be required, with associated biological evaluation. Constraints on

VBS area and allowable flow up the slot could preclude development of an effective JBS design for pool drawdowns of more than approximately 40', or even less. The Outline of Biological Plan for Evaluation notes the need to study those design aspects.

7. The much lower forebays associated with several of the drawdown alternatives may result in changes to vertical fish distribution and impacts (possibly reductions) to FGE values. The need to study this concern should be included in the outline.

SPECIFIC COMMENTS ON CONCEPT REPORT - UPSTREAM COLLECTION FACILITY:

1. Page 1 - The design flow of 225,000 cfs could be significantly reduced, since at such high flows collection would not be necessary. The overall size of the screen facility could be reduced. The study should be evaluating an appropriately sized facility.

2. Page 2 - The key features of the design should include a full trashrack to protect the screen mesh and avoid large debris in the fish collection facility. The trashrack would need to be of the type used at the powerhouse intakes, with similar raking/debris handling capability. A trash boom would not adequately protect the facility.

3. Page 4 - Debris would be a major problem at such a facility. There is no experience with such a large facility, but screens for a few thousand cfs in more protected situations have severe debris problems at times. Even with upstream removal of large debris, smaller debris concentrations would be severe in the fish collector/separator, since all the debris in the river larger than 1/8-inch and not removed by the upstream rack would be channeled into that facility. Fish condition would be expected to suffer significantly at times as a result. Current fish separator technology may simply not be functional with such debris loads. Experience at some fish separators during high debris periods has shown this problem. Research would be necessary to determine if adequate separator technology could be developed.

4. Apparently it is proposed that the screen would be designed based upon criteria commonly used for screens that handle up to 3,000 cfs at most. However, with a screen this large, the present criteria for approach velocity, distance between collection entrances, and other design aspects would need to be verified and/or new criteria developed. How fish would behave or survive when subjected to such a long expanse of screen mesh is unknown. The biological evaluation would need to address these

criteria.

5. This alternative should be considered a significant extrapolation of existing technology, and for some components could require developing new technology.

6. Page 9 - It does not appear likely that such a concept could be implemented within 5 to 10 years. It could take much longer.

7. Other major concerns would include:
- Maintaining desired (uniform, minimum, maximum) velocity through screen mesh with changes in river flow, wind-waves, etc.
- Predation potential is significant. The presence of such a large structure would be expected to result in large populations of predator fish in the area, particularly near points of collection.

SPECIFIC COMMENTS ON MIGRATORY CANAL AND PIPELINE:

1. Very few details (even at a conceptual level) have been presented with these basic concepts. That is undoubtedly because very few of the problems that such a facility design would need to address have previously been formulated, let alone solved. The brief presentation at the meeting provided only limited conceptual description of a few aspects of a canal or pipeline. Providing the necessary head, necessary water exchange, and determining an appropriate route are but a few of the engineering problems. Much more information is needed defining the proposed facilities before many specific comments can be made as to the biological plan that would be required for evaluation.

2. Concerning the pipeline concept, the CBFWA letter of January 28, 1992, to Mr. Dick Woodworth (copy attached), commented on a proposal by Mr. Boylan involving a long pipeline for downstream migrants. You are referred to that letter. It reflects several basic concerns about a fish migratory pipeline of the general type proposed at the meeting.

3. One major aspect of the canal concept discussed at the meeting was the probable need for lift mechanisms at several locations along the canal to obtain necessary head for the system to operate. This would be a major component of this concept. The manner as to how this would be done would need to be developed, and biological research done to determine its feasibility, in addition to the elements already noted in the Outline of Biological Plan for Evaluation of Drawdown. I am sure numerous other major problems will come to light if the concept is developed further.

COMMENTS ON LIST OF "SYSTEM IMPROVEMENTS" TO BE EVALUATED UNDER THE SYSTEM CONFIGURATION STUDY:

1. An adult fish passage improvement that should be added for The Dalles Dam is provision of a standby auxiliary attraction water system, to function in the event one or both of the fish water turbines fail. This has received some preliminary discussion between agencies and tribes and the Portland District.

2. The juvenile fish transport facility listed for John Day Dam will require fishery agency and tribal approval.

3. Replacement of temporary wooden miters (with concrete) in the south shore John Day ladder should be postponed until passage problems there are fully solved.

4. A new wet separator at Lower Granite Dam should be added to the list of juvenile facility improvements. In addition to an open channel fish transport flume.

5. We suggest inclusion of evaluations of existing and proposed juvenile bypass outfall sites.

Attachments (2)

[illegible]

DAHO FISH & GAME
REGION 2
1540 Warner Avenue
Lewiston, ID 83501
(208) 743-6502

September 11, 1992

Greg Graham, Study Manager
Corps of Engineers
Walla Walla District
Building 602, City-County Airport
Walla Walla, WA 99362-9265

Dear ~~Mr. Graham~~ Greg:

We have reviewed the preliminary draft of the Technical Report on the Lower Snake Reservoir drawdown. It is obvious that the Walla Walla (CENPW) staff has worked long and diligently to produce such a thorough draft in so few months since TAG formalized the original 20 drawdown alternatives. The draft has been very helpful in visualizing what project modifications would be required for each of the options within the five alternative classifications. However, the Implementation Schedules, even in their incomplete form, would lead readers to an immediate conclusion that the critical salmon stocks would have become extinct long before any of these options could have been authorized, appropriated, and constructed. We can only hope that these initial schedule estimates can be significantly shortened.

Based on two guiding principles; expediting drawdown capability and a desire to work with a minimum number of unproven fish passage technologies, we urge the CENPW to concentrate their efforts on Alternatives 13 and 17 for Lower Granite Dam. It seems obvious that a single project attack offers several advantages:

- Lower Granite adult ladder is already modified to pass fish at a pool elevation of 710 feet, and most likely could be modified to deliver fish to a drawdown depth of 33 feet.
- Modifying Lower Granite initially, and testing reservoir drawdown concept at a single project appears to make sense before an unproven technique is adopted for the remaining three dams and reservoirs.
- The multitude of problems associated with both adult fish attraction

and fishway entrance would be eliminated since the tailwater would not be altered.

- Avoids the need to employ unproven technologies associated with proposed variable pool bypass systems.

- Maximum draft to 33 feet avoids the requirement to modify the existing spillway.

Idaho feels strongly that the only way to effectively measure and scientifically evaluate the reservoir drawdown concept is to draft Lower Granite pool and evaluate it! If it proves effective in reducing juvenile mortality and improving travel time, then the techniques can be adopted downstream at the remaining Snake River dams.

We look forward to working on these alternatives at the future TAG meetings.

Sincerely,

Steve Pettit
Fishery Staff Biologist

SP/en
cc: Sara Wik

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
ENVIRONMENTAL & TECHNICAL SERVICES DIVISION
911 NE 11th Avenue - Room 620
PORTLAND, OREGON 97232
503/230-5400 FAX 503/230-5435

September 15, 1992 F/NWO3

MEMORANDUM FOR: Sarah Wik, TAG Coordinator

FROM: Bob Pearce and Jim Caballos, TAG Members

SUBJECT: Comments on Draft Reports on Lower Snake Reservoir Drawdown, Upstream Collector/Migratory Canal/Pipeline, and Existing System Improvements.

This memo responds to your letters requesting comments on the three draft reports on Lower Snake Reservoir Drawdown, Upstream Collector/Migratory Canal/Pipeline and Existing System Improvements. These comments are not to be construed as final comments on the various configuration alternatives due to the rather limited time available for review, and the preliminary nature of the reports. They do not represent a comprehensive listing of NMFS concerns, nor have they been coordinated with other fishery agencies or tribes with expertise in these areas.

Report on Lower Snake Reservoir Drawdown

1. Comments provided in my 6/16/92 memo to you, both general comments and specific comments on drawdown alternatives, are pertinent to this document. Generally the draft report adequately describes the proposed drawdown alternatives and their potential impacts, subject to the following items.

2. Pertinent Data Sheets: Recommend adding more information about adult passage facilities for Little Goose and Lower Granite dams and brief information on juvenile passage facilities for all four dams.

3. Executive Summary - Evaluations and Additional Required Studies: The need for hydraulic studies of drawdown impacts on FGE are mentioned several times, but no mention is made of the need for important biological studies to define potential impacts, including impacts on FGE and OPE.

Also, the summary should point out the likelihood that adult passage conditions throughout the long construction periods will suffer significant adverse impacts due to specific units or spill bays being out of operation, the presence of cofferdams, temporary passage facilities in lieu of permanent facilities, and other factors. Adult passage disruptions during construction of various alternatives should not be underestimated and may be one of the largest drawbacks to any alternative.

The Executive Summary Recommendations appear generally appropriate as to the alternatives that most likely warrant further study (alternatives 4A and 13/17), based on the information developed to date in the draft report.

4. Page 40, Adult Fishway Criteria: Concerning statement 5, there is need for trapping and monitoring facilities at a new north ladder at Lower Granite Dam, but no apparent need for such facilities at a new Little Goose north ladder.

5. Page 114: The spillway tailwater control structure (drum gates in place of the end sill) was selected for purposes of concept design and cost estimates, but the report recommends that other modifications including adjustable flow deflectors and shallow stilling basins with additional baffles be pursued in later stages of the study. We support that recommendation. However, in addition to studying these alternatives with respect to effect on dissolved gases and energy dissipation, the study should include potential for adverse impacts to adult passage conditions below the spillway and juvenile passage conditions relative to survival through the spillway (especially for a shallow baffled basin). The proposed model studies should be useful in this regard. If the control structure is to be designed to block adult passage, the head differential across the structure would need to be maintained at 10 feet or more.

6. Page 47, Summary: This paragraph notes that "Adult passage will not be ideal during the construction process" for alternative 4A. The potential for adult passage disruptions should be stated more clearly, and for all the alternatives. See second paragraph of comment 3 above.

7. Page 54, Adult Fishway Systems: Again, anticipated adverse construction impacts on adult passage should be noted. This comment also applies to similar paragraphs for the other alternatives.

8. Page 62, Unknowns and Future Studies: The potential for effects on JBS performance should be noted, including vertical distribution and intake hydraulic conditions affecting FGE, and OPE. This comment applies to similar paragraphs for the other alternatives also.

Report on Upstream Collector/Migratory Canal/Pipeline

1. The draft has very little discussion of biological concerns and uncertainties as yet incorporated into it. There is very limited information provided, and thus the following comments are limited. These comments are not intended to indicate modifications that would, if included in the report, make the alternatives feasible. They are provided to assist you only in completing the report. Comments provided to you in my 6/16/92 memo, both general comments and specific comments on these alternatives, are pertinent to this document. These alternatives continue to raise many concerns and serious doubts about their feasibility, especially when biological considerations are considered in addition to engineering considerations. The collector component of these alternatives would require extending current criteria and technology beyond the bounds within which we have a high level of confidence.

The migratory canal and pipeline components of the alternatives would be attempts to develop new technology, involving many years of research. Based on experience at existing and past juvenile bypass systems, alternatives involving pressure pipelines would not be acceptable. This report should provide the basis for recommending the migratory canal/pipeline alternatives be dropped from any further consideration.

2. Third page of the Executive Summary, Uncertainties and Research Required: The use of the word "---some---" falls far short of adequately describing the research needed to determine the most effective INEL floating conduit design. Numerous difficult problems are anticipated, such as development of a pumping method not injurious to fish, impacts of pressure changes, water quality, predation potential between salmonids, etc. Also, "Some---" does not adequately describe the uncertainty about the overall success of these canal/pipe alternatives. The summary should be written to more accurately describe the unknowns and concerns.

3. The Executive Summary and the Design Criteria on page 10 state that 75 degrees F would be the maximum water temperature. Maximum temperature criterion for juvenile salmonids would need to be much lower, probably less than 70 degrees F, based on collection/transport experience at McNary Dam.

4. Page 7, Upstream Collector: The draft does not provide much additional information on the upstream collection facility beyond that reviewed earlier and commented on in my 6/16/92 memo. The second paragraph does state that debris collection would be accomplished primarily by the floating boom or raked off the screens and dumped downstream, with the captured smolts passed

into a fish lift or lock and lifted to the canal. This reflects an unrealistic understanding of the debris problem that would occur with such a facility. Screens of this type require an upstream trashrack. Most of the smaller debris reaching the screen face then could be expected to be channeled into the fish collection area (rather than sticking on the screen mesh as stated in the draft), where it would cause major problems for fish sorting and holding. Research would be needed to determine if sorting and holding facilities could be developed that would function under such a debris loading.

Alternative guidance systems that would use acoustics, light or other non-obstructive devices are discussed briefly on pages 8 and 13, noting they would not collect 100 percent of the smolts. These devices should not be considered. Despite years of study, there is no information that indicates such devices could be developed to be a feasible option within a reasonable time frame.

5. Page 10, Design Criteria: The water flow requirements (fish density), water quality requirements, resting area requirements, and the (minimal) use of pressure pipe are noted as being preliminary criteria, but the lack of sound technical basis for such criteria should be stressed more.

6. Page 13, first paragraph: The alternative of collectors in the Snake and Clearwater rivers above Lewiston would for any conceivable plan require major dam structures to create reservoir velocity conditions to allow screening. This requirement, and the associated implications for adult passage, should be stated.

7. Page 14, Sorting Facilities: This discussion totally ignores the major problem of debris accumulation that would occur in such a collection facility and how it would impact sorting facilities. See comment 4 above. Also, it is not possible to eliminate non-salmonid species from the canal by a sorting facility of the type developed to date that is based on physical size.

8. Page 14, Lift Facilities: The mechanical lift system appears even more complex and damaging to fish than the hopper system used at Little Goose collection facility during the late 1970's to load trucks. The hopper system was unacceptable and was replaced with gravity loading.

9. Figures 2 and 3, Conceptual Plan for INEL Pipe Passage: The concept shown includes a downwell and pressure pipe system of the type that is no longer considered acceptable design.

10. Page 57 and Figure 4: The time requirements given for design/research/construction are grossly underestimated.

Report on Existing System Improvements Design & Operation Plan

The document does a good job of identifying in general terms needed improvements and providing a basis for evaluating their technical feasibility. Much detail is also included, which we will review in a more comprehensive manner when the document is finalized and coordination begins with fishery agencies and tribes to more fully develop plans for these improvements.

Page 2-3, Item 3: Relative to Little Goose Dam, all but Unit 1 orifices are partially or fully submerged.

________, Item 6: Excess water from the Lower Monumental primary dewatering structure is piped to the north shore fishway to provide auxiliary attraction for upstream migrants.

Page 2-4, Item 9(c): Bulkhead slot orifices at Lower Granite Dam have 10-inch diameter orifices. Note other major difference; the Lower Granite project is unique in that it has upstream fish screen slots. These slots are equipped with 8-inch orifices.

Page 2-5, top para.: You might note that stated 70% collection is only for spring migrants.

________, Item 4, last sentence: You should note that tagged wild fish losses include over-winter mortality. Studies are not similar unless both groups are tagged the previous summer/fall.

Page 2-8, Item c(1): Type - Tanker truck hauling capacity should be 1,750 pounds, not 1,705.

Page 3-1, Improvements to Fish Hatcheries: Consideration should be given to providing pathogen-free water supplies for egg incubation and early rearing. This could substantially improve fish health and quality.

Page 3-2, The agencies and tribes have requested modifications to allow direct-loading into barge compartments to eliminate the need for subjecting collected fish to the stresses of loading from raceways.

The new wet separator design for use at Lower Monumental will become the "standard" if evaluation results indicate better size separation efficiency and less delay.

Page 3-2, Item a: Consideration should be given to reducing fish ladder water temperature by simply using existing air bubbler systems at ladder exits to raise cooler water to the surface.

Page 4-5, Additional Containment Facilities: This discussion notes that at many hatcheries, there is limited room and water supply for expansion. Consideration could be given to off-site long term acclimation ponds, in addition to additional hatcheries mentioned. However, it should be noted that at this time, it is not known whether NMFS will support new hatcheries in the Snake River Basin.

Page 4-10, Assumption 3: Suggest you talk with Tom Poe, U.S. Fish and Wildlife Service, relative to spacing of flume drop gates. We understand squawfish react quite rapidly to changes in operations and spacing them 100 feet apart may be too close. Random timing for operation of drop gates should be considered.

_________, Assumption 4: Only small fish, predominantly yearling salmon, are bypassed. Therefore, steelhead would be held for transport.

Page 4-14, 4(b)2: same comment as above.

Page 4-15, Item 3, last sentence: It has been shown that much less than 100% of the fish are being guided with the extended screens.

Page 4-18, Item b(1): Given ESA and the occasional observance of fry in April, we recommend 0.4 fps velocity, since that is our updated screening criterion.

Page 4-20, Item c: Now that 100% sampling occurs in the summer, a direct line from the sample holding tank for truck loading would be necessary in case water temperatures are too high for sample processing.

Page 4-21, Item 5(b): Direct-barge loading may negate/reduce the need for increasing raceway capacity.

Page 4-24, Net Pens: There is enough evidence given here to recommend dropping this concept from further study as a long haul transport vehicle.

Page 4-28, Barge Water Temperature Control: Perhaps simply adding the capability to lower/raise a water intake pipes 5-10 feet would afford access to cooler water.

cc: F/NWC1
FPAC

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Office of Columbia River Coordinator
9317 Highway 99, Suite A
Vancouver, Washington 98665

September 17, 1992

Ms. Sarah Wik
U. S. Army Corps of Engineers
Walla Walla District Office
Bldg. 602, City-County Airport
Walla Walla, Washington 99362-9265

Subject: Comments on Draft Lower Snake River Drawdown, Existing System Improvements and the Upstream Collector/Migratory Canal/Pipeline Reports

Dear Ms. Wik:

I have reviewed the subject report and forward the following comments. These comments are not meant to be inclusive, and they have not been coordinated with any other agencies or Fish and Wildlife Service offices.

Snake River Drawdown

1. Executive summary. Biological studies to help identify impacts on fish guidance efficiency (FGE) and orifice passage need to be included, along with the hydraulic studies that are mentioned.

   Due to the protracted construction periods, there will be impacts to adult passage. These impacts need to be pointed out here.

2. Page 47, summary. This paragraph states impacts to adult passage will occur during the construction phase of alternative 4A. As per the above, adult fish passage impacts need to be clearly stated.

3. Page 54, Adult Fishway Systems. Same comment as above.

4. Page 62, Unknowns and Future Studies. Impacts on the existing juvenile bypass system (JBS) need to be added. Concern about vertical distribution, water velocities, FGE changes and other hydraulic conditions should be mentioned.

Upstream Collector/Migratory Canal/Pipeline

1. The biological uncertainties are not addressed. Again, attempting to develop this new technology and have it benefit the species of concern in a relatively short time period is very doubtful.

   As I mentioned at the TAG meeting in July, extending existing screening criteria, assuming we know enough about fish behavior in a 400 mile long tube and attempting to recreate a stream suitable for anadromous fish needs are not reasonable or prudent.

Existing System Improvements

1. Page 3-1, Improvements to Fish Hatcheries. Due to concerns over fish health and fish quality, the inclusion of providing disease free water supplies for egg and early rearing should be considered.

   Consideration should also be given to modifying the water supply at Dworshak National Fish Hatchery (NFH) to allow water temperature control for the production facilities.

2. Page 3-2. The tribes and agencies have recommended direct loading in barges. This would eliminate or reduce handling and loading stresses experienced by fish in the existing facility configuration.

3. Page 4-24, Net Pens. This idea should be dropped from consideration as a long-haul possibility due to existing information.

Thank you for the opportunity to comment on this draft document. If you have any questions please call me at (206) 695-7888.

Sincerely,

Craig A. Tuss
Acting Columbia River Coordinator

cc: John Grettenberger, OFO, Olympia, WA
Frank Young, ODFW, Portland, OR
Steve Pettit, IDFG, Lewiston, ID
FPA[illegible]

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