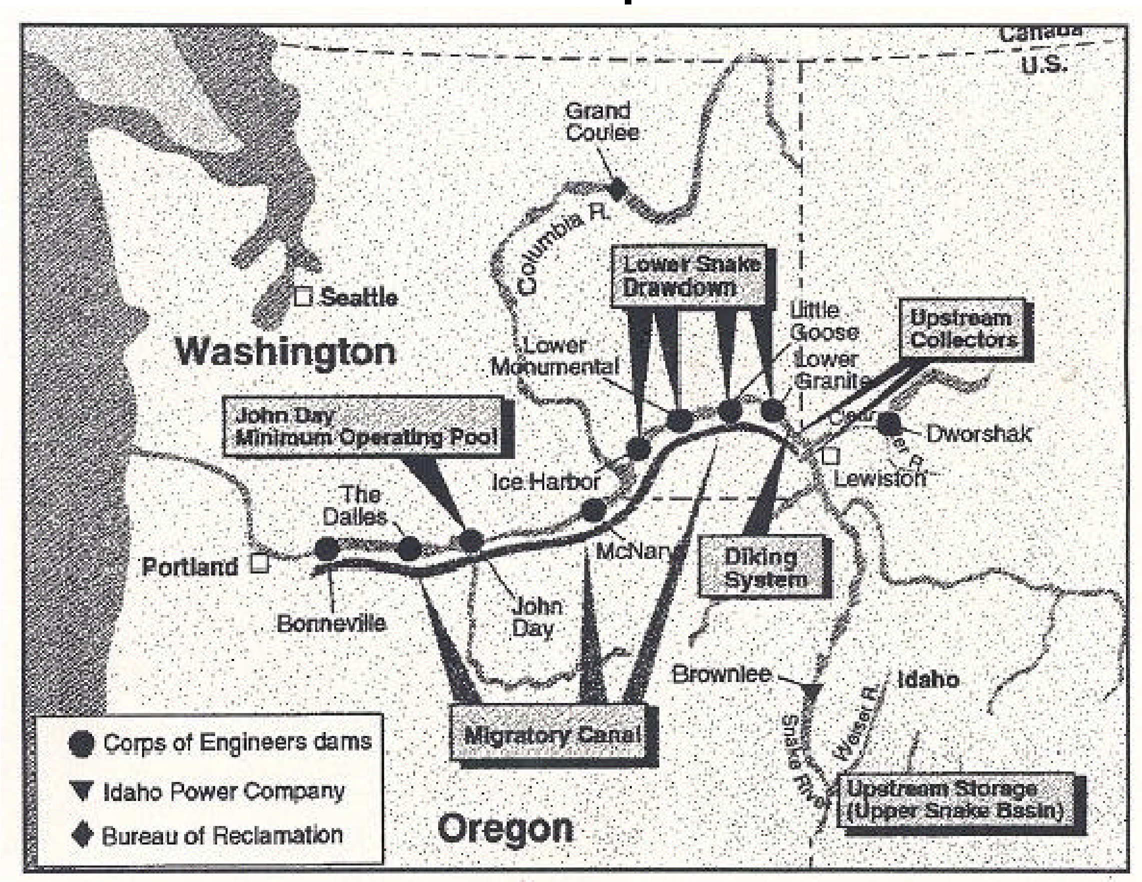
US Army Corps
of Engineers®
Walla Walla District

Columbia River Salmon Mitigation Analysis
System Configuration Study
Phase I

Main Report



Prepared in Response to
Northwest Power Planning Council
Columbia Fish and Wildlife Program

March 1994
DRAFT

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Section 1 - Introduction

1.01. General

The genesis of the System Configuration Study (SCS) was in response to the Northwest Power Planning Council's (NPPC) *Fish and Wildlife Program Amendments (Phase Two),* issued in December 1991. The SSCS is assessing various possible alternatives for improving conditions for anadromous fish migration through the eight mainstem projects of the lower Columbia and Snake Rivers. The study is being conducted in two phases. Phase I is a reconnaissance-level assessment of the various alternatives. The alternatives that display the most potential for benefiting anadromous fish will be carried into Phase II, where detailed studies will be conducted and a plan of action will be identified.

Phase I provides a preliminary assessment of the costs, environmental opportunities, economic effects, and implementation schedules associated with the various alternatives under study. This preliminary report has been submitted to the U.S. Army Corps of Engineers (Corps) in Washington D.C., various state and Federal agencies, NPPC, and other regional interests for review and comment. A decision to continue these studies will be based on recommendations made by the Corps, as well as input received from regional interests. The more detailed Phase II studies and resulting report may be used for Congressional authorization and subsequent funding for the implementation of those specific alternatives that have received regional and Federal support. A general discussion of the major steps of the Corps study, review, and authorization process is provided in Section 1.06.

In November 1992, an interim report on SCS was distributed in the region. That report provided a status on the Phase I studies, and met the reporting date established by NPPC. This draft report represents the culmination of the Phase I process, subject to regional review.

The Phase I draft report consists of this main document and following appendixes:

A. Lower Snake River Drawdown Technical Report.

B. John Day Operation at Minimum Operating - Technical Report.

C. Additional Snake River Storage - Technical Report.

D. Anadromous Fish Collection and Conveyance - Technical Report.

E. System Improvements Technical Report - Snake River and McNary.

F. System Improvements Technical Report - Lower Columbia River.

G. Biological Plan - Lower Snake River Drawdown.

1.02. Authority

The SCS is an element of the Columbia River Salmon Mitigation Analysis (CRSMA). The System Configuration component of the CRSMA 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 74-409, dated August 30, 1935. For the John Day and The Dalles Projects, the authority is the Rivers and Harbors Act of 1950, Public Law 81-516, dated May 17, 1950. For all other projects, the authority is the Rivers and Harbors Act of 1945, Public Law 79-14, dated March 2, 1945.

1.03. The Corps of Engineers Involvement in Salmon Recovery

The Columbia River Juvenile Fish Mitigation Program provides mitigation for the impact that Corps dams have had on migrating juvenile salmon and steelhead. This program includes construction of new or improved facilities for protecting and bypassing juvenile fish at the eight mainstem dams. Additional mitigation measures are being considered as a result of NPPC's regional efforts for rebuilding upriver salmon stocks, and the National Marine Fisheries Service (NMFS) listing of Snake River salmon as threatened/endangered. The Mitigation Analysis began in 1991, and will provide a regionally-coordinated scope for Corps of Engineers actions in the furtherance of both regional and NMFS recovery plans.

The Corps has four primary functions in assisting regional efforts to rebuild Columbia River salmon populations: 1) providing river operations at the dams and reservoirs to minimize adverse effects on adult and juvenile fish passage through the system; 2) operating the juvenile fish transportation program; 3) constructing and operating improved facilities for juvenile and adult passage at Columbia and Snake River dams (*e.g.*, powerhouse fish screens and juvenile bypasses); and 4) providing the region with technical and engineering information relating to hydrosystem operational and structural options. The CRSMA and SCS are efforts to provide the best available scientific and technical information on regionally-proposed measures for hydrosystem passage improvements. The Corps' Fish Passage Development and Evaluation Program (FPDEP) is another area where the Corps is providing engineering and technical assistance to the regional effort.

1.04. Purpose of the SCS.

There are many factors affecting the decline of the anadromous fishery within the Columbia River Basin. These factors include: 1) overharvesting; 2) loss of habitat; 3) hatchery operation; and 4) migration-related problems associated with dams and reservoirs and other human-related problems (water quality, irrigation, urbanization, *etc.*). These factors are discussed further in Section 3.04. The purpose of Phase I is to screen structural measures that can increase the survival of juvenile and adult anadromous fish as they migrate through the eight Federal projects on the lower Snake and lower Columbia Rivers, while still allowing for the continued operation of Federal and non-Federal facilities on the projects. The SCS Phase I defines and evaluates potential long-term actions for further development in the more detailed Phase II studies. The Phase I study addresses the following objectives:

- Identify and define alternatives to improve the survival of juvenile and adult anadromous fish through the lower Snake and Columbia Rivers, from the confluence of the Snake and Clearwater Rivers to below Bonneville Dam.

- Compare the impacts, costs, and biological benefits of the various alternatives.

- Meet the November 1992 target date for interim measures established by NPPC (Phase I Interim Report).

- Provide information for the Columbia River System Operation Review (SOR) draft Environmental Impact Statement (EIS).

- Develop a document that can be presented to the various agencies and the region for review and comment. However, the Corps will have the final approval of this document, in consultation with the region.

1.05. Scope of the SCS.

a. Study Area.

The SCS addresses potential modifications to both Federal and non-Federal facilities on the lower Snake and lower Columbia Rivers (see figure 1-1). This area extends from the upper end of the Lower Granite reservoir (above Lewiston, Idaho, and Clarkston, Washington) to the estuary below Bonneville Dam (near Portland, Oregon). Sites in the Snake River Basin above Lewiston and Clarkston will be evaluated for potential flow augmentation storage (reservoirs) and juvenile salmon collection. Hatchery facilities above Lewiston and Clarkston are also evaluated for possible improvements.

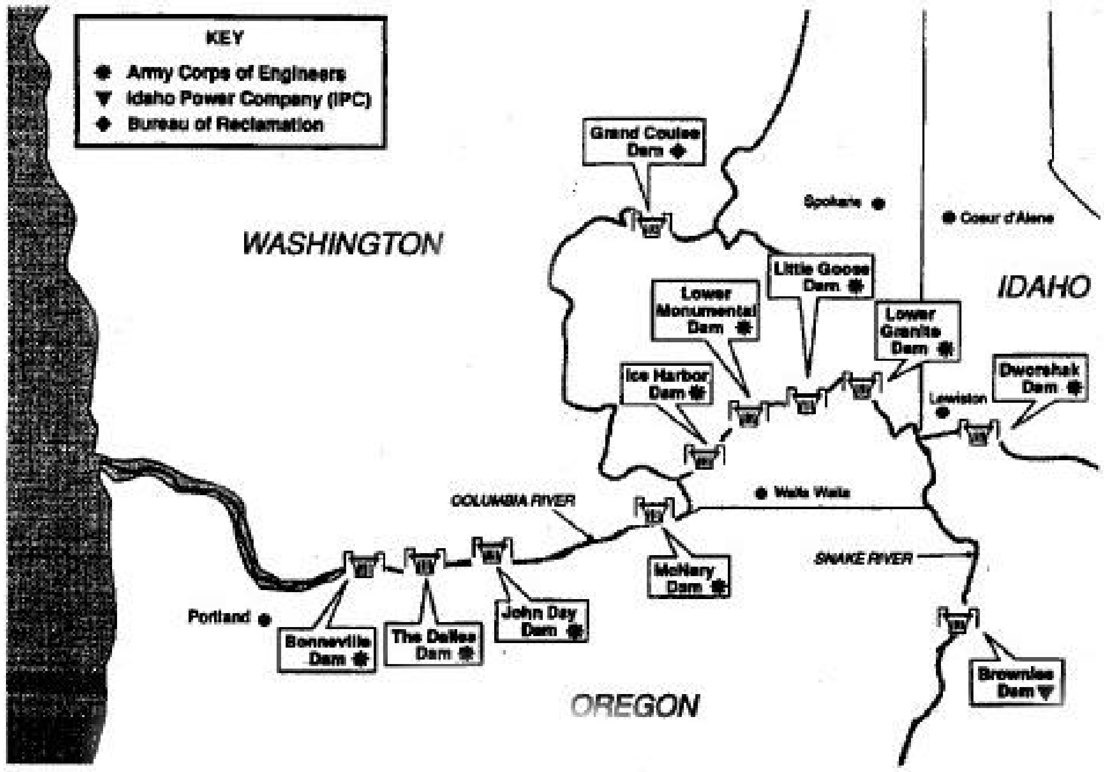

Figure 1-1. Study Area

b. Level of Detail.

The level of detail for most analyses was reconnaissance-level, unless otherwise noted. Appraisal- (sub-reconnaissance) and feasibility- (post-reconnaissance) level analyses were conducted for some alternatives, based on the levels of available information and the uniqueness of any particular alternative.

c. Types of Studies.

The Phase I study focused on the engineering aspects (particularly design and cost estimates) of constructing the various alternatives, as well as their continued operation. Also, analysis of the impacts to fisheries (anadromous and resident), and other aquatic and terrestrial ecology resources and habitats were conducted to estimate potential positive and negative impacts of the design, construction, and operation of each alternative. Impacts to economic and cultural resources were also assessed, and potential mitigation opportunities were identified. In cases where there is not enough time to fully evaluate impacts and mitigation opportunities, significant potential problems were identified for future study. Reservoir operation/regulation, and biological effectiveness studies were also performed. Hydropower, and other economic effects, were evaluated. Cost effectiveness in producing anadromous fish outputs was the measure of economic performance.

d. Biological Drawdown Test.

On April 6, 1993, the National Marine Fisheries Service and the Corps announced their plan to study the potential for conducting a biological drawdown test on the lower Snake River. The objective of such a test is to gather scientific data to help in deciding whether drawdown operation of lower Snake River reservoirs is an effective means of increasing juvenile salmon survival. Provided an appropriate test can be designed and useful information gained at acceptable cost, National Marine Fisheries Service and the Corps consider biological testing of drawdown an essential element in evaluating the use of drawdown. Drawdown testing is an integral part of the SCS and, if carried out, will support the evaluation of drawdown in the SCS Phase II studies.

In 1992, the Corps conducted a 1-month, two-reservoir drawdown test to gather information on the physical effects of drawdown. This test was conducted in March, since few fish are migrating during that period, to minimize the impacts of a drawdown on anadromous fish migration. The next step is a drawdown test when salmon are present, so that biological effects can be measured.

Currently, the two agencies are working with regional experts to design a test. The timing, duration, location, and type of test is dependent on a number of factors. One is the need for sufficient baseline data against which to measure test results. To effectively measure whether survival of juveniles through the system improves during a drawdown, biologists would first need to determine juvenile survival under normal operating conditions. The National Marine Fisheries Service researchers are presently conducting field studies to measure the survival of juvenile salmon in the lower Snake River. Survival data acquired in the 1993 pilot phase of the research, as well as in 1994 and future years, could have a significant bearing on the design and viability of biological drawdown tests under consideration.

Other factors that are critical to decisions regarding test implementation include engineering and biological effectiveness in providing juvenile passage during the tests, costs, and other environmental effects. The Corps and National Marine Fisheries Service are preparing an Environmental Impact Statement (EIS) concerning the biological test options. A draft EIS is expected to be distributed for public review in April 1994.

1.06. Other Related Studies and Processes

This paragraph contains brief descriptions of related programs and studies that focus specifically on the coordinated Columbia River System.

a. Columbia River SOR.

The Columbia River SOR is a study undertaken jointly by the Corps, Bonneville Power Administration (BPA), and the United States Bureau of Reclamation (BOR). It is a comprehensive study intended to coordinate the long-term operation of Federal water resource projects in the Columbia River Basin. Within the Corps, project management is led by North Pacific Division, with technical assignments designated to the Walla Walla, Portland, and Seattle Districts. Cooperating agencies include NMFS, the United States Fish and Wildlife Service (USFWS), the National Park Service, and the United States Forest Service (USFS). One of the key goals of the SOR is to establish guidelines for the agencies to follow in operating the coordinated Columbia River System. The SOR takes into account impacts on all river users, including anadromous fish, power, recreation, resident fish, irrigation, and navigation. It will also provide National Environmental Protection Act (NEPA) documentation to review the Pacific Northwest Coordination Agreement and the Canadian Entitlement Allocation Agreements. The Pacific Northwest Coordination Agreement is a contract that sets the terms for coordinated operation of the river system for power production, while the Canadian Entitlement Allocation Agreements provide for United States utilities to deliver a certain amount of energy to Canada as a result of the Columbia River Treaty.

The SCS is related to the SOR, but is a separate study. The SCS is evaluating physical or configuration modifications to the Federal hydropower system, while the SOR is investigating potential operational changes to the same system. Some of the operational changes being investigated under the SOR would require physical modifications of existing projects (dams, *etc.* and/or new construction. These changes are addressed in the SCS. Therefore, SCS studies have been coordinated with the SOR.

The SOR is scheduled to release a draft EIS in mid-1994. Preliminary operational and impact analyses of lower Snake River and John Day Reservoir drawdown alternatives conducted in the SOR -provide some of the analysis reflected in the SCS. Hydroregulation studies, environmental impacts and economic effects are areas of united analysis between the SOR and the SCS. Drawdown effects on anadromous fish survival is a key area of common analysis. Some of the anadromous fish evaluations are continuing in the SOR, most notably the analysis of the effects of the juvenile fish transportation program and its relationship to river operation alternatives to improve juvenile survival.

b. The NPPC Fish and Wildlife Program.

The NPPC, made up of representatives from the States of Idaho, Montana, Oregon, and Washington, was entrusted (under the Northwest Power Act of 1980) to perform the following tasks: 1) develop a conservation and electric power plan that will ensure an adequate, efficient, economical, and reliable power supply for the Pacific Northwest; 2) prepare a program to protect, mitigate, and enhance fish and wildlife (including related spawning grounds and habitat) that are affected by the development and operation of hydroelectric projects on the Columbia River and its tributaries; and 3) involve the public in these activities.

In 1992, NPPC issued a comprehensive Columbia River Basin Fish and Wildlife Program addressing salmon and steelhead production, safe passage, and harvest management; resident fish and wildlife protection; future hydroelectric development; and coordination among Federal agencies with responsibility for Columbia River Basin resources. It has since been amended several times, most recently in 1991 to 1993. The first three phases of that series of amendments are known as the *Strategy for Salmon*, and address production and habitat measures for salmon and steelhead stocks, mainstem survival, harvest, rebuilding schedules, and biological objectives. The final phase addresses protection of resident fish and wildlife.

Many of the measures in the *Strategy for Salmon* recommendations are incorporated into the annual operating plans, as well as in the SCS and the Columbia River SOR evaluations.

c. Endangered Species Act (ESA) Recovery Plan.

While programs to improve the status of Snake River salmon have been ongoing for decades, the filing of formal petitions with NMFS in 1990 for ESA listing of three stocks as threatened or endangered focused regional attention on the need for more aggressive action addressing the precarious status of specific wild salmon stocks. Outgrowths of the petition filing included the Salmon Summit, the beginning of NPPC's amendments to rebuild salmon stocks, and several Corps studies to improve dam operations. The formal listings of Snake River sockeye in December 1991, and Snake River spring/summer and fall Chinook in May 1992 triggered the initiation of the NMFS recovery plan and Federal agency consultation on the effects of actions, including the operation of the coordinated Columbia River System, on listed salmon. Under the ESA, the Corps and cooperating agencies have a responsibility to ensure that their actions do not jeopardize the continued existence of the listed species.

Ultimately, a recovery plan will guide all activities that might affect salmon restoration and recovery. A recovery team has been established, and has developed draft Recovery Plan recommendations. These recommendations will assist NMFS in preparing a Recovery Plan. The Recovery Plan will provide guidance on policies and actions for restoring listed Snake River salmon stocks.

d. The BOR-Led Storage Study.

In response to the Salmon Summit and NPPC's amendment for its Fish and Wildlife Program, BOR is facilitating an interagency inventory and analysis of additional potential storage sites in the Snake River Basin. These additional storage sites were evaluated for use to augment or improve flows for anadromous fish, or refill lower Snake River projects following drawdown, particularly during their downstream migration period. The study participants include representatives from BOR, the Corps, BPA, and the various involved states. Potential storage sites will be evaluated by the Corps and BOR, depending on prior involvement. The final report from BOR was submitted to NPPC in February 1994.

e. John Day Advanced Planning and Design (AP&D).

The Corps has initiated studies for the John Day operation at minimum operating pool(MOP) concurrent with Phase I SCS studies, in response to the region (NPPC) and legislative direction. The scope of work includes studies to further evaluate and quantify environmental and user impacts, address mitigation alternatives, develop mitigation plans, and design mitigation measures for the impacted users in anticipation of a decision to implement. The scope also includes biological studies intended to address some of the uncertainties with regard to the biological effects of the proposal and, with completion of a smolt monitoring facility at the project, to obtain baseline flow/survival data prior to potential implementation. The projected date to complete a draft decision document and EIS is 1996. With a positive decision to implement, MOP operation could begin in 1999.

f. Extended Screens at John Day.

Provision of extended-length screens for the John Day juvenile bypass system is an improvement measure being evaluated in the Phase I SCS studies. Congress provided separate funding for this measure. Concurrent with the Phase ISCS, the Corps is in the process of developing a scope of work and initiating studies and key activities (*e.g.*, hydraulic modeling).

1.07. Corps Study, Review, and Authorization Process.

a. General.

Projects developed by the Corps are studied, reviewed, authorized, funded, and implemented in accordance with a process defined by Federal law, Corps regulations, and the Department of the Army. The following paragraphs are intended to provide an overview of the Corps study, review, and authorization process used for the SCS. An understanding of this process by external interests is important to the overall success of the coordination of the study with regional interests.

As discussed earlier, the SCS is currently in Phase I of a two-phase study process. The Phase I findings result in a recommendation that selected alternatives warrant additional, more detailed study during Phase II. This report will be submitted to Corps Headquarters, other state and Federal agencies, NPPC, and other regional interests for review and comment.

b. Phase I Report--Preliminary Studies.

The objective of the Phase I report is to provide sufficient information to determine whether or not a study should proceed to the more detailed Phase II study. Study findings are presented in this report.

A draft plan of study for Phase II studies was prepared as part of the Phase I activities. This plan of study provides an outline of alternatives, tasks, schedules, and costs for the completion of feasibility-level analysis, evaluations, and alternative comparisons.

The final Phase I report will be transmitted to Corps Headquarters for review and approval. The NPPC and other regional interests will have an opportunity to review and comment on the draft Phase I report prior to final approval by the Corps. A review conference will be held to ensure that the report is consistent with current policies and budgetary priorities of both the agency and the regional interests; as well as to discuss concerns from Corps Headquarters and the region regarding issues, formulation, and evaluation of alternatives. The conference will also attempt to establish procedures for the resolution of outstanding issues.

c. Recommendations.

A decision to continue studies will be based on regional support and recommendations developed by the Corps, with input from the region. Following regional review of the draft Phase I report, decisions on which alternatives warrant more detailed analysis in Phase II will be presented as recommendations in the final Phase I report. The more detailed Phase II report will be used for Congressional authorization and subsequent funding for the implementation of those specific alternatives that have received regional and Federal support. A general discussion of the major steps of the Corps study, review, and authorization process is provided below.

d. Phase II--Detailed Studies.

The Phase II study will result in the completion of a report that is consistent with the plan of study. The Phase II report will accomplish the following:

- Provide a complete presentation of study results and findings, including a summary evaluation of alternatives developed in Phase I, so that readers can reach independent conclusions regarding the reasonableness of the recommendations.

- Provide compliance with applicable statutes, executive orders, and policies.

- Provide a sound and documented basis for both Federal and regional decision makers to judge the recommended solution(s).

A Project Management Plan will also be prepared during the Phase II study. It will provide the scope, schedule, budgets, and technical performance requirements for implementation of the alternatives recommended for implementation in the Phase II report.

e. Preauthorization Engineering and Design.

Engineering and design work on the recommended plans can generally commence prior to actual construction authorization. These activities are intended to accomplish detailed design work for the proposed plans, as well as any special studies or additional research that needs to be completed prior to the initiation of construction. All specific preauthorization engineering and design tasks are presented in the management plan completed as part of the detailed studies in Phase II.

Section 2 - Agency Coordination And Public Involvement

2.01. Oversight and Coordination

a. Columbia-Snake River Drawdown Committee

Studies of the operation and configuration of the lower Snake River projects and the John Day Dam (on the Columbia River) are being monitored and overseen by the Columbia-Snake River Drawdown Committee. The committee is specifically charged with oversight of studies that examine the long-term drawdown of these projects during the downstream migration of juvenile salmon and steelhead.

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; BOR; the states of Idaho, Oregon, Washington, and Montana; the Columbia River Inter-Tribal Fish Commission; and the Shoshone-Bannock tribe. 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 committee's specific responsibilities include the following: 1) identify roles and responsibilities; 2) review activities relevant to Snake/Columbia River drawdown; 3) identify various drawdown strategies; 4) identify design/operational objectives; and 5) explore biological parameters to recover salmon stocks.

The BPA, in coordination with the committee, funded an independent technical contractor (HARZA) to review the adequacy of analyses conducted by the Federal agencies, as well as to conduct their own analyses when deemed appropriate by the committee or the chair. The Corps has worked very closely with HARZA in its SCS evaluations.

b. The Technical Advisory Group (TAG)

The assessment of biological impacts and the effectiveness of alternative measures studied as part of the SCS are conducted under the full collaboration of the TAG.

The TAG is a group of technical experts representing regional fish agencies and tribes, river operating agencies, user groups, conservation groups, and other interested parties. It was formed in the spring of 1991 to develop plans for the 1992 Lower Snake reservoir physical drawdown test. This group has continued to meet, since the completion of the March drawdown test, to address issues related to the SCS.

The TAG is responsible for the following: 1) developing and reviewing criteria for each alternative being considered by the Corps in the SCS; 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 NPPC's Fish and Wildlife Program Amendments; 4) development of the scope of the Biological Plan for the Lower Snake reservoir drawdown; and 5) providing guidance and review during the completion of the Biological Plan. Input from the TAG is provided to NPPC's Drawdown Committee, as well as to the Corps.

The 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 commented on various drafts of this document.

2.02. Public Involvement

The study plans, progress, and alternatives reflect a sustained interaction with regional interest groups and the general public. The alternatives chosen for study stem from discussions at the Salmon Summit, NPPC's *Strategy for Salmon,* and ideas from members of the public and various interest groups. Publications, media coverage, and public meetings have involved a broad representation of the public in study activities. In a series of meetings held throughout the region in July 1992, the public expressed concerns about potential costs of system configuration changes, equitable sharing of economic sacrifices necessary to improve salmon survival, the importance of determining, with reasonable levels of uncertainty, the biological benefits associated with the various alternatives under study, and other items.

In November 1992, an Interim Status Report was released for public review, and briefed to NPPC. This report provided preliminary information of (to date) from the SCS. The report also responded to the target date for a report on interim plans for the drawdown of the lower Snake River and John Day projects, as established by NPPC's *Strategy for Salmon*.

This draft SCS Phase I report is also being distributed for public review and comments. Comments received during this review were considered in completing the final Phase I report, which is scheduled for release in the summer of 1994. During the review of the draft SCS Phase I report, another series of Public Information Meetings will be held, in cooperation with NPPC. The purpose of these meetings is to present the results of the draft SCS Phase I evaluation, and to get public input. The exact dates and locations have not yet been determined. An announcement will be distributed that will identify these dates and locations.

In addition to the draft SCS Phase I report, a draft EIS for the Biological Drawdown Test will be distributed for public review. This draft EIS is scheduled for distribution in April 1994. During this review period, a series of public hearings will be conducted. In an effort to reduce the number of regional meetings, these hearings will be combined with the SCS Phase I public meetings.

Section 3 - Problems, Issues, and Uncertainties

3.01. Overview

The NMFS has listed the Snake River sockeye salmon as endangered, and the spring/summer and fall Chinook as threatened species under the Federal Endangered Species Act (ESA). These actions are the culmination, to date, of a historical decline in wild salmon stocks in the Columbia/Snake River system.

There are many factors, some natural and some human-caused, that have contributed to the listing of these salmon stocks. This study only addresses one of these factors, the modification of the natural river by eight Federal run-of-river dams and reservoirs on the Columbia and Snake Rivers.

This system of dams and reservoirs has provided many benefits to the region, including power, commercial navigation, irrigation, water quality, recreation, and resident fish and wildlife. However, the projects also have lowered the velocity at which the water flows through the impounded reaches of the river system. This slower water velocity has increased the time it takes juvenile salmon to migrate from their freshwater spawning grounds to the saltwater of the Pacific Ocean. Some believe the longer migration time may affect salmon survival by increasing their chances of being eaten by predators. It may also interfere with the natural physical changes required for them to adapt from freshwater to saltwater, thus reducing their instinct to migrate and decreasing their survival.

3.02. Life History of the Pacific Salmon

An understanding of the unique life cycle of the Pacific salmon helps to explain why the river flows and hydropower dams along the Columbia and Snake Rivers play such a critical role in salmon survival. Salmon are anadromous fish. They spawn in freshwater, rear in freshwater streams and rivers, migrate downstream to the estuary, enter the ocean, grow to maturity in the ocean, and return to freshwater to reproduce and die (see figure 3-1). This movement from freshwater to saltwater historically followed the natural flow patterns of their spawning and rearing waters before human development altered that flow pattern. Most species spawn in late fall when flows are at their lowest or are rising, increasing the change that eggs are always covered with water. The eggs typically hatch in December or January. The hatchlings, called alevins, live for a month or more on nutrients stored in their yolk sac. Once the sac is absorbed, the young fish (called fry) must find and capture food to survive. Alevins typically develop into fry during the spring thaw when the first hatch of aquatic insects occurs, thus providing a ready source of food. As the waters and temperatures become warmer, more and different kinds of invertebrate food sources become available, and the fry grow rapidly.

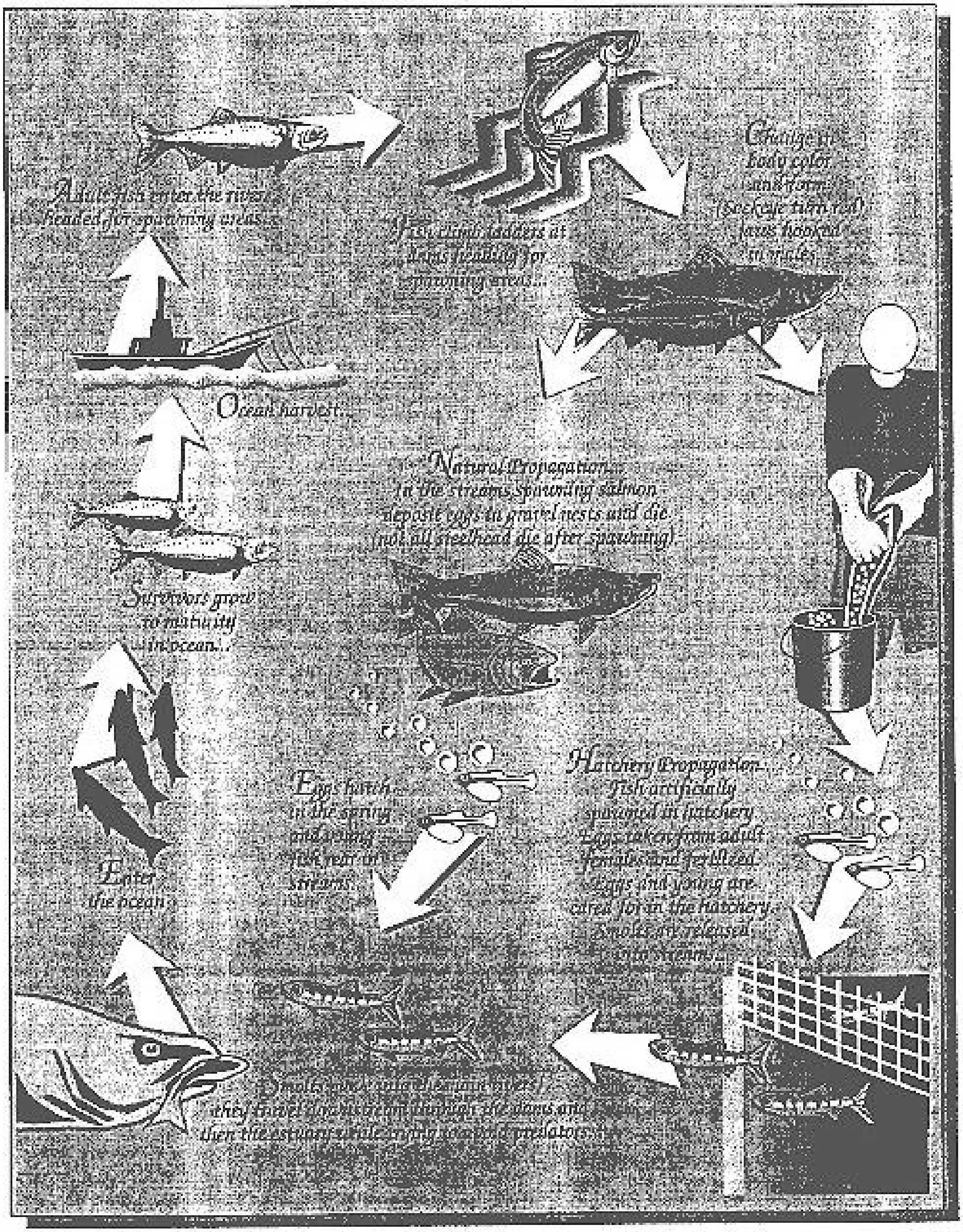

Figure 3-1. Anadromous Fish Life Cycle

Depending on the species and stock, fry will spend as little as a month to over a year in the stream of their birth. Sometime during their first or second spring season, the fry begin a biochemical change, called smoltification, that triggers the urge to migrate. Smoltification is the change that adapts the body from a freshwater to a saltwater environment. The young salmon, now called smolts, move down the river from tributaries, migrating mainly during the spring and summer when natural water flows would normally be at their highest (see figure 3-2). Smolts are moved along by the flow of the river, and must reach the ocean before the physiological capability of surviving in saltwater ceases. An understanding of the unique life cycle of the Pacific salmon helps to explain why the river flows and hydropower dams along the Columbia and Snake Rivers play such a critical role in salmon survival [Options Analysis/Environmental Impact Statement (OA/EIS, 1992)].

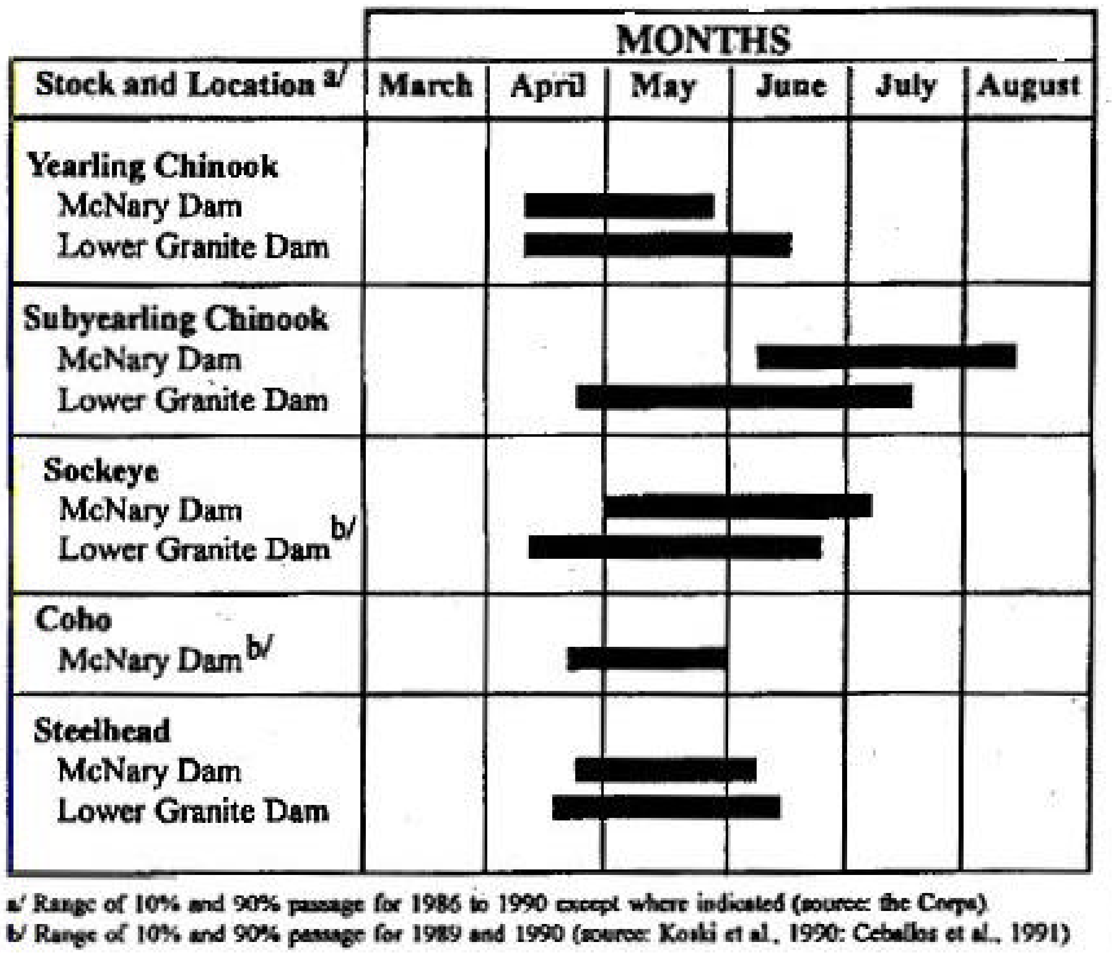

Figure 3-2. Peak Periods of Downstream Migration of Juvenile Salmonid Smolts

The ocean provides the food resources required for salmon to grow to maturity (6 to 60 pounds). These fish may spend as little as 1 year, or as much as 5 years in the ocean before they become sexually mature and being their return to freshwater (figure 3-3). They must undergo physiological changes in order to return to freshwater. Most return to the same stream where they were hatched. It is believed that they do this by being able to distinguish minute differences in the chemical composition of the water of different streams. In order to make this trip upstream, fish need bypass facilities (fish ladders) to get up and around the dams on the rivers and back to their spawning grounds. Here they spawn and die, producing a new generation in the same waters that gave them life.

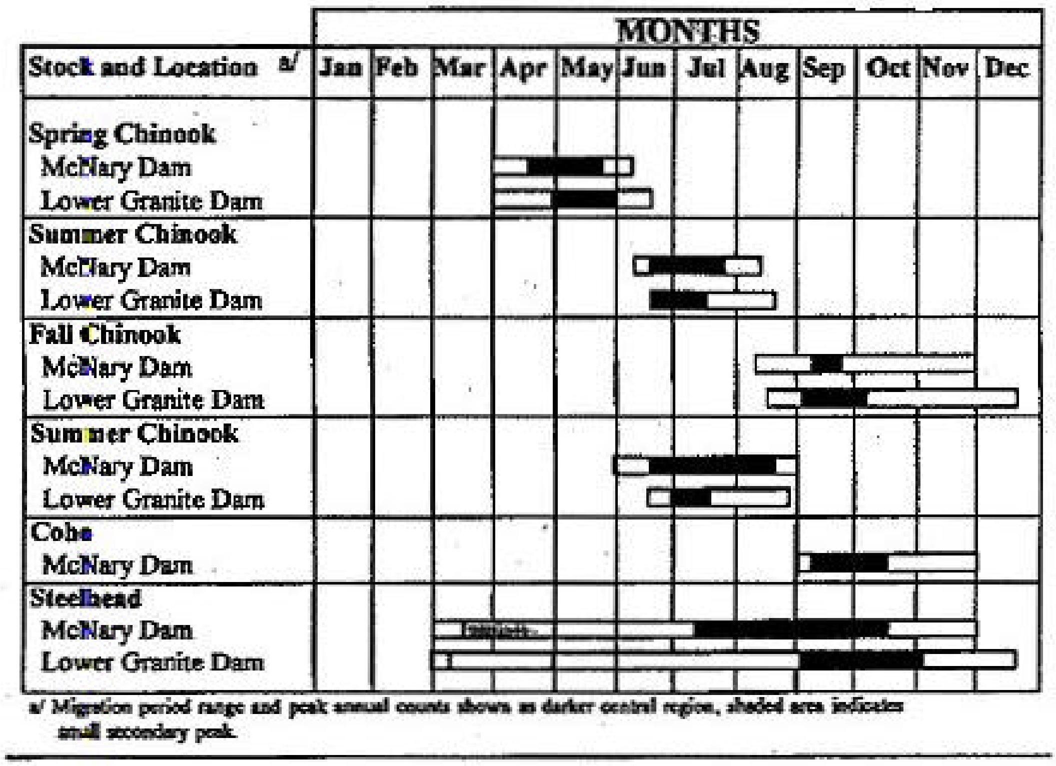

Figure 3-3. Adult Salmonid Main Upstream Migration Periods

This complex, unique life cycle, as well as their significant commercial value, make the Pacific salmon highly vulnerable to the actions of modern human activity. Changes in water quality caused by agricultural, municipal, industrial, and mining actions; overharvest; the diversion of the Columbia/Snake River system all have contributed to the decline of Pacific salmon (OA/EIS, 1992; Draft Recovery Plan, 1993).

3.03. Status of Pacific Salmon.

The population decline of adult fish returning from the ocean to their freshwater spawning grounds paralleled the development of dams, irrigation diversion, livestock grazing, mining, municipal and industrial development, and over-fishing of the salmon and steelhead runs. Before these developments in the Columbia Basin, up to 16 million wild salmon and steelhead are estimated to have returned to the Columbia and Snake Rivers to spawn in streams where they were born. By 1938, when Bonneville Dam was completed, this number had fallen to 5 to 6 million, mainly as a result of over-fishing and the effects of upstream activities that blocked spawning access or degraded habitat. Today the total run is typically about 2.5 million, including known fish harvested in the ocean. About 0.5 million of these are wild fish. Figures 3-4, 3-5, and 3-6 show recent declines for Snake River salmon stocks.

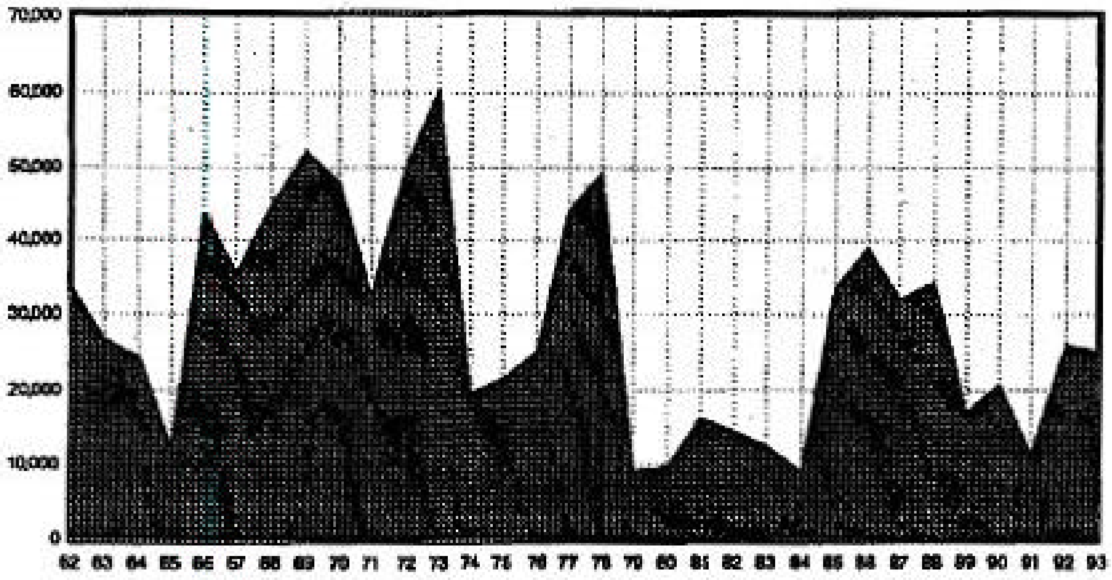

Figure 3-4. Fall Chinook Adult Returns to Ice Harbor Dam

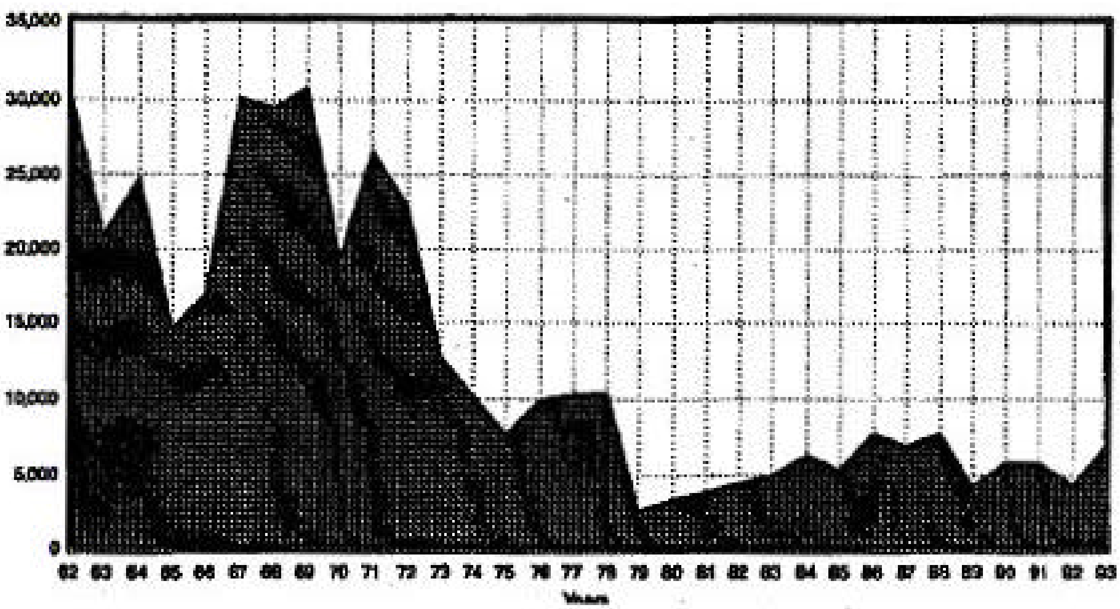

Figure 3-5. Spring Chinook Adult Returns to Ice Harbor Dam

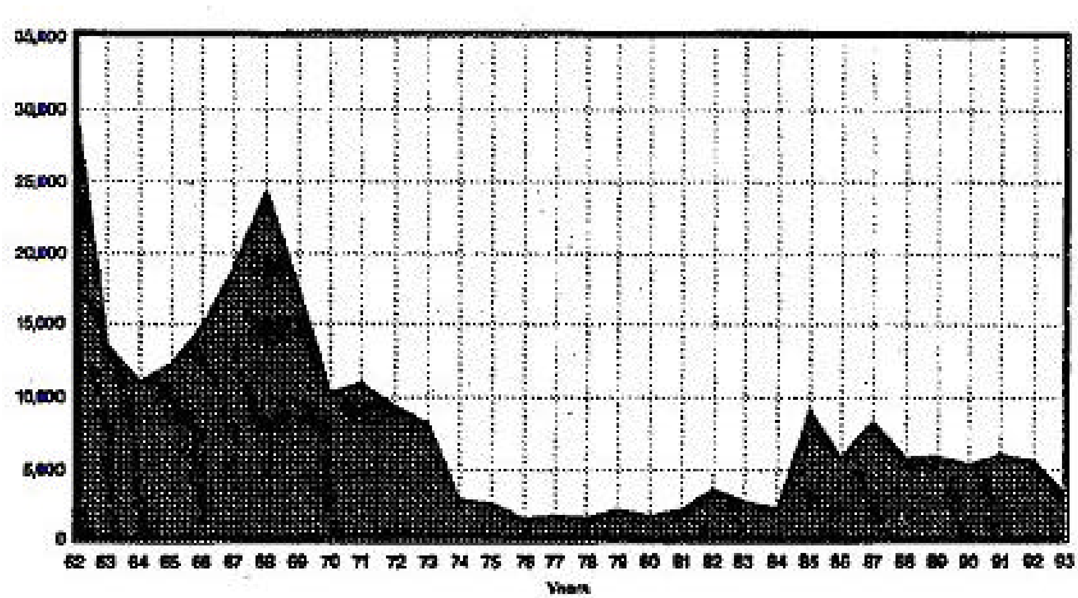

Figure 3-6. Spring Chinook Adult Returns to Ice Harbor Dam

While programs to improve the status of Columbia and Snake River salmon have been ongoing for decades, the filing of formal petitions with NMFS in 1990 for ESA listing of three Snake River stocks as threatened or endangered focused regional attention on the need for more aggressive action to address the precarious status of specific wild salmon stocks. Outgrowths of the petition filing included the Salmon Summit, the beginning of NPPC's amendments to rebuild salmon stocks, several Corps studies to improve dam operations, and joint studies with other Federal entities to evaluate long-term operational strategies. The formal listings of sockeye salmon as endangered in December 1991, and of spring/summer and fall Chinook salmon as threatened in May 1992, triggered the initiation of a NMFS recovery plan and Federal agency consultation of the effects of actions, including the operation of the coordinated Columbia River System, on listed salmon.

Ultimately, the NMFS recovery plan will guide all aspects of activities that might affect salmon restoration and recovery. A recovery team was established and has recently (October 1993) released a draft recovery plan for regional review. A final recovery plan will direct rebuilding efforts. In the interim, the Corps, along with cooperating Federal agencies, continues to consul on operations of the Federal Columbia River Power System, and continues to move quickly to work with the region on evaluating alternatives. The 1992 OA/EIS, the 1993 Supplemental EIS (SEIS), the Biological Drawdown Test EIS, the action responses to NMFS' Biological Opinions, the SCS, the SOR, and continued upgrade and improvements to existing mainstem hydroelectric projects through the Columbia River Juvenile Fish Mitigation Program, the CRSMA, and the Project Improvements for Endangered Species are some of the major programs underway within the Corps and other involved Federal, state, tribal, and regional parties.

3.04. Factors Affecting Decline.

Several recent documents review the history of factors associated with the decline of the anadromous fishery. For further detail to the general overview provided below, the reader is directed to the following documents: *Saving the Salmon: A History of the U.S. Army Corps of Engineers' Role in the Protection of Anadromous Fish on the Columbia and Snake Rivers* (Mighetto and Ebel, 1994); *Draft Snake River Salmon Recovery Plan Recommendations*, Section II., Background, 1993; OA/EIS, 1992; and the Columbia River Basin Fish and Wildlife Program, Appendix D (*Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin*), NPPC, 1986.

The NPPC (1986) estimated that average annual salmon runs before development of the basin (1850 is used to characterize pre-development) range from about 10 to 16 million fish. Today's average run size is about 2.5million fish, resulting in a net basin loss of about 7 to 14 million fish. Four general categories are used to encompass the range of factors associated with the decline of the anadromous fishery in the Columbia River Basin. These factors are harvest, habitat, hatcheries, and hydropower.

Harvest declines were obvious as early as the late 1800's. Biologists observed significant reductions in salmon in the Columbia River and its tributaries by the 1890's. In 1894, the Oregon Fish and Game Protector warned that Chinook populations were threatened with annihilation (Mighetto and Ebel, 1994). Fishwheels (large dipnets kept in constant motion by river currents) scooped fish from the river into storage bins. Many of these were used by canneries to catch as much as 70,000 pounds of fish in a single day (Mighetto and Ebel, 1994). Conservation measures included the elimination of these devices by 1934, and closures of fishing seasons and restrictions on certain types of fishing gear in the late 1800's. However, poor enforcement and limited funds were ineffective in stopping the salmon run declines (Mighetto and Ebel, 1934).

Habitat losses have been significant since pre-development times. Salmon and steelhead require clean, cool water; suitable gravel for spawning and egg incubation; and an ample supply of food and space for rearing (NPPC, 1986). The NPPC document estimates a 31-percent habitat loss in stream habitat prior to 1850. Habitat losses in the Columbia River above Bonneville Dam are estimated at about 35 percent since 1850. Below Bonneville Dam, habitat losses are estimated to be about 15 percent. Habitat has been degraded by forest and farming (irrigation and grazing) practices, mining, waste disposal, and water resource development. By 1900, mining had become significant in the Pacific Northwest states. By 1925, land devoted to agriculture, irrigation, and logging had increased dramatically (NPPC, 1986). For example, agricultural and mining developments in the early 1900's on the Weiser and Powder River systems resulted in significant habitat damage (siltation) or complete loss.

Logging practices, particularly in the Willamette River drainage, resulted in the sedimentation of spawning areas, the blockage of migration by log and log debris dams, and the degradation of water quality. Logging was extensive by 1925 in the lower river (NPPC, 1986). Agricultural impacts, primarily due to irrigation practices, have affected many subbasins, particularly within the Snake River system, which has had nearly twice as much water diverted for irrigation than any other area. Nearly half the total water diverted in the Columbia River Basin is in the Snake River area (NPPC, 1986).

Hatcheries were constructed to compensate for habitat loss or to mitigate for mortalities associated with the hydropower system development. Fishery management practices at the time of hatchery program development assumed that providing additional production would help to rebuild (or replace) the runs lost to the hydroelectric system. What was not understood at the time was the impact this program would have on natural populations. Problems associated with the hatchery programs include genetic impacts from stock transfers or supplementation efforts (adding hatchery fish to natural/wild areas), interaction with natural populations leading to competition for resources and habitat during stream or mainstem passage, possible interactions in the estuary and near-shore ocean life stage, and possible disease interactions. The hatchery compensation and mitigation programs (for Chinook) have not restored adult populations to levels present prior to large hydroelectric project development (Draft Recovery Plan Recommendations, 1983).

Dams and reservoirs associated with hydropower have substantially reduced the abundance of salmon in the Columbia River Basin. Direct impacts are due to blockage or alteration (inundation, sedimentation, or change in water quality or temperature)of habitat, and as a barrier (either complete blockage, or a delay in passage) to juvenile or adult migration. Major spawning areas were lost in the upper Snake River Basin with the completion of the Hells Canyon complex. Over 95 percent of the fall Chinook used habitat upstream from the Hells Canyon Dam site [Irving and Bjornn (1981) in NPPC (1986)]. On the Columbia River, construction of the Grand Coulee and Chief Joseph Dams blocked off large areas that had supported salmonid runs. More than 55 percent of the Columbia River Basin accessible to salmon and steelhead before 1939 (when Grand Coulee Dam was build) has been blocked by large dams (NPPC, 1986).

Another impact facing salmonid stocks is the change in natural flow runoff. When spring flows are stored in large headwater reservoirs for use during low flow periods, salmon migrations are affected (NPPC, 1986). The speed of migrations is slowed in slackwater reservoirs. 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 are typically quoted. No study has measured travel time for the complete river stretch, either prior to or following dam construction. Under existing flow improvement measures, an average travel time of 17 to 21 days was estimated for Snake River spring Chinook between the head of the Lower Granite reservoir to below Bonneville Dam. Fall Chinook travel time is estimated to be 49 and 57 days, based on the 50-year average and critical water years, respectively. These fish move more slowly through the reservoir system because they spend time feeding and growing within the reservoir.

Other river passage hazards include turbine mortalities, if fish pass through operating projects rather than being collected by mechanical guidance systems that avoid turbine passage (see discussion in section 4.05.b.); collection and bypass system mortality; gas supersaturation associated with water spilled over spillways; and predation on juvenile migrants moving downstream by squawfish, smallmouth bass, channel catfish, and other resident fish.

The NPPC(1986) estimates that total loss due to all causes (hydropower, fishing, logging, mining, irrigation, grazing, and urbanization) is about 10 million fish (range: 7 to 14 million). Although difficult to quantify, these estimates have been developed to provide a reasonable range (NPPC, 1986). About 8 million of this loss is attributable to hydropower development, with half of the loss due to blockage associated with Grand Coulee and Hells Canyon Dams, and the remaining half attributable to other mainstem projects (Draft Recovery Plan, 1993).

3.05. Issues and Uncertainties.

The listing of Snake River wild spring/summer and fall Chinook, and sockeye salmon, raised the consciousness of the region to the current status of salmon and the ecosystem in which they live. In effect, the ESA listings emphasized the general decline in the overall quality or health of the natural system (due to man's development of that system) that often is first reflected in the loss of water quality, watershed quality, riparian quality, and impacts on the fish and wildlife populations that rely on the natural health of the system to survive.

Several issues and uncertainties are at the forefront of decision-making that affect water resource management, and how best to optimize the hydroelectric system to meet the multiple-use demands (most with competing interests) that were the justification for the very projects now headlined as the major contributor to the salmon declines. The multi-use purposes; navigation, flood control, irrigation, power, and recreation; were the initial uses authorized to construct the Columbia River hydropower system. "Equal consideration" of conservation and enhancement of fish and wildlife, together with water development objectives, has directed the Corps' planning even before the 1958 amendment to the Fish and Wildlife Coordination Act required such consideration (Mighetto and Ebel, 1994). Many of the issues and uncertainties relate to biological parameters associated with anadromous fish. These and other areas are discussed in the preceding paragraphs.

a. Flow/Survival Relationship.

Considerable debate exists within the scientific community over the relationship of flow (water velocity) and fish survival. Some regional biologists believe fish survival is directly tied to the level of flow available during their downstream migration. Others believe that, above a certain threshold flow, additional benefit is not gained in fish survival. Other factors, such as the level of smoltification (the physiological change that transforms a fish's system to adapt from freshwater to saltwater) is believed to play a major role in the success of fish moving downstream, independent of flow.

The issue of quantifying the effects of lowering reservoir pools on smolt survival still remains. There are very little data on the survival of smolts. Although potential benefits seem apparent, data and analyses to support these benefits are few.

If it is assumed that the rate of juvenile salmonid travel is directly related to water velocity, improving flow conditions would increase the survival of juvenile salmon. Increased water velocity, as measured by water travel time through the reservoirs, would presumably translate into reduced travel time for migrating smolts. However, it is not clear that increasing water particle travel time alone would recreate the productivity levels of earlier times (Draft Recovery Team, 1993) because other factors (*i.e.*, smoltification, water quality, turbidity, predation, water temperature, and fish condition) are also at play and have significantly changed from conditions existing in the 1970's when the flow and travel time research was conducted (OA/EIS, 1992). For further information, the reader is directed to the OA/EIS of 1992, section 4, or the recent review by Cade (*et al.,* 1993) for NPPC, which details much of the information surrounding this debate and refers the reader to published literature for further information.

The belief that increasing the velocity of water as it flows through the reservoirs would increase survival of juvenile migrants led to the concept of drawing down the reservoirs to increase the water velocity and reduce the time that juveniles spend in the reservoir. It has also continued the debate as to the merits of in-river passage versus collection of downstream migrating juveniles for transport by barge to below Bonneville Dam.

b. Transportation Versus In-River Migration.

The question of the efficiency of the transportation program as a method of enhancing salmon survival, at least as an interim measure until better alternatives re researched, is a second major issue; and is heatedly debated within the region. A description of the program can be found in section 4.06. A review of the research conducted to evaluate the relative survival of transported versus non-transported fish generally shows that survival is improved for transported fish. Of 28 tests conducted, 13 indicated significant changes in survival. Of these, 12 were positive, but 1 (a truck test) was negative for transported versus non-transported fish. In another 10 tests, improved survival was measurable positive, but not statistically significant (OA/EIS, 1992). The most recent research, conducted in 1986 and 1989, indicated a positive transport benefit for spring/summer Chinook salmon and steelhead (60 percent and 150 percent more fish returned if transported than if left in-river).

Despite the significant data set available, and the scrutiny that this program has had, concern remains over the benefits of transporting fish. One concern is that survival of transported fish is not as high as would be expected, if in fact transported fish avoid known mortality factors of river passage. Critics believe that the assumptions used in determining transport benefits are flawed. They believe that differential mortality may be affecting transported fish either prior to collection, or following release from the transport barges. Some of these critics have attempted to establish survival rates for in-river migrants, as compared to the number of returning adults. If the assumption of "fixed" transport survival (no change in survival of transported fish regardless of flow conditions and those effects of fish prior to transport) versus "flow-related" transport survival (some reduction in transport survival based on fish condition due to in-river travel up to the time of collection for transport) is considered, then the real benefit (if any) could be addressed. This discussion is currently under review in the various models and modeling activities underway within the region, primarily for the SOR.

c. Spill/Dissolved Gas.

A third issues is the use of spilled water to pass juvenile salmon and steelhead past the dams, and its effectiveness in improving in-river survival. The regional state agencies and tribes believe that spill provides a safe and efficient passage route for juvenile fish. A spill agreement was adopted in 1989, as a temporary measure, until permanent fish bypass facilities could be installed. This agreement provided a specific amount of water to be passed over the spillways of four dams in the spring to protect juvenile fish from passage through the turbines. However, the issue of dissolved gas supersaturation, and its impact on both juvenile and adult fish, is contested by various regional interests.

Spilled water traps atmospheric air deep into the water of the plunge pool, where increased hydrostatic pressure dissolves the air into the water. At depth, this dissolved gas is supersaturated. The gas will either come out of solution and equilibrate with atmospheric conditions, or form bubbles. If these bubbles form within the tissue of aquatic organisms, they can injure or kill the organism. Gas levels can successively increase downstream as water is passed over successive dams. State and Federal water quality standards of 110 percent are often exceeded when spill at run-of-river dams on the lower Snake and Columbia Rivers causes high levels of total dissolved gas (TDG). There is considerable controversy over what level of TDG is acceptable, and there is disagreement on the interpretation of extensive data that appear to justify the existing 100-percent standard. Controversy also extends to the potential impact that some of the reservoir drawdown options could have from increased spilling and levels of dissolved gas supersaturation. Drawdown options causing major spill could produce gas levels shown to be lethal to fish over extended river reaches. These options could result in increased net mortality within the system, and negate any benefits that might accrue from reduced water travel time. While this consequence is uncertain, the possibility of major losses of fish must be weighed carefully when evaluating options.

d. Wild Versus Hatchery Fish.

Prior to 1968, nearly all returning Snake River Basin adults were of natural origin. Since then, adult returns have been comprised of ever-increasing numbers of hatchery-reared progeny. The tremendous increase in hatchery production may be contributing to the decline of natural Snake River stocks. Little is actual known about the interaction and competition between hatchery and wild stocks, or how wild stocks respond to major regional programs such as transportation. There is also concern over how flow augmentation efforts, such as the Water Budget, have been and should be used to maximize in-river conditions for wild stocks, rather than for the bulk of the migration (if comprised primarily of hatchery stocks). Major concern focuses on the apparent poorer survival of the hatchery stocks, and the return of the investment in the expansive hatchery program that was instituted to replace fish losses associated with the lower Snake River projects through the Lower Snake River Fish and Wildlife Compensation Plan.

As perhaps an indicator of the concern for the wild versus hatchery issue, the Draft Recovery Plan discusses specific concerns related to hatchery management to avoid inhibiting recovery of natural stocks. These include specific concerns about the geometric increases in numbers of smolts over recent decades, and the decreasing quality of hatchery-produced smolts (Draft Recovery Plan, 1993). The draft plan proposes several areas for improvement (see section VI., *Improving Freshwater Production of Chinook Salmon*).

e. Estuary and Ocean Unknowns.

The estuary (the zone in which saltwater mixes with freshwater, due to the tides) environment has been impacted with modern day development, including construction of mainstem dams, dredging and filling for navigational improvements, rapid growth in human population, overfishing, and irrigation and industrial growth. Water quality degradation, due to irrigation and industrial return flow; and changes in flow regulation due to dam construction and operation, altered salinity regimes, and decreased sediment transport; have changed the estuary environment (Weitkamp, 1993). The lack of historical data, both physical and biological, prior to the changes associated with man's activities, limits the capability to evaluate resulting biological changes that affect fish survival as fish pass from freshwater into saltwater.

Changes in water quality and other factors that have occurred may affect the growth rates and health of anadromous fish in the estuary, particularly for fall Chinook, which have longer residence times in the estuary. The NMFS found that juvenile coho, yearling Chinook, and steelhead move through the estuary at approximately the same rate as they migrate downstream. Fall Chinook may slow to about 70 percent of their riverine migration rate, but generally pass through the estuary within 6 days (Dawley *et al.*, 1986). Since most juvenile salmon spend little time in the estuary, and general migrate directly through to the ocean, the estuary may not be a critical factor in survival success. However, for fall Chinook, feeding and rearing conditions may be factors, as well as predatory/prey interactions.

The impact of timing of arrival of both in-river migrants and releases of large numbers of transported fish to within 140 miles of the estuary is an area of uncertainty on how the estuary ecosystem responds to this influx of fish. Prior to dam construction and flow regulation, the majority of all fish arrived at the estuary within a relatively short duration, timed to high runoff flows. Following dam construction, travel time of in-river migrants more than doubled, with later arrival to the estuary. With transportation, arrival to below Bonneville Dam is a scheduled event and, following barge release, fish travel to the estuary within 48 to 72 hours after release (Shreck and Congleton, 1993). Competition of these transported fish, and in-river migrants, for resources and life history needs within the estuary are not well defined, nor is the timing of arrival, as related to survival.

The ocean environment, in which salmon may reside for as long as 5 years, is not well studied in terms of the conditions necessary (*i.e.*, period of entry and food availability) to support salmon survival. The impact of El Niño, for example (Draft Recovery Plan Recommendations, 1993), is known to have an extreme effect on productivity and changes in prey and predator species distribution. Near-shore and ocean ecological and interrelated natural factors may affect West Coast salmon runs outside those factors influencing the freshwater life-cycle stage. The migration patterns, food habits, and the impacts of predators and competitors in the marine community are all areas of limited knowledge. Studies by Pearcy (1992) and others suggest that smolt availability to predators, rather than alternative prey (*e.g.*, Pacific herring), is influenced by high coastal upwelling and dispersal. The Draft Recovery Plan cites work by Pearcy and other marine investigators (Lichatowich, 1993; and Ware and Thompson, 1991) that suggest that oceanic conditions and various components of marine ecosystems can have profound effects on the growth and survival of salmon and, therefore, on the ultimate return of adults to their rivers of origin.

f. Effects of Mortality Above the Reservoirs.

Factors outside the dam and reservoirs may have significant effects on downstream migrating smolt survival prior to fish ever arriving at these projects. For example, mortality of Chinook and steelhead in 1989 from the Crooked River to the head of Lower Granite pool (about 120 miles) was 60 and 47 percent, respectively (Kierfer and Forster, 1990a). A similar study in 1988 showed 63- and 85-percent mortality for spring Chinook and steelhead from the upper Salmon River to the head of Lower Granite Pool (about 420 miles). Recent studies by NMFS and USFWS with wild/natural and hatchery spring Chinook in the upper Snake River system showed low survival to Lower Granite Dam (mortality prior to reservoir was not separated out). In these studies, approximately 6 percent of the wild/natural fish (range: 4.5 to 7.8 percent) were recovered at Lower Granite; 31 percent and 8 percent of hatchery fish (Dworshak National Fish Hatchery and Sawtooth State Fish Hatchery, respectively) were recovered at Lower Granite. Poor overwintering success, due to extended drought years, is one probable cause for the poor survival of wild stocks. Competition with, and impacts due to, the high numbers of hatchery-released fish within the migratory corridor may also account for losses to wild fish. For hatchery fish, poor transition from the hatchery environment to the riverine system, inability to compete and/or adapt to the river system, disease condition, and general fish vitality, may account for the poor survival even within the free-flowing riverine stretches. Recent work by NMFS (1993)in the Lower Granite pool showed almost no mortality to marked spring Chinook released at Nisqually John and recaptured at Lower Granite Dam (about 16 miles of the 30-mile reservoir). Data suggests that significant losses are occurring to both hatchery and wild stocks prior to entry into reservoirs.

g. Survival Model Limitations.

Models can be useful tools in helping managers and decision-makers evaluate relative benefits or differences among options or alternatives when actual biological data is limited. However, models are based upon assumptions put into mathematical format. If the assumptions of the data used to develop the parameters for input cannot be validated, or have a large range of uncertainty associated with them, any resulting analyses will have commensurate confidence around the model estimate.

The regional interests have developed several models that are currently used to aid reconnaissance-level studies. The CRiSP, version 1.4 (developed by BPA and the University of Washington), and PAM (developed by NPPC) are juvenile passage models used to model juvenile downstream travel times and survival rates. The CRiSP model differs from PAM an several ways, and is in many ways a more detailed model of juvenile passage. The primary difference is that, in PAM, the main parameter that determines reservoir mortality is flow. The CRiSP model takes into account specific mechanisms (primarily enhanced predator effects and gas supersaturation generation) contributing to river morality. The difference in how the models are accepted regionally is based on whether one believes use of the flow/survival data [estimated by Sims and Ossiander (1981) in the 1970's, prior to major structural and operational changes that have occurred since then] to be valid, or whether calibration to more mechanistic factors is more suitable in describing today's passage conditions. Fish Leaving Under Several Hypotheses (FLUSH) is a third juvenile passage model, developed by the state and tribal fishery agencies. It assumes that smolt survival is sensitive to the Sims and Ossiander (1981) flow/survival relationship and temperature-related predator effects.

In addition to juvenile passage models that only attempt to capture downstream passage factors, life-cycle models are also used to describe the return of adult fish to upstream spawning grounds. Lack of sufficient data for calibrating all of the life-cycle sub-models has limited their use for specific endangered stock dynamic predictability. Life-cycle models include the Stochastic Life-Cycle Model (SLCM), developed by BPA and Resources for the Future; the System Planning Model (SPM), developed by NPPC; and the Empirical Life-Cycle Model (ELCM). For SLCM, the only truly stochastic life-cycle model, random draws from appropriate probability distributions determine the values of the number of fish transiting each life stage. This is intended to capture some of the variation in lifestage survivals that naturally occurs due to factors such as fluctuating hydrologic conditions, and is somewhat independent of changes to the hydrosystem. The SPM and ELCM utilize a multi-run process that selects somewhat randomly from either a 50-year or a subset of a 63-year flow record reflected in their linked juvenile passage model survival distribution.

Key uncertainties associated with the ability to predict absolute juvenile survival estimates using any model include in-river system survival estimates, dam passage survival, transportation survival assumptions, gas supersaturation effects, and wild smolt performance (Preliminary Draft EIS for the Columbia River SOR, 1994, appendix C, *Anadromous Fish*). For these reasons, relative survival and relative change in survival estimates are produced and compared until some reasonable means of validation for critical assumptions can be accomplished. A regional model comparison and coordination process [Analytical Coordination Work Group (ANCOOR)] initiated 1.5 years ago, continues to facilitate an understanding of the different modeling systems currently in use. Agencies involved include NMFS, NPPC, ODFW, WDF, Idaho Department of Fish and Game, University of Washington, BPA, and the Corps (Preliminary Draft EIS for the Columbia River SOR, 1994, appendix C, *Anadromous Fish*).

h. Predation.

Predation is one of the major sources of smolt mortality occurring during migration within the Columbia and Snake River system, and is believed to cause mortality equal to or greater than that caused by passage through dams (Rieman *et al.*, 1991). Reservoirs slow the rate of downstream travel for juvenile salmonids, and provide favorable habitat for predator species. The adverse effects of increased predation and competition have likely been grater for fall Chinook that have slower travel rates, since they feed and rear as they migrate later in the summer when predator activity is more intense because of higher water temperatures. The ODFW (1991) estimated that 14 percent of juvenile Chinook salmon were consumed during the April-to-August period for John Day reservoir alone, which equates to an estimated 2.7 million juveniles lost each year. Fall Chinook losses were even higher, reaching a high of 61 percent in August. Northern squawfish were the most abundant predator, accounting for 78 percent of the salmonids consumed. Results of other studies suggest that total annual losses of salmonids to predation by northern squawfish in the migratory corridor is likely many times the number estimated for the John Day reservoir. Predation is documented to occur at higher rates near concentrated areas of juvenile salmonid presence, such as just above or below dams and at bypass release sites, where squawfish are more successful in targeting prey.

The BPA initiated a bounty squawfish removal program in 1990, based on modeling projections that suggested a 50-percent reduction in juvenile predation could be achieved in 5 to 10 years if 10 to 20 percent of the squawfish population greater than 11 inches in length were removed. The use of toxins has also been investigated, but Federal Drug Administration approval for its use has not been achieved. Control of predation by squawfish is identified as an important element in the overall plan for recovery of the listed Chinook and sockeye (Draft Recovery Plan Recommendations, 1993). Predation by other fish also has been documented by Bennett *et al.*, who identified smallmouth bass as a significant predator on subyearling Chinook in the Lower Granite reservoir (Curet, 1994). Birds also prey on juvenile salmonids during their mainstem passage. Marine mammals (seals and sea lions) prey on returning adult fish. Recent documentation of bite marks by NMFS at the Lower Granite Dam adult trap suggests incidences ranging from 14 to 19 percent (Harmon *et al.*, 1993), and open wounds ranged from 36 to 47 percent (Park, 1993). Park (1993) estimates total consumption in the Columbia River during the upstream passage period could be as high as 22,500 salmon, of which 4,500 are of Snake River origin.

One benefit attributed to the transport program is removal of a large portion of the Snake River salmon and steelhead from immediate impact of predation within the reservoir system.

i. Multi-Purpose Use.

The Corps, as directed by Congress and with the approval of the Northwest region, constructed eight mainstem dams for a variety of purposes. Since the 1930's, the Corps has coordinated and balanced these often-competing interests (navigation, flood control, irrigation, power, and recreation) in the management of the dams. The various uses impact anadromous fishery resources. The Corps continues to face trade-offs that must be carefully weighted as decisions about water uses are made (Mighetto and Ebel, 1993). Decision on the future operation of the system will continue to require trade-offs between competing uses and the conservation of natural resources. The SCS and SOR are major efforts to define the options, their associated costs and benefits, and provide national and regional decision makers with a basis for determining how the system should be operated in the future.

3.06. The Corps' Activities.

The Corps has had a significant history and involvement in researching the causes of fish losses since before the construction of the eight mainstem projects. Research first focused on adult passage issues during the late 1930's and 1940's, primarily fishways and fish ladders, but early research effort was limited by funding and personnel constraints. In 1951, the Corps established the Fisheries Engineering Research Program [later called the Fish Passage Development and Evaluation Program (FPDEP)]. This interagency program was a part of the Corps' efforts to research and mitigate for fish losses resulting from the proposed construction of additional dams.

Focus began to shift to juvenile passage issues, primarily turbine passage, when it became clear that juvenile losses were higher than initially believed. Research led to the development of bypass systems that divert juvenile migrants away from turbine intakes and safely pass them around the dams for return to the river or transportation. The first guidance device, the submersible traveling screen, was cooperatively developed and tested with NMFS in 1969. This led to years of testing at all Snake and Columbia River projects to develop effective and efficient methods for protecting juvenile migrants.

Over 20 years of research and modifications to these screens has resulted in the recent development of extended-length screens that intercept an even higher percentage of juvenile fish. Other components of the bypass system, such as vertical barrier screens (VBS's) that restrict fish from reentering the turbine intake once they have been guided, orifices, and raised operating gates, have been tested and redesigned to provide the highest level of protection for downstream migrating fish. Extensive use of hydraulic model studies has helped to evaluate optimal designs for prototype testing and construction for field evaluation.

Operational changes and/or improvements are continually being made as research shows where fish passage could be improved. For example, in 1978, the Corps excavated a large channel through the dam at Little Goose, eliminating the collection conduit and its associated problems. With Congressional approval of the Columbia River Juvenile Fish Mitigation Program, funding was made available in 1988 to make major facility improvements, such as construction of the state-of-the-art Little Goose juvenile fish facility (based in part on research conducted at Lower Granite Dam to develop an open flow, gravity flume for the movement of fish from the collection channel to the facility located downstream of the dam), the new permanent juvenile fish facility at Lower Monumental and Ice Harbor Dams, and construction of a similar facility at McNary Dam.

In addition to the design and construction of this major bypass system (see paragraph 4.06.b. for further detail on how the bypass system operates), additional research through the Corps' FPDEP process has evaluated complementary areas of concern, such as the condition of fish (physical injury, and physiological status of stress and fatigue, for example), smoltification status, disease condition, and how these factors affect the performance of fish during the collection process.

The transportation research program has been a major effort in evaluating the benefit of transportation since 1968. Offshoots of this research include investigating questions associated with hatchery versus wild stock responses, and whether fish should be transported closer to the estuary.

The Corps has continued to develop and improve the collection and transportation systems annually as research and operation directs improvements. Improvements to the facilities, including improved debris handling capability to eliminate injury to juvenile migrants, have been successful in improving project passage and survival. Routine monitoring conducted at all collector projects shows minimal injury during the collection and transportation process. However, as discussed in section 3.05., *Issues,* the benefits of the transportation program, and bypass itself, are questioned. Recent research at Bonneville Dam suggests that passage through that particular bypass system is not safer than passage through the turbines, primarily because of predation occurring at the bypass outlet to the river. It should be stressed that each project is unique, and data cannot be extrapolated from one project to another. However, it is valid to question the overall performance of bypass systems since completed bypass systems have not been evaluated on the basis of project survival. Until this type of comprehensive study is made of every completed bypass system, bypass benefits are assumed to exceed those of turbine passage.

Other research efforts through the Corps' research program have included migrational characteristics and survival, delays in migration, dissolved gas impacts ("gas bubble trauma"), and disease research. Recent research efforts have focused on project survival, adult passage survival, and the continued development of the juvenile bypass system.

The Corps has generally supported the efforts of NPPC and the development of the Columbia River Fish and Wildlife Program as it affects those areas of Corps responsibility. Many of the Columbia River Fish and Wildlife Program elements are reflected in ongoing Corps programs, such as the previously referenced Columbia River Juvenile Fish Mitigation Program, and the CRSMA (the Corps' long-term study to address salmon recovery and potential structural responses). The Corps SEIS (1993) details the relationship among many of these programs and Corps activities to address salmon recovery. The SCS has become the primary focus of CRSMA and efforts to develop long-term plans. The SOR is another ongoing long-term study to coordinate the operation of Federal water resource projects in the Columbia River Basin. One of its key goals is to establish guidelines for operating the coordinated Columbia River System, taking into account impacts on all river users (including anadromous fish, irrigation, and navigation).

The NMFS ESA Recovery Plan, when released, will focus the region on the recommended paths to address salmon recovery. The Corps will respond to this plan, as will all regional users, to provide the best operation of the system for all its multi-purpose uses. The Corps will continue to coordinate with regional interests in addressing recovery measures.

Section 4 - Description of the Affected Projects and Programs

4.01. Overview.

This section provides information on the Columbia River Basin system of dams and reservoirs and how it operates. In addition, it identifies the projects (dams and reservoirs) that are affected by actions being considered under the SCS, and their relationship to the operation of the entire system.

4.02. Columbia River System.

a. Description of the System.

Dam construction in the Columbia River Basin has developed the hydroelectric potential of the rivers, provided inland navigation on the lower Columbia/Snake River reaches, supplied water for irrigation, and improved flood control for areas subjected to flooding in the past. Some 255 Federal and non-Federal projects have been constructed in the basin, making it one of the most highly developed in the world.

Operators of Columbia River Basin projects must take into account diverse interests and a broad spectrum of agencies and river users. This fact demands an integrated approach to planning and operations among the projects. Key projects are operated in a coordinated manner that supports multiple uses, and increases the benefits to the people of the western United States and Canada.

Dam development in the Columbia River Basin began in the 1800's. Mainstem dam development began with Rock Island Dam (a non-Federal project) on the Columbia River in 1933, and continued through 1975 with the completion of Lower Granite Dam on the Snake River. Most of the dams were constructed from the 1950's through the 1970's. Federal agencies (the Corps and BOR) have built 30 major multipurpose dams, with hydropower facilities, on the Columbia River and its tributaries.

b. Storage and Run-of-River Projects.

The Federal projects fall into two major categories: storage and run-of-river. It is important to understand the difference between the two categories. The difference between storage and run-of-river projects, graphically illustrated in figure 4-1, is explained below.

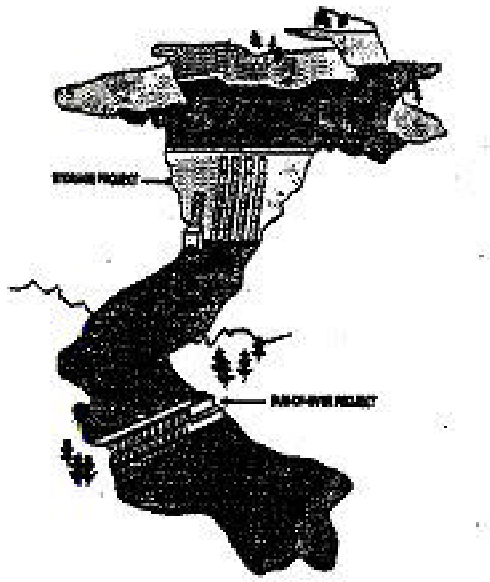

Figure 4-1. Storage and Run-of-River Projects

Storage is the key to the operation of the multiple-use river system. The main purpose of the storage reservoirs is to adjust the river's natural flow patterns to conform more closely to water use patterns, storing water from rain and snowmelt until it is needed. In addition, shaping helped reduce downstream flows during the flooding season. In recent years, however, storage has also been used to increase flows during periods of fish migration. Balancing the various uses of system storage has thus become more challenging as the demands on the system increase. Only a finite amount of water and storage space is available in the system to meet competing needs.

The total water storage in the Columbia River system is 55 million acre-feet (MFA), of which 42 MAF is available for coordinated operations. About half of that storage capacity is in Canada. This is an enormous amount of water, but it is only about 30 percent of an average year's runoff (as measured at The Dalles Dam). While there is a large amount of storage on the Columbia River, the degree of control that exists on other large river systems in the United States (*i.e.*, the Missouri and Colorado River systems) is not available.

Reservoir levels at storage projects typically vary greatly during normal operations. Variations between full pools and lowered pools tend to occur seasonally. Just prior to the spring snowmelt, pools are generally kept low to provide enough space for increasing flows and flood control. When possible, operators try to operate pools near full during the summer, when recreation demand is the highest.

The eight Federal projects on the lower Snake and Columbia Rivers are considered to be run-of-river projects, which have limited storage capacity, were developed primarily for navigation and hydropower generation. All run-of-river projects provide hydraulic head for power generation. They also form enough to channel depth to permit barge navigation. Run-of-river projects pass water at the dam at nearly the same rate as it enters. The water that backs up behind run-of-river projects is referred to as pondage. The pondage at these projects is sufficient to control flows on only a daily or weekly basis. Use of the pondage causes frequent, small fluctuations in water levels. Reservoir levels behind these projects typically vary only 3 to 5 feet.

While it is physically possible to draft these reservoirs well below the normal minimum pool levels, the projects were not designed to operate at levels below minimum operating pool (MOP). Some of the project facilities at the dams (*i.e.*, navigation locks, fish ladders, and juvenile fish bypass facilities) would no longer function at lowered reservoir levels. Irrigation structures and recreational facilities on these reservoirs depend on normal water levels. Also, railroads and highway fills and other embankments would not be protected against increased wave action on the reservoir.

c. System Planning and Operation.

Each Federal project was constructed under specific Congressional authorizing legislation identifying the major intended uses for each project. This Congressional authorization, multiple-use operating principles, project control manuals, and known public concern provide overall guidance for system planning and management. Within this overall framework, relatively short-term planning is needed to guide system operations in response to actual hydrologic conditions. As a result, there are several annual planning processes that guide system operations from year to year.

(1) Annual Planning.

The Columbia River Treaty requires the United States (the Corps and BPA) and Canada (BC Hydro) to prepare operating plans each year. These plans are the basis for the operating rule curves for the Treaty projects in Canada. These plans, in turn, are factored into the annual plan developed by parties to the Pacific Northwest Coordination Agreement (PNCA), because releases of water from the Canadian storage reservoirs are crucial for coordinated system planning in the United States.

Annual planning for coordinated power system operations occurs pursuant to PNCA. Planning studies are made as if the total coordinated system had a single owner, synchronizing operations to maximize power production.

The annual planning process starts each February, and it incorporates non-power considerations. Each reservoir owner submits multiple-use operating requirements (*e.g.*, specified instream flows) that must be accommodated in the resulting plan. Utility parties also submit forecasts of their electricity loads, the output of their non-hydro generating resources, and planned maintenance outages for their resources. Studies are conducted to determine how much power can be produced from the whole system as well as by each PNCA party. These studies are updated throughout the operating year, and guide reservoir operations that produce the planned power capability while still meeting numerous other operating requirements.

Annual plans are also developed for purposes other than power. In particular, anadromous fish operations are planned through a Coordinated Plan of Operation (CPO). The Federal operating agencies work with the fisheries agencies and tribes to develop the CPO. Another key plan is the Corps annual fish passage plan, which specifies operations for the juvenile and adult fish passage facilities.

(2) Annual and Short-Term Operations.

The operation of the Federal system over the year is based on meeting several related, but sometimes conflicting, objectives. These include: providing adequate flood storage space for controlling spring runoff; providing sufficient water levels for navigation, recreation, and fish and wildlife; maintaining an acceptable probability that reservoirs will refill to provide water for next year's operation; providing adequate water supply for irrigation; providing flows to aid the downstream migration of anadromous juvenile fish; and maximizing power generation, within the requirements imposed by other objectives.

The lead agencies have some flexibility in operating the system while attempting to meet the diverse and changing needs of the region, based on information that becomes available over the course of the operating year. Many factors cause short-term operational adjustments. For example, sometimes more rain causes higher flows in the fall. This water can be used to produce surplus energy (non-firm energy), or the water can be left in storage for future use if storage space is available. In a poor snowpack year, it may be necessary to draft reservoirs to levels jeopardizing their refill to get enough power to meet firm energy demand in the region or to meet other obligations. Runoff can be so lot that, about 25 percent of the time, reservoirs in the system fail to fully refill. When this occurs, optional power sales cease and power generation is limited to meeting firm power requirements.

The actual operations take place in what is described as "real time." Decisions must be made in a few hours, days, or at most a few weeks. Operators regulate the system in an effort to satisfy all the power and nonpower purposes contained in the annual operating plan. They may need to make decisions to respond to in-stream conditions for fish or navigation, or to take advantage of an opportunity to make a profitable power sale. Boating accidents, generator outages, short-term climatic events, and even the timing of recreational events can influence operational decisions.

4.03. Affected Projects.

Most juvenile salmon originating from the Snake River Basin must make their way past eight Federal dams and reservoirs (projects) on the lower mainstem Snake and Columbia Rivers before reaching the Pacific Ocean. Juvenile salmon originating from the Columbia River (depending on the stream from which they originate) must make their way past as many as nine projects, four of which are on the lower Columbia River. The actions considered in the SCS involve only the eight mainstem (run-of-river) Federal projects on the lower Columbia and Snake Rivers. These projects are Lower Granite, Little Goose, Lower Monumental, and Ice Harbor on the lower Snake River; and McNary, John Day, The Dalles, and Bonneville on the lower Columbia River.

These are multi-purpose projects that provide many public benefits in many different areas. Project facilities include dams and reservoirs, spillways, hydroelectric powerplants and high-voltage transmission lines, navigation channels and locks, irrigation diversion and pumps, juvenile and adult fish passage facilities, parts and recreational facilities, lands dedicated to project operations, and areas set aside as wildlife habitat. Figure 4-2 shows a plan view of a typical project on the Snake River, and identifies many of these types of facilities.

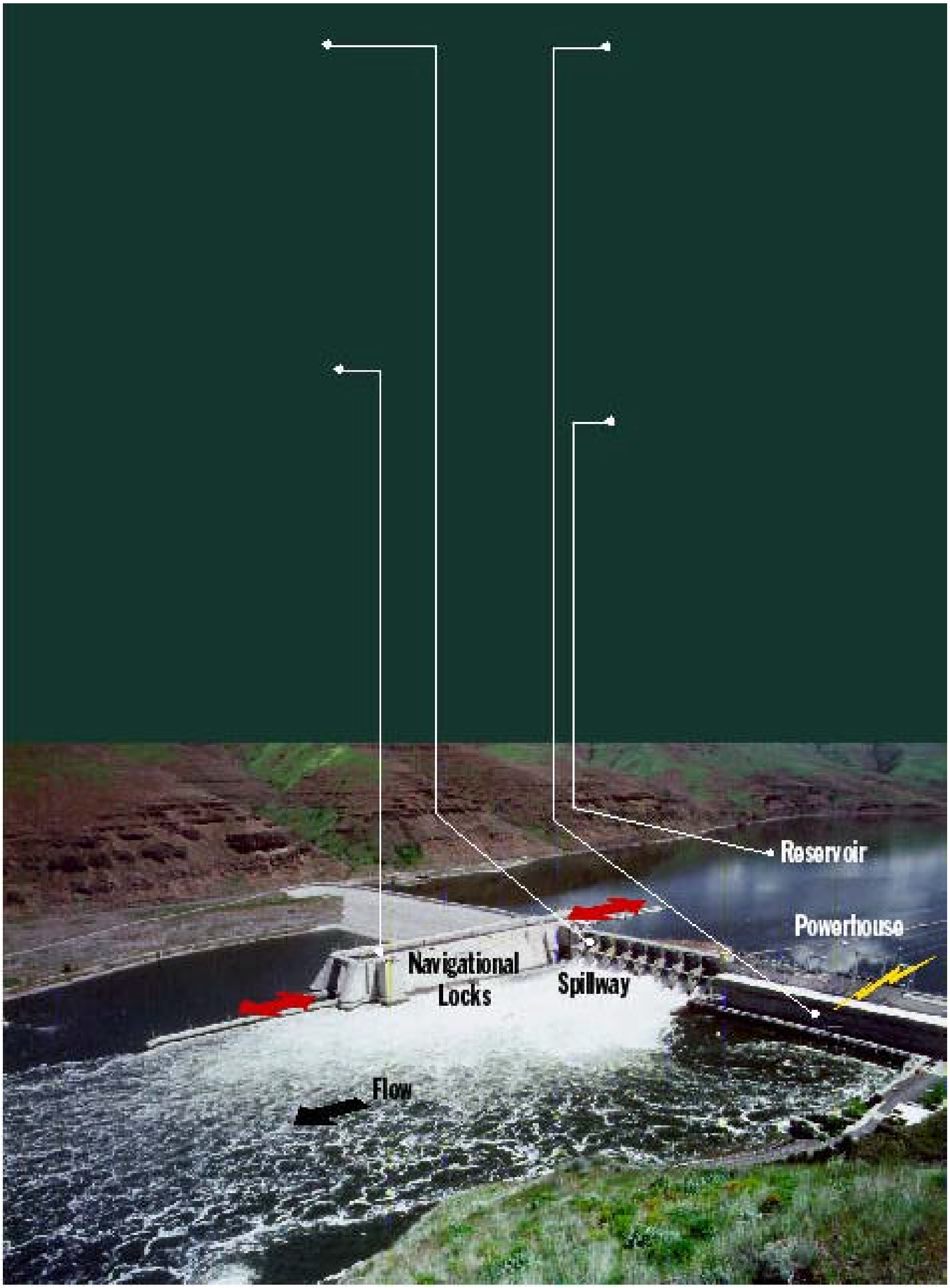

Figure 4-2. Key Features of a Typical Run-of-River Project

4.04. Project Purposes and Use.

Each project was constructed under specific Federal authorizing legislation identifying the major intended uses. Projects were specifically authorized for power production, navigation flood control, or irrigation. The abundance of water and the predictability of its use allows a project to support other purposes as well, but only after its authorized uses are met. Generic Congressional authorization allows for such uses as water quality, fish and wildlife, recreation, and municipal and industrial water supply. While the authorizing legislation stipulated intended use, it seldom contained explicit provisions for operating the individual projects or for their coordinated operation within the total system. As previously discussed, the Corps is largely responsible for deciding how to operate their projects based on principles of multiple-use operation, operating experience, and public concerns. The major uses of the projects are summarized on table 4-1.

Table 4-1
Authorized Project Purposes

Project	Authorized Project Purposes						
	Hydropower	Navigation	Irrigation	Recreation	Flood Control	Fish and Wildlife	Water Quality
Lower Columbia River							
Bonneville	X	X		X		X	X
The Dalles	X	X	X	X		X	X
John Day	X	X	X	X		X	X
McNary	X	X	X	X	X	X	
Lower Snake River							
Ice Harbor	X	X	X	X		X	
Lower Monumental	X	X	X	X		X	
Little Goose	X	X	X	X		X	
Lower Granite	X	X	X	X		X	

The only project that has flood control as an authorized project purpose is John Day. The amount of flood control space is limited, and is used to fine-tune flood control requirements on the lower Columbia River, particularly in the Portland/ Vancouver area.

4.05. Project Operation.

The current annual operation of the lower Columbia and Snake River projects is 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 integrated system. To accomplish this objective, the projects are regulated as run-of-river projects, with primary functions of navigation and hydroelectric power generation. They also provide the best possible conditions for other project uses (*i.e.*, flood control, fish and wildlife, recreation, and irrigation). Flood control is not an authorized or planned function, with the exception of John Day, because of the limited amount of usable reservoir storage. However, the Lower Granite Project is regulated to assure that the Corps levees in the Lewiston area are not overtopped.

Each of the projects is operated within a maximum and minimum operation pool level, and minimum discharge limits (identified for each project in table 4-2). These projects are operated for power production within these pool level and discharge limits, as well as in accordance with a working agreement between the Corps and 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 storage between the minimum and maximum pool levels when the reservoir inflow is less than powerplant capacity.

Table 4-2
Reservoir Operating Characteristics

Project	Reservoir Capacity[1] (Acre-Feet)	Minimum Operating Pool (Feet)	Normal Operating Pool (Feet)	Normal Full Pool (Feet)
Lower Columbia River				
Bonneville	100,000	70	71.5	77
The Dalles	53,000	155	155	160
John Day	534,000	257	Varies	268
McNary	185,000	335	337	340
Lower Snake River				
Ice Harbor	25,000	437	437	440
Lower Monumental	20,000	537	537	540
Little Goose	49,000	633	633	638
Lower Granite	49,000	733	733	738

[1]Represents pondage between minimum and normal full pool.

4.06. Activities and Programs Related to Anadromous Fish.

a. Overview.

Historically, salmon migrated nearly 1,200 miles up the Columbia River to Lake Windemere, Canada; and 600 miles up the Snake River to Shoshone Falls near Twin Falls, Idaho (Lavier, 1976). Dam construction blocked anadromous fish access to much of the upstream portions of the Columbia and Snake Rivers, along with their tributaries. The completion of Grand Coulee Dam, in 1941, blocked access to over 500 miles of the upper Columbia River, excluding tributaries. Another 52 miles of the mainstem (the current upstream limit of salmon and steelhead in the Columbia River) were lost with the building of Chief Joseph Dam (Lavier, 1976). Over 50 percent of the originally inhabited mainstem of the Snake River is no longer accessible to anadromous fish, since Hells Canyon Dam (a non-Federal dam owned and operated by Idaho Power Company) now limits access to the lower 247 miles of this river. Dworshak Dam blocked upstream migration on the North Fork of the Clearwater River when it was built in the early 1970's.

The Corps has developed an extensive array of fishery programs and facilities at the downstream projects to accommodate anadromous fish migration to and from the remaining accessible portions of the basin. Some fish facilities were included in the initial design of the projects, and others have been added as the agencies learn more about the needs of the species. Facilities and operations designed to benefit fish include ladders for adults and diversion screens for juveniles; a transportation program consisting of collection facilities, barges, and trucks for juvenile migration; hatcheries to supplement wild stocks; and instream flow management for both juveniles and adults. Research and monitoring programs have been established to guide future actions. These efforts have evolved over time as project operators have sought to meet specific needs.

The Pacific Northwest Electrical Power Planning and Conservation Act of 1980 significantly expanded fish programs in the Columbia River Basin. The Act created NPPC; and led to its Fish and Wildlife Program to protect, mitigate, and enhance fish and wildlife. The following paragraphs discuss relevant facilities and programs that contribute to ongoing regional efforts to improve the status of anadromous fish runs.

b. Adult Passage.

Fish ladders that allow adult fish to migrate upstream were built during the original construction of all eight Federal run-of-river projects on the lower Columbia and Snake Rivers. [The five public utility department (PUD) dams on the mid-Columbia River also have fish ladders to maintain anadromous fish access to the Wenatchee, Methow, and Okanogan Rivers.] Each of these projects has from one to three ladders that operate continuously, except during winter maintenance outages. Storage projects effectively blocked the upstream migration of anadromous fish, and were not designed with adult passage facilities.

Bonneville Dam has three fish ladders. The Dalles, John Day, McNary, Ice Harbor, and Lower Monumental Dams have two fish ladders each. Little Goose and Lower Granite Dams each have one fish ladder. Adult fish enter a ladder through collection systems that run along the entire front of a dam's powerhouse, and at other key locations. Specific flow conditions near the ladder entrances are needed to attract adult fish into these systems. The attraction water is provided by pumps, small turbines, or gravity flow from the reservoir behind the dam, depending on the design of the individual system. Once inside a collection system, the fish swim upstream to the base of the fish ladder where they migrate up the ladder and exit into the reservoir above the dam (see figures 4-3 and 4-4). Each ladder contains a fish-counting station where the fish pass an underwater viewing window, allowing them to be counted and identified by species.

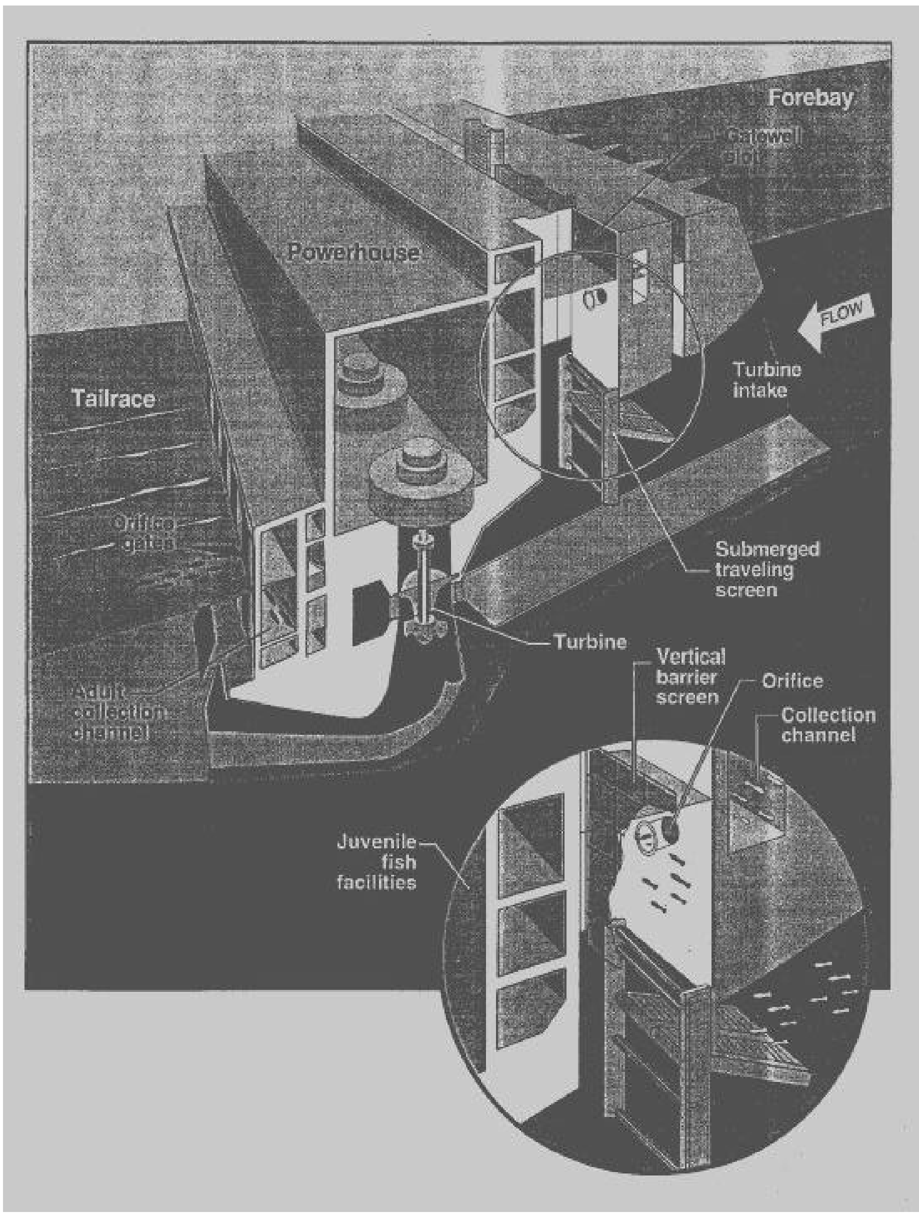

Figure 4-3. Cross section showing adult and juvenile fish passage facilities

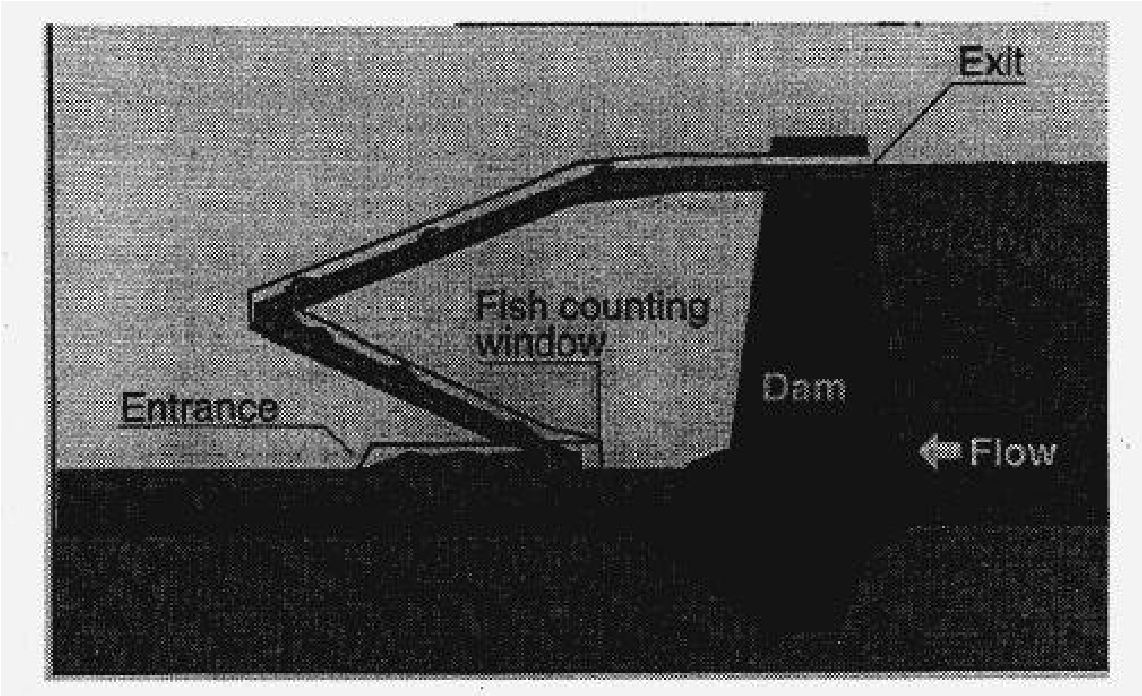

Figure 4-4. Diagram of a typical fish ladder

c. Juvenile Bypass and Transport.

In the early 1950's, the Corps began the Fish Passage Development and Evaluation Program (FPDEP) to develop methods of safe juvenile fish passage at the mainstem dams. Regional fish agencies and other experts have cooperated in the program. These intensive research efforts led to the installation of submersible traveling screens that steer juvenile fish away from turbine intakes the fish are diverted into special channels for bypass around the dam or collection for transport downstream by truck and barge (see figure 4-5).

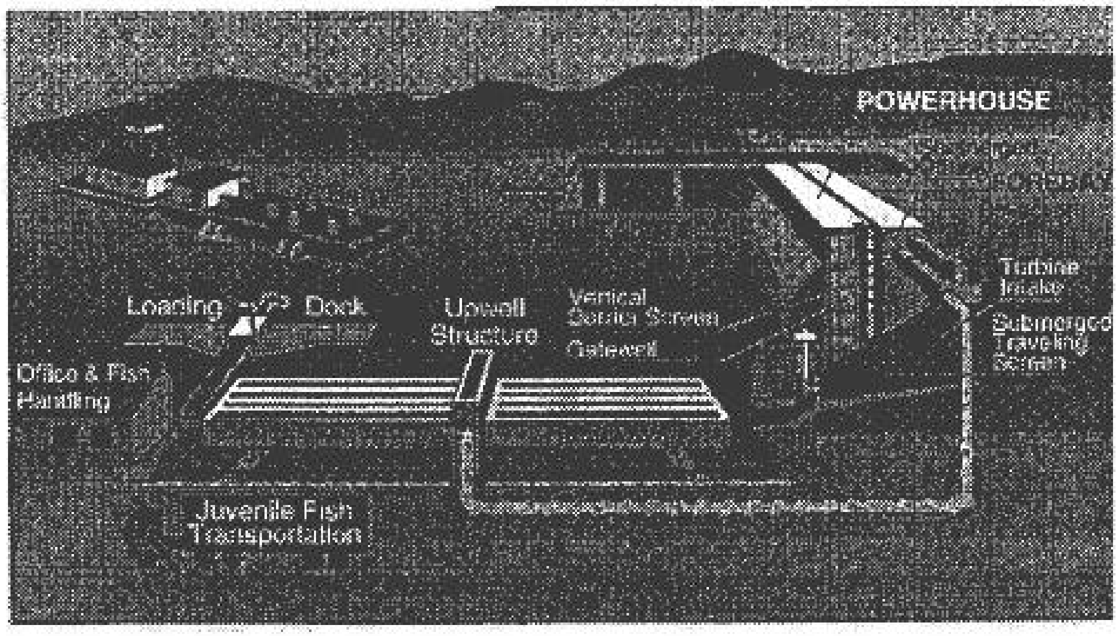

Figure 4-5. Juvenile fish passage illustration, including collection and transport

Studies indicate that the injury and mortality of juvenile fish can occur through all routes of passage at dams, but mortality through turbines is usually high relative to other route of passage (Snake River Salmon Recovery Team, 1993). Juvenile fish passing directly through the turbine chambers can be killed by rapid changes in water pressure or by striking turbine blades. Juveniles not immediately killed are often stunned as they exit the turbine chambers, leaving them susceptible to predation. All eight lower Columbia and Snake River dams, therefore, have been equipped with some type of system to bypass downstream migrants through the powerhouse without passing through the turbines. Six of the projects have screening facilities to divert juvenile and anadromous fish away from the turbine intakes and through a bypass system to the tailrace, where they are collected for transport or released back into the river. The bypass systems at Lower Granite, Little Goose, and McNary Dams are used to collect fish for the juvenile fish transport program (described later in this section). The bypass system at Lower Monumental began full operation for collection and transportation in 1993. The bypass system sat Bonneville and John Day Dams, projects closer to the Pacific Ocean, discharge fish back to the river below the projects. Bypass facilities at The Dalles and Ice Harbor Dams, which in the past have used existing ice-and-trash sluiceways to pass fish, are being designed. They are scheduled to be operational in 1998. Table 4-3 shows the current construction schedule for juvenile bypass facilities on the lower Columbia and Snake River dams.

Table 4-3 Construction Schedule for Juvenile Bypass Systems					
Project	**Bypass Channel**	**20-Foot Screens**	**Gantry Crane[1]**	**Extended Screens**	**Holding and Loading Facilities**
Lower Granite	Complete	Complete	1994	1996	1997
Little Goose	Complete	Complete	1994	1996	Complete
Lower Monumental	Complete	Complete	1994	n/a	Complete
Ice Harbor	1996	Complete	1996	n/a	n/a
McNary	Complete	Complete	Complete	1995	Complete
John Day	Complete	Complete	n/a	n/a	n/a
The Dalles	1999	n/a	1998	1995	n/a
Bonneville	Complete	Complete	n/a	n/a	n/a

[1]Gantry cranes are required for extended screens.

Before the dams were built in the Columbia River Basin, smolts migrating downstream generally experienced swift river flows from their hatching areas to the Pacific Ocean. Since the construction of the projects, juvenile migration takes longer because smolts must swim through slack water reservoirs as they move downstream. Longer migration times have been linked to higher predation, increased disease, and some fish remaining in the reservoirs instead of completing their migration. To improve the survival of juvenile fish through the system of dams and reservoirs, NMFS and the Corps, in cooperation with the fish agencies and tribes, developed a Juvenile Fish Transportation Program. This program began in the early 1970's, with mass transportation beginning in 177 (Park and Athearn, 1985). Essentially, the program is a mass-transit system, using barges and trucks to move smolts downriver. The goal of the program is to increase the smolt survival rate by reducing their migration time. In 1981, NMFS transferred the operation of the transport program to the Corps, but continues its involvement (along with state agencies) through the Fish Transportation Oversight Team.

As described above, screens are used to divert fish into collection systems for transport at four projects: Lower Granite, Little Goose, Lower Monumental, and McNary. After being separated from adult salmonids, larger resident fish, and debris; juvenile fish are either routed directly onto a barge for transport, or into raceways and held for later transport by truck or barge. Barges, used during peak migration periods, constantly circulate river water so the smolts can imprint on the chemical composition of the water, which helps them locate their home stream when they return as adults. Trucks are used to transport the smaller numbers of smolts collected during the early and final stages of the season. The transport program operates from April through October on the lower Snake River, and from April through December on the lower Columbia River.

As many as 15 to 20 million young salmon and steelhead are transported each year from the Columbia and Snake Rivers. The NMFS has concluded that transport is beneficial to Chinook and steelhead under all flow conditions (Matthews *et al.*, 1992). Nevertheless, within the region there is considerable debate and disagreement over the benefits of transporting fish and the acceptability of the program.

d. Hatcheries.

Despite the historical abundance of wild runs of salmon and steelhead in the Columbia River Basin, nearly 75 percent of current runs in the system are of hatchery stock [Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fisheries (WDF), 1991]. The ratio of wild to hatchery fish varies from species to species. To supplement stocks of wild fish, Federal and state fishery agencies began raising hatchery stocks of steelhead and salmon and releasing them into the river system in 1876. Today, over 80 hatcheries producing salmon and steelhead are located on the Columbia River System (Corps, 1992a). A number of these facilities were built specifically as mitigation for the effects of the Federal dams on anadromous fish populations.

Releases of hatchery-raised fish vary from year to year, with numbers increasing over the last several years. During the 1993 migration year, over 88 million juvenile salmon is were released from state, Federal, and tribal fish hatcheries into the system above Bonneville. Releases included stocks of Chinook, coho, sockeye, and steelhead (see figure 4-6 for a breakdown by species). Over 21 million of this total represents fish released into the Snake River, while the remaining 67 million fish originated in the middle and lower Columbia River [Columbia Basin Fish and Wildlife Authority (CBFWA), 1993]. Like the Juvenile Fish Transportation Program, there is regional debate concerning the benefits of hatchery-raised fish in the system. Fish produced in hatcheries are generally not as strong as wild fish. They also seem to be more susceptible to disease, predation, and other forms of mortality. Some critics of the hatchery program argue that the proliferation of hatchery stocks is likely to influence the gene pool of wild stocks. It is generally thought, however, that the recovery of anadromous stocks to the Columbia River Basin will rely in part on hatchery fish.

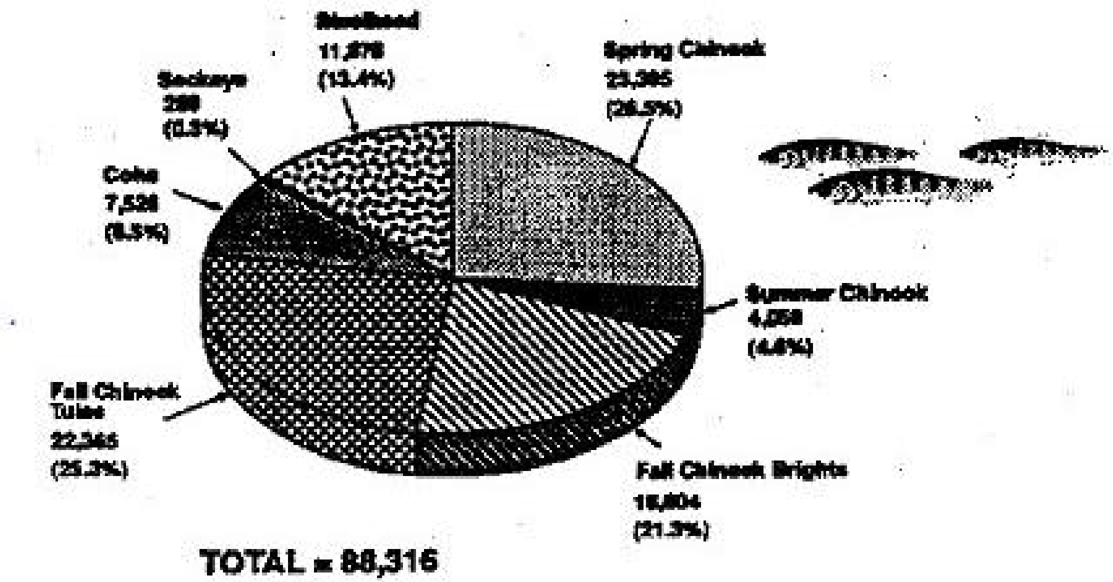

Figure 4-6. Summary of Hatchery Releases by Species for 1992 (Numbers in Thousands). (Source: CBFWA, 1993).

e. Instream Flow Management.

(1) Water Budget.

In addition to physical facilities, operating measures have been put into effect to protect anadromous fish. One such measure is the Water Budget, in which water is discharged from storage projects to increase spring and summer flows for juvenile fish migration in the Snake and Columbia Rivers. The Water Budget was instituted in 1983, as one of the initial actions in NPPC's Fish and Wildlife Program. The amount and timing of Water Budget releases are determined annually. Releases from storage reservoirs are made after considering requests from the Fish Passage Center in Portland, which represents the fisheries agencies and tribes. The increased flow is presumed to help flush fish downriver and reduce their exposure to predators and other hazards in reservoirs. Up to 4.64 MAF of water can be released each spring. The total Water Budget volume includes up to 1.19 MAF on the lower Snake River, and up to 3.45 MAF on the middle and lower Columbia River. On the Columbia River, Water Budget flows and releases from Grand Coulee and other upstream storage projects. There is relatively less storage capacity on the Snake River, and most spring flows depend on natural runoff. As a result, the high flows depend on natural runoff. As a result, the high flows cannot be achieved in low runoff years, even with large releases from storage reservoirs such as Dworshak and Brownlee.

(2) Interim Flow Improvements.

Over the last few years, a number of interim flow improvement measures in response to the ESA listings of Snake River salmon have been implemented. The primary measures consist of: provision for an additional 3.0 MAF for flow augmentation on the Columbia River; an additional 300 thousand AF (KAF) in the spring and 470 KAF in the summer from Dworshak for flow augmentation; system flood control shifts from Dworshak and Brownlee to Grand Coulee; operating John Day and the lower Snake River projects somewhat below normal pool levels during the migration period; and up to 427 KAF of additional water from the upper Snake River.

(3) Spill.

In 1989, fisheries agencies, Indian tribes, BPA, and others signed a Long-Term Spill Agreement, which established a plan for spilling water to help juvenile salmon and steelhead migrating from their spawning grounds to the ocean. The NPPC Fish and Wildlife Program calls for a 90-percent salmon survival rate at each dam on the Columbia River by using spill during most of the spring and summer migration. The spill agreement provides that a specific amount of water be passed over the spillways of three Corps projects (Ice Harbor, John Day, and The Dalles) in the spring and summer to protect young fish. When water is spilled, fish are drawn with it, passing them over the spillways instead of through the turbines. The spill agreement was adopted as a temporary measure to improve juvenile fish passage for 10 years, or until permanent juvenile fish bypass facilities (*i.e.*, screens) can be installed at these dams. Although the Corps did not sign this agreement, the agency considers the spill requests each year, and has provided spills in each of the last 5 years.

The Water Budget and spill agreement are both instream flow measures to help fish, but they are quite different. The Water Budget moves fish *between* dams, while spill is used to move fish *over* dams.

(4) Vernita Bar Agreement.

Under an agreement signed in 1988, dam operators provide certain flow levels from fall to early spring to protect salmon spawning and hatching at Vernita Bar (below Priest Rapids Dam). This is the last remaining major fall Chinook salmon spawning area on the mainstem Columbia River. In the past, operators of Federal projects had informally cooperated to ensure lower flows over Vernita Bar during the fall spawning period and higher flows in the winter while eggs are incubating. The Vernita Bar Agreement made formal the efforts by Grant County PUD, BPA, and others to deliver flows needed to encourage and protect salmon spawning at this location.

(5) Non-Treaty Storage Fish Agreement.

A portion of the water storage capacity in the reservoir behind Mica Dam in British Columbia is not covered by the Columbia River Treaty. The BPA and BC Hydro developed a contract called the Non-Treaty Storage Agreement (NTSA) to coordinate the use of 4.5 MAF of water storage. The power generating capability represented by the storage is to be shared equally by BPA and BC Hydro. In October 1990, BPA signed a related agreement with the CBFWA, which represents Northwest fish and wildlife agencies and 13 Indian tribes. The purpose of the agreement is to assure, through operating guidelines and regular communication, that use of non-Treaty storage water will pose no significant risks to fish. The NTSA water has been used at times in the past few years to meet requests for additional flows to aid fish migration.

(6) Research and Monitoring.

Many agencies and organizations are involved in fishery research and monitoring programs related to Columbia and Snake River salmon and steelhead. These efforts encompass the dams and fish passage facilities, transportation, hatcheries associated with the projects, the reservoirs, and tributary streams.

The Corps monitors juvenile and adult migration at Corps dams, conducts or sponsors ongoing research on anadromous fish, and participates in the research programs of other organizations. The Corps also operates 23 stations along the river system that monitor dissolved gas levels, which can be harmful to fish.

f. Miscellaneous Fish-Related Actions.

(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 fisheries agencies, "zero" river flow is allowed for water storage during low power demand periods (at night and on week-ends), when there are few (if any) actively migrating anadromous fish present in the Snake River. From March through July and August through November, the minimum Ice Harbor project discharge will be 9,500 and 7,100 cubic feet per second (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 ,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 the 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. 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.

Section 5 - Description of Alternatives

5.01. General.

As stated in section 1.03, the objective of the SCS is to define and evaluate alternatives for improving mainstem passage of juvenile and adult anadromous fish. Under this major objective, alternatives address one or both of two general sub-objectives: 1) reduce reservoir-associated mortality; and 2) reduce dam-passage mortality. Reservoir-associated mortality factors include predation and effects associated with fish travel time to the estuary (*i.e.*, incidence of disease and physiological conditioning for transition from freshwater to saltwater environment). These and other concerns are thought to be fundamental to, or inherent in the relationships between flow, velocity, fish travel time, and juvenile survival generally supported in the region, but not well understood. Mainstem reservoir drawdowns, flow augmentation, and improvements in juvenile fish collection and transportation are the concepts considered to address this objective (see table 5-1). Dam-related mortality includes turbine, juvenile bypass system and spillway passage-induced mortality on juvenile fish, and adult passage mortality. Various system improvements, collection and transportation options, and mainstem drawdowns are considered to reduce or eliminate dam-related mortality.

Table 5-1
General Objectives of SCS Phase I Studies

Alternative	Reduce Reservoir-Associated Mortality	Reduce Dam Passage-Associated Mortality
Lower Snake Reservoir Drawdown	X	X
John Day Drawdown	X	
Additional Upstream Storage	X	
Upstream Collection and Conveyance	X	X
System Improvements		X

Many of the structural and operational alternatives and/or concepts considered in Phase I were initially identified in the 1990 and 1991 Salmon Summit, and carried forward in NPPC's *Strategy for Salmon.* The alternative long-term actions considered in this study include: 1) annual drawdown of the four lower Snake River reservoirs; 2) drawdown of John Day reservoir on the lower Columbia River; 3) development of additional storage in the upper Snake River Basin to support flow augmentation; 4) constructing an upstream (above Lower Granite Dam) collector facility and a new conveyance system, such as a migratory canal or pipeline, past the mainstem dams; and 5) making further improvements to existing systems to aid salmon migration. These alternatives are described in detail in the following paragraphs.

5.02. Lower Snake River Drawdown.

a. General.

The idea of drawing down reservoirs below design operational levels during the salmon migration season first surfaced at the regional Salmon Summit meetings, convened by Senator Hatfield in 1990. The idea was pursued in the NPPC's Fish and Wildlife Program Amendments.

There are four dam and reservoir projects located on the Snake River between river miles (RM's) 9.7 and 107.5. The projects are Ice Harbor (RM 9.7), Lower Monumental (RM 41.6), Little Goose (RM 70.3), and Lower Granite (RM 107.5). The projects were constructed between 1961 and 1975, and are operated as run-of-river for navigation and power generation. The maximum lift for the navigation locks and head for power generation varies from 101 to 105 feet at each project.

The Corps conducted a drawdown test of the Lower Granite and Little Goose reservoirs on the lower Snake River in March 1992 to measure the physical impacts of drawdown. The test was purposely conducted when there were few salmon in the river, out of concern that a test with migrating fish in the system would have harmful impacts on already troubled salmon stocks.

b. Objective.

Various proposals have suggested changing the current operation of the lower Snake River projects. These operational changes focus on decreasing the average water travel time through the reservoirs created by the four lower Snake River dams. Water travel time has been identified as a possible factor in juvenile fish survival. The relationship between water travel time, migration time, and fish survival is a general one, and is not considered to be a quantitative expression. Migration research that supports this general relationship applies mainly to spring and summer Chinook salmon. One 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. Drawdown is considered to be an effort to keep juvenile fish migrating inriver, thus replacing the need for the existing transportation program. In any event, navigation would not be possible with lowered reservoir water surface elevations on the Snake River. Collection and transport from McNary Dam would be possible. However, this was not evaluated because it was not consistent with the goal of in-river navigation.

c. Operational Drawdown Alternatives.

This paragraph describes the operational drawdown alternatives under consideration for each of the four lower Snake River projects.

There are three basic types of drawdown options that were used to develop the array of alternatives:

- **Variable Pool.** This would allow the reservoir surface elevation to be lowered or raised, depending on river flow or discharge, to meet flow velocity objectives.
- **Constant Pool.** The reservoir, under drawdown conditions, would be operated within a 5-foot operating range, similar to the existing operating condition.
- **Natural River Flow.** To the extent possible, reservoirs would be lowered to allow the river to flow freely past the dams at the level of the natural river.

There are several different drawdown levels that could be examined. These range from normal MOP levels to a complete river bypass of the dams (near pre-dam river conditions), but there are numerous drawdown levels that fall between these two extremes. There are various ways each dam's operation could be modified in order to achieve a 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-two different alternatives have been identified as potential drawdown conditions on the lower Snake River. The alternatives are defined by the drawdown level, as well as by the features at each dam that would need to be modified or newly constructed to achieve the drawdown level.

d. Initial Alternative Screening.

To limit the number of drawdown alternatives for which design and cost information would be required, conceptual designs were screened based on engineering feasibility, biological effectiveness, and acceptability. The review of biological effectiveness was accomplished by the TAG. Alternatives that proposed spillway-only operations were found to be not feasible due to the adverse impact on adult fish passage, associated high dissolved gas levels, and problems associated with passing 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.

During initial screening, 12 alternatives were found to be unacceptable and were eliminated from further study, based on the reasons identified in the previous paragraph. Ten alternatives, however, were further evaluated. These 10 alternatives are outlined in the following section. Table 5-2 shows a list of the 22 alternatives initially considered, and identifies those considered further.

Table 5-2 Initial Screening of Drawdown Alternatives			
Alt	**Description**	**Drawdown Level (Feet)**	**Further Study in Phase I**
	Variable Pool--No Powerhouse Operation	(Note 1)	Eliminated
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 Regulation Outlet (ARO) Only	>76	
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
Note 1. A 57-foot drawdown represents an upstream pool at a level equal to the existing spillway crest at Lower Granite Dam.			

e. Alternatives Considered Further.

The ten alternatives that were not eliminated during the initial screening process are shown in Table 5-1. 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.

(1) Alternative 4A--Natural River Option.

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 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. 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 feet per second) for adult fish passage during river flows up to 225,000 cfs.

(2) Alternative 5--Existing Powerhouse and Existing Spillway - Variable Pool.

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 powerhouse and the spillways.

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. (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.)

As the river discharge increases, the pool elevation will increase. The approximate total pool elevation increases, as the river flow increases from 62,000 to 225,000 cfs, is about 19 feet for the Ice Harbor pool and 20 feet for the other three projects. At this level (225,000 cfs), the powerhouse hydraulic capacity increases approximately 20 to 25 percent.

(3) Alternative 9--Modified Powerhouse and Existing Spillway - Variable Pool.

This alternative is the same as alternative 5, except for the 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. 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 submerged traveling screens (STS's), are in place. It is unknown how STS's affect turbine efficiencies.]

(4) Alternative 13--Existing Powerhouse and Existing Spillway - Constant Pool.

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 30 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).

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 80,000 cfs at the 25-foot drawdown level (pool elevation 415).

The combined hydraulic capacity at each project 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.

(5) Alternative 13A--Existing Powerhouse and Existing Spillway - Constant Pool, Lower Granite Only.

This alternative describes the necessary modifications, schedules, and costs associated with a 33- to 35-foot near constant pool drawdown (5-foot fluctuation) at Lower Granite Dam only.

(6) Alternative 14--Existing Powerhouse and Modified Existing Spillway - Constant Pool.

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.

(7) Alternative 15--Existing Powerhouse With New Low-Level Spillway - Constant Pool.

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 48feet 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).

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 at each project of existing powerhouse and modified spillways at the drawdown pool levels is estimated to be about 225,000 cfs, assuming spillway gate control is maintained.

(8) Alternative 17--Modified Powerhouse and Existing Spillway - Constant Pool.

This alternative is the same as alternative 13, except for powerhouse modifications, as described for alternative 9.

(9) Alternative 18--Modified Powerhouse and Modified Existing Spillway - Constant Pool.

This alternative is the same as alternative 14, except for the powerhouse modifications described above for alternative 9.

(10) Alternative 19--Modified Powerhouse With New Low-Level Spillway - Constant Pool.

This alternative is the same as alternative 15, except for the powerhouse modifications described above for alternative 9.

5.03. John Day Reservoir Drawdown.

\The drawdown of the John Day Project reservoir, to elevation 257 (MOP level), is addressed in NPPC's *Strategy for Salmon*. This operation would be in effect each year from May 1 to August 31. Lowering the pool levels at the John Day project is being considered as a means of improving the downstream migration of juvenile fish. Normal operating pool level during this period varies, but is about elevation 265. Since the Salmon Summit, an operation at "minimum operating pool" (defined as the lowest level the pool can be operated without impacting irrigation pumping stations) has been employed. This level is elevation 262.5 or higher, as required.

The objective of the drawdown is to increase river velocities so that the travel time currently required for smolts to transit the river system to the ocean is reduced. Travel time has been identified as a possible factor in smolt survival, and it is generally believed that a reduction in travel time will increase smolt survival.

This evaluation will examine the effects the proposed change in operation would have on juvenile migrants, as well as the impacts to the environment and other uses of the reservoir. Evaluation of the potential effects will involve the examination of the body of information regarding flow/survival relationships, and employ existing modeling techniques to attempt to quantify the potential effects.

Potential impacts of the operation include existing project flood control, hydropower, navigation and fish passage facilities and/or operations, recreation facilities, agricultural irrigation pumping stations, groundwater and other water supplies, fish hatcheries, resident fish and wildlife habitat, cultural resources, and others.

A preliminary evaluation of alternative measures, and costs to mitigate impacts and restore use of the facilities to normal operational capacities and service, will be made. For irrigation pumping stations, an alternative to construct irrigation canals will be examined in lieu of modifying the impacted stations. Year-round operation at MOP has been suggested as a potential measure to mitigate the environmental effects of the proposed 4-month drawdown. This option will also be examined.

5.04. Additional Upstream Storage--Snake River Basin.

Analysis of additional storage in the Snake River Basin is included in the SCS in order to provide a comprehensive assessment of potential measures for improving flow (flow augmentation) and salmon survival in the lower Snake River. The objective of flow augmentation is to increase water velocity in an effort to decrease fish travel time to the estuary. Theoretically, this will reduce reservoir-related mortality. The analysis was conducted as a separate study, with the Bureau of Reclamation as the lead Federal agency, in specific response to a request by NPPC. The NPPC request for the study is contained in NPPC's Phase One *Regional Salmon Program for 1991*, as follows:

> *Beginning in 1991 the Bureau of Reclamation, the States of Idaho and Oregon, the Northwest Power Planning Council, and other appropriate agencies will participate in a cooperative appraisal of the potential for additional Snake River Basin Storage dedicated to increasing the volume of regulated water supplies available to enhance lower Snake River flows for salmon migration. The effort would identify sites and evaluate their engineering, hydrology, economic, and environmental aspects. The study will be cost-shared with other regional interests. If results are positive, detailed studies could follow.*

The Bureau of Reclamation initiated work on the storage appraisal study in late 1991 with the formation of an appraisal study work group with representatives from water-user organizations, fish and wildlife agencies, and other State and Federal agencies. Potential storage sites were identified and study procedures, including site screening criteria, were developed by the study work group. In addition, the study work group reviewed interim and final results of the study. Technical studies were completed by the Bureau of Reclamation and the Corps.

The work group completed the inventory of potential sites in July 1992. The work group then screened potential sties, based on institutional constraints that would prevent development. These constraints included wild and scenic river status, location within a state or national park, and substantial impact to resident fish spawning and rearing habitat. Further screening was then accomplished based on the results of analyses of water supply and site development costs. Following this final screening, the remaining sites were evaluated for their effects on the survival of juvenile salmon and system power costs.

The Bureau of Reclamation submitted the final report on the study to NPPC in February 1994. Study procedures and findings are summarized in section 6.04, of this report, and additional detail is presented in Appendix C, *Additional Snake River Basin Storage*.

5.05. Upstream Collection and Conveyance.

Upstream collection and conveyance of downstream migrating salmon and steelhead is addressed in NPPC's *Strategy for Salmon*. Several options for collecting and transporting downstream migrants are examined, including alternative collection and diversion sites and transportation methods.

The collection facilities would divert juveniles from the river into holding facilities for barge or net pen transport, or for bypass to a channel or pipe transportation system that would carry the fish below Bonneville Dam. The collection concepts identified include constructing one or more new collection facilities upstream of Lower Granite Dam (near Lewiston, Idaho, and Clarkston, Washington) for juveniles, and the diversion point for a bypass channel/pipe.

By collecting juvenile fish at the upper end of the Lower Granite reservoir and transporting them to below Bonneville Dam, both reservoir and dam passage-related mortality can be eliminated.

Alternative conveyance methods that will be considered include an open canal or pressure pipeline along the river shoreline, an underwater/floating pipeline, and barges.

The migratory canal concept was suggested at the Salmon Summit. Following the summit, a migratory canal committee was formed. Several meetings were held, and were attended by regional interests. The committee formulated some preliminary concepts for this alternative. In addition, information developed by the Idaho National Engineering Laboratory (NEL) for the floating pipeline was incorporated.

5.06. Existing System Improvements.

The existing system improvements have been broken down into two separate categories. The first category includes the lower Snake River projects and McNary Project on the lower Columbia River. These projects are operated by the Walla Walla District. The second category includes the remaining projects on the lower Columbia River, which are operated by the Portland District.

This element of the study defines and evaluates potential improvements to existing systems (both adult and juvenile) that may enhance fish survival by reducing dam passage-related mortality or stress caused during transportation. It was limited to those measures not currently scheduled for implementation.

a. Lower Snake River and McNary.

(1) General.

This section addresses system improvements for the lower Snake River. These modifications include actions identified by the NPPC in their *Strategy for Salmon*, as well as improvements identified by the Corps. The improvements on the lower Snake River have been grouped into five specific categories: 1) juvenile passage facilities; 2) adult passage facilities; 3) barge transport; 4) hatchery modifications; and 5) other dam modifications.

(2) Juvenile Facilities.

Potential juvenile facility improvements are identified in NPPC's *Strategy for Salmon* by Corps personnel. The ongoing studies to evaluate these improvements include the following:

- Evaluate the installation of dispersed release structures at juvenile bypass facility outfalls, or utilize barges/net pens for dispersed release. In addition, dispersed release at Bonneville Dam, for juvenile fish transported by truck from the Lower Snake River projects, was examined.

- Examine extended length screens at the Lower Monumental and Ice Harbor Projects for improved fish guiding efficiency (FGE).

- Investigate the construction of a new flume transport system at Lower Granite Dam similar to those found at Little Goose, Lower Monumental, and McNary Dams. The new flume transport system would replace the existing pressure pipe system.

- Evaluate the possibility of improving surface flow conditions in order to collect smolts located in the top portion of the pools (near the dam).

(3) Modification of Transport.

Potential barge transport improvements include the following:

- Examine the use of net pens, rather than barges.

- Investigate the installation of refrigeration units for collecting transport vessel water.

- Evaluate larger exits for juvenile fish barge releases.

- Examine the use of additional fish barges to aid in reducing transport densities of juvenile fish and the associated stress, reduce forced bypass, and improve direct loading capabilities. The size and number of barges needed will be determined in consultation with the TAG and other fisheries interests. In addition, the need to replace the existing 23,000-pound capacity barges with larger ones was assessed.

(4) Adult Facilities.

Potential adult facility improvements are identified in NPPC's *Strategy for Salmon*. They include the following:

- Evaluate the potential for reducing water temperatures in adult ladders. Shading, sprinkler systems, bubbler systems, and pumping cooler water from the forebay are possible alternatives.

- Investigate the possibility of installing additional collection channels and ladders at the lower Snake River projects to reduce the delay of adult fish during spill operations.

- Examine the addition of more attraction water to existing ladder and collection systems as a possible enhancement to adult fish passage conditions.

- Examine the possibility of adding vertical slot ladder controls to ladder exits at McNary Dam.

(5) Hatchery Modifications.

Hatchery modifications have been added in an effort to improve the quality of hatchery-reared salmon. By improving hatchery fish quality, there could be a decrease in the negative impacts on wild juvenile salmonids (primarily competition). The following improvements will be evaluated:

- Investigate the installation of gravity-fed, truck-loading capability for smolts in order to improve fish conditions.

- Evaluate the use of additional raceways, or other containment facilities, to reduce fish densities.

b. Lower Columbia River.

In addition to NPPC's Fish and Wildlife Program measure to permit drawdown of the John Day reservoir to MOP, there are a number of project modifications with the potential to enhance the passage survival of migrating adult and juvenile salmonids. Some of these improvements relate to specific measures addressed in the NPPC's Phase Two Amendments. Others were identified through coordination with regional fishery agencies and Tribes.

This section identifies those possible improvements from the screening process that were selected for study at projects operated by the Portland District. Existing system improvements to be evaluated for possible increases in passage survival were screened to eliminate those measures currently being studied, including Project Improvements for Endangered Species (PIES), and research projects under the Corps' FPDEP. Also, programs normally funded through the Corps' operation and maintenance (O&M) procedure were not included.

(1) Extended-Length Screens at John Day.

Evaluate the benefits of installing extended-length turbine intake guidance screens to intercept a greater depth of water entering the turbine intakes. This will presumably intercept a larger percentage of downstream migrant salmonids, increase FGE, and increase project survival. Also included in this analysis is the identification of a prototype test program, and post-construction evaluation of project survival and biological benefits.

(2) Juvenile Transportation at John Day.

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

(3) Juvenile Bypass Outfall Locations at Bonneville.

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

(4) Bonneville First Powerhouse.

Evaluate the potential to improve Bonneville first powerhouse FGE. Increased FGE will guide a larger percentage of downstream migrant juvenile salmonids away from turbine passage, and increase project passage survival.

(5) **Turbine Passage Survival.**

Evaluate the potential to make improvements to the turbines. Identify to increase passage survival. Identify potential areas of study with regard to the casual agents of mortality to juvenile fish passage through the turbine environment.

(6) **Spill Patterns/Flip-Lips at John Day.**

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

(7) **Analysis of Juvenile Downstream Migrant System (DSM) Facilities at Bonneville First and Second Powerhouses.**

This study investigates the potential to improve DSM facilities at both powerhouses. Baseline passage survival data is reviewed and possible options as well as ranges of benefits, are presented. Changes since the construction of these facilities in JBS fisheries criteria are addressed, and improvements are evaluated for possible benefits in passage survival.

(8) **The JBS Outfall Release Alternative (Short-Haul Barging)**

Evaluate an alternative strategy (short-haul barging) to fixed, single-site juvenile bypass outfall release locations. This study is conceived as a potential outfall/release strategy to decrease indirect mortality at, and near, the JBS outfall release site.

(9) **Bonneville Package Analyses.**

Two package analyses were conducted. Package A includes improvements to both powerhouse DSM's, Bonneville first powerhouse FGE, and the relocation of both outfall sites. Package B includes improvements to both powerhouse DSM's, Bonneville first powerhouse FGE, and short-haul barging.

5.07. Other Alternatives.

a. General.

Because of ongoing work within the region to identify measures and develop plans that promote the recovery of anadromous fish runs in the Columbia River basin, the SCS process has been designed to allow the addition of new alternatives. One new alternative, a proposal to construct diking systems within reservoirs to increase flow velocity, was identified. It will be addressed during the completion of Phase I studies. A brief description of this concept is presented below.

b. Montana Plan--Reservoir Diking Systems for Salmon Recovery.

A potential alternative to reservoir drawdown, that would improve conditions for migrating salmon without the serious impact to other river users, is a reservoir diking system. Dikes or levees, built in shallow portions of the reservoir, would reduce the cross-sectional area of the reservoir pool and increase flow velocity.

Reservoir drawdowns reduce area by lowering the elevation of the pool and making the pool shallower. Dikes reduce the cross-sectional area by encroaching on the affected flow area from the sides. This results in a narrower flowing section of water. Unlike major drawdowns, dike systems allow limited elevation changes without dewatering shoreline areas.

This concepts was proposed by the staff at the Montana office of NPPC. Detailed information about the concept and the analysis of this alternative is contained in the report, *Reservoir Diking Systems for Salmon Recovery,* written by Pacific NPPC, Montana, in November 1992. The analysis was conducted by the Montana office of NPPC and the Montana Department of Natural Resources, using data provided to them by the Corps, Walla Walla District.

Section 6 - Evaluation of Alternatives

6.01. Overview.

a. General.

This section presents a summary of preliminary estimates of anticipated physical, environmental, and economic effects associated with the implementation of the alternatives discussed in section 5. Where appropriate, mitigation opportunities are also identified. This information is used as the basis for comparison of the alternatives. The information presented in this section has been extracted from technical reports prepared for each oft he alternatives, as discussed in section 5. These technical reports have been attached to this report as appendixes A through F.

b. Assumptions and Procedures for the Analysis of Economic Impacts.

(1) General.

The Federal objective of water and related land resources projects planning is to maximize contributions to National Economic Development (NED), consistent with protecting the Nation's environment; pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. The strict use of the NED analysis was not considered for the following reasons: 1) economic values have not been established for threatened or endangered species; 2) potential benefits to anadromous fish were estimated in terms of a percent change in survival of juvenile fish; and 3) without project conditions (*i.e.*, what would happen between the present time and the time by which the various alternatives could be implemented) for anadromous fish was not estimated. However, costs and benefits foregone for existing project functions (opportunity costs) will be evaluated from a NED perspective.

(2) Assumptions and Procedures.

The analysis of economic impacts, which includes implementation costs and impacts to other river users, was made using the following assumptions and procedures:

- The price level for estimates of implementation costs is October 1992.
- Annual costs are computed using an interest rate of 8 percent.
- The period of analysis for all alternatives is 100 years.

- Interest during construction is added to construction costs for all expenditures that occur prior to the time an alternative would be put into operation.

- Construction expenditures are assumed to occur in equal amounts during each year of the construction of an alternative, with each year's expenditure occurring at the mid-point of the year.

- The annual cost of maintenance, operation, and replacement of capitol equipment is added to annual investment costs to obtain total annual costs.

(3) Comparability of Economic Costs.

Economic costs and benefits presented in this report do not account for differences in the implementation timing of the alternatives. This difference spans almost two decades, with some system improvements being implementable within 1 or 2 years, while some of the drawdown alternatives would take about 17 years to implement, following completion of feasibility-level (Phase II) studies and Congressional authorization and funding. As a result, costs are not comparable from an economic analysis viewpoint, and should only be used to identify the relative magnitude of costs of the alternatives.

c. Consideration of Uncertainty.

Findings, conclusions, and recommendations presented in this report are subject to a great deal of uncertainty, particularly with respect to potential impacts on anadromous fish. Additional data on the biological effects of the alternatives is needed to resolve this uncertainty. Research on the actual level of the survival of anadromous fish in the lower snake River is on-going through cooperative studies involving NMFS, BPA, the Corps, and others. These studies address reservoir survival, dam passage survival, the FGE of existing bypass systems, and travel time. Also, a biological drawdown test of lower Snake River reservoirs is in the planning process. Other planned studies include the analysis of turbine performance under drawdown and modified entrance conditions, and research on improved (from a fish-passage standpoint) turbine designs. Additional studies are needed to resolve uncertainties regarding reservoir and dam passage survival at other projects in the system, especially at John Day. Results from ongoing and planned studies could change the findings, conclusions, and recommendations of the preliminary study.

6.02. Lower Snake River Drawdown.

a. General.

A complete analysis of this alternative can be found in appendix A, *Technical Report - Lower Snake River Drawdown*. This technical report accomplishes the following purpose: 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. In March 1992, a physical drawdown test was conducted at Lower Granite Dam and reservoir. Information gained during that test has been used for this drawdown evaluation.

Throughout this section, the term "near spillway crest alternatives" is used. This term refers to those alternatives that will use the spillway (existing, modified, or new) under drawdown operation. These alternatives include 33-foot drawdown (alternates 13, 13A, and 17), 43-foot constant pool drawdown (alternatives 14 and 18), 52-foot drawdown (alternatives 15 and 19), and the variable pool drawdowns (alternatives 5 and 8).

b. Drawdown Alternatives.

Twenty-two drawdown alternative were identified and screened for technical feasibility. These alternatives included drawdowns ranging from 33 feet below maximum normal operation pool levels to alternatives that attempt to restore near-natural flow conditions. During initial screening, 12 alternatives were found to be unsuitable, as determined by the TAG. Additional information concerning the initial screening, as well as why alternatives were eliminated can be found in Appendix A. The ten alternatives that were further evaluated are outlined in table 6-1.

Table 6-1 Operating Pool Ranges (Feet Mean Sea Level) 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
Lower Granite Only	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
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.

c. Drawdown Operations.

The proposed drawdown operation would occur during the annual juvenile migration period, and would replace the existing juvenile fish transportation program, since navigation would not be possible with lowered reservoir water surface elevations.

The following assumptions are made in this study: 1) all four lower Snake River reservoirs will be operated each year at lowered pool levels (below normal MOP) during a part of the juvenile fish outmigration period (15 April through 15 June), or the total (15 April through 31 August) juvenile fish outmigration period; and 2) following the lowered pool level 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, other operational constraints can be examined (*i.e.*, early refill, different peak flow design levels, conditions where drawdown would not occur, drawdown duration, timing, *etc.*)].

Each operational alternative will have associated drawdown and refill periods and volumes, and will be highly dependent on the type of physical modifications that can be made at each of the lower Snake River projects.

The maximum rate at which the reservoir can be safely lowered (without substantial embankment failures) has been determined to be 2 feet per day. Actual reservoir lowering would start between mid-February and mid-March, depending on the actual drawdown level. This would allow the reservoirs to be drawn down to the specified level by 15 April. This is the time when juvenile salmon are starting to migrate. It was assumed that all reservoirs would be lowered simultaneously. The rate of refill is dependent on the flows in the river during the refill time. For this analysis, it was assumed that refill would occur with the natural river flows, or assuming no upstream storage would be released specifically for refill purposes. Normally, flows are starting to recede during the refill period. This is particularly true for the 4.5-month drawdown, where refill does not begin until 1 September. It was assumed that the reservoirs would be refilled starting downstream and sequentially working upstream, with Lower Granite being the last to refill. This would reestablish navigation to the lower reservoirs as soon as possible. Table 6-2 provides information on the durations for lowering and refilling the reservoirs, and other drawdown operational information.

Table 6-2
Lower Snake Drawdown Operational Data

Alt	Description	Reservoir Volume Evacuated (AF)	Actual Reservoir Lowering Duration (Days)[1]	Refill Duration Natural Flows Only[2]		Total Duration Below MOP	
				2-Month Drawdown (Days)[3]	4.5-Month Drawdown (Days)[3]	2-Month Drawdown (Days)[3]	4.5-Month Drawdown (Days)[3]
4A	Natural River Option	1,664,000	55 to 60	5 to 99	29 to 129	120 to 209	219 to 324
5/9	Variable Pool Options	1,313,000	14 to 20	3 to 78	24 to 102	77 to 158	173 to 257
13/17	33-Foot Constant Pool	900,000	17	3 to 48	16 to 54	80 to 125	168 to 206
13A	Lower Granite Only	231,000	17	2 to 6	3 to 8	79 to 83	155 to 160
14/18	43-Foot Constant Pool	1,110,000	22	4 to 59	20 to 75	86 to 141	177 to 232
15/19	52-Foot Constant Pool	1,250,000	28	4 to 67	22 to 84	90 to 153	183 to 245

[1]The maximum rate at which the reservoir can be lowered is 2 feet per day.
[2]Refill durations were estimated assuming natural river flows only (no additional storage releases).
[3]Refill durations represent low and high flow conditions during the refill period. Refill for the 2-month and the 4.5-month drawdowns start on 15 June and 1 September, respectively.

d. System Operation Studies.

System operation studies were conducted through the SOR, sing a computer hydroregulation simulation model called HYDROSIM. This model simulates the operation of the Columbia River system up to, and including, Brownlee Dam on the Snake River. A number of alternatives were evaluated to show the effects on reservoir elevations and power production in the Columbia River system. The Columbia River system was modeled using a continuous operation (the results at the end of one year are the starting condition for the next year) over a 50-year hydrologic period-of-record, extending from waster year 1929 through water year 1978.

e. Structural Modifications.

The features of each dam ere originally designed with set operating criteria (*e.g.*, minimum and maximum water surface elevations). Changes in operating criteria (as proposed) affect the operation of the existing fish passage facilities, stilling basins, spillways, powerhouses, and navigation locks. As a result, 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 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 whenever possible, especially with regards to fish bypass systems; and 3) maintain project integrity during, and after, construction. This study is limited to the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Projects. A summary of the required modifications is shown in table 6-3.

Table 6-3
Summary of Structural Modifications

Feature	Alternatives					
	Natural River Option (Alt 4A)	Variable Pool Option (Alt 5/9)	33-Foot Constant Pool (Alt 13/17)	33-Foot Lower Granite Only (Alt 13A)	43-Foot Constant Pool (Alt 14/18)	52-Foot Constant Pool (Alt 15/19)
Lower Existing Spillway					•	
New Spillway Section						•
River Bypass Section	•					
Stilling Basin Drumgate	•	•	•		•	•
Modify Adult Fish Facilities	•	•	•		•	•
Modify Juvenile Fish Passage Facilities	•	•	•	•	•	•
Embankment Protection	•	•	•	•	•	•
Relocate Roads/Railroads	•					•
Miscellaneous Modifications	•	•	•	•	•	•

There are a number of alternative modifications that were identified during the drawdown evaluation. The two primary alternative modifications that warrant further consideration are the downstream weir and surface juvenile fish collector system. The downstream weir would maintain a normal tailwater water surface below each dam during drawdown, and replace the need for stilling basin drumgates and adult collection modifications.

f. Construction Costs and Schedules.

(1) Costs.

The reconnaissance-level construction costs, including real estate, for the drawdown alternatives range from an estimated $70 million to $3.2 billion. The construction costs are based on an October 1992 price level. 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. These costs are to b used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation. The fully-funded costs (shown on table 6-4) are adjusted for inflation to the midpoint of construction, using OMB inflation factors, and range from $900 million to $4.9 billion.

Table 6-4
Summary of Construction Costs and Schedules

Alternative	October 1992 Price-Level Construction Cost ($ Billions)	Average Annual Cost[1] ($ Millions)	Fully-Funded Construction Cost ($ Billions)	Imp Schedule (Years)
Natural River Option (Alt 4A)	3.2	523.9	4.9	17
Variable Pool Option (Alt 5)	0.9	133.4	1.3	14
33-Foot Constant Pool (Alt 13)	0.9		1.3	14
Lower Granite Only (Alt 13A)	0.07	9.9	0.09	4
43-Ft Constant Pool (Alt 14)	1.7	242.5	2.4	14
52-Ft Constant Pool (Alt 15)	2.0	363.6	3.3	17
Variable Pool Drawdown (Alt 9)	1.2	174.0	1.7	14
33-Ft Constant Pool (Alt 17)	1.2	171.0	1.7	14
43-Ft Constant Pool (Alt 18)	2.0	282.9	2.8	14
52-Ft Constant Pool (Alt 18)	2.5	410.2	3.8	17

[1]Computed from investment costs which include interest during construction but exclude inflation during construction.

A summary of the project construction and average annual costs is shown in table 6-4. Estimated annual costs range from $9.9 million to $523.9 million. Annual costs include interest and amortization of present-value investment costs; and operation, maintenance, and replacement costs. 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.

(2) Implementation Schedules.

The implementation of a drawdown will vary depending on the alternative selected. Implementation schedules, as presented, would begin following authorization and appropriation; and would include feature design memorandums, engineering and design, construction, and post-construction evaluation. In spite of uncertainties surrounding the authorization of modifications and completion of design work, the analysis of annual costs is based on the assumption that construction of each of the alternative modifications could commence in 1996. 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, 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, funding, or materials may impact these time periods. A summary of the implementation times for each alternative is also shown on table 6-4.

g. Economic Effects.

(1) The Without Project Condition (No Action).

The without project condition, or base case, reflects the current operation of the Snake River, with interim flow improvement measures made in response to the ESA listing of Snake River salmon. It includes up to 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 427,000 AF of additional upper Snake River water. The base case is very similar to the way the system operated in 1993, and reflects the results of ESA Section 7 consultation with NMFS in 1993. The strategy is consistent with the 1993 operation described in the Corps' *Interim Columbia and Snake River Flow Measures Supplemental EIS (SEIS)*, dated 1993. However, as stated in section 6.01.a.(1), above, potential changes between the present and the implementation of drawdown alternatives were not evaluated.

(2) Overall Effects of Alternatives.

An economic analysis for the drawdown alternatives 4A, 13, and 13A were performed through the SOR. The analysis examine 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 $949 million annually, excluding SOR estimates of benefits to anadromous fish. These costs include the amortized construction costs and operation, maintenance, and replacement costs; economic impacts to recreation; changes in expected flood damages; changes in net farm income; increased municipal and industrial water costs; changes in shallow draft transportation costs; changes in Dworshak log-trucking transportation costs; and changes in system power generation costs.

Table 6-5 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).

Table 6-5
Net Economic Costs Associated With Lower Snake River Drawdown*

Alt	Annual Recreation Costs	Average Annual Flood Damage Costs	Annual Net Farm Income Benefits²	Annual Increased M&I Water Cost¹	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

*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

(3) Regional Economic Development.

Regional economic activity is measured using input/output models, a method used to estimate the size of economic impacts to regions and communities. Many of the alternatives would affect local and regional economies. For example, alternatives that decreases 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 estimate potential impacts on regional and local economies. [Note: This analysis is ongoing and the information was not available for the draft report, but will be included for the final.]

h. Environmental Effects.

(1) General.

This information was summarized from information contained in Appendix G, *Biological Plan*, and information provided from the SOR Anadromous Fish Work Group. The analysis includes a qualitative discussion of the anticipated environmental effects and, where appropriate, a quantitative analysis (*i.e.*, anadromous fish survival). A discussion of the uncertainties associated with the anadromous fish survival models is located in section 3 of this report.

(2) Physical Effects.

(a) Water Quality.

Drawdown will cause substantial changes in water quality, but it is not possible to precisely predict the magnitude of those changes or the extent 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 the resuspension of sediments deposited within the reservoirs being re-exposed to precipitation, wind, and wave action. The natural river option will probably 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. This is because powerhouse hydraulic capacity is reduced under drawdown, resulting in the increased frequency of spill. 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 each of the dams will require cofferdam installation in front of the powerhouses for up to 2 years, resulting in increased spill (due to the powerhouse blockage) and 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.

(b) Water Velocity.

Water travel time will be reduced from 50 to 70 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 approximately 10 percent 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. Figure 6-1 shows the effect that each alternative has on average water travel time through the lower Snake River system.

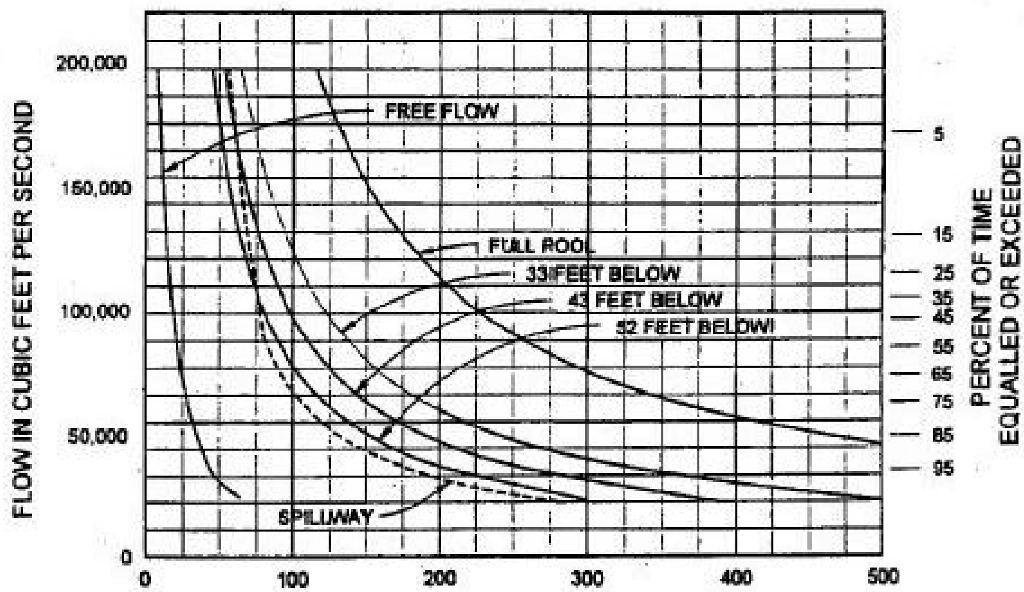

Figure 6-1. Water Travel Time, in Hours, for Lower Snake River Drawdown (Snake River From Clearwater River Confluence to Columbia River Confluence)

(c) 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. Drawdown would likely increase levels of dust in the atmosphere adjacent to the lowered reservoirs, but no health effects are anticipated.

(3) Biological Effects.

(a) Anadromous Fish.

1. 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 can reduce the efficiency of salmon predators, but high turbidity has the potential to cause physical 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 (see section 3.05.c.). All drawdown alternatives may result in increased mortality during the construction of adult fish passage modifications. The degree to which salmonids can, and do, compensate for increased dissolved gas levels by lowering their position in the water column is uncertain. 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.

2. 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, 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 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. 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.

3. 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, dam 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. The base case consists of the current operation conditions for the lower Snake River projects. This implies the use of a juvenile fish transportation program (truck and barge). It should be noted that the base case survival estimates do not include all currently planned and programmed adult and juvenile fish facility improvements (*i.e*., extended screens at McNary, Little Goose, and Lower Granite, or new juvenile bypass and collection facilities at Lower Monumental, McNary, and The Dalles). As a result, the survival estimates for the drawdown alternatives are artificially inflated relative to the base condition.

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-oot 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 (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 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 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. With those results considered, the Lower Granite only alternative does seem to have some marginal potential as an upstream collector for transportation, and should be compared to the other collector options.

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). The percent relative change from the base case for each of the alternatives is summarized in tables 6-6 (critical water years) and 6-7 (50-year average.

Table 6-6
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 6-7
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.

(b) 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 (stream) environments, and could benefit from a drawdown. Northern squawfish utilize shallow near shore 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.

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 (reservoir) 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 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 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 if 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, 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 colorize 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 decrease due to stranding. Plankton will be entrained downstream, thus reducing the food supply for juvenile centrarchids (bass, bluegill, crappie, *etc.*). Less suitable 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.

(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.

i. Mitigation Opportunities.

All reservoir drawdown alternatives will impact natural resources, cultural resources, and commerce. The mitigation opportunities 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. The intent was only to identify and briefly evaluate potential mitigation opportunities, for information purposes only. Where it is not possible to develop specific mitigation measures, sufficient data was collected to identify the magnitude of potential implementation of alternative action and costs.

The NPPC, in its *Strategy for Salmon*, 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 drawdowns.

Reservoir drawdowns would reduce or eliminate the operating head on the turbines, thus impacting hydroelectric production. Physical modifications to turbines and generators to improve efficiency and output are under consideration, where appropriate. 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. Constructions costs range from $29 to $33 million for constant near spillway crest and variable pool drawdowns. The construction cost (undiscounted) 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 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 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 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 could be exposed under constant pool drawdown 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.

j. Summary and Discussion - Lower Snake River Drawdown.

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. Project cost estimates for the four reservoir drawdown alternatives range between $0.9 billion and 3.2 billion ($1.3 and $4.9 billion fully-funded). The fully-funded construction cost estimate for alternative 13A (Lower Granite only) is $70 million ($90 million fully funded). These costs are based on the October 1992 price level adjusted for inflation to midpoint of construction (using OMB inflation factors) and are not discounted to account for differences in implementation timing.

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 $950 million (alternative 4A), annually. These economic costs include the cost of construction, interest during construction, and direct economic impacts to other system users. Economic impacts to other users include recreation impacts, flood damage reduction charges, farm income losses, 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, fish and wildlife, and indirect economic impacts on regional and local economies.

There are many negative environmental impacts that would result form 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.

Two mathematical models (PAM and CRiSP) 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.

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. Although this alternative includes drawdown, it is more closely associated with the upstream collection and conveyance alternative. The other four-reservoir drawdown alternatives, which were near spillway crest, showed negative impacts to all juvenile stock investigated. Other qualitative evaluations, and a sensitivity analysis, verified these results.

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 than PAM. The CRiSP estimated a reduction in survival for fall Chinook, and no substantial change for steelhead.

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 could 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. The base case (for both PAM and CRiSP) used for comparison consists of the current operation, which includes flow augmentation, operation at MOP at certain projects, and juvenile fish transportation. This base case 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.

The relationship used with the existing mathematical models assumes that increasing flows and velocities directly reduces juvenile fish travel time, thereby theoretically reducing their reservoir-related mortality and increasing survival. This increase in reservoir survival for the near spillway crest alternatives is not enough to overcome other factors reducing survival through the lower Snake River (*i.e.*, increased mortality from turbines, and spill and bypass operations). In addition, the fish are then subjected to reservoir and dam mortality through the four dams and reservoirs on the lower Columbia River. Unless actions are taken on the lower Columbia River to significantly reduce reservoir and/or dam-related mortality, the near spillway crest drawdowns on the lower Snake River do not appear to be an effective action to improve system-wide migration conditions for juvenile salmon. The natural river option eliminates the effects of the four lower Snake River dams, which is enough to potentially offset the mortality through the lower Columbia River.

6.03. Operation of John Day Reservoir at Elevation 257.

a. General.

Detailed discussion of this proposal can be found in Appendix B. Operation of John Day project at its minimum operating pool (MOP) level (elevation 257) from 1 May through 31 August has been evaluated for its benefits and impacts to the existing project, anadromous fish, the environment and other uses of the reservoir. An option to operate at MOP year-round to potentially provide for partial mitigation of impacts was also evaluated.

In general, project facilities have been designed for operation at this level. However, it is noted that the purpose for evacuating the pool to this level was to provide storage space to assist in controlling flooding in the Portland/Vancouver area on a forecast basis. Because it was designed for flood control, the original project design did not envision regular or sustained operation at the MOP level.

b. Project Modifications.

Implementation of the proposed operation would appear to require some modifications to existing adult fish ladders at John Day and to adult fish ladder entrances at McNary Dam to meet existing criteria. Modifications to juvenile passage facilities or turbines have not been included in the costs at this time because the effects are unknown (see subparagraph e., below.

c. Impacts to Reservoir Users and Others.

Reservoir users, particularly agricultural irrigation pump station operations would be impacted by the proposed operation. Modifications to restore pumping capability are anticipated to be necessary at 23 or 24 pump stations on the reservoir. Most appear to be relatively straightforward measures to extend intakes, however several large stations would require the addition of new low-head pumping facilities.

Municipal water supplies would also be impacted as well as other groundwater users in the project area. Over 2,000 groundwater wells have been identified in the area. A preliminary evaluation and estimate indicates that approximately 10% of these facilities could be impacted to the point of requiring modifications, but a monitoring program would be necessary to identify the problem areas.

Based on recent testing, the existing Umatilla and Irrigon Hatcheries' water supply would not appear to require supplementation due to the operation for 4 months. Under the year-round operation a substantial shortfall is projected, however, requiring new sources of supply or other measures such as water recycling and reuse.

From preliminary field studies, it appears that 15 recreation sites on the pool would require modifications to extend boat ramps, swimming beaches, and dock facilities. Several marinas could require dredging and at two sites, maintaining channel depths would require costly rock removal. Evaluation of alternative mitigation opportunities and incremental justification will be required in subsequent studies. Other potential impacts to utility pipeline crossings and an existing landslide area have been identified.

d. Environmental Impacts.

Resident fish and wildlife habitat will be impacted by the proposed operation. The annual 4-month operation at MOP and annual fluctuation will affect an estimated 8,000 acres of shallow water habitat and 2,000 acres of marsh-riparian zones throughout the reservoir. The existing shallow-water habitat is also believed to be important to rearing juvenile anadromous fish. The Umatilla National Wildlife Refuge and two state-managed wildlife areas contain the majority of the habitat areas. Year-round drawdown is estimated to provide replacement habitat area for about 25 percent of the losses after a recovery period. No other opportunities to mitigate resident fish impacts have been identified to date. Offsite mitigation is anticipated for wildlife impacts.

The drawdown could have an impact on migrating Umatilla River adult salmon due to blockages at the mouth of that river. Periodic dredging may be required.

Significant cultural resources exist on the project, and will be impacted by the proposed operation. No reliable estimate of mitigation costs can be projected at this time. A monitoring program would need to be implemented with the drawdown.

e. Biological Effects.

Operating John Day at MOP reduces the water travel time (WTT). In the pool itself, the relative change in WTT is reduced about 12 to 15 percent. From the Granite pool on the Snake River or from Wells pool on the mid-Columbia to below Bonneville, the change in WTT due to John Day at MOP is estimated to range from 2 to 5 percent. Based on these estimates, under average flow conditions in May, an approximate 15-day travel time would be reduced by 0.5 days. Under average August conditions, an approximate 56-day WTT from Granite to below Bonneville would be reduced by about 1.7 days. From Wells pool in August, an approximate 30-day WTT would be reduced by about 1.5 days.

Effects of the operation of John Day at MOP on juvenile salmonids were estimated using two regional fish passage models (CRiSP and PAM). Results varied. Snake River, mid and lower Columbia River stocks of steelhead, fall Chinook, spring and summer Chinook salmon were modeled using CRiSP. The PAM modeling was limited to Snake River and mid-Columbia River spring Chinook. For preliminary comparisons with the lower Columbia system improvements evaluated using CRiSP, results for representative mid-Columbia stocks (Methow spring Chinook, Methow Well Index fall Chinook, Hanford Ferry summer Chinook, and Wenatchee steelhead) are presented in table 6-8.

Table 6-8
Changes in Relative Survival With John Day Lowered to MOP-CRiSP (in Percent) for Representative Mid-Columbia Stocks

	Species			
	Spring Chinook	Summer Chinook	Fall Chinook	Steelhead
Relative Change in Survival	-4	0	3	3

Fish survival was estimated from the point of origin to below Bonneville Dam, using both models. Results from CRiSP modeling showed relative changes in survival (from the base case) for operation of the pool at MOP of -4 to +3 percent (absolute changes were -1 to +1 percent) for the mid-Columbia stocks above. These results would be considered to be essentially no change from the base condition due to the variability (stochasticity) of the model. Results from PAM modeling show a relative increase in survival for mid-Columbia spring Chinook of 7 percent, and a 2-percent increase for Snake River stocks. Differences in how each model treats reservoir travel time changes and the variability of the CRiSP model are likely causes for the different results for mid-Columbia spring Chinook.

Potential effects of the operation on survival of Snake River stocks is minimal in both models due to transport. The vast majority of juveniles from the Snake River would not be affected by actions in the lower Columbia River. It is noted that model runs of John Day at MOP without transportation showed significantly lower survival than the base condition with transportation.

Estimates of survival through the John Day pool only were also made using CRiSP. Evaluation of survival changes through the John Day pool alone resulted in absolute changes of -2 percent for spring Chinook and +2 percent for the other mid-Columbia stocks.

Other potential effects on migrating juveniles due to operation of John Day at MOP have been identified and include: changes in fish guidance and/or orifice passage efficiencies, turbine passage survival, shallow water habitat (rearing areas), and predation. These were not included in the modeling due to high levels of uncertainty, or inability to model. It is possible that these changes could have adverse effects on juvenile fish which might offset benefits derived from the reduced travel time. Studies can be conducted to improve understanding of the possible extent of some of these effects in an attempt to reduce uncertainties.

f. Costs.

The estimated project costs for a 4-month and a 12-month drawdown are $65 million to $99 million, respectively (see table 6-9).

Table 6-9
Estimated Costs and Implementation Schedule for John Day at MOP

Option	Implementation Schedule (Years)	Total Project Cost	Fully-Funded Costs	Annual Economic Costs	Total Average Annual Costs
4-Month Drawdown	5	65,060,00	73,930,000	3,867,000	10,555,000
12-Month Drawdown	5	98,537,000	111,988,000	2,501,000	23,621,000

The most significant project cost items include the mitigation of impacts to adult fish passage facilities, habitat, recreation sites, irrigation pump stations, and other water supplies. Monitoring costs for a potential landslide and cultural resources are included. No costs for mitigation of cultural resource impacts have been included at this time. Other smaller mitigation items are identified in the appendix.

These costs also include contingencies, engineering and design, and construction contract supervision. Fully-funded costs are adjusted for inflation to the midpoint of construction, using OMB inflation factors, and range from $74 million to $112 million.

Economic impacts for the proposed operation are substantially derived from lost hydropower generation. For a 4-month drawdown, this is estimated to be about $3.8 million. For the year-round option, the estimate is $12.3 million.

For this reconnaissance-level study, it has been assumed that recreation sites impacts would be restored and, therefore, economic impacts on recreation would be negligible. It is noted from the SOR study that the impacts to recreation were estimated to be $6 million annually for operation at MOP without mitigation.

Total average annual costs include amortized project and interest during construction costs, annual OM&R costs, and annual economic costs.

A minor impact to the navigation industry was identified due to increased lockage time under drawdown conditions.

6.04. Additional Snake River Storage.

a. Background.

A complete analysis of this alternative can be found in Appendix C, *Technical Report - Additional Snake River Basin Storage.*

Successive years of consultation with NMFS concerning system operation under the ESA have continued to result in increasing requirements for flow augmentation. These requirements are driven by the NMFS opinion that incremental flow increases are needed and effective as salmon recovery techniques. The need to provide these flows has significant impacts on Dworshak reservoir storage, and is leading to increased demand on upper Snake River storage.

During the Salmon Summit, BOR offered to initiate an appraisal study of new Snake River storage. This new storage could provide additional water for lower Snake River flow augmentation, or refill, in efforts to aid migrating salmon and steelhead. This element was incorporated in the Governor's Report to Senator Hatfield on May 1, 1991.

As a result of commitments made at the Salmon Summit (and reiterated in NPPC's *Strategy for Salmon*, BOR facilitated an interagency committee effort to inventory and screen potential storage sites for further development. The committee was made up of representatives from BOR, the Corps, and BPA; as well as from the states of Washington, Oregon, and Idaho. The sites were evaluated by the Corps and BOR, depending on prior involvement at the specific sites. The final evaluations were completed in 1993, and the final report was submitted to the NPPC, by letter dated 11 February 1994. Participation in this process by the Corps was initiated by a letter, dated October 11, 1991, from BOR.

The development of additional Snake River basin storage will examine the possibility of providing additional upstream storage for flow and temperature improvements during anadromous fish migration periods. The study utilized existing information on previously proposed storage sites, such as the Galloway and Teton sites on the Weiser and Snake Rivers, respectively. Information on site location, storage, possible flows, type of structures, preliminary design and costs, and estimated implementation schedules are presented. In addition, benefits to juvenile fish passage were evaluated.

The Corps terminated a feasibility-level study of the Galloway site, and released a technical report in August 1990. Information on the Galloway Project found in the technical report is summarized in this report. This study was terminated prior to completion, due to a lack of Corps interest (due to budgetary priorities) in developing the site for hydropower, fish, and wildlife enhancement.

b. Status/Summary of BOR-Led Interagency Upstream Storage Study.

(1) General.

The purpose of the study was to evaluate the potential for upstream storage development and the effectiveness of augmenting streamflows to increase salmon survival in the lower Snake and Columbia Rivers. The following is a summary of the study and results, primarily reflecting the results of the report, *Snake River Basin Storage Appraisal Study.*

(2) Inventory and Screening.

As the first step of the study process, an interagency team prepared an initial inventory of potential sites (both onstream and offstream storage) above the mouth of the Snake River. Because of the large number of potential sites, only those with a minimum of 10,000 AF of storage were identified. The inventory included 295 potential onstream (including potential enlargements of existing facilities), and 119 potential offstream storage sites. These sites were identified in the BOR report, dated 2 July 1992, titled *Snake River Basin Damsite Review.*

A preliminary initial screening of the inventoried sites was completed, based upon the following parameters:

- Wild and scenic river designation
- Sate scenic waterway(s)
- The NPPC Areas designation
- Sites adversely impacting:

  Anadromous fish habitat

  Resident fish habitat

  Wildlife habitat

  Sanctuaries and refuges

  Threatened, endangered, or sensitive species
- State or National Parks

- Commercial forest lands
- Sites where development is not authorized by local government land use plans and regulations
- Water quality criteria

Based on the above information, the Snake River Basin Cooperative Appraisal Study Work Group reduced the large number of potential sites to a workable quantity, based on discretionary application of screening criteria. The work group then selected sites for hydrology analysis, and selected particular damsites to receive appraisal-level evaluations. The sites selected include both offstream and onstream sites all located in the Snake River basin above Lower Granite Dam. Table 6-10 shows a list of damsites that were chosen for further appraisal evaluation.

Table 6-10
Storage Sites Investigated

Onstream Sites	Offstream Sites
Galloway site, Oregon Teton River, Idaho Owyhee Dam and Reservoir Enlargement, Oregon Thief Valley Dam, Oregon; replace existing Dam	Moores Hollow, Oregon Jacobsen Gulch, Oregon Succor Creek, Idaho Saylor Creek, Idaho Rosevear Gulch, Idaho Bissel Creek, Idaho Conant Creek, Idaho

Potential environmental impacts were evaluated for each site. It was determined that there are minimal environmental impacts on the Rosevear Gulch, Moores Hollow, Bissel Creek, and Jacobsen Gulch sites. Some of the other sites had environmental impacts that could be mitigated. There is some concern about the water quality in the Galloway reservoir, due to the presence of mercury ore deposits in the reservoir area, included abandoned mercury mines. However, it is estimated that the problem will diminish over the first years of operation.

Through an analysis of water availability studies, analysis of the cost of developing and operating the project, and assessment of potential environmental impacts, the above list was further screened down to six sites. These six sites are: 1) Galloway; 2) Rosevear Gulch; 3) Jacobsen Gulch; 4) Teton; 5) Thief Valley; and 6) Owyhee enlargement. Due to limited water supplies at the Teton, Thief Valley, and Owyhee sites, the list of sites recommended for further analysis was reduced down to the Galloway, Rosevear Gulch, and Jacobsen Gulch sites (see figure 6-2).

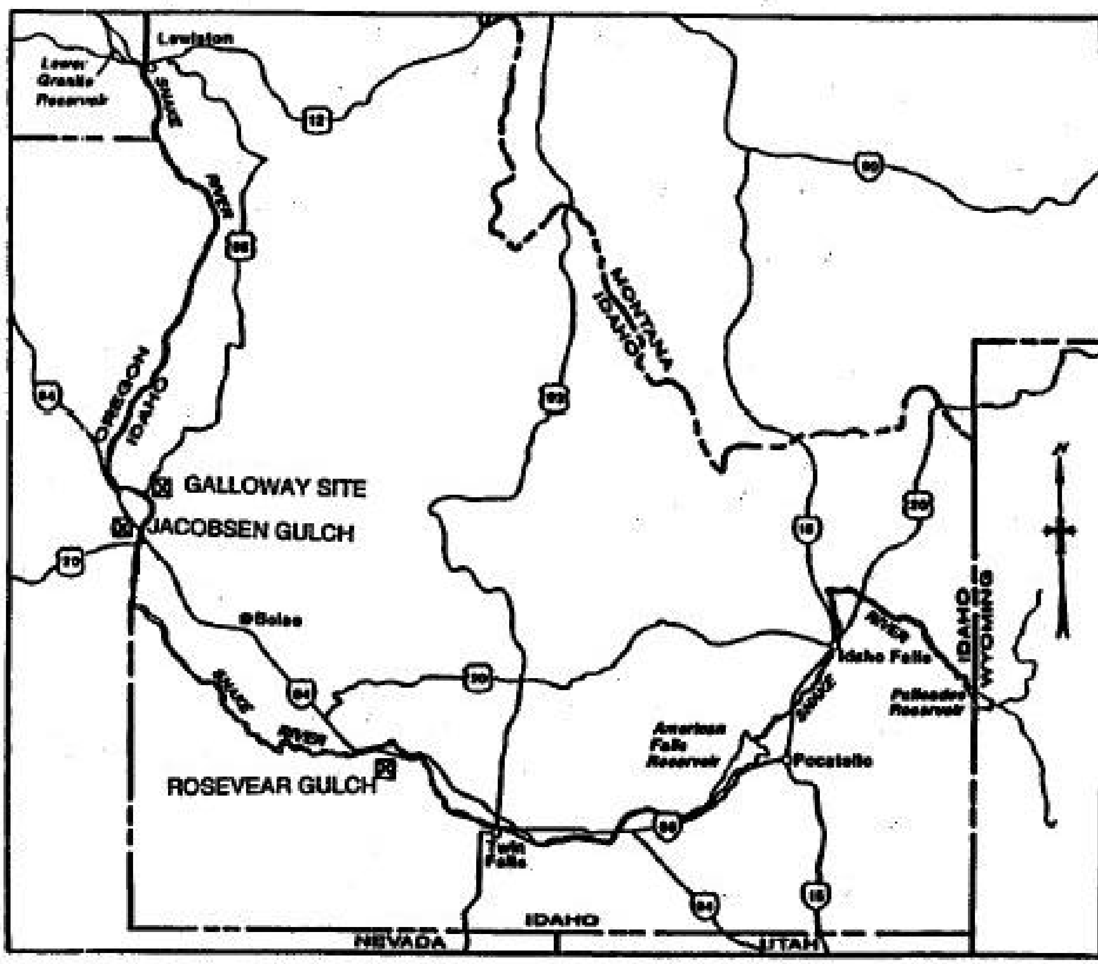

Figure 6-2. Snake River Basin Storage Appraisal Study

A summary of reservoir storage capacity, average annual water that could be released from each reservoir, and the total cost per AF of water released, is shown on table 6-11.

Table 6-11
Reservoir Storage Capability

Project Name	Gross Storage AF	Active Storage AF	Average Water Released AF/Year	Cost Per AF $/AF/Year
Galloway Project	900,000	715,000	335,650	61
Rosevear Gulch Project[1]	675,300	607,800	607,740	224
Jacobsen Gulch Project	209,600	188,600	188,680	269
Total	**1,784,900**	**1,511,400**	**1,132,070**	

[1]Upper Site

To facilitate further analysis, the Rosevear and Jacobsen Gulch Projects were combined. Consequently, further studies were limited to two scenarios including: 1) Galloway Project; and 2) a combination of the Galloway, Rosevear, and Jacobsen Gulch Projects.

(3) System Operation Studies.

System operation studies were conducted to evaluate the impacts of adding the new storage projects toward meeting flow targets at Lower Granite Dam, and impacts on the northwest power generation system. The studies were conducted using the Hydrologic System Seasonal Regulation (HYSSR) computer model, which simulates the operation of each project in the Columbia River System based on predetermined operation criteria for each project. The computer model was run both with and without the new storage projects for flow targets of 85,000 cubic feet per second (cfs) and 120,000 cfs, and evaluated over a 2.5-month (16 April to 30 June), and 4.5-month (16 April to 31 August) flow period. Output from this study was then used to evaluate the impacts of the projects on improving juvenile anadromous fish survival as well as costs to power generation.

(4) System Power Cost Study.

Studies were also conducted to evaluate the impacts (added costs) of operating the Pacific Northwest Power System for flow augmentation.

It was determined that the most significant impact for alternative storage options for flow augmentation would be on the Pacific Northwest power system costs. This evaluation was completed, using the HYSSR model in conjunction with a spreadsheet model developed by the SOR Power Work Group. The analysis was completed as part of the BOR-led Interagency Upstream Storage Study. System generation is estimated by the HYSSR model. The SOR spreadsheet model was designed to calculate the total system cost for alternative system operation strategies, using estimates of hydrosystem generation developed using HYSSR. The primary output of the model is the total annual cost of operating the entire Pacific Northwest power system under each condition evaluated.

(5) Construction Cost and Economic Analysis.

The total project cost for the Galloway Project was estimated to be $192,500,000 at a July 1993 price level. The cost estimate is based on design and cost data included in the Galloway Technical Report, dated August 1990, and updated to a July 1993 price level. The cost estimate is considered to be between reconnaissance- and feasibility-level of detail, and is not of sufficient detail for project authorization. Cost data in the Technical Report includes all costs incurred in the construction of the project, including real estate, and assumes that the existing railroad branch line located in the reservoir area (currently owned by the Idaho Northern and Pacific Railroad) will be purchased and not relocated. The cost estimates include an overall contingency rate of about 17.1 percent. Costs for planning, engineering and design, and construction management were approximately 8.3 percent and 7.2 percent of the total construction cost (including real estate), respectively.

The total project costs for the Rosevear Gulch and Jacobsen Gulch Projects are estimated to be $1,046,116,000 and $388,365,000, respectively, at a July 1993 price level. The cost estimates were prepared by BOR, using BPA's hydropower analysis model (HAM). Construction costs include costs for the dam and reservoir, and the water delivery/conveyance system, including pumping plants, pipelines, and release channels.

Total investment costs include interest during construction, based on a construction period of 5 years with an interest rate of 8.25 percent. Interest and amortization is based on an interest rate of 8.25 percent over a 100-year project life. Annual costs include amortized investment costs, based on an interest rate of 8 percent and an economic project life of 100 years. For the Rosevear Gulch and Jacobsen Gulch Projects, the annual cost includes the cost of electric power for the pumping facilities.

A summary of the project costs, investment costs, and average annual costs is included in table 6-12. Table 6-13 is a cost analysis including total average annual net costs for the three projects. The net costs reflect reduced system power costs resulting from operating the hydropower system with the projects for increased anadromous fish survival.

Table 6-12
Summary of Costs ($1,000)

Site	Project Cost	Investment Cost	Average Annual Construction Cost[1]
Galloway	192,500	226,640	20,545
Rosevear Gulch	1,046,116	1,284,442	136,159
Jacobsen Gulch	388,365	476,842	50,740

[1]Total average annual costs for all three projects is $207,444.

Table 6-13 Cost Analysis Average Annual Costs Galloway and Rosevear Gulch Projects ($1,000)				
	Flow Target			
	85,000 cfs		120,000 cfs	
	Flow Duration Months		Flow Duration Months	
	2.5	4.5	2.5	4.5
Galloway Project Only				
Implementation Cost[1]	20,544	20,544	20,544	20,544
System Power Cost	(63,000)	(49,000)	(48,000)	(26,000)
Total	(42,456)	(28,456)	(27,456)	(5,456)
Galloway, Rosevear Gulch, and Jacobsen Gulch				
Implementation Cost	207,444	207,444	207,444	207,444
System Power Cost	(58,000)	(65,000)	(63,000)	(42,000)
Total	149,444	142,444	144,444	165,444

c. Anadromous Fish Survival Analysis (All Sites)

The impact of these storage projects on increasing the survival rate for anadromous juvenile fish through the Columbia and Snake River systems was analyzed using the Columbia River Salmon Passage (CRiSP) 1.4 model. The model was developed using regionally coordinated input from the Center for Quantitative Studies at the University of Washington, under contract to BPA, for SOR. The effect of the additional storage on increasing the survival was evaluated under two conditions, including both with and without fish transportation. For each transportation condition, four cases were evaluated; including combination of flow targets of 85,000 cfs and 120,000 cfs, and flow duration periods of 2.5 and 4.5 months. The model used average monthly streamflow data output from the HYSSR system operation studies that were converted to average daily flows using a modulator built into the program. Table 6-14 is a summary of the estimated median smolt survival rates by species:

Table 6-14
Median Smolt Survival[1] Model Results

	Flow Target			
	85,000 cfs		120,000 cfs	
	Flow Duration Months		Flow Duration Months	
Species	**2.5**	**4.5**	**2.5**	**4.5**
Dworshak (Base) With Galloway Added				
Spring Chinook				
Base Condition	25	24	25	24
With Project	23	24	24	25
Summer Chinook				
Base Condition	28	27	28	29
With Project	28	28	27	28
Fall Chinook				
Base Condition	11	11	09	10
With Project	09	11	09	11
Dworshak Steelhead				
Base Condition	28	27	28	29
With Project	28	27	27	29
Dworshak (Base) With Galloway and Rosevear/Jacobsen Gulches Added				
Spring Chinook				
Base Condition	25	24	25	24
With Project	24	23	25	25
Summer Chinook				
Base Condition	28	27	28	29
With Project	28	28	29	29
Fall Chinook				
Base Condition	11	11	09	10
With Project	09	11	10	11
Dworshak Steelhead				
Base Condition	28	27	28	29
With Project	28	28	29	28

[1]The information was based on no fish transportation program.

Generally, the model results showed only small changes in survival for the Snake River spring/summer and fall Chinook smolts compared to operation of existing storage at Dworshak to meet the same target flows at Lower Granite. However, most of the changes were considered to be within the variability of the model and, therefore, considered to be negligible.

Negative results were generally obtained when available water was released to aid one stock (*e.g.*, spring/summer Chinook salmon). This, then, may result in lower flows that would be available for another stock (*e.g.*, fall Chinook). Since the flow augmentation scenarios concentrated on providing specific flows over long time periods (2.5 and 4.5 months), and since monthly average data were used in the scenarios, the additional water supplies resulting from new storage were probably not used in the most effective manner for improving survival. It is possible that the additional supplies could be used in conjunction with an in-season water management process to provide improved flows during the time of greatest smolt movement to obtain a more significant increase in smolt survival benefit.

d. Summary Discussion--Additional Snake River Storage.

Based on studies completed to date, it has been found that benefits attributable to upstream storage for increasing anadromous fish survival appear to be limited. In some instances, the survival rates are increased slightly. In other cases, the survival rates are actually decreased. These limited findings, however, can be expected based on the method and level of detail used in the evaluation. The analysis was based on an appraisal level of detail which, by its very nature, cannot be responsive to what is considered to be the more critical parameters and considerations. In addition, comparisons were made against operating the existing system (Dworshak) to meet the same flow targets, rather than existing system operations.

Although this analysis showed no quantifiable benefits for fish survival, there are strong arguments that the system operation studies accomplished as part of the analysis do not allow for adequate fishery-related input. In addition the flow duration periods evaluated were too general to evaluate migration periods of specific species. Only median survival rates over the period of record were evaluated, and only a cursory evaluation of the impacts of upstream storage during a series of low flow years (when flows are most critical for fish passage) was completed. Other variations of operation plans that could identify measurable fishery benefits, and should be evaluated in future studies, include:

- Upstream storage could benefit fall Chinook salmon, from the confluence of the Salmon River to Lower Granite Dam, during critical low flow years by augmenting flows in the Snake River.

- Upstream storage could improve water temperature control to aid in fish passage. For example, the Galloway Project could be used to augment flows for spring Chinook, allowing the colder water in the Dworshak Project to be saved for water temperature control in the Snake River for fall Chinook.

- If releases from upstream storage were made to coincide with known high migration periods of specific stocks, the effectiveness of the stored water could be greatly increased through pulsing or flow block management. Higher releases could be made over a 1- to 3-week period, to meet stock-specific targets, as opposed to spreading flow over the 2.5- or 4.5-month period assumed in the Phase I study. These optimized flows would be designated release, rather than trying to meet a constant specified flow target of 85,000 cfs. This would tend to increase the efficient use of the stored water and, consequently, increase benefits.

- Upstream storage could be an effective alternative, in combination with other improvements (*e.g.*, surface-oriented juvenile fish collector). Benefits from such a combination would be limited to the reach of river between the alternatives, but could increase juvenile fish survival for the total system due to cumulative overall increased efficiency.

- The feasibility of transferring flood control storage space from the Brownlee Project to the Galloway Project could improve the effectiveness of upstream storage by making additional water available for flow augmentation.

- Variable flow targets and duration periods should be used in the analysis, as opposed to the set targets used in the Phase I analysis. In doing so, stored water can be used much more efficiently.

Of the alternative projects that were evaluated, the Galloway Project was found to be the most cost-effective alternative. By shifting the flow augmentation operation requirements from the Dworshak Project to the Galloway Project, the Dworshak Project would be able to operate at a higher head for hydropower generation, resulting in a significant reduction in system power generation costs.

The biological uncertainty inherent in the flow survival relationships used in modeling efforts, as well as other areas of biological uncertainty surrounding the adult and juvenile life cycle, make it extremely difficult to draw definitive conclusions with respect to the biological efficacy of upstream storage for flow augmentation. Additionally, successive years of consultation with NMFS concerning system operation under ESA have continued to result in increasing requirements for flow augmentation. These requirements are driven by the NMFS assessment of the "best available science," and an opinion that incremental flow increases are needed and effective as salmon recovery techniques. The need to provide these flows is stressing the use of Dworshak reservoir storage, and leading to increased demand on upper Snake River storage. Therefore, further consideration of a means to reduce the impact of the water demands on the Columbia River system, and particularly existing Idaho storage, may be prudent.

The estimated project cost associated with the construction of Galloway, Rosevear Gulch, and Jacobsen Gulch are $195,000, $1,100,000, and $390,000, respectively. The estimated time required for implementing Galloway is 11 years, starting from the date authorization is enacted and construction funds are appropriated.

6.05. Upstream Collection and Conveyance.

a. Background.

It may be possible to significantly improve upon present fish collection and conveyance systems if design constraints related to hydropower are no longer applicable. Most of the present systems were designed as major retrofits to existing hydropower generation facilities, with the primary motive to limit adverse effects upon hydropower operations. This section presents preliminary design and cost estimates for various alternative means of collecting juvenile salmonids from upstream of Lower Granite Dam and conveying (transporting) them by canal, pipeline, or vessel to below Bonneville Dam. It also identified potential benefits to juvenile salmon survival, other environmental effects, and economic consideration. A complete analysis of this alternative can be found in Appendix D, *Upstream Collection and Conveyance Technical Report.*

b. Project Alternatives--General Discussions.

Concepts for upstream collection and conveyance were considered that incorporated various methods for the collection of juvenile salmonids, as well as various methods of conveyance to below Bonneville Dam. Each alternative was designed to carry a total of 50 to 60 million juvenile salmonids during the downstream migration period (April through November), with an expected peak of 2 million fish per day. Juvenile salmonids would be introduced into the system from new collection facilities located upstream of Lower Granite Dam, as well as from the existing juvenile bypass system at each of the downstream dams.

Four basic alternatives were analyzed for costs and schedules. For each of these alternatives, a single upstream collection system using one design option was assumed (see following paragraphs). For each alternative, three different collection design flows (100,000; 160,000; and 225,000 cfs) were evaluated. Alternatives related to other site locations, dual collection systems located upstream of Lewiston on the Snake and Clearwater Rivers, and other types of upstream collection designs would be evaluated further if this concept is carried into future studies. It should be noted that a dual collection system design for collectors located upstream of Lewiston would probably require the construction of small dams to create proper hydraulic conditions for the fish diversion barriers. This might require additional biological, as well as cost-related, impacts not associated with a single collection system located downstream of Lewiston.

There are major questions and uncertainties associated with the different upstream collection and conveyance system concepts. Biological research and preliminary engineering studies will need to be completed prior to the construction of any of these systems in order to resolve these uncertainties.

c. Alternative Discussions.

All alternatives were assumed to consist of a single collection system on the Snake River in the vicinity of Silcott Island, located about 7 miles downstream of Lewiston. Detailed site studies to evaluate this and other sites will be completed in later studies. Each alternative would have fish sorting facilities, and would allow for additional intermediate fish collection at downstream dams. An upstream collection system using a low velocity design, assuming a bridge structure/fixed barrier collection component, was selected for developing costs and schedules. It was also determined that cost and schedule data related to floating platform/moving barrier concepts would be comparable to a bridge structure/fixed-barrier collection system.

Alternative 1 (Migratory Canal) provides for fish collection, sorting, and lifting to a migratory canal, and conveyance through each reservoir reach by a series of open channels, flumes, and tunnels. This canal would carry approximately 200 cfs. Resting ponds would be incorporated at regular intervals along the canal, approximately every 10 miles. These ponds would allow the smolts to rest and/or feed, and would also provide a point where fresh river water would be exchanged.

Alternative 2 (Pressure Pipeline) provides for fish collection, sorting, and lifting to a buried pressure pipeline and related system along the reservoir shoreline.

Alternative 3 (Barge Transport System) provides for fish collection, sorting, and transfer for fish collection, sorting, and transfer into existing barges, where collected fish would be transported downstream to below Bonneville Dam. This system would require, at the upstream collection system, a fish barge lock to allow gravity loading of fish from the collection facility into existing barges. There would be no additional costs or schedule time required beyond the construction of the upstream collection facilities, since it is assumed that existing fish barges would be used to transport the fish.

Alternative 4 (Floating Pipeline) provides for fish collection, sorting, and transfer into a floating open channel or enclosed low-pressure conduit to be conveyed downstream to below Bonneville Dam.

d. Construction Costs and Schedules.

Table 6-15 summarizes reconnaissance-level cost and schedule information for the alternatives. Project costs are based on an October 1992 price level, and include construction costs, real estate costs, engineering and design costs, construction management costs, and contingencies. Contingencies reflect the anticipated level of construction risks and unknown. The fully-funded costs adjusts for inflation to the midpoint of construction, using OMB inflation factors. Fully-funded costs are normally used for budgeting purposes.

Table 6-15
Upstream Collection Conveyance Cost Schedule and Information

Alternative	Project Cost	Fully-Funded Costs	Average Annual Cost ($ Million)	Schedule (Years)
1 (Migratory Canal)	$4.3 bil	$5.5 bil	$570 mil	11.5
2 (Pressure Pipeline)	$4.1 bil	$5.2 bil	$548 mil	11.5
3 (Transport)	$260 mil to $360 mil	$370 mil to $470 mil	$34 mil to $45 mil	5.5 to 8
4 (Floating Pipeline)	$790 mil to $860 mil	$920 mil to $1 bil	$135 mil to $144 mil	11.5

The average annual costs include interest and amortization of investment costs; and operation, maintenance, and replacement (OM&R) costs. The OM&R costs range from $5 million to $32 million annually.

These costs are intended for planning purposes only. They are not of sufficient detail for authorization or appropriation use.

Design and construction schedules shown, starting from the date of authority and appropriation, assume funds and resources are available when required. Costs and schedules indicating a range in values reflect differences in collection facility design flows (ranging between 100,000 and 225,000 cfs).

e. Anadromous Fish Benefit Analysis.

The proposed migratory canal and floating pipeline conveyance options have received various critical reviews by such regional groups as the TAG. The TAG and the U.S. Fish and Wildlife Service, in its Planning Aid Report, expressed a considerable amount of concerns with reliance on such untested artificial conveyance system designs. Primary concerns that are common to all of the currently proposed options are both biological and ecological. They include the following:

- Bioengineering capability to artificially replicate natural ecological processes and biological conditions that are functionally interacting to the degree exhibited naturally (*i.e.*, resting ponds/areas, temperature, and flow regulation).

- The mechanical complexity of each proposed apparatus, and their synchronized operation, would require constant maintenance.

- In the low probability event that a means can be devised to artificially replicate the natural passage system into a pipeline or canal system, the need for adequate safe and efficient passage within the river system would not diminish or be considered mutually exclusive in any manner, especially for adults migrating upstream.

- Each alternative would require either some mechanical means of lifting the fish into the channel or a pumping/fanning system to move the fish.

- Exclusive increased concentration of salmonid smolts through a closed system would act to separate smolts from their natural food sources and the diversity in their food items.

- Increased concentration of salmonid smolts would be highly vulnerable to inescapable stress-related factors (*i.e*., disease outbreaks and manifestations; predator invasion, including predation by larger steelhead smolts; increased inter- and intraspecies competition; and mechanical failure or accidents that would act as catastrophic events and potentially be detrimental to small population genetic fitness and viability).

Designs currently engineered for upstream collection with conveyance systems are new and untested. One design advantage afforded to a new upstream collector is its independence of the powerhouse operational and structural constraints that have influenced the design of current collection and bypass systems at the lower Snake River dams. This will allow for a more biologically-functional design.

The success of any upstream collection concept coupled with barge transport would be highly dependent on the biological success of the fish transportation program currently operated for all Snake River salmonid stocks. If the primary objective of an action is to deliver the maximum number of live smolts to some point below Bonneville Dam, or into the estuary from the top of the Lower Granite reservoir, the improved collection and barge transport of smolts around the Snake and Columbia River dams would be one of the most reasonable alternatives (from a biological perspective) for increasing smolt-to-adult survival.

A low velocity guidance/collection facility located near the top of the Lower Granite reservoir for the collection, tagging, and subsequent transport of migrating smolts to the lower Columbia River has several potential advantages. These advantages include: 1) the removal of smolts from less than optimal reservoir conditions where predator activity is assumed substantial; and 2) a reduced need for extreme levels of flow augmentation that continues to be a real concern with the region's coordinated inability to store enough water and then efficiently shape and pass that water for any measurable benefit to downstream migration.

An upstream collector, designed as a low velocity system, would address the concern posed by many biologists in the region that the turbine intakes at dams offer inhospitable environments for the collection and bypassing of juvenile salmonids. Passage through current spillway configurations offers little benefits with stress-related tradeoffs, and can not be considered more optimal for the smolt population. A collector designed with surface orientation (as opposed to a turbine collector system), located upstream in the Lower Granite reservoir and designed specifically for salmonid smolt collection without any powerhouse constraints imposed upon the design could be a beneficial alternative, as long as the biological needs of the respective listed salmonid stocks are fully incorporated into the collector design and operation.

Critical research and site monitoring would have to determine the most appropriate location for constructing an upstream collector facility. The entire mainstem passage corridor is designated by the National Marine Fisheries Service (NMFS) as critical habitat for spring/summer and fall Chinook salmon. High velocity sites positioned outside of the Lower Granite reservoir would be too complex, and ecologically cost to salmon and native anadromous species. Low velocity sites would be less ecologically and biologically costly. All potential sites possess similar ecological and population effect tradeoffs (*i.e.*, rearing habitat, transport survival derivation, predator effects). This suggests that site selection would be difficult.

Assuming the collector could be initially designed and constructed to meet an FGE of 95 percent with a 2-percent or less direct bypass mortality, the relative biological benefit (juvenile survival) over the base case would be -30 percent for spring and summer Chinook, and 59 percent for fall Chinook salmon.

It was determined, through a sensitivity analysis with the Columbia River Salmon Passage (CRiSP) 1.4 model, that an upstream collector near the top of the Lower Granite reservoir would need to achieve a fish guidance efficiency (FGE) equal to or above 75 percent, while maintaining no higher than an estimated 2-percent direct bypass mortality for spring Chinook salmon to surpass that survival provided by the 1993 base case operation (SOR 2C). This sensitivity analysis suggests that if the upstream collector concept is to be implemented, adequate research through prototype modeling in in-river conditions should be performed to determine that an FGE of 75 percent and bypass mortalities comparable to the current estimates of 2 percent can be achieved. It is also suggested that concurrent ecological and passage studies be designed to address the estuary survival of transported and in-river juvenile salmon. These types of studies would be pursued in Phase II.

f. Summary and Discussion--Upstream Collection and Conveyance.

The estimated benefits associated with the collector with barge transportation appear to provide significant improvements in terms of juvenile salmon survival. This survival estimate seems to be consistent with the analysis prepared by the NMFS Recovery Team (October 1993). The other biological effects (resident fish and wildlife impacts) do not appear to be significant with this alternative.

The migratory canal and pipeline proposals have significant biological concerns and uncertainties.

The estimated project cost associated with the construction of the collector facility and new barges is $260,000 to $360,000 (not including inflation). The estimated time required for implementation is 6 to 8 years, following authorization and the appropriation of design and construction funds.

6.06. System Improvements--Lower Snake River and McNary Dam.

a. Overview.

The objective of existing system improvement is to improve existing fish-related facilities or any other existing facilities that would improve conditions for migrating fish. There are several factors or mechanisms associated with these facilities that could affect fish survival, such as fish stress, predation, and physical injury. The specific steps for this evaluation include: 1) a determination o f the technical feasibility of implementing these improvements; 2) estimation of the biological benefits to salmon that may result from implementing the improvements; 3) identification of operational requirements and potential problems associated with the improvement; and 4) development of cost estimates and implementation times for the improvement work. The improvements comprise new construction, modifications to existing structures and systems, an changes in current operational practice. The results of these evaluations are meant only for use in comparing alternatives being investigated under the SCS.

The following paragraphs identify the alternatives and options evaluated, the biological effects on anadromous fisheries, and the associated construction costs and implementation schedules for each action. The information is broken down by category or area of improvement (*i.e.*, juvenile fish passage, adult passage, transportation improvements, hatchery modifications, and dam modifications).

Under each category, there are a number of specific actions under investigation. Only a general description of the action and the associated benefits to anadromous fish are provided. If more detailed information is required, it can be in Appendix E, *Improvements to the Systems--Lower Snake River and McNary.* Costs and implementation schedules for each action re summarized at the end of this section.

Each improvement was examined for its value as a long-term or near-term action. The improvements considered to be near-term measures had relatively small costs, and may or may not provide a significant system-wide anadromous fishery benefit. However, they do not require extensive or costly research or testing to verify their potential benefits. In other words, they can be implemented quickly without significant further evaluation. In any case, these improvements, either independently or in groups, are not considered to be actions that can be equally compared to other SCS alternatives (*i.e.*, drawdown or upstream collectors). These small items are more suited to interim actions that could, and should, be pursued and implemented prior to the identification and implementation of long-term actions.

The effects these improvements would have on anadromous fish are evaluated principally on a qualitative basis. Quantitative evaluations are provided for those improvement options for which limited data has been collected through previous or ongoing research. The greater reliance on qualitative evaluations is based upon the lack of specific data and/or uncertainties related to each improvement that could be confidently used to parameterize the regional analytical juvenile passage and life-cycle models. Therefore, input values are assumed, in most cases, for a system-wide effect on survival. A single improvement at a single dam would not be reflected beyond the variability produced by the model for a system-wide effect on survival. The limited effectiveness information that is produced is fairly consistent with regional discussions and comments from such technical forms as the TAG and FPDEP. Most of the singular improvements can be considered to be operational and maintenance-type improvements that would be locally beneficial.

b. Improvements to Juvenile Fish Collection and Bypass Systems.

(1) General.

The objective of these improvements are to improve juvenile passage through the dams. This can take the form of improving the guidance associated with the current collection and bypass systems, a reduction in predator-related mortality associated with bypass, or the elimination of undesirable passage conditions. The following alternatives were evaluated to improve the juvenile fish collection and bypass system: 1) dispersed release sites; 2) extended-length screens; 3) modifications to the Lower Granite Dam Juvenile Fish Facilities; 4) auxiliary water intake screens at McNary Dam; and 5) surface-oriented bypass and collection systems.

(2) Dispersed Release Sites/Short-Haul Barging.

To reduce estimated predation losses, providing dispersed release at the release points (outfalls) of the existing juvenile bypass systems at Lower Granite, Little Goose, Lower Monumental, and McNary Dams were considered. Alternative means of providing dispersed release sites included: 1) short-haul barging to alternate release points; 2) extending release flumes downstream of the current release points; and 3) flume modifications to provide multiple release points near the juvenile fish facilities.

Providing a flume with multiple release points requires the least amount of modification, but is estimated to be biologically ineffective for the lower Snake River projects. Stationary dispersed release sites could only be expected to result in potential short-term benefits related to confusing predator activity at McNary Dam. The proportionally greater abundance of arriving juvenile salmonids at McNary from the mid-Columbia River could logistically limit the effective operation of short-haul barging. Predators such as northern squawfish could condition their behavior and redistribute to new optimal smolt interception locations within a relatively short time. This effect could occur even if the release of smolts from the multiple exit system was totally randomized, because the exits would remain stationary points of concentrated smolt release into relatively restricted areas of the river channel. Although high velocity areas of the channel would be targeted for release sites, predators could act to "average" the randomized release effect by redistributing themselves short distances downstream to locations where the high concentrations of smolts would pass. Therefore, no long-term benefit could be expected.

Short-haul barging with direct loading of smolts is estimated to be the more biologically effective dispersed release option, and would provide more long-term effects than those of a stationary system with multiple exits and randomized smolt release patterns. Short-haul barging could be used in conjunction with the existing barge-loading facilities at Lower Granite, Little Goose, Lower Monumental, and McNary Dams. Barges would need to be direct loaded, then moved to randomly selected release points that would meet the velocity criteria. If the region chooses to maximize the existing transport operations from Lower Granite and McNary Dams, one small-capacity (20,000 pound) barge for each of the Little Goose and Lower Monumental projects would probably be sufficient to provide the required flexibility in selecting optimal release sites. If the region chooses to keep all salmonid outmigrants in the river for 100 percent of the passage, or as a continuation of some "spread-the-risk" policy based on flow triggers, multiple small-capacity barges or additional medium- or large-capacity barges would be required at each collection dam to efficiently handle direct-loading operations during the peak outmigration period, at least for spring and summer Chinook salmon.

Smaller barges would provide a more flexible release system, both across the channel and geographically down the channel, allowing less predator conditioning to particular high velocity locations. However, a within-project short-haul barging system for each dam and reservoir could result in additional delay as fish are collected and transported past perceived predator concentration areas and then released at a randomized location for each respective dam and reservoir. A cumulative negative effect could occur due to incremental project delays accumulating into an extended system delay. Cumulative stress responses could appear in those smolts that are continually collected, held in raceways, and transported and released only a relatively short distance from their point of collection. Direct loading from the bypass flume into barges would have to serve as a compensatory criteria for achieving any maximal benefit.

The development of dispersed release site mechanisms would be near-term actions, both for short-haul barging and multiple-exit flumes, because existing technology would reduce design and testing time. Short-haul barging is expected to provide marginal overall benefits that would only be expressed by total in-river passage of juvenile salmonids, because tradeoffs would have to be considered in possible collection and holding delays. The direct loading of bypassed juvenile salmonids would be required to reduce stress for any success with short-haul barging. Multiple-exit flume dispersed release has been discussed in regional technical committees for possible implementation at new collection and bypass facilities. Although design and implementation at new collection and bypass facilities. Although design and implementation could occur in a relatively short timeframe, it is expected that very little biological effectiveness would result in terms of system-wide passage efficiency and population viability, because of the estimated degree of predator adaptability.

(3) Extended-Length Screens.

Existing turbine intake screens are 20 feet in length. Existing research has indicated that extended-length screens measuring 40 feet in length increase FGE at each dam, because of their extension deeper into the turbine intake entrances. This allows them to intercept a higher proportion of juvenile salmonids that would otherwise pass underneath a 20-foot screen. Regional technical design and review groups have supported the current extended screen design, and testing for implementation at McNary, Little Goose, and Lower Granite Dams. These completed planning processes indicate that extended-length screens would be a biologically-effective action, based on the relatively low cost and implementation time associated with their implementation at Lower Monumental and Ice Harbor Dams. The NMFS has identified the implementation of extended-length screens for immediate implementation in their 1994 to 1998 Federal Columbia River Power System Biological Opinion.

Based upon the present knowledge which the Corps has regarding extended-length screen performance, it can be reasonably expected that Snake River spring/summer and fall Chinook and sockeye salmon would benefit from the improved design and implementation of extended-length screens. At least an estimated 10-percent increase in FGE for all salmonid stocks passing each dam would cumulatively reduce turbine passage mortality for a greater portion of the total juvenile salmonid outmigrant population. Similar benefits would be expected to accrue for adult fallbacks of those same protected salmon stocks, in addition to Snake and Clearwater River steelhead. Based on the design of the existing extended-length screens that have been tested, screens could easily be designed for Lower Monumental and Ice Harbor Dams. Although relatively few wild Snake River juvenile salmon would be expected to remain in-river downstream to these two lower snake River dams during maximum transport operations, improved FGE would benefit tributary and hatchery fall Chinook salmon stocks that enter the mainstem below Little Goose Dam. This train of thought is particularly consistent with the incremental benefit of the improved FGE for fall Chinook salmon afforded by extended-length screens. The maximum benefit of extended-length screens would be afforded to operational scenarios without transportation, especially from Lower Granite Dam. Any benefits attributable to extended-length screens at Lower Monumental and Ice Harbor Dams, during operational scenarios involving a high degree of transportation from each existing smolt collection dam, would be limited to Snake River subyearling (fall) Chinook salmon that are wild, as well as those releases from the Lyons Ferry hatchery. Although extended screens have been extensively researched and tested, and are scheduled for implementation at other dams, they are considered to be long-term activities, based on the high implementation cost and the fact that other measures may be as, or more, effective. For example, extended screens should be compared with improvements such as the surface-oriented collection system [see 6.05.b.(6)], which have shown tremendous promise, based on the Wells Dam operation studies. Additional study on surface collectors is needed to determine their effectiveness on the lower Snake River projects. Once these studies have been completed, a true comparison of surface collectors and extended screens can be made.

(4) Modifications to the Lower Granite Dam Juvenile Fish Facilities.

The Lower Granite juvenile fish bypass facilities were analyzed for improved passage and separator efficiency, because they are the oldest and most outdated facilities in the entire lower Snake River hydrosystem. The Lower Granite Project is also the most upstream project, resulting in the greatest interception of outmigrating juvenile salmonids. This geographical effect to juvenile salmonid migration dynamics makes Lower Granite the most critical reservoir and dam, and also makes it extremely influential to overall smolt survival. The improvements to this facility include an improved collection channel, new dewatering structure, bypass flume that extends to the river, new wet separator with species separation capabilities, new passive integrated transponder (PIT) tag sample and holding tanks, new sample and holding tanks, new raceways, and improved barge loading and river release conditions. These improvements use many features of other existing facilities developed at other projects down river. The proposed improvements offer numerous advantages: open channel flow conditions, direct open channel bypass from the collection channel to the river, the capability to separate juvenile fish by size at the wet separator, direct barge loading or river release from the separator, and PIT-tag diversion/holding/river release system.

The biological community within the region generally agrees that pressurized passage systems increase stress to juvenile salmonids. It is generally accepted that the existing pressurized pipeline system at Lower Granite Dam should be replaced with an open flume system based upon the Little Goose design to reduce this stress, and this would be a biologically-effective action. Wet separator construction at Lower Granite would be designed to separate smaller chinook salmon from larger steelhead trout juveniles much like the existing separators at Little Goose and Lower Monumental Dams. Although these modifications are very expensive ($20 million), they are considered to be near-term actions, based upon the regional interest and the state-of-the-art nature of the improvements, which implies that limited testing is required in order to implement. The NMFS and the regional technical committees have expressed interest to expedite these improvements, based on the existing technology. Additional research is required to determine to what extent spring Chinook smolts benefit from segregation from steelhead smolts. The degree of potential benefit of wet separator implementation would be determined from this additional research.

(5) Auxiliary Water Intake Screens at McNary Dam.

Water supply intake structures for the adult ladder located along the north shore (Washington side) of McNary Dam are not screened properly to control water velocity, and prevent juvenile fish from entering the intake past the existing trash racks of the north shore or impingement on the existing traveling screen of the south shore (Oregon side) intake structure. Providing modern screening system sat these intakes or modifying them to meet current fish criteria could reduce juvenile mortality. A number of different options were investigated. Modifying the existing traveling screen system at the south shore intake structure with the new three-sided screen design, and retrofitting the trash racks of the north shore intake structure with the new three-sided screens were identified as the most desirable actions. North Wasco County Public Utility Department is installing a generating unit under a Federal Energy Regulating Commission (FERC) license within the north shore intake. Their FERC license requires the public utility department to maintain a mitigation fund for affected anadromous salmonids.

The Corps currently has limited empirical data concerning the north shore water supply intake. However, the data available suggests that a significant number of juvenile subyearling salmonids (representing fewer than 24 adult equivalent returns) would not be removed annually from the total population, due to entering this auxiliary water intake. This is thought to be partially the result of the near 60-foot depth of the intake, where juvenile fish are not found routinely migrating. However, the attraction force of the north shore generating unit could pull juvenile salmonids into such depths, just like the turbine unit operations at any of the run-of-the-river dams in the Columbia River Basin. The critical measure would be the proportion of those subyearling salmon intercepted by operation of the north shore structure that are listed Snake River subyearling (fall) Chinook salmon in proportion to the much more abundant Columbia River subyearling populations arriving at McNary Dam. This improvement would be specific to a single dam, and it is not expected to provide a measurable increase in system-wide survival of the total population attributable to this one improvement. Although any improvement to fish passage efficiency and survival would be beneficial, the redesign of the south shore traveling screen to current criteria would be warranted and would be an interim measure, where construction of a new three-sided screen system for the north shore generating unit would be considered more long-term and should remain the responsibility of North Wasco County Public Utility Department under their FERC licensing requirements, in coordination with the Corps.

(6) Surface-Oriented Juvenile Fish Collection and Bypass Systems.

Juvenile anadromous fish in the water column appear to be in the top 20 to 30 feet of the reservoir surface as they migrate downstream. The objective of a surface-oriented collector is to guide and collect these fish before they have to dive to depths of 60 to 80 feet in order to be intercepted by the existing turbine screening bypass system. This type of surface collection system has been in operation at Wells Dam, on the Columbia River, and is reported to be very effective. Two design concepts of a forebay collection system were given cursory consideration: 1) vertical juvenile fish entrance slots based on the system at Wells Dam; and 2) a shallow skimmer weir or orifice similar in principal to the system at Ice Harbor Dam and The Dalles Dam (sluiceways). A single concept design using a version of the Wells Dam fishway entrance in conjunction with a collection/sample and bypass system was identified as the preferred system and further developed in this study. For this evaluation, only the Lower Granite project was investigated. This project is considered to be representative in powerhouse and spillway structure for the other lower Snake River dams, although flow dynamics in the forebay of each dam would vary. If this system proved to be effective at Lower Granite, this information could be transferred and hydrologically adapted to other dams, not only on the Snake River, but on the Columbia River as well.

A surface-oriented system could be designed specifically for fish passage in union with improved submerged screening systems to equal or exceed the estimated FGE expected for an upstream collector screening structure (95 percent). This estimate is based on the reported 90-percent guidance efficiency experienced at Wells Dam using only the surface collector system. A surface-oriented collector could reduce forebay delay of those juvenile salmonids not intercepted by the pull of the turbine intake flow. One of the more promising aspects of the surface-oriented concept is its potential flexibility in operation: juvenile salmonids would be intercepted and collected via the existing bypass system or directly bypassed without handling or delay back to the river via the spillway while using much reduced spill water volume.

This surface-oriented collection concept is considered to be a new generation of fish passage facility with high biological effectiveness expected. Therefore, a significant amount of research and study would be required prior to implementation. As a result, this action is considered to be a ***long-term*** activity**.**

c. Improvements to Juvenile Fish Transportation Systems.

(1) General.

The objective of these improvements is to improve the conditions of juvenile anadromous salmonids barged to and released below Bonneville Dam. The following alternatives were evaluated to improve juvenile fish transportation systems: 1) net pens; 2) barge water temperature control; 3) enlarged fish barge exits; and 4) additional new fish barges.

(2) Net Pens.

Net pens were considered because fish could be transported in natural water and light conditions that should reduce stress and allow the smolts to undergo normal physiological processes. In addition, fish would have some form of natural current to swim against. Net pens would be comprised of an external framework with nylon netting measuring about 100 feet long by 40 feet wide by 13 feet deep, capable of carrying approximately 45,000 pounds of fish. It would take about 24 such net pens to provide transportation equivalent to that of the existing fish barges and trucks. The piping and/or flumes for fish loading at each existing collection facility would require modification. Concerns with net pens include longer travel time than with barges, structural integrity during adverse weather conditions, inability to reduce dissolved gas concentrations and restricted monitoring and testing capability. The mobile net pen concept may be applicable to the concept of variable release as an alternative to fixed location bypass release.

Net pens have been previously proposed to replace the juvenile barges or be used in short-haul barging scenarios. Overall, there seems to be no apparent significant advantages to net pens over the existing barge system, with the possible exception of potential application to the concept of short-haul variable release sites. The application to short-haul variable release has limitations due to the conditioning ability of reservoir predators to readily recognize concentrated prey in a moving net pen, and redistribute themselves upon release of that prey. Therefore, the randomized or variable release strategy to reduce predation would be compromised. Technical review committees such as TAG and FPDEP has generally eliminated any traveling net pen scenarios based upon: 1) the ability of visual and olfactory predators to condition to nonbarrier-producing effects of open netting; 2) the inability to control for dissolved gas concentrations and/or elevated water temperature encountered in the reservoirs; 3) greater travel times through the total hydrosystem compared to the existing barge operation; 4) limited decrease in travel time through a single reservoir with additional stress imposed, compared to proposed in-river passage condition improvements; 5) limited benefits to homing cue perception received from passage through the natural ecosystem, compared to the existing open barges (*i.e.*, existing barges continually recirculate 25 percent of the barge water volume with that of the natural ecosystem, and are open to the natural astrologic and atmospheric conditions); 6) limited estimates for reduced stress because stress responses are more closely associated with the loading and evacuation activities, not the actual transit time while physically being within a barge. The acute stress from loading could be prolonged in a net pen environment, with confinement while in the visual presence of predators, whereas stress from loading has been shown to reduce during transit in the existing barges; and 7) limited benefits estimated from horizontal disease transmission due to the more open flowing environment. Disease vectors (*e.g.*, for BKD) are readily found in river water and have been estimated to be within close to 100 percent of the population sample passing Lower Granite Dam during some years. The BKD transmission is highly dependent on hatchery practices and control activities, and can be genetically transferred, indicating that juvenile salmon can be considered to be constantly exposed. Density-dependent manifestation between river versus barge/net pen fish densities has yet to be scientifically determined, but could be assumed to be slightly less in reduced density conditions (*i.e.*, river passage or open flowing net pen transit).

The net pen concept would involve <u>long-term</u> activity because of the extensive research needed to clarify the above uncertainties related to determining benefits between in-river versus net pen versus existing barge environmental conditions. The majority of these studies would require a much better understanding and ability to technically measure condition and stress variables and their indicators than the region currently possesses. In addition, time would be required to design an adequate net pen transport vessel that could maximize travel time from the collection dam to below Bonneville Dam without collapsing and resulting in reduced fish physical condition due to crowding stress, behavior stress, and/or netting abrasion.

(3) Barge Water Temperature Control.

The concept of controlling large water temperature below a maximum of 68 degrees Fahrenheit was considered to provide a more optimal temperature for juvenile salmonids. Two general alternatives were identified to cool the water, including drawing cooler water from the bottom of each reservoir during transit, or the addition of "chillers" powered by diesel engines. It was determined that drawing water from the bottom of the reservoirs was not feasible, because the run-of-the-river reservoirs on the Snake and Columbia Rivers do not stratify to any significant extent, although temperature gradients may occur during some summer conditions. Only marginal decreases in temperature would be expected. Additional concerns exist both logistically and biologically due to the expense, maintenance, and ecological disturbance caused by a barge traveling with a telescoping pumps suction hose extending below the barge to the riverbed. Therefore, the addition of "chillers" was the chosen alternative for further evaluation. It was determined that the existing barges would be overwhelmed by the weight of the new chiller equipment. Consequently, separate new (small) chiller barges would be needed, including one chiller barges would be needed, including one chiller barge for each of the existing six barges. Single-pass water flow was required, since heat exchangers to recoup energy were found to be extremely expensive. The operation and maintenance costs for the chiller barges were found to be extremely high, requiring 7,000 gallons of diesel fuel per day per barge, based on maintaining an average temperature differential of 5 degrees Fahrenheit.

There is little biological effectiveness estimated for artificially controlling barge water temperature. If the maximum daily temperature has exceeded threshold temperatures for juvenile salmonid survival, and artificial control of the water temperature can be relied on to reduce the temperature to non-lethal limits, the biological effectiveness would be more important for Snake River subyearling (fall) Chinook salmon. Water temperature monitoring in the Snake River has indicated that near-threshold temperatures may be reached during some extreme low-flow conditions during the summer months. However, exposing a juvenile salmonid to an artificially "optimum" low temperature when taken from the high temperature conditions of the river may cause a more prolonged acute stress response than conditioning that juvenile salmonid to the gradual temperature changes in the 25-percent replacement of river water experience in the barge. The critical measure for juvenile salmonid viability would be the minimal amount of stress imposed on the fish at the point of barge evacuation. The internal water temperature of the barge should more closely reflect the water temperature of the river at the point the fish exit the barge below Bonneville Dam. At this point, the fish should experience the least degree of thermal shock through a low gradient between temperatures. Since 25 percent of the barge water surrounding the transported juvenile salmonids is continually replaced with river water, this gradual temperature change would act to condition the fish and control any perceivable stress and physiological adaptation changes to rates adjustable by the fish.

Barge temperature control would be a <u>long-term</u> activity with little biological effectiveness, except for during those extreme low flow conditions during the summer outmigration of Snake River subyearling (fall) Chinook salmon. Little additional research to establish direct temperature effects or thresholds on salmonids would be required because adequate information exists as to temperature ranges that need to be achieved for salmonid productivity and survival. Alternatives that aim toward reducing the overall river and reservoir temperatures through carefully executed seasonal flow augmentation during those problem low flow years would be more effective biologically, not only for outmigrating juvenile salmonids, but also for adult salmonid in-migrants and the ecosystem as a cumulative whole (*i.e.*, predator activity and possibly disease transmission would be commensurately depressed with decreased water temperature).

(4) Modify Fish Barge Exits.

The size of the barge release exits has been identified as a possible source of concern. The exits on the existing barges range from 10 inches to 17.25 inches, and may be too small for efficient evacuation of juvenile salmonids. Increased acute stress and delay during the release operations may result from forced crowding and a rapidly changing water velocity gradient through a small diameter exit. Enlarging the exits may reduce this stress. Exits on four of the barges could be replace with 35-inch internal diameter (ID) exits. The exits on the other two barges could only be enlarged to 17.25 inches. The water velocity in the 35-inch exit would be reduced to about one-fourth that of the 17.25-inch exit. The velocity in the 17.25-inch exit would be about one-third that of the 10-inch exit. In addition to significant decreases in the discharge velocities, the enlarged exits could potentially improve the distribution of the fish as they exit the barge, allowing them to seek river velocities that would reduce their concentrated exposure to awaiting predators downstream.

The biological effectiveness of increasing the diameter of the barge exits would not be directly measurable. However, any means of reducing acute stress and efficiently transferring juvenile salmonids down river past predators would be beneficial. Modification of the barge exits would require the barges to be dry-docked, and could be accomplished outside of the smolt passage season. This improvement would be a near-term action, with low cost and no additional research required outside of the ongoing transportation program studies that involve stress response measurements.

(5) Additional Fish Barges.

Currently, there are not enough barges available to load collected smolts directly into awaiting barges. Based upon recent studies measuring plasma cortisol levels, direct loading of smolts for transport is generally accepted as a means of reducing acute stress in juvenile salmonids diverted through Snake River dams. In the existing operations, collected smolts must be held in raceways until a barge is available for loading. Normally, fish are only held in raceways for a few hours. However, this period can be much longer during both the peak migration period, when arriving fish numbers rapidly fill a barge; and the tails of the passage distribution when the operators must delay until enough fish arrive to fill a barge. During this low abundance time, fish may be loaded into trucks and transported, but trucking is considered to be more stressful and a less reliable means of fish transport. The acquisition of new fish barges was considered to improve the direct loading capability from the juvenile collection facilities. This practice would substantially reduce the stressful raceway crowding that may occur prior to transferring the fish into barges. After evaluating three different options, it was determined that an additional four barges of 75,000-pound capacity would satisfy a direct-loading target.

Direct-loading capability for the Corps smolt transport program has been identified by NMFS in their recent Biological Opinions for FCRPS operation, and supported by the regional technical committees and fishery agencies, as a beneficial action with high biological effectiveness. This improvement would be a near-term action with moderate costs to construct additional barges, relatively little implementation time, no additional or long-term research or design requirements, and direct biological benefits. The feasibility of constructing more moderately-sized barges should also be further evaluated for maximizing the direct-loading potential by increasing the flexibility within the fleet across the full rang eof arriving smolt abundance distributions. Early and late season reliance on truck transport should be effectively eliminated, resulting in more maximal benefit to overall juvenile salmonid viability derived through increasing use of the more benign barge transport.

d. Improvements to Adult Fish Passage Systems.

(1) General.

A number of improvements were evaluated to improve conditions related to dam passage for adult anadromous fish during their upstream migration. The following alternatives were evaluated: 1) fish ladder water temperature control; 2) additional fish ladders; 3) fish ladder entrances and attraction water; 4) fish ladder exits at McNary Dam; 5) adult collection channel modifications at McNary; and 6) extended fishway channels.

(2) Fish Ladder Water Temperature Control.

Fish ladders are used to pass adult fish around the dams. These ladders consist of a series of weirs or steps within an open, shallow flume. Water temperatures in these ladders can be significantly higher than in the tailrace below the dam during the summer months, and this discourages adult fish from entering the ladders. The University of Idaho has measured more than a 10-degree Fahrenheit increase in adult ladder water temperatures when compared to tailrace water temperature at Lower Granite Dam. It is postulated that this difference in temperature could have a "blocking" effect that contributes to adult passage delay. Reducing water temperatures in these ladders could reduce this delay effect. Three methods of reducing the water temperature in the adult ladders at all of the Snake River dams were identified. These three methods are: shading, sprinklers, and pumping cooler water from the bottom of the forebay behind each dam. It was determined that cooling the ladder temperature directly would only result in physically relocating the temperature differential effect up the ladder to its exit, thus providing no solution to reducing the delay effect. A reasonable temperature gradient needed to be established in the area of the forebay that supplies water to the ladder, in order to functionally eliminate any thermal shock zone that would be detected by adult salmonids climbing the ladder. The most effective means of lowering the water temperature around the ladder exit was to recirculate cooler water from the depths of each forebay (*e.g.*, NMFS has proposed using existing air-bubbler system technology), and introduce that water to the vicinity of each fish ladder exit.

This improvement would have high biological benefits and effectiveness, but would be a long-term activity because an undetermined amount of research and concept development and design would be necessary to develop those innovative approaches, thus increasing the cost and implementation time. The additive ecological benefits would justify a phased-in approach that could expedite implementation with operational measures. Obviously, any decrease in water temperature would be more beneficial to adult summer and fall chinook salmon due to their average run timing during the summer. Cold water releases from Dworshak reservoir have been studied to cool the downstream river conditions in hopes of reducing a perceived temperature "block" at the confluence of the lower snake and mid-Columbia Rivers. Monitoring has shown that temperature reduction can be achieved in the upstream section of Lower Granite, but mixing through powerhouse operations acts to diminish any beneficial effects below Lower granite Dam. No difference in water temperature remains once the monitors reached the confluence with the Columbia River below Ice Harbor.

(3) Additional Fish Ladders.

Both Lower Granite and Little Goose Dams are the only projects on the lower Columbia or Snake Rivers that have only one adult fish ladder. Consideration was given to adding an additional fish ladder to the north shore of both Lower Granite and Little Goose Dams to supplement existing adult fish passage efficiency. This would provide a backup to the single fish ladders at each dam, potentially reducing the number of adult fish dropping out of the powerhouse entrances and providing more direct passage for adults entering the north shore entrances. The proposed ladder at Lower Granite Dam would be located between the right spillway training wall and the navigation lock. The ladder at the Little Goose Project would be located in the south side of the earthen embankment. The design for these ladders would be similar to the existing ladders.

Additional adult ladders at Lower Granite and Little Goose Dams are desirable due to their expected ability to function as backup facilities and compliment the existing ladder configuration because of ladder failures or maintenance work required after nearly 20 years of constant seasonal use. Concerns with this concept are the design requirements to achieve and maintain the critical attraction flows retrofitted across the full range of operational conditions of those specific dams. A primary consideration is the potential increase in access for undesirable competitive species (*e.g.*, the advancing population of American shad). Shad can be readily observed crowding the Lower Monumental Dam ladders. Increase access routes past the single ladder dams could provide a releasing mechanism into previously limited pelagic habitat. Observations of predators gorging on juvenile shad are photographically recorded at Little Goose Dam and, therefore, the advancing distribution of shad could have an ecological consequence on maintaining or enhancing predator age-class strength and fitness.

Since current technology can be reliably utilized, the additional adult ladder improvement could be a near-term action in terms of the limited design and testing requirements. The time required for construction, and the associated ecosystem disturbance during established work windows, would be considered more of a *long-term* action. Monitoring of the potential shad in-migration would have to be planned in unison with additional ladder implementation in order to estimate the feasibility of an acceptable control program. Control of their distributional increase potential could be as simple as building the new ladders and retrofitting the existing ladders with passage barrier structures designed for impeding shad, while still allowing for efficient salmonid passage.

(4) Fish Ladder Entrances and Attraction Water.

Upstream migrating adult fish pass over the dams by entering the passage system through the fish entrances located at the downstream side of the dam, swimming along the collection channel to the fish ladder, swimming up the ladder, and exiting the ladder into the forebay. The fish entrances and attraction water discharge, located at the base of the dams, are critical to the successful operation of the adult fish passage systems. The existing systems at the four lower Snake River projects do not allow for adequate performance during low tailwater conditions.

The fish entrances along the powerhouses at the Lower Granite, Little Goose, and Lower Monumental projects are a combination of floating orifices and weir gates, located in the wall of the fish collection channel. The width of the orifices varies from project to project. To allow the systems to operate within criteria at low tailwater conditions, the control gates and transportation channel behind the gates must be lowered. At the Ice Harbor Projects, the entire transportation channel serving the south shore collection system must be lowered, which is a substantial effort requiring a cofferdam. In addition, the Ice Harbor north powerhouse entrances, north shore entrances, and portions of the collection channel behind, must be lowered to allow submergence. The control gates will also require lengthening. The Ice Harbor south shore entrances also require lowering.

Auxiliary attraction water, pumped from the tailrace, is currently introduced into the lower portions of the ladder and collection channel at all four projects to supplement the ladder flows. The amount of exiting flow is critical to successfully attracting adult upstream migrating salmon. The attraction water is distributed into the collection channel through a system of conduits, junction pools, gated and ungated openings, and diffusers that deliver water at reduced velocities into the channel. The systems at the four lower Snake River projects must be modified by adding new sluice and operation gates, similar to those already in existence. Due to an increase in flow, the existing pumping systems will also have to be replace with higher output systems.

To improve the fish ladder entrance operating efficiencies during low tailwater conditions imposed by reservoir operation at MOP at each lower Snake River dam, it is proposed to lower the level of each dam's series of adult ladder entrances, control gates, and transportation channels behind the gates. Improvements to attraction water would involve enlarging and adding new gate openings to the powerhouse diffusers. Revised adult ladder attraction criteria was established prior to the design and construction of Little Goose and Lower Granite Dams. This revision caused the operation of the existing dams at that time (Ice Harbor and Lower Monumental) to be operated more marginally within the new criteria. The operation of the reservoirs at MOP for improving flow conditions for salmonid migration imposed since the listing of the Snake River Chinook and sockeye salmon stocks has further imposed restrictions on the operational criteria for adult attraction of those fish, due to the decrease in tailrace water elevation. Lower Granite, Little Goose, and Lower Monumental Dam modifications, to adequately meet criteria throughout their operating ranges, would require the lowering of the adult entrances and associated channels nearly 3 feet in elevation. Ice Harbor Dam modifications are more substantial, and involve lowering the adult entrances and associated collection channels from 1.5 to 5.5 feet, and the transport channel 2 feet in elevation. This would require cofferdam construction and an interim means of adult passage during the time duration needed to perform the work on the powerhouse face in the tailrace.

The biological effectiveness of this improvement must consider the enhanced need for efficient adult attraction into the ladder entrances from the lowered tailwater conditions imposed during MOP operation. Since the region has accepted that reservoir operation at MOP is incrementally beneficial to juvenile salmonid outmigration travel time, the modification of the dams to maintain passage criteria established for adult salmonids through regional consensus of the technical committees has to be considered as beneficial to the viability of the passing adult population. Any action that efficiently reduces delay and associated stress of in-migrating adult salmonids, who are already physiologically diverting a significant portion of their stored energy reserves to upstream travel and spawning activities, would act to incrementally increase population viability. This effect could not be measured directly to ascertain the specific benefit of that increment, however. Any such benefit attributable to improving the attraction flow and ladder entrance efficiency would only be maximized proportionately with powerhouse operation, as it has been readily shown through research reviews and discussed in technical committees, as the effect of spillway operations on the effectiveness of the attraction flow force in guiding adult salmonids to those entrances provides a substantial influence.

The implementation time required for this improvement at all of the lower Snake River dams, and any additional research and associated modeling, would indicate more of a long-term activity.

(5) Fish Ladder Exits.

The fish ladders at McNary Dam currently use a series of tilting weirs to regulate the flow of water in the upper portion of the ladder. This regulation is required to account for reservoir level fluctuations. This system requires manual manipulation of the weirs on a daily basis. To simplify and improve the fish ladder exits at McNary Dam, it is proposed to replace the existing tilting weirs with fixed vertical-slot control weirs that do not require adjustment during reservoir fluctuations. Makeup water would then be added to make up the remaining water requirement. The improved system would be similar to those facilities at the projects on the lower Snake River.

Any action that efficiently reduces delay and associated stress of in-migrating adult salmonids, who are already physiologically diverting a significant portion of their stored energy reserves to upstream travel and spawning activities, would act to incrementally increase population viability. However, the effect could not be measured directly to ascertain the specific benefit of that increment. In addition, any improvement that can reduce the potential for human error would be beneficial, as long as an appropriate maintenance and operational accuracy check across the full range of flow variability can be implemented.

This improvement would be a near-term action due to the reliance of the design on existing technology and system performance. The implementation time should be minimal. However, this project is better suited as an operation and maintenance improvement that can be implementable more readily than in the SCS process.

(6) Adult Collection Channel Modifications at McNary Dam.

The current collection channel at McNary Dam has areas where the channel water velocity is much too low, which results in poor adult passage. To improve the adult collection channel at McNary Dam, it is proposed to narrow the collection channel. This would increase the velocities in the low velocity area of the collection channel. The solution is felt to be simple, and will provide predictable hydraulic conditions.

Although the greater velocity of water traveling through channel may incrementally enhance the adult attraction flow across the face of the powerhouse, there is no empirical evidence that suggests that this has any negative effect on attracting or delaying adult salmonids. In fact, there is uncertainty as to whether the low velocity condition actually exists at the estimated location within the channel. It has never actually been measured, and only appears in a modeled situation (Existing System Improvements Technical Appendix, page 4-80). Also, reduced velocity areas may provide short-term resting areas, where maintaining a sustained high level of swimming performance may be beneficial to reducing energy depletion. A greater concern for adult passage would be the possible construction of the channel to the point of creating a bottleneck area that could act to crowd and possibly delay adult salmonids. The estimated channel width at the low velocity area, if modified, would be less than 10 feet, and could be outside of established criteria. This improvement would be near-term action that is easily implementable with little cost to improving perceived adult attraction efficiency in the ladder system. However, some video monitoring of the area of the collection channel in question should be performed to give insight into whether this is an area contributing to adult delay and possibly crowding. This project is better suited as an operation and maintenance improvement that can be implementable more readily than in the SCS process.

(7) Extension of Adult Fishway Channels and Entrances.

Lower Granite and Little Goose Dams each have fishway entrances on the north side of, and immediately adjacent to, the spillway. The entrance configurations at both dams are similar. The navigation lock and fishway dike crests a dead zone of water on the north shore below the earthen embankment at each dam. Fish traveling up the north shoreline tend to enter this dead pool, and must swim around the navigation lock fishway dike to reach the fish ladder entrances. During periods of spill, fish traveling along the north shore are unable to reach the north shore entrances due to the turbulent, high velocity flows from the spillway into the stilling basin. Extending the fishway channel, and providing new entrances available to the north shore adult migrants outside of turbulent conditions, may reduce the delay of those fish trying to enter the fish ladder system.

At Lower Granite Dam, it is proposed to extend the fishway channel and its entrance downstream to the end of the navigation lock guidewall, while still maintaining operation of the existing entrance. At the Little Goose Project, the entrance would be moved to the other side of the fishway dike, away from the forces that cause turbulent conditions.

Any action that efficiently reduces delay and associated stress of in-migrating adult salmonids, who are already physiologically diverting a significant portion of their stored energy reserves to upstream travel and spawning activities, would act to incrementally increase population viability. However, the effect could not be measured directly to ascertain the specific benefit of that increment. Therefore, enhancement of a more functional adult ladder attraction channel system designed to operate efficiently under a wider variation in possible powerhouse and spillway scenarios would have high biological effectiveness. However, additional design and testing would have to be performed and hydrologically modeled to establish adequate flow velocity patterns and water sources for providing a very high degree of attraction flow gradient away from the wide mouth of the dead zone area to make this improvement functional. This improvement could provide high biological effectiveness, with a moderate amount of advanced design that considers the attraction flow concerns and potential union with other proposed adult passage improvements (*e.g.*, additional ladders), which could act to modify any final design. Extension of adult fishway channels and entrances to compensate for turbulent conditions during spill operations would be a long-term activity, due to the extensive construction activity and associated timeframe, costs, and additional design considerations required to address adult attraction flow criteria that would be needed to measure a biological benefit to population passage survival. The long-term aspect of this improvement is partially reduced because of the available technology and testing at other Columbia River Basin dams related to modifying spill operations for maximizing adult passage efficiency.

e. Improvements to Fish Hatcheries.

(1) General.

The objective of the hatchery-related improvements was to produce a better quality fish that could reduce negative impacts associated with the interaction with wild fish. The following alternatives were evaluated to improve the operation of existing fish hatcheries: 1) improved truck loading; and 2) additional containment facilities (*e.g.*, raceways).

(2) Description of Evaluations.

Improved truck loading at existing fish hatcheries was considered to eliminate the current practice of using fish pumps that can cause physical injury and acute stress for planting or transportation operations. Two alternatives to conventional fish pumping were identified: incorporating gravity-fed truck loading, and providing an improved pumping system (*e.g.*, an Archimedes-type fish pump). Although the gravity system would be the preferred alternative for producing the greatest biological benefit in terms of reducing stress and physical injury, it is less feasible due to the following reasons: 1) existing piping would have to be excavated and replumbed, or a whole new transportable open-flume system would have to be constructed; 2) truck loading would require excavation, in some cases below groundwater levels; and 3) limited available area on the facility property. These factors made the costs for a gravity system extremely high. An Archimedes-type fish pump was considered to be very simple to operate, inexpensive, and very sensitive to reducing physical injury to soft tissue. In the event that a better method is identified in the future, only a small investment would be lost, with full consideration that the better method identified in the future may involve a gravity-fed system.

Additional containment facilities at existing fish hatcheries were considered to reduce fish rearing densities and produce healthier fish at similar abundances to those currently produced. Of the ten Lower Snake River Fish and Wildlife Compensation Hatcheries evaluated, only the Dworshak and Magic Valley hatcheries were found to have an adequate water supply and room for expansion. The Magic Valley Hatchery was designed with planned expansion potential. However, there is a lack of sufficient property to separately raise both steelhead and Chinook salmon. In addition, the water supply is too warm to rear salmon. Consequently, expansion of the Magic Valley Hatchery would be limited to the production of steelhead. The Dworshak Hatchery has adequate space and water supply to separately raise steelhead and Chinook salmon, but the water supply would have to be upgraded and more pumping capacity would be required. A total of 20 new raceways could be added, and some of the existing burrow ponds could be converted to raceways.

It is believed in much of the region that perpetuating any improvements projects directed toward increasing the production of hatchery origin juvenile salmonids, and especially steelhead trout, would be premature and would act against the objective of focusing on wild salmon recovery. This is true at least until the completion of the recently initiated USFWS's Programmatic Environmental Impact Statement on the Federally-funded and operated hatchery program. Currently, hatchery function has focused disproportionately on steelhead production in both the Snake River and Columbia River Basins, possibly at the expense or ecological bottlenecking of the more depressed wild Snake River Chinook salmon stocks. Dependent upon the results derived through the USFWS evaluation, it is suggested that more study should be directed toward the improvement of subbasin supplemental facilities, with natural acclimation and disease eradication. Additional raceways at facilities such s these subbasin sites may be beneficial by reducing rearing densities for juvenile Chinook salmon. The primary point being perpetuated is that a more exerted effort from the subbasin level, concentrating on fry production from more localized wild broodstock, would be the more ecological and evolutionarily adaptable choice for maintaining genetic fitness in the wild salmon stocks.

Additional raceways for steelhead production at Magic Valley or Dworshak hatcheries would not have any biological effectiveness for improving the chances for recovery of wild Snake River Chinook stocks. Additional raceways for spring Chinook salmon at either Dworshak or Magic Valley (if the water temperature could be effectively modified) could have moderate biological effectiveness, but not to the positive potential of redistributing that effort to the subbasin rearing and acclimation level. Regional discussion addressing the effectiveness of current hatchery operations for productivity-oriented goals on wild salmonid interactions and ultimately population viability continues on various planning levels. The region must jointly make the ultimate decision on future direction for how hatcheries within the region will be operated for species composition and quality versus quantity output, all in compliance with ESA requirements. Hatchery improvements have not been considered long-term activities until some regional consensus can be developed for future direction. The proposed improvements would be considered near-term in terms of implementation design, cost , and timing. The new Archimedes-type pumping system would reduce acute stress and physical damage to juvenile hatchery salmonids compared to current practices, but not to the more maximal levels that would be provided by a gravity-fed loading system. The proposed loading improvements are considered to be more appropriately an operational and maintenance activity, and are not within the scope of the SCS process.

f. Dam Modifications--Spillway/Stilling Modifications.

This alternative pertains to potential modifications that may be used to improve the performance of the existing spillways and stilling basins to reduce dissolved gas saturation levels generated during periods of high spill. Three different alternatives were considered, including: 1) tailwater devices; 2) adjustable/relocated spillway flow deflectors; and 3) elevated stilling basins. An elevated stilling basin was chosen for further evaluation because it was determined tat a shallower basin would more predictably reduce dissolved-gas levels by reducing the deep plunges in the stilling basins. Shallower stilling basins would require that the basins be longer and/or contain baffles to ensure that the energy is fully dissipated over the wide range of discharges and tailwater levels.

Spillway flow deflectors ("flip-lips") at the lower Snake and Columbia River dams were initially proposed in the 1970's to assist in reducing dissolved gas supersaturation. Deflectors were installed at McNary Dam on the Columbia River and the three uppermost dams on the lower Snake River at that time, but deferred from Ice Harbor due to: 1) the shallow nature of the tailrace that acted more naturally to reduce the generating potential for dissolved as; 2) the coming online of additional turbines at all of the lower Snake River dams (thus reducing the upstream spill volumes by increased powerhouse capacities); and 3) the reduced number of outmigrating juvenile salmonids that were anticipated to arrive at Ice Harbor Dam facilities as a function of the regional decision at the time to disproportionately transport juvenile salmonids. The Ice Harbor deflector proposal has been recurring through the years as the state and tribal fishery agencies desire to increase spill for the passage of juvenile salmonids. Subsequent discussion has resulted in the advanced schedule of the design and evaluation by the Corps on the most recent proposal. Flip-lip construction at Ice Harbor Dam could result in only small relative benefits to juvenile salmonid viability because much of the physical processes responsible for dissolved gas generation is dependent on upriver dam operation in relation to incoming flow volume and those dissolved gas concentrations transported by that flow. Spill limits at Ice Harbor dam in the near term could have comparative effective results and be more beneficial to the efficiency of adult passage. The viability of adult salmonids in relation to spill rate and distribution is a greater concern, and any effective means of reducing passage delay and physical injury to adult fish would have a commensurate benefit on the viability of the overall salmonid populations. Further discussion of the biological effectiveness of Ice Harbor flip-lips can be located in that documentation recently prepared by the Walla Walla District.

No matter what modifications may be made to the spillways in attempts to further reduce the potential for dissolved gas generation, the spillways and stilling basins would still have to provide adequate energy dissipation for all design spill levels. In addition, spillway operations and function, as it relates to effective adult fish passage, would have to be studied to guide design revisions.

Stilling basin modification is the only action for which design engineers have confidence for effectively reducing dissolved gas generation. Judgments related to the effectiveness of various spillway-related modifications for reducing dissolved gas concentrations are based upon the examination of existing technical information for the specific dams, regional technical committee discussions, and observations documented during spill operations at the existing shallow stilling basin of The Dalles Dam and the spill tests performed during the 1992 Physical drawdown Test of Lower Granite and Little Goose Reservoirs (Wik *et al.*, 1994). Reducing the depth at which spilled water is allowed to plunge by elevating and elongating the floor of the stilling basin within the tailwater is applicable across all of the lower Snake River dams, thus mediating the cumulative effects of dissolved gas generation for the whole ecosystem corridor. However, potential direct and indirect effects related to the physical injury of juvenile salmonid outmigrants and delay for adult passage due to water velocity increases in the tailwater interfering with ladder attraction flows would be a concern that must be incorporated into the final design.

Spillway and stilling basin improvements would be <u>long-term</u> activities with high biological effectiveness at the ecosystem level, but require extensive hydrologic and biological testing and evaluation supported by prototype and analytical modeling. Construction would take over 1.5 years per dam with cofferdam establishment during established biological work windows outside of the passage season, likely impeding efficient adult salmonid passage.

g. Construction Cost Estimates and Implementation Schedules.

Cost estimates and schedules presented below are preliminary, and are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation. Project cost estimates are based on a 1 October 1992 price level. "They include costs for engineering and design, construction management and contingencies to reflect risks and unknown. Fully-funded estimates are escalated to midpoint of construction, using inflation factors established by the Office of Management and Budget. Average annual costs include interest and amortization at 8-percent interest, interest during construction, and increased OM&R costs. Duration periods represent the length of time, in months, to implement the alternative, including design memorandums, plans and specifications, review, award of construction contracts, and actual construction. A summary of the estimated construction costs and implementation schedules can be found in table 6-16.

Table 6-16 Estimated Construction Costs and Implementation Schedules				
Improvement	Schedule (Months)	Estimated Costs		
		Project Cost	Fully-Funded Cost	Average Annual Cost
Juvenile Fish Systems				
Dispersed Release Sites (Flumes)	33	3,326,000	4,177,000	303,000
Short-Haul Barging	39	9,428,000	12,144,000	2,266,000
Extended-Length Screens	41	45,753,000	59,666,000	4,622,000
Modifications to LGR Juvenile Facility	59	19,684,000	25,652,000	1,862,000
Auxiliary Water Intake at McNary	61	24,340,000	31,682,000	2,298,000
Surface-Oriented Collection (LGR)	70	101,530,000	133,840,000	10,053,000
Juvenile Fish Transportation				
Net Pens	41	21,051,000	26,606,000	6,758,000
Barge Water Temperature Control	53	48,617,000	63,507,000	7,130,000
Fish Barge Exits	23	1,476,000	1,809,000	146,000
Additional Fish Barges	27	45,452,000	58,546,000	4,748,000
Adult Passage Systems				
Fish Ladder Water Temperature Control	26	12,445,000	15,396,000	1,243,000
Additional Fish Ladders	61	150,879,000	200,972,000	13,733,000
Fish Ladder Entrance and Attraction Water	33	19,781,000	24,844,000	1,676,000
Fish Ladder Exits	37	856,000	1,101,000	75,000
Adult Collection Channel Modifications	21	353,000	434,000	31,000
Fish Channel Extensions	51	52,007,000	67,299,000	4,586,000
Dam Modifications				
Spillway/Stilling Basin Modifications	79	137,468,000	187,788,000	12,420,000
Hatchery Modifications				
Truck Loading	6	360,000	473,000	55,000
Added Containment Facilities				
Dworshak Hatchery	65	14,109,000	18,563,000	1,400,000
Magic Valley Hatchery	49	3,569,000	4,695,000	358,000

h. Summary and Discussion.

The preliminary evaluations conducted for these improvements has indicated that several of the improvements may warrant further evaluation, based on their potential benefit to anadromous fish. In addition, each improvement was examined for its value as a long-term or near-term type of action. Table 6-17 is a summary of the potential of each alternative to increase salmon fish survival, whether it is an near-term or long-term action, and the average annual cost.

Table 6-17 Summary of Existing System Improvements Evaluations						
Alternative	**Salmon Survival Benefits**			**Average Annual Cost ($1,000)[1]**	**Near-Term Meas[2]**	**Long-Term Meas[3]**
	Eff	**Maybe Eff**	**Not Eff**			
Improved Juvenile Fish Systems						
Dispersed Release Sites						
Short-Haul Barging		X		303	X	
With Flume System				4,622	X	
Extended-Length Screens (Fall Chinook)	X			1,862	X	
Modifications to LGR Juvenile Facility	X			2,298	X	
Auxiliary Water Intake at McNary			X	2,266		
North shore		X				X
South shore		X			X	
Surface-Oriented Collection and Bypass	X			10,053		X
Improved Juvenile Fish Transportation Systems						
Net Pens				6,758		
Barge Water Temperature Control			X	7,130		X
Spring Chinook						
Fall/Summer Chinook			X			X
Fish Barge Exits	X	X		146	X	X
Additional Fish Barges	X			4,748	X	
Improved Adult Passage Systems						
Adult Ladder Temperature Water Control				1,243		X
Additional Adult Fish Ladders				13,733		X
Ladder Entrance and Attraction Water	X	X		1,676		X
Adult Ladder Exits	X	X		75	X	
Adult Collection Channel Modifications			X	31	X	
Adult Channel Extensions		X		4,586		X
Improved Fish Hatcheries						
Truck Loading Pump		X		55	X	
Additional Containment Facilities		X		1,758		X
Dam Modifications						
Spillway/Stilling Basin Modifications		X		12,420		X

[1]Construction costs at October 1992 price level and fully-funded cost estimates are presented above.
[2]Near-term measures are considered to be relatively minor improvements that could be implemented without extensive additional research or testing, provided they have regional support and funding is available.
[3]Long-term measures are considered to be major improvements requiring significant research and testing prior to implementation. These actions require further study.

6.07. Improvements to Existing Facilities--Lower Columbia River.

a. General.

The report on lower Columbia River system improvements is contained in Appendix F, *System Improvements Technical Report - Lower Columbia River*. Eight improvements to various existing project facilities were evaluated. All eight studies were evaluated for potential benefits to downstream migrant juvenile passage and survival. The John Day Spill Pattern/Flip-Lips study was also considered for possible benefits to upstream migrant adult salmonids. It should be noted that these are reconnaissance-level studies, and no new biological and/or engineering research studies have been executed to assess the possible benefits to increased survival for these improvements. The following list is the eight Portland District system improvements that were evaluated:

- John Day Extended-Length Screens
- John Day Spill Patterns/Flip-Lips
- John Day Transport
- Bonneville First Powerhouse FGE
- Bonneville First and Second Powerhouse DSM Facilities
- Bonneville First and Second Powerhouse Outfalls
- Bonneville Outfall Alternative Release Strategy (Short-Haul Barging)
- Turbine Passage Improvements

The turbine improvement measure was evaluated for application throughout the system. The other system improvements evaluated were located at either the Bonneville or the John Day projects. Each system improvement was evaluated for its potential effect on various species/stocks. Specific information on the numbers of each species/stock of juveniles arriving at each project are not available. information from the Fish Passage Center, and hatchery production input (as discussed in appendix F), were used to derive estimates of the numbers arriving at specific projects. Numbers displayed in table 6-18 are presented to illustrate the significant variation in the numbers and origins of fish involved in considering the potential value of lower Columbia River system improvements.

Table 6-18 Estimates of the Number of Downstream Migrant Juvenile Salmonids Arriving at John Day and Bonneville (Wild and Hatchery)		
Species/Stock	**John Day**	**Bonneville**
Yearling Chinook	600,000	5,040,000
Subyearling Chinook	2,190,000	12,070,000
Steelhead	240,000	740,000
Sockeye	130,000	110,000
Coho	110,000	4,220,000

b. System Analysis.

Both John Day transportation and turbine passage improvement will be included in a cost-effective analysis with the John Day operation at MOP analysis, using CRiSP. Originally, all eight Portland District system improvement studies were analyzed for biological benefits using the CRiSP regional passage model. Since CRiSP measures system-wide effects, survival changes from the other system improvements were not detected by the model. The CRiSP model is not sensitive to relatively small changes in project passage conditions at specific projects. For the analysis, representative mid-Columbia stocks (Methow spring Chinook, Methow Well Index fall Chinook, Hanford Ferry summer Chinook, and Wenatchee steelhead) were used for comparison. Under the current transport program for most Snake River juveniles, the effects of these lower Columbia improvements would be negligible.

c. Project-Specific Analysis.

To estimate possible benefits resulting from lower Columbia project system improvements, a spreadsheet model was developed to estimate project-specific benefits for all system improvements except John Day transportation and turbine passage improvements (see Appendix F). These two studies were not analyzed with a project-specific spreadsheet since they involved actions at, or past, more than one project (*i.e.*, John Day transportation involves passage through, or past, two other projects and reservoirs). The assumptions and parameters used to evaluate the project-specific benefits are discussed in detail in appendix F. Assumptions and parameters were derived from information developed from previous studies and/or represent regionally-accepted values. The overall change in project-specific survival was calculated based on the estimated changes in direct and indirect mortality for the particular passage route or facility analyzed. Survival changes for comparison are presented for subyearling and yearling Chinook steelhead, and coho (for Bonneville improvements). Coho were not evaluated due to the low numbers involved. Estimated effects for sockeye, which were similar, are displayed in the appendix.

d. Evaluation of Improvements Using CRiSP.

The two system improvements evaluated using CRiSP are discussed in the following paragraphs. Table 6-19 presents a summary of the relative system survival changes for these system improvements. Costs for these two measures are discussed in the following paragraphs, and summarized in table 6-20.

Table 6-19
Relative System Survival Changes--CRiSP (In Percent)
Mid-Columbia River

Improvement	Species			
	Spring Chinook	Summer Chinook	Fall Chinook	Steelhead
John Day Transport	**-7**	**3**	**6**	**-3**
Turbine Passage Improvements	**2**	**5**	**8**	**3**

Table 6-20
Estimated Costs and Implementation Schedules
Lower Columbia System Improvements

Improvement	Implnt Schedule (Years)	Estimated Costs			
		Total Project Cost	Fully-Funded Cost	Annual Economic Cost	Total Average Annual Cost
John Day Juvenile Transport	7	37,472,000	50,076,000	--	3,681,000
Turbine Passage Survival	10	289,131,000	436,722,000	--	35,280,000
John Day Extended Screens	7	60,715,000	83,107,000	(2,800,000)	3,335,000
John Day Spill Pattern/Flip-Lips	5	22,520,000	29,183,000	--	1,954,000
Bonneville First Powerhouse FGE	7	29,869,000	37,485,000	1,118,000	4,425,000
Bonneville First/Second Pwrhse DSM Fac	5	9,103,000	11,446,000	--	804,000
Bonneville Outfalls	6	49,450,000	59,920,000	--	4,521,000
Bonneville Short-Haul Barging	6	48,295,000	67,967,000	--	4,703,000
Combination A	7	88,422,000	108,898,000	1,118,000	9,750,000
Combination B	7	88,267,000	116,888,000	1,118,000	9,932,000

Combination A = Bonneville FGE, DSM, and Outfalls
Combination B = Bonneville FGE, DSM, and Short-Haul Barging

(1) John Day Transport.

This measure would provide a juvenile transportation system at John Day Dam. Transportation of downstream migrants would be implemented to reduce in-river travel time, and avoid bypass predation and reservoir mortality. New equipment and facilities include barges, fish tanker trucks, a three-cell sheet pile barge-loading facility and dock, a truck loading area, covered concrete raceways, and employee parking. The measure would require the replacement of the existing ogee and full-flow transportation channel with a reduced-flow transportation channel and a new outfall.

Available literature and data suggest that transportation is beneficial to migrating juvenile salmonids and, although it is not a substitute for natural river conditions. It increases survival of downstream migrants under existing river conditions and operation.

The majority of past studies have focused on the relative survival of transported and non-transported fish as adult returns from which transportation benefit ratios (TBR's) are calculated. The most recent completed studies (released in 1986) have shown TBR's of 1.6 (1.0 to 2.5) for yearling Chinook, 2.8 (1.4 to 5.6) for subyearling Chinook, and 2.0 (1.4 to 2.7) for steelhead for projects indicated below.

These TBR's were used to develop estimated transportation survival factors relative to control fish (in-river) survivals to below Bonneville Dam. Yearling Chinook and steelhead control fish were "released" from Little Goose Dam, and subyearling Chinook control fish were "released" from McNary Dam, to estimate in-river survival. For the modeling, it was assumed that transportation survival was constant at all projects (independent of distance transported), and over the full range of flow conditions. Therefore, survival of transported fish at John Day was the same as index dam estimates.

The relative survival changes from the CRiSP modeling for the mid-Columbia stocks described above are displayed in table 6-21. The modeling yielded mixed results, with summer and fall subyearlings showing a small survival improvement, while survivals for spring Chinook and steelhead showed a negative result. These small changes would not be considered statistically significant, given model variability.

Table 6-21
Relative Project-Specific Survival Changes
(In Percent)

Improvement	Stock/Species			
	Yearling Chinook	Subyearling Chinook	Steelhead	Coho
John Day Extended Screens	2	1	1	n/a
John Day Spill Pattern	1	1	1	n/a
Bonneville First Powerhouse FGE	(-5 to -2)	(-8 to -1)	(-4 to -2)	(-4 to -1)
Bonneville First/Second Pwrhse DSM Fac	0 to 1	0 to 1	0 to 1	0 to 1
Bonneville Outfalls	0 to 2	1 to 2	1 to 2	1 to 3
Bonneville Short-Haul Barging	2 to 3	2 to 3	3 to 4	3 to 4
Combination A	-2 to 4	-1 to 2	-1 to 4	-1 to 4
Combination B	0 to 5	0 to 4	0 to 5	1 to 6

Combination A = Bonneville FGE, DSM, and Outfalls
Combination B = Bonneville FGE, DSM, and Short-Haul Barging

A project-specific (John Day to Bonneville tailrace) analysis was conducted, as reported in Appendix F. This analysis assumed a higher transport survival, and resulted in positive and much greater survival improvements. The two analyses tend to bracket the potential for transport as a means to increase juvenile survival from John Day Dam, based on preliminary assumptions. Additional studies would be needed to resolve uncertainties, with regard to transportation survivals.

(2) Turbine Passage Improvements.

This potential measure is premised on the fact that, even with current guidance technology, many juvenile salmon still must pass through the turbine environment. Therefore, the potential to rehabilitate existing turbines, modify unit operations, and/or design and construct new turbines using advanced turbine designs based on biological design criteria, warrants investigation. The goal is to increase the survival of unguided fish, and improve survival past the projects. Recognizing that turbine mortality figures have been shown to vary widely, this preliminary study provides an estimate of the system survival improvements that could be realized, based on an assumption of turbine passage survival of 89 percent and a range of potential improvement to this figure of from 2 percent to 8 percent. The study also evaluates the feasibility of, and prescribes, a research program to evaluate, quantify, and test the various casual agents of turbine mortality. The methods proposed will include laboratory studies, numerical analysis, turbine design, and prototype testing.

The CRiSP model was used to evaluate potential survival for various stocks of the Snake/Columbia Rivers, both with and without the existing transportation, and assuming a number of turbine replacement scenarios. These scenarios included: 1) assumed replacement of all turbines on the Columbia/Snake system; 2) replacement of turbines on the lower Columbia only; and 3) replacement of turbines on the Snake only. These results are reported in the appendix. For purposes of comparing the potential survival improvements and costs with other lower Columbia measures analyzed using CRiSP (John Day transport and John Day MOP), only the lower Columbia scenario benefits and costs are discussed in this report. It is noted from the appendix, however, that even with the most optimistic assumption of turbine survival improvement at all Columbia/Snake dams, system survival of Snake River stocks would not improve over the base condition (with transport).

The CRiSP model results for the representative mid-Columbia stocks discussed above are summarized in table 6-19. The system survival changes for the mid-point of the range of potential turbine survival improvement is presented. As expected, fish with lower FGE levels (subyearlings) would benefit more from the improvement.

The estimated costs for replacement of all lower Columbia River turbines are summarized in table 6-19. This provides a conservative cost estimate relative to other measures. As discussed above, other implementation outcomes could result from the research.

e. Evaluation of System Improvements Using Project-Specific Analysis.

The following paragraphs discuss the evaluation of the other lower Columbia system improvements, using the project-specific analysis. The project-specific survival estimates are presented in table 6-21. The costs of these measures are summarized in table 6-20.

(1) John Day Extended-Length Screens.

Currently, 20-foot submerged traveling screens (STS's) guide juveniles at John Day Lock and Dam. The screens became operational in 1986. Forty-nine STS's are operated in the 16 existing units.

Extended screens could either by STS's or submersible bar screens. Existing screens on the Columbia and Snake River projects are now all 20-foot traveling screens. Prototype testing on the alternative types of extended screens continues at The Dalles and McNary projects. The tests, to date, are not conclusive, and tend to be site-specific. A prototype testing program would be beneficial at John Day in determining the most biologically-effective design. For this preliminary study, 40-foot extended STS's were assumed, in order to provide a conservative cost estimate. Based on the prototype testing that has been completed at McNary, the vertical barrier screens at John Day will have to be remodeled or replaced.

Existing FGE values used in this analysis were taken from a NMFS memorandum, dated January 25, 1993, subject: input parameters for computer modeling of the Columbia River Basin (NMFS, 1993), for spring/summer Chinook salmon, fall Chinook salmon, and sockeye salmon. Existing FGE values used in this analysis for steelhead are from Krcma *et al.*, 1986.

The estimated high and low FGE values utilized in this analysis for installing extended-length screens were calculated from existing FGE values, and the differences realized from testing at McNary Dam (Brege *et al.*, 1992, 1993). These estimated values, based on testing at McNary, are considered preliminary. Prototype extended-length barrier screens and extended-length traveling screen testing will be necessary to better define the actual FGE that will be realized at John Day with extended-length screens (see table 6-22).

Table 6-22
FGE Values Used For Biological Analysis

Species/Stock	FGE		
	Present	High	Low
Yearling Chinook	0.72	0.94	0.91
Subyearling Chinook	0.26	0.49	0.46
Steelhead	0.86	1.00	1.00
Sockeye	0.41	0.59	0.55

Mortality estimates for alternative downstream passage routes used in the analysis are shown in table 6-23. These are not project-specific mortality estimates, but generic estimates utilized for hydroelectric facilities within the Columbia River Basin.

Table 6-23
Mortality Estimates Used
For Biological Analysis

Passage Route	Mortality
Turbine	0.11
Bypass	0.02
Spill	0.02

Estimated project-specific survival changes for the various downstream migrant species/stocks are summarized in table 6-21. Survival improvements due to installation of extended-length screens ranged from 1 to 2 percent. These estimates do not account for other possible mortality factors that can not be evaluated without hydraulic modeling, prototype testing, and survival studies. One factor that should be addressed in the hydraulic model testing is effects on turbine mortality for unguided fish with the use of extended-length screens. Also, it is noted that, with increased FGE, it was assumed that spill would be reduced. This would tend to dampen the survival improvement estimates, with an economic benefit as discussed in the next paragraph.

The economic benefit of $2.8 million reflects the assumption that, with improved FGE, voluntary spill to achieve overall project FGE could be reduced, thus producing a benefit to hydropower production.

(2) John Day Spill Patterns and Flip-Lips.

The John Day project includes a 20-bay spillway. This measure considers the potential survival benefits provided by adjustments in the spill patterns for adult and juvenile migrants, as well as the installation of flip-lips. In 1979, the Corps began hydroacoustic monitoring of juvenile salmonid locations and concentrations at both the spillway bays and the turbine intakes. The present guidelines for juvenile spill patterns were established on the basis of that study. Adjustment of the spill patterns for adult fish passage were made in 1968, based on visual observations.

Under current spill agreements, the quantity of water to be spilled is approximately 20 percent of the total river flow during summer juvenile migration, which amounted to a significant increase above previous spill. There is no current spill requirement for fish during the spring, but forced spill occurs with flows exceeding powerhouse capacity, or during periods of low power demand.

Adult patterns are used during 0500 to 2000 hours. At low flows, the spill pattern is set so that a greater proportion of flow is passed through the bays at the ends of the spillway. During the juvenile passage period, spill for the passage of juvenile fish is in effect during 2000 to 0500 hours. The current spill pattern schedule initially opens the south bays adjacent to the powerhouse. This arrangement enables the juveniles to take advantage of the powerhouse flows, and thus minimize the potential for delays to the downstream migrants.

The existing adult patterns could be modified to improve adult fish attraction. Stable, positive flow with velocities of approximately 4 to 8 cubic feet per second leading to the fish ladder entrances would be the goal. The existing juvenile spill patterns could be modified to improve juvenile bypass conditions. Stable, positive downstream flow, with velocities at 4 feet per second or greater, fairly equally distributed, with the majority of the flow away from the banks and other structures, would be the goal.

The primary purpose of the flip-lips is to reduce the impact of nitrogen supersaturation on juveniles and adults contained in plunging spillway flows. Under the current summer spill program and, given summer flows, it does not appear that nitrogen supersaturation would exceed the recommended 110-percent level. However, as discussed above, high levels of forced spill during periods in the spring could raise nitrogen levels above the recommended maximum. A potential side benefit to flip-lips would be a skimming flow for spill, and less boiling and other irregular flows, and a potential for reduced predation. Retractable flip-lips would provide even greater flexibility by allowing no flipping action at low spill quantities.

Hydraulic model studies will be necessary to determine the ultimate spill pattern design, as well as the biological effectiveness of the installation of flip-lips.

For the summer spill period, preliminary biological benefits are based on estimated differences in indirect juvenile survival associated with new spill patterns, which would improve tailrace flow conditions. Currently, there is no physical model of John Day. The differences were estimated using spill pattern and downstream flow information from The Dalles, as these projects have similar spill patterns and assumptions regarding relative differences in indirect mortality. Indirect mortality values are not available for John Day or The Dalles. The assumed values and changes are based on information from the Bonneville Dam survival study conducted from 1987 through 1990.

Based on the preliminary analysis, the assumed indirect mortality at John Day during the summer is 8 percent, due to tailrace conditions; and the total spillway survival is 90 percent (2-percent direct mortality, and 8-percent indirect mortality). With spill pattern improvements, this may be increased to 97 percent, with a range of from 90 percent to 97 percent.

The project-specific analysis was performed using passage route mortalities displayed in table 6-23 and indirect spill mortality of from 1 to 8 percent. The model results showed a potential increase of 1 percent in project-specific survival, due to spill pattern improvements.

The effect of adding flip-lips was not included in the project-specific analysis. The combined effects of spill pattern improvements and flip-lips were estimated for overall spillway survival, however, including direct and indirect mortality based on the potential improvement in tailrace flow conditions and the reduction of gas supersaturation. Base condition spillway survival in the spring during high flow periods was assumed to be 92 percent; with mortalities of 2-percent direct, 2 percent due to nitrogen supersaturation, and 4-percent indirect, due to tailrace conditions. The potential improvement in spillway survival was estimated to be 4 percent to 96 percent, with elimination of nitrogen-caused mortality and a 2-percent improvement in indirect mortality.

The spill pattern/flip-lip measure would also be expected to benefit adult migrants, although no quantitative estimates have been made at this time.

For spill pattern improvements, there are no construction costs. The cost of the measure would be the engineering, biological, and model studies required to develop the spill patterns. Construction cots shown are for the addition of flip-lips.

(3) Bonneville First Powerhouse FGE.

The FGE of the first powerhouse has been the subject of considerable research, and there appear to be a number of potential sources of problems. Current estimated FGE values for spring migrants are below regional goals. The FGE levels were generally increased by raising the operating gate for most species in most years tested. This increase suggests that, currently, insufficient flow up the gate slot is available to guide and attract fish away from the intake. While improved under this condition, however, FGE levels were still below regional goals. Analysis of vertical distribution data suggests spring migrants are distributed just below the STS. Attempts to reach these fish by lowering the STS were confounded by a reduction in FGE associated with fish going over the top of the guidance screen and reentering the intake.

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

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

A number of factors potentially affecting first powerhouse FGE have been preliminarily identified that would require further engineering, modeling, and biological studies. These include channel approach conditions, intake reconfiguration, pier extensions, trashrack modifications or relocation, extended screens of alternative designs, modifications to the VBS's and/or the gatewells, and raising or removing operating gates. The preliminary cost estimate provides for extended screens, modifications to the VBS's and streamlined trashracks, which represents a likely scenario for FGE improvements. Other potential measures have not been estimated at this time, due to unknown. It is further noted in the cost estimate that an economic impact cost of $1.1 million is shown. This is due to an estimated impact to hydropower production with the extended screens. However, as discussed above with regard to the extended screens measure at John Day, with improved FGE, reductions in spill could be anticipated with an accompanying economic benefit to hydropower production. An estimate of the potential benefit is not available at this time.

In addition to the FGE studies described above, research efforts were initiated in 1992 to estimate the survival of fish passage through various passage routes at Bonneville First Powerhouse. The studies will be discussed in the following paragraphs. In summary, the studies show that any improvements made to FGE to meet regional goals should not be implemented without other improvements to bypass survival.

The FGE improvement values were derived through consideration of several methods: flow intercept, relative and absolute improvement, based on studies at McNary Dam. The FGE values used are shown in table 6-24.

Table 6-24
FGE Values Modeled

Species/Stock	Base Case (Percentage)	Improvement Range (Percentage)
Chinook 1	37	65 to 86
Chinook 0 Prior to 6/15	39	62 to 84
Chinook 0 After 6/15	10	18 to 63
Sockeye	23	75 to 82

The biological benefit projections for the FGE improvements reflect the current bypass survival problems. Survival changes for all species/stocks estimated using the project-specific model were negative for implementing FGE improvements alone, as would be expected. The results are summarized in table 6-21.

(4) Bonneville First and Second Powerhouse DSM Facilities.

The juvenile bypass system through the first powerhouse was constructed within the existing ice-and-trash sluiceway. The system is conceptually similar to bypass systems at the upstream Columbia and Snake River projects. The bypass channel carries the juveniles to the north end of the powerhouse where they pass over a dewatering screen that removes the excess flow. The approach velocity to the screen is approximately 5.2 feet per second, and was designed to be between the minimum trapping velocity of 4.0 feet per second, and was designed to be between the minimum trapping velocity of 4.0 feet per second and the maximum safe velocity criterion of 6.0 feet per second. The inclined screen was designed for maximum velocity through the screen of 1 foot per second. Since then, the criteria for maximum allowable velocity through a dewatering screen has been modified to 0.4 feet per second.

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

In the second powerhouse DSM facilities, areas proposed for improvement are briefly described as follows:

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

Previous studies, judgement, and assumptions regarding sources of mortality in the bypass and outfall system, described in detail in the appendix, were used to make preliminary estimates of bypass system mortalities and potential changes that could result from the improvement measures. At the first powerhouse, bypass survival was estimated to be 70 percent for summer migrants and

85 percent for spring migrants. Survival improvements of 3 and 1 percent, respectively, were estimated for modification of the inclined screen. For summer and spring migrants at the second powerhouse, bypass system survivals are estimated to be 82 and 91 percent, respectively. Bypass channel improvements were estimated to increase these survivals to 87 and 94 percent, respectively.

To derive specific changes in survival, a range of improvement from no effect to twice the above effects was used. The results of the analysis for the various species/stocks, as shown in table 6-21, yielded a project-specific survival improvement of from 0 to 1 percent.

(5) Bonneville Bypass Outfalls.

From 1987 to 1990, an evaluation was initiated to evaluate the survival of subyearling fish passing Bonneville Dam. The primary goal of this study was to determine the relative survival of juveniles passing through the various passage routes, including the bypass, spillway, and turbines. Predation studies have shown that indirect mortality is an important factor influencing juvenile survival below Bonneville Dam. Other studies have shown that predation is an important factor in tailraces below lower Columbia projects, and is most severe in areas immediately below the dams. To increase survival past the first and second powerhouse at Bonneville Dam, new release sites would be identified to meet criteria, including:

- Water velocities of 4 feet per second or greater near and downstream of the outfall.
- Recovery area downstream of the release site. Time necessary for juveniles to recover from stress and disorientation related to passage through the bypass system.
- Distance from in-water structures or backwater areas. This is based on the squawfish strike distance to prey from holding cover.
- Dispersal of flows downstream. This factor attempts to categorize the behavioral movements of juveniles under a range of flows below the release site.

The primary objectives of the proposed release sites are to provide a safe passage route for juveniles exiting the bypass system, as well as to minimize predation on juveniles downstream of the release site.

At each powerhouse, existing pressurized underwater outfalls would be replaced with an open channel flume. Both systems will include a new transportation channel and outfall, designed in conjunction with new smolt-monitoring facilities under design for each powerhouse.

Biological benefits are based upon the difference in indirect juvenile survival associated with the new release sites, compared to the existing sites. It is assumed that the new proposed release sites would be located in an area that adequately meets the criteria discussed above. The indirect survival estimates are based on the assumption that survival is affected by flow levels, hydraulic conditions near, and downstream of, the release sites, as well as the condition of the juveniles at release.

The studies and assumptions discussed above regarding DSM improvements provided information to estimate bypass and outfall mortalities and potential improvements. For summer and spring migrants at the second powerhouse, bypass survival is estimated to be 82 and 91 percent, respectively. With a relocated outfall meeting the criteria, it is preliminarily estimated that bypass survivals could increase by 4 and 2 percent, respectively.

Relocation of the outfall at the first powerhouse will require that the pressurized pipe and downwell be converted to an open transportation flume. This improvement, along with the relocation to meet the criteria, is preliminarily estimated to increase survival for summer migrants from 70 to 87 percent, and from 85 to 93 percent for spring migrants.

Mortality rates associated with the new outfalls vary depending on the fitness of the fish, hydraulic conditions near and downstream of the outfall, and the timing of fish passage (summer versus spring). Many other factors may influence mortality rates of fish through the bypass or at the outfall, and there is considerable uncertainty in assigning mortality rates to specific changes in the system. Due to this uncertainty, ranges of values based on the above estimated values were used in the project-specific analysis to evaluate the potential for increased survival with relocation of the outfalls. A summary of the results of the project-specific analysis is shown on table 6-21. The results show an improvement of 0 to 3 percent in project-specific survival, depending on stock.

(6) Short-Haul Barging.

Short-haul barging is conceived as a potential outfall/release strategy. Juveniles would be transported downstream of the tailrace to avoid predation in the general vicinity of the fixed outfall site. Juvenile fish would be collected into raceways or directly onto the barge docked below the dam and released into the reservoir below the dam daily. The operation could be a full-time release strategy, or it could be used only during low flow periods. Prototype testing and survival studies would be needed to assess program application.

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

In appendix F, the short-haul concept is discussed for the three lower Columbia projects. The Dalles juvenile bypass system is currently being designed to allow for potential future transport facilities. Transportation at John Day has been discussed above. For this reconnaissance-level study, the costs and biological benefits have been evaluated for implementation at Bonneville.

At Bonneville, two barging sites have been assumed in the preliminary analysis; one at each powerhouse. A single site was considered, but the existing bypasses could require extensive modifications, and the flume would have to cross over the spillway to combine and form a common barge-loading site. All fish would be directly loaded into a barge docked at a new dock site, or released through a new outfall when barge loading is not in operation. Neither raceway storage or outfall sampling capability are planned. New smolt monitoring facilities are assumed to be designed to accommodate future transport facilities.

From research programs discussed in detail in appendix F, it appears that the use of short-haul barging as an outfall release strategy could enhance the fitness of bypassed salmonid smolts by providing time to recover from the rigors of bypass. Also, during low flow periods, the measure could ensure that migrants were released in higher flow areas, where predators cannot hold for long periods of time. It would also ensure that bypassed migrants were not released near structures where predators may hold in slackwater. Another benefit would be the elimination of "point source" bypass outfall sites that predators may learn to key on. Finally, with further distance from the project, loss time would be spent within predator-infested waters, and fewer predators would be encountered.

With available indirect mortality data for Bonneville from NMFS studies, a preliminary evaluation of potential survival benefits can be made. Baseline bypass survival estimates were discussed regarding outfall relocation above. For the project-specific analysis, it was estimated that mortality attributed to tailrace predation at the second powerhouse could be reduced to 1 to 3 percent for summer migrants, and 0 to 2 percent for spring migrants. For the first powerhouse, it was estimated that mortality attributed to tailrace predation could be reduced to 1 to 3 percent for summer migrants, and 0 to 2 percent for spring migrants. Using these estimated values, project-specific survival increases of 2 to 4 percent resulted from the analysis, as summarized in table 6-21.

(7) Combinations of Bonneville Improvements.

A project-specific analysis was conducted for combinations of the Bonneville measures discussed above. One would combine the FGE, DSM, and outfall measures (combination A). The other would include the FGE, DSM, and short-haul barging measures (combination B). For this preliminary estimate, costs were simply combined and, therefore, the costs could be overstated somewhat as items such as mobilization and demobilization would conceivably be less. It is also noted that the discussion, with regard to the economic costs involved with FGE improvement, would also apply here.

The summary of the survival changes resulting from the project-specific analysis are displayed in table 6-21. Survival improvements ranged from -1 to 4 percent for combination A, and from 0 to 6 percent for combination B. It is noted that the assumption of reduced spill associated with these improvements would tend to dampen the survival improvement changes.

6.08. Montana Plan--Reservoir Diking.

The analysis of this alternative was conducted by the Montana office of the NPPC and the Montana Department of Natural Resources, using data provided to them by the Corps, Walla Walla District.

The results of this analysis showed that there was very limited benefit to water travel time. There was approximately a 2-hour decrease in water travel time through Lower Granite reservoir at an average flow condition during the juvenile migration period. The costs associated with the construction of reservoir dikes are approximately $45 million. In addition, there are several significant effects or uncertainties associated with the construction of these dikes, which include:

- Shallow Water Habitat: The construction of these dikes would eliminate a substantial amount of already limited shallow water habitat. Juvenile fall Chinook rely heavily on this rearing habitat as they migrate downstream.

- Effects of Ecosystem: There is an unknown effect on the river ecosystem associated with large amounts of material placed in the river. Currently, there is a length "test" process required for in-water disposal or fill.

- Dredge Spoils: The material periodically dredged from the confluence of the Snake and Clearwater River is primarily sand. This material would not be suitable for dike construction.

In conclusion, due to the low potential to improve water travel time and ultimately improve juvenile salmon survival, high relative construction cost, and other biological concerns, it appears that this alternative does not warrant further consideration.

Section 7 - Comparison of Alternatives

7.01. Overview.

This section presents the criteria for comparison of the alternatives described in sections 5 and 6.

7.02. Comparison Criteria.

This criteria for evaluating the alternatives analyzed in the SCS Phase I includes: 1) technical feasibility; 2) biological (anadromous fish) effectiveness; 3) other significant environmental effects; 4) cost effectiveness; and 5) regional acceptability. Plan formulation and plan comparison criteria are based on the screening process, as depicted in the decision chart shown in figure 7-1.

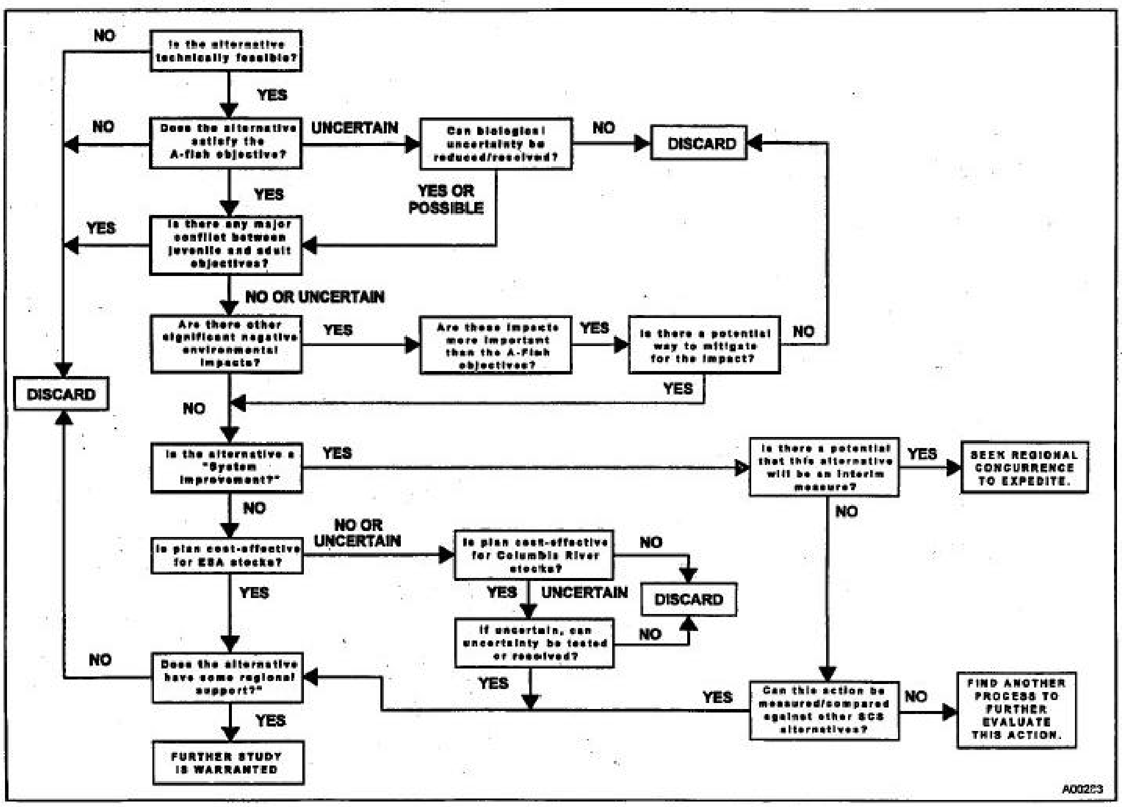

Figure 7-1. Plan Selection Diagram

The range of potential actions are compared against each other using the criteria identified above. This evaluation only looked at individual alternatives. There is no comparison of combinations of alternatives. Combinations will be evaluated in Phase II.

a. Technical Feasibility.

The feasibility of implementing or constructing an alternative plan, from a technical or engineering perspective, is the starting point for comparing or screening alternatives. If an alternative cannot be implemented, for whatever reason, it was discarded.

b. Biological Effectiveness.

The effects of the alternatives on salmon survival were analyzed and estimated. Both qualitative and quantitative procedures were used in an effort to estimate survival. Originally, the quantitative estimates were to be based on a life-cycle model called the Stochastic Life Cycle Model (SLCM), developed by Resources for the Future. This life-cycle model has an accompanying juvenile passage model called the Columbia River Salmon Passage (CRiSP) model, developed by the Center for Quantitative Sciences at the University of Washington. The CRiSP model estimates survival for juvenile fish in their migration to a point below Bonneville Dam. The goal was to estimate the effects on survival by measuring returns to the spawning grounds, by species and/or stocks. Unfortunately, due to time constraints, SLCM was not run for the majority of the alternatives; and the quantitative analysis was limited to downstream migrant survival estimates utilizing CRiSP. A detailed description of both CRiSP and SLCM can be found in the Biological Plan (Appendix G). Due to the project-specific nature of the "System Improvements" (and additional time limitations), CRiSP was not used for the "System Improvements," and the biological effectiveness was limited to a qualitative analysis.

The primary purpose of the salmon models is not to predict actual numbers of surviving juvenile fish or adult fish returning to the future, but to compare the results of different alternatives.

For some alternatives, there may be a conflict between making improvements to juvenile and adult migration. If considered to be a significant effect, this could lead to the elimination of an alternative.

c. Cost Effectiveness Analysis.

Cost effectiveness is an evaluation tool, calculated in terms of relative costs needed to achieve a change in salmon survival, in this case juvenile survival to below Bonneville Dam. The analysis will look at each species or stock separately. The cost-effectiveness approach avoids the issue of assigning monetary values to endangered species by comparing alternatives, in an attempt to identify the least-cost way to increase survival. This approach does not determine how much improvement of the environmental objective is economically justified but, rather, it provides information regarding the cost of action for various levels of salmon survival improvement. It is not anticipated that the cost-effectiveness analysis will be able to rank alternatives in terms of economic performance, due to the limited level of analysis performed. However, it will, in general terms, identify some alternatives that are definitely cost effective, and some that are definitely not cost effective.

d. Regional Acceptability.

Regional acceptability for each of these alternatives will be assessed. The primary entity for determining regional acceptability is NPPC; but State and local entities, interest groups, industry, and the general public input are also important. The vehicles for obtaining regional input are: 1) 45-day review of this draft report; and 2) public information meetings held throughout the region to present the draft results.

7.03. Comparison of Alternatives.

a. Technical Feasibility.

All the alternatives being evaluated are considered to be implementable from a technical or engineering standpoint.

b. Biological Effectiveness.

Salmonid passage survival is influenced by many physically and ecologically dynamic processes. Direct effects to mortality (*e.g.*, turbine mortality) can be measured more readily. Indirect effects (*i.e.*, stress responses or delay, causing greater exposure to predators or near-threshold temperatures) can occur in a short time, be accumulated over the length of the migration for a life stage, or not occur until the ocean phase. The significance to overall salmonid population survival of many of these indirect effects are difficult or impossible to measure. This limitation leads analysts to formulate educated assumptions for those effects that data indicates may be important to a specific salmonid stock's overall survival. The analytical models have been developed for the simulation of juvenile salmonid passage and life-cycle processes. They were calibrated to historical trends in adult returns and/or physical conditions that were measured during monitoring or experimental conditions. This calibration process is needed for adjusting the model's simulation to recorded conditions and population estimates. This can partially account for the variability and uncertainty in the assumptions and across the conditions for which the experimental or monitoring data was collected. Calibration allows for a more accurate simulation of the models, but is not validation or verification that all assumptions within the models are accurate.

The CRiSP 1.4 model was determined to have the most flexible model to compare a system operation or improvement to a base case. The other juvenile passage models in the region (PAM and FLUSH) were incorporated where existing runs were available for comparison. All of the models have a similar overall structure, composed of partitioning mortality (reflected as survival changes in the simulation) into dam and reservoir factors. The models are highly sensitive to the fish transportation assumptions of survival. Dam-related mortality factors (*i.e.*, FGE and turbine, bypass, and spill survival) are more directly estimated and applied based upon previous study at the various dams. Very little data is available for the more indirect factors acting upon salmonid passage as a consequence of, or an input modification to, the direct effects. Spill efficiency and dissolved gas generation effects on salmonid survival are two examples of these factors, which are not easily measurable. Reservoir-related mortality factors (*i.e.*, predation by various resident species and flow/velocity/fish travel time) are influenced to various degrees by fish size/age and condition (including stress and disease expression), which may or may not be influenced by dam-related operations (*i.e.*, dissolved gas concentration gradients and pressure changes through turbine passage). Many of these modifying factors are highly variable, with little evidence indicating direct cause-and-effect relationships. This is because of the technical abilities to measure such responses across all reservoir conditions are limited or uncertain. The fish transportation program may have delay and fish condition effects associated with the holding, loading, and evacuation processes. Most of the effects are characterized by acute stress and possible disease exposure that may have some form of indirect effect mortality on the smolts after release from the barge into the estuarine environment. Since quantification of many of these factors relating to mortality is limited, they are either: 1) excluded from the analytical modeling of salmonid passage; 2) incorporated indirectly by an estimating assumption; or 3) included in the calibration procedure, if similar conditions occurred during the calibration time series. In addition to these possible uncertainties, the juvenile passage models incorporate variability into their simulations to account for differences in flow years and variance in the conditions of when the data for a particular parameter estimate was collected.

(1) Lower Snake River Drawdown.

Based on both a qualitative and quantitative (CRiSP 1.4) analysis, only one of the four reservoir drawdown options on the lower Snake River showed potential benefits to juvenile salmon survival. The CRiSP results, for the natural river option, showed measurable benefits for spring and summer Chinook salmon and steelhead. This same alternative had a negative impact on fall Chinook. The near spillway crest drawdown options (33-foot, 43-foot, 52-foot, and variable pool) all showed a potential decline in juvenile survival. A sensitivity analysis, which simulated juvenile survival with both optimistic and pessimistic model parameters, verified these findings. This sensitivity analysis used model parameters that significantly decreased dam passage mortality (*e.g.*, 25 percent increase in FGE over current conditions, and only a 2-percent turbine mortality). Even with this condition (which almost eliminates dam passage-related mortality) these near spillway crest options still showed declines in survival.

The only other drawdown option to show a possible juvenile survival benefit was the Lower Granite only option, with transport. However, these benefits are marginal (1 to 5 percent), and are only realized under the very optimistic modeling assumptions identified above. This alternative may have potential as an upstream collector and transport option, and was compared to other collector and transport alternatives (refer to the following paragraphs).

(2) Upstream Collection and Conveyance.

A juvenile collector system located at the upper end of the Lower Granite reservoir, in combination with barge transportation, has potentially the highest juvenile salmon survival benefits of all of the alternatives evaluated in the SCS Phase I. This estimate is based on the CRiSP model analysis, using the most current transport assumptions of the regional modeling committees.

Quantitative model analyses on the biological benefits for the migratory canal and pipeline options were not prepared. However, based upon qualitative reviews of these options within regional technical committee discussions, several biological (salmon-related) concerns were identified. These concerns were substantial enough to eliminate these options from further consideration in Phase II.

(3) Additional Upstream Storage.

None of the storage sites investigated showed a measurable benefits to juvenile salmon survival, based on a CRiSP model analysis. However, the Phase I analysis may not indicate the true potential of this alternative. The Phase I quantitative evaluation was based on monthly hydroregulation models (HYSSR), rigid flow targets, and lengthy augmentation release periods, which together could understate the benefits to fish migration.

The biological uncertainty inherent in the flow survival relationships used in modeling efforts, as well as other areas of biological uncertainty surrounding the adult and juvenile life cycle, make it extremely difficult to draw definitive conclusions with respect to the biological efficacy of upstream storage for flow augmentation. Additionally, successive years of consultation with NMFS concerning system operation under ESA have continued to result in increasing requirements for flow a7ugmentation. These requirements are driven by the NMFS assessment that incremental flow increases are needed and effective as salmon recovery techniques. The need to provide these flows has significant impacts on Dworshak reservoir storage, and leading to increased demand on upper Snake River storage. Therefore, further consideration of means to reduce the impact of the water demands on the Columbia River System and, particularly, existing Idaho storage, may be prudent.

(4) John Day Operation at MOP.

The biological effectiveness of John Day operation at MOP is uncertain from the reconnaissance-level evaluation. General flow/survival uncertainties, and the magnitude of the physical change in pool level and water travel time, contribute to the uncertainty.

The fish passage models provide no measurable results. The CRiSP modeling showed a relative change in survival from the base condition, ranging from -4 percent for spring Chinook to +3 percent for fall Chinook and steelhead (absolute changes were -1 to +1 percent). The PAM modeling yielded a +7-percent relative improvement for spring Chinook. For CRiSP, a stochastic model, the magnitude of the survival changes measured would not be considered significant, given the variability of the model. Also, the results for the stocks analyzed by CRiSP, as well as the results for spring chinook analyzed by both models, are neither consistently positive or negative.

The potential effects on survival due to changes in dam passage conditions, predation, and/or habitat, which were not modeled, would presumably be small. However, given the magnitude of the physical effects of drawdown to MOP and the model results, these effects could be important and further add to the uncertainty of the biological effectiveness.

(5) System Improvements--Snake River.

Salmon survival benefits have not been quantified for a majority of these improvements. However, qualitative analyses on the effects to anadromous fish identified how these improvements would increase the survival of migrating salmon/steelhead. For this reason, it is difficult to extract a precise quantitative biological effectiveness estimate for a single structural improvement at a single dam from the total modeled estimate of survival. This level of detail for proposed system improvements goes beyond the scope of a reconnaissance-level study, especially when no or limited empirical data is available to derive an appropriate assumption. Modeling with this level of detail will be attempted for those improvements advanced into Phase II activities.

A reconnaissance evaluation based upon regional technical committee discussion and comment, and limited sensitivity analyses with CRiSP 1.4 modeling, has indicated that a number of improvement actions would benefit both juvenile and adult salmonid passage survival through the lower snake River dams and McNary Dam on the lower Columbia River. Interim actions that could be implemented within a relatively short timeframe (for low cost) and would have positive biological effectiveness include additional barges, larger barge exits, new wet separator and flume at Lower Granite Dam, dispersed release of bypassed smolts, and adult fish ladder improvements for more efficient passage at MOP reservoir elevations. Long-term activities that would have positive biological effectiveness, but would require advanced design, supplemental testing, longer implementation times, and associated higher economic cost include surface-oriented collectors and bypass facilities for all lower Snake River dams (if testing at Lower Granite Dam results in high biological effectiveness), extended-length fish screens, and new adult fish ladders at Lower Granite and Little Goose Dams, and spillway stilling basin modifications.

(6) System Improvements--Lower Columbia River.

The CRiSP modeling for the John Day transport and turbine improvement measures yielded results that would not be considered significant and were, therefore, inconclusive, given the model variability (see section 6). For turbine improvements, a positive trend in all of the stocks analyzed can be observed from this preliminary analysis. The system survival effects for John Day transport were mixed, depending on stocks. The results were positive for the mid-Columbia summer and fall Chinook stocks, and negative for spring Chinook and steelhead. The extremes, both positive and negative, were somewhat greater than the results for John Day operation at MOP.

For those measures that were evaluated based on project-specific survival, all but one demonstrated a potential to provide modest biological benefits (see section 6). The exception to this is the improvement of Bonneville First Powerhouse FGE as a stand-alone measure. Because existing bypass system mortality is higher than turbine mortality, guiding additional fish into the bypass system would increase total project mortality. Therefore, this measure should only be considered in conjunction with the other measures at Bonneville.

The biological effectiveness of other measures in combination will be considered in follow-up studies. For instance, extended screens and the spill pattern/flip-lip measures at John Day would be considered together in light of fish passage objectives.

c. Other Significant Environmental Effects.

The majority of the available information on the abundance and distribution of native and introduced native and introduced resident fish, and those aquatic invertebrates that support both the resident fish species and migrating anadromous fish for the lower Snake River reservoirs, has been collected in Lower Granite and Little Goose. Since most of the proposed SCS alternatives are either more specific to sole implementation at Lower Granite, or would be initially implemented at Lower Granite and then adapted to specific conditions at the remaining dams, it can be assumed that the current database is relatively representative for an evaluation of potential environmental effects on resources other than anadromous salmonids.

Reservoir drawdown could have the most wide-ranging environmental effects o the current reservoir ecosystem. The significance of the effects would largely depend on the target elevation and the timing and duration of drawdown for the water evacuation, elevation holding, and refilling periods. It would be expected that drawdown to near natural river would have the greatest impact on the invertebrate and resident fish fauna of the ecosystem. Once the reservoir is down, it should probably remain down in order to minimize the negative environmental effects, because this action would act to facilitate the ecosystem's natural response to reach a new equilibrium level with respects to flow/substrate-related processes (*i.e.*, sedimentation and turbidity). Introduced sportfish species (*e.g.*, smallmouth bass) would be expected to be affected to the greatest extent over native species. The current invertebrate diversity has already been reduced, when compared to pre-dam estimates. Any implementation of drawdown would accentuate this declining trend, resulting in very limited resources as prey items for both resident fish and rearing juvenile fall Chinook salmon.

Upstream collection could be relatively non-intrusive if designed properly, with consideration for resident fish behavior and distribution. High velocity alternatives, and those low velocity alternatives that involve a full blockage structure to the riverbed, would impede white sturgeon and other native species' seasonal migration patterns. Construction of such a facility could reduce the limited rearing habitat for threatened Snake River fall Chinook. Hence, geographical placement would be a critical element. Such a structure could also suggest more reliance on the transportation of smolts, because the structure could act to benefit the native Northern squawfish and smallmouth bass by creating additional low velocity areas for the capture of bypassed smolts.

Additional upstream storage would have no perceived negative environmental effects on the lower Snake River reservoir fauna. More localized environmental effects specific to the subbasin containing the new dam structures would be expected. Relatively short-term effects typically associated with new reservoir filling would be expected. Reduced dissolved oxygen and pollution compound resuspension at, or above, threshold levels could be expected to negatively impact the resident fish populations and water quality in the river below the newly constructed dam until the environmental effects of a reservoir aging could act in time to produce a new equilibrium level.

John Day operation at MOP would reduce spawning and rearing habitat used by resident fish species and Snake/Columbia River subyearling Chinook salmon, as well as their invertebrate prey. The operation would impact fish and wildlife habitat. Impacts to shallow water habitat for the 4-month operation would not appear to be mitigatable. Offsite mitigation would be required for wildlife impacts. The year-round option would be expected to provide partial onsite mitigation of the impacts. Other reservoir uses, groundwater levels and supplies, and cultural resources would also be impacted.

No impacts to other environmental resources were identified for the system improvement measures considered for the Lower Columbia projects.

The array of proposed system improvements would have environmental effects more specific to migrating juvenile and adult salmonids. Short-term effects to resident fish and downstream aquatic invertebrate fauna, resulting from increased turbidity and dissolved gas concentrations, would be expected during the actual construction activities for each specific improvement action. The number of improvements implemented sequentially would result in the cumulative degree of impact. Most resident fish would temporally redistribute outside the zone of influence, whereas the invertebrate abundance would likely decrease due to increased dislodging and drift associated with redistributed flow and elevated dissolved gas saturation levels if the modified operation caused increased spill rates.

Only the drawdown alternatives could impose additional negative effects on other threatened and endangered species known to exist in the mainstem lower Snake River. Surveys are continuing to assess the existence and distribution of listed mollusk species during MOP operations of the lower Snake River system. Comparisons will be made based upon this monitoring database for anticipated effects attributable to lowered reservoir elevations. This database would also be instrumental in locating any geographical placement of an upstream collector.

d. Cost-Effectiveness Analysis.

(1) Procedure.

A cost-effectiveness analysis was prepared to assist in determining which alternatives to carry into the SCS Phase II. The analysis compares the costs of proposed alternatives to expected environmental outputs (change in the survival of salmonids to below Bonneville Dam), to determine which alternatives provide the most environmental benefits for the least cost. This information, combined with other environmental, social, economic, engineering, and political information, will serve to guide the recommendation process.

As shown in figure 7-1, the cost -effectiveness analysis for Snake River projects was utilized only for alternatives that would: 1) be technically feasible; 2) contribute to satisfying the anadromous fish objective established for the SCS; 3) not have major conflicts between juvenile and adult objectives; and 4) not have significant other environmental impacts.

Evaluation of lower Snake River alternatives (*i.e.*, drawdown and upstream collection) additional storage alternatives, extended screens at the lower Snake River projects, John Day operation at MOP, transport at John Day, and turbine passage improvement used e4stimates of biological effectiveness modeled by CRiSP. The remaining system improvement alternatives were evaluated using a qualitative analysis of each measure, or a project-specific estimate of increases in juvenile survival.

The cost-effectiveness analysis relies on estimates of project costs and expected changes in salmon and steelhead survival, which contains a great deal of uncertainty. This is a reconnaissance-level study, and detailed cost and benefit estimates have not been prepared. The analysis of improvements to salmonid survival were made using a considerable number of assumptions. Users of the cost-effectiveness analysis must recognize that changes in assumptions used in the analysis could result in significant changes in the results. Therefore, findings presented here should be considered to be preliminary.

The cost-effectiveness analysis follows a simple principle: decision makers select actions that produce a desired result in a least-cost manner. Care must be undertaken to consistently define the economic costs, as well as to clearly define the desired output. The steps taken to do this are listed below. An appropriate biological objective must be defined to weight the alternative costs against. In the case of alternatives being investigated in the SCS, the biological goal is to improve the survival of juvenile salmon and steelhead to below Bonneville Dam.

The cost-effectiveness approach is accomplished by identifying a cost-effectiveness frontier by plotting the costs and level of biological effectiveness of each proposed alternative on a graph. Figure 7-2 shows a hypothetical example of this graph. The frontier defines the most cost-effective measures. Points on the frontier represent alternatives that: 1) are equally biologically effective, but cost the same or less than an alternative not on the frontier (compare points B and A in figure 7-2); or 2) are more biologically effective, but cost the same or less than alternatives not on the frontier (compare points D and C in figure 7-2).

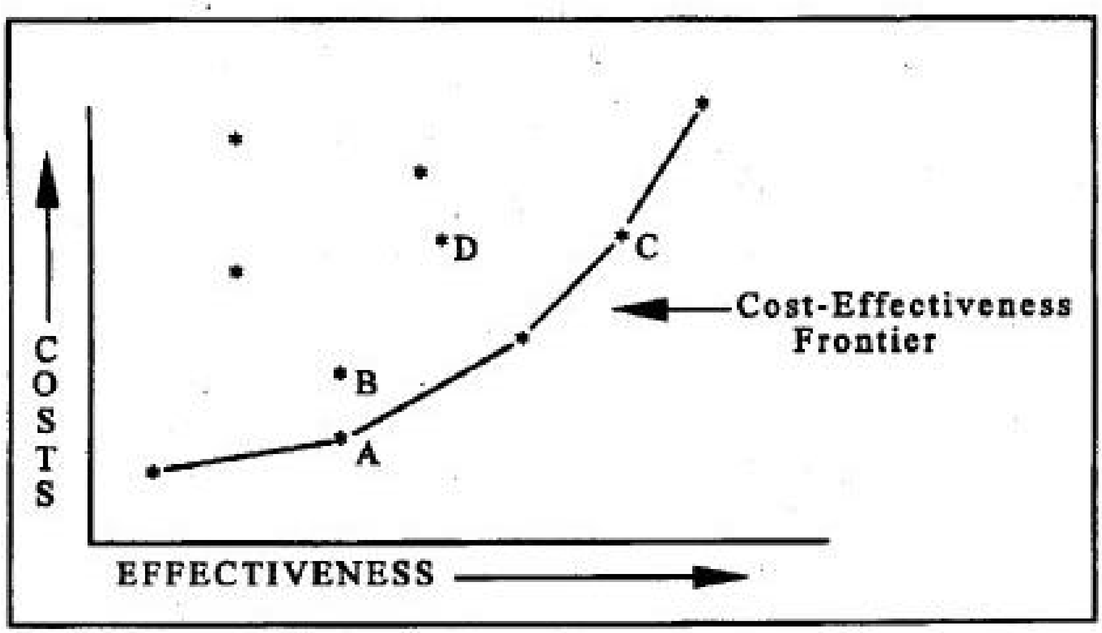

Figure 7-2. Cost-Effectiveness Frontier.
Each Point Represents a Hypothetical Snake River Recovery Measure

The cost-effectiveness approach discussed above implies a degree of certainty in the economic costs and biological effectiveness that simply does not exist at this time. Points in figure 7-2 would be better defined as boxes that reflect the uncertainty associated in both the economic costs and the biological effectiveness of the different alternatives. So, in determining which are the cost-effective measures for each species, care has been taken to identify those measures that could possibly be on the cost-effective frontier if either the costs or biological effectiveness were either somewhat higher or lower to account for the uncertainty of these estimates.

Several steps were undertaken to combine the cost information with the environmental output information. These steps are described in the following paragraphs.

- **Step 1:** Identify all costs for each alternative, including the construction costs; the interest incurred on the money through the construction period; the operation, maintenance, and replacement costs; and the opportunity costs lost or gained by implementing the alternative.

- **Step 2:** Convert costs to average annual amounts using an 8-percent interest rate and an amortization period of 100 years. Due to the unavailability of life-cycle estimates of changes in the number of adult salmon, costs were present-valued to account for differences in the implementation timing of the various alternatives.

- **Step 3:** Estimate fish survival changes with each plan. The biological-effectiveness results identify the expected change in juvenile salmon and steelhead survival from the base condition (defined as the current operation of the Columbia-Snake system). The biological effectiveness for alternatives evaluated with the CRiSP model were based on the percentage change in juvenile survival, to below Bonneville, of the stocks of fish that migrate at the respective projects. Other alternative were evaluated based on the relative juvenile survival changes at the specific project with the proposed measure.

The survival percentage changes are for the initial year of the alternative. The model assumes that percentage change for the first year remains constant for the entire period of analysis. The CRiSP model is not a life-cycle model, so the possible compounding of the number of returning fish that could occur over time are not included in these estimates. That is, the analysis does not account for the fact that if a 10-percent increase in juvenile survival occurs with a plan each year, an increasing percentage from the base condition will occur up to a point in which the carrying capacities of streams or hatcheries are reached. This point-in-time survival may understate the biological impacts of an alternative, but the understatement is applied to all alternatives.

- **Step 4:** Compare cost with the relative change in fish survival for each alternative by species.

- **Step 5:** Determine which alternatives are most cost effective, by species.

(2) Results of the Cost-Effectiveness Analysis.

Figure 7-3 provides an example of the designation of the cost-effectiveness frontier for the Snake River alternatives for the Snake River spring Chinook species. A similar analysis was done for summer and fall Chinook, and steelhead. The results are not shown in this report, but they are similar to the analysis for spring Chinook.

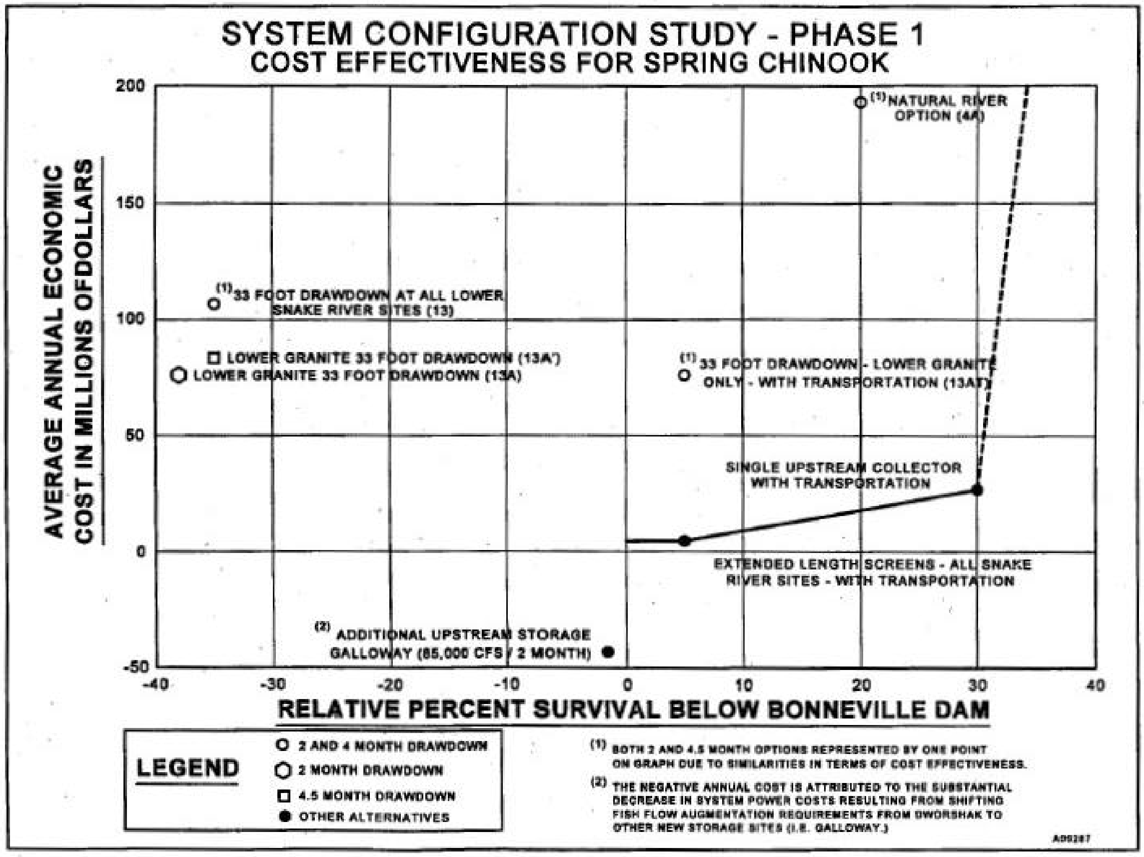

Figure 7-3. Cost Effectiveness for Spring Chinook

Tables 7-1 and 7-2 show the classification of alternatives in terms of cost effectiveness. The alternatives designated as cost effective provide a level of biological output at the lowest cost for the particular species. The alternatives re not classed as cost effective either had negative survival percentages, or were clearly more costly or less biologically effective than other alternatives. To define the cost-effective measures, this analysis recognized that a great deal of uncertainty surrounds both the cost estimates and the biological model results. In consideration of this uncertainty, some alternatives were classed as possibly cost effective because they may be cost effective within the range of possible project costs and biological effectiveness. For example, on figure 7-3, if survival estimates for the natural river drawdown were higher than 30 percent, this option would lie on the cost-effectiveness frontier. It was judged that, given the uncertainty surrounding the survival estimate, this option should be classified as possibly cost effective.

Table 7-1. Summary of Comparison of Alternatives													
		Biological Effectiveness					Cost Effectiveness 1/				2/	3/	4/
Measure	Technically Feasible	Spring Chinook	Summer Chinook	Fall Chinook	Steelhead	Other Environ. Effects	Spring Chinook	Summer Chinook	Fall Chinook	Steelhead	Regionally Acceptable	Project Cost ($ Million)	Annual Cost ($ Million)
LOWER SNAKE RIVER DRAWDOWN													
Natural River Option	Yes	●	●	●	●	Yes	◒	◒	○	○		3,200	950
Variable Pools	Yes	○	○	○	○	Yes	○	○	○	○		1,200	360
33-Foot Constant Pool	Yes	○	○	○	○	Yes	○	○	○	○		1,200	360
33-Ft. Lower Granite Only	Yes	●	●	●	●	Yes	○	○	○	○			150
43-Foot Constant Pool	Yes	○	○	○	○	Yes	○	○	○	○		2,000	---
52-Foot Constant Pool	Yes	○	○	○	○	Yes	○	○	○	○		2,500	---
ADDITIONAL STORAGE													
Galloway	Yes	◒	◒	◒	◒	Maybe	○	○	○	○		200	20.5
Galloway/Rosevear/ Jacobson Gulch	Yes	◒	◒	◒	◒	Maybe	○	○	○	○		1,600	207
COLLECTION AND CONVEYANCE	Yes	●	●	◒	◒	No	●	●	●	●		260-360	34-45
EXISTING SYSTEM IMPROVEMENTS--LOWER SNAKE RIVER AND MCNARY DAM													
Dispersed Releases	Yes	◒	◒	◒	◒	No						10	2.2
Extended-Length Screens	Yes	◒	◒	●	◒	No	●	●	●	○		48	4.6
L Granite Juv Facil. Mods	Yes	●	●	●	●	No						20	1.9
Aux Water Intake - McNary	Yes	◒	◒	●	●	No						24	2.3
Surface-Oriented Collector	Yes	●	●	●	●	No						100	10.0
Net Pens	Yes	○	○	○	○	No						21	6.8
Barge Temperature Control	Yes	○	○	○	○	No						48	7.1
Barge Exits	Yes	●	●	●	●	No						1.5	0.1
New Barges	Yes	◒	◒	●	●	No						45	4.7
Ladder Temp Control	Yes	◒	●	●	●	No						12	1.2
Additional Adult Ladders	Yes	●	●	●	●	Maybe						150	13.7
Ladder Attraction Water	Yes	◒	◒	●	◒	No						20	1.7
Adult Ladder Exits	Yes	◒	◒	◒	◒	No						0.9	0.1
Collection Channel Mods	Yes	○	○	○	○	No						0.4	0.1
Adult Channel Extensions	Maybe	◒	◒	◒	◒	No						52	4.6
Truck Loading at Hatchery	Yes	◒	◒	◒	◒	No						0.4	0.1
Add Raceways - Hatchery	Yes	○	○	○	○	No						17	1.8
Stilling Basin Mods	Yes	●	◒	◒	◒	Maybe						137	12.4

● Effective ◒ Maybe Effective ○ Not Effective

1/ Survival modeling not done for alternatives with blank cells.
2/ Regional acceptability to be determined through the draft report regional review.
3/ Costs are based on October 1992 price levels, and do not include inflation.
4/ Annual costs include economic impacts.

Table 7-2. Summary of Comparison of Alternatives--Lower Columbia													
		Biological Effectiveness					Cost Effectiveness				1/	2/	3/
Measure	Technically Feasible	Spring Chinook	Summer Chinook	Fall Chinook	Steelhead	Other Environ. Effects	Spring Chinook	Summer Chinook	Fall Chinook	Steelhead	Regionally Acceptable	Project Cost ($ Million)	Annual Cost ($ Million)
John Dat MOP	Yes	○	○	◒	◒	Yes	○	○	○	●		65.0	10.6
John Day Transport	Yes	○	◒	●	○	No	○	●	●	○		37.5	3.7
Turbine Improvements	Yes	◒	◒	●	◒	No	●	●	●	◒		289.1	35.3
		Biological Effectiveness					Cost Effectiveness				1/	2/	3/
Measure	Technically Feasible	Yearling Chinook	Subyearling Chinook	Steelhead	Coho	Other Environ. Effects	Yearling Chinook	Subyearling Chinook	Steelhead	Coho	Regionally Acceptable	Project Cost ($ Million)	Annual Cost ($ Million)
John Day Extended Screens	Yes	◒	◒	◒	n/a	No	●	◒	◒	n/a		60.7	3.3
John Day Spill/Flip-Lips	Yes	◒	◒	◒	n/a	No	◒	◒	◒	n/a		22.5	1.9
Bonneville 1st PH FGE	Yes	○	○	○	○	No	○	○	○	○		29.9	4.4
Bonneville 1st & 2d PH DSM	Yes	◒	◒	◒	◒	No	●	●	●	●		9.1	0.8
Bonneville Outfalls	Yes	◒	◒	◒	◒	No	◒	●	●	●		49.4	4.5
Bonneville Short-Haul	Yes	●	●	●	●	No	●	●	●	●		49.3	4.7
Combination A 4/	Yes	◒	◒	◒	◒	No	◒	○	◒	○		88.4	9.7
Combination B 5/	Yes	●	●	●	●	No	●	●	●	●		88.3	9.9

● Effective ◒ Maybe Effective ○ Not Effective

1/ Regional acceptability to be determined through the draft report regional review.
2/ Costs are based on October 1992 price levels, and do not include inflation.
3/ Annual costs include economic impacts.
4/ Combination A = Bonneville FGE, DSM, Outfalls.
5/ Combination B = Bonneville FGE, DSM, Short-Haul Barging.

e. Regional Acceptability.

Information received during the 45-day regional review of the draft Phase I report will be used to determine regional acceptability for the SCS alternatives.

7.04. Summary of Comparisons.

a. General.

Based on the performance against the five established criteria, a summary of the preliminary observations or findings from the comparison of the alternatives are presented below. Tables 7-1 and 7-2 show a consumer report type of summary of the Phase I alternatives. In this table, the biological and cost effectiveness are shown in terms of effective, possibly effective, and not effective. This general type of evaluation was identified because of the significant amount of uncertainty associated with the evaluations, particularly with respect to the biological effectiveness of the anadromous fish benefits. However, this type of comparison is considered to be sufficient for reconnaissance evaluations with the objective of identifying alternatives that may have promise and warrant further, more detailed, study.

7.05. Preliminary Conclusions.

a. Overview.

The information in this section identifies preliminary conclusions concerning the alternatives evaluated in Phase I. Due to the level of regional interest, biological uncertainty, and the critical nature of the problem, no recommendations are identified in this draft report. It is very important that the NPPC, agencies, Tribes, other interest groups, and the public have the opportunity to comment on the tentative Phase I findings prior to developing final recommendations. This opportunity to comment will occur during the regional review of the draft report. The public input will help shape recommendations, which will be included in the final Phase I report, and reflected in the Phase II Plan of Study.

The function of the Phase I study was to screen out alternatives that showed little or no potential to improve salmon migration conditions or are not cost effective, and identify alternatives that showed some promise in this regard. Due to the regional controversy and uncertainty over the flow survival relationship, juvenile fish transportation program, estuary uncertainties, salmon survival simulation model limitations, and other areas, it is important that both in-river migration and transportation alternatives be further evaluated in Phase II.

These preliminary conclusions are drawn with full recognition that a high degree of uncertainty concerning the salmon life-cycle biology exists, and there is controversy surrounding the relative merits of transport compared to in-river migration. Knowledge of biological parameters in the estuary portion of the juvenile migration is severely lacking, and could be of significance in evaluating various recovery alternatives. Efforts are underway to identify potential tests and research to reduce these levels of uncertainty. A few examples of research, funded by the Corps, include:

1) NMFS reach survival study (Lower Granite reservoir juvenile salmon survival and travel time, turbine passage mortality, *etc.*); and 2) evaluation of alternative barge release sites and strategies below Bonneville Dam, by Oregon State University and the University of Idaho. In addition, BPA and other public/private utilities continue to coordinate and fund extensive passage improvement research efforts in the Snake and Columbia Rivers. Whatever course of action is pursued further, it should be done in an adoptive management approach, with the flexibility to be modified, should results from current or future efforts yield information that would lead to conclusions different from those resulting from the Phase I study.

b. Preliminary Conclusions.

(1) Lower Snake River Drawdown.

Only the Natural River drawdown option warrants further analysis in Phase II. This determination is based on the fact that this option was the only four-reservoir drawdown alternative to identify any anadromous fish benefits.

Two mathematical models (PAM and CRiSP) were used to attempt to quantify the potential relative juvenile salmon benefits of reservoir drawdown alternatives. Based on these models, the natural river option was the only four-reservoir drawdown alternative to show a consistent potential benefit for anadromous fish, although the benefits were limited to spring and summer Chinook, and no potential benefits were identified for fall Chinook or steelhead. The other four-reservoir drawdown alternatives, which are considered to be near spillway crest, showed negative impacts to all juvenile stocks investigated. Other qualitative evaluation supported this determination. The models were run with a range of assumptions as a sensitivity analysis, which verified the results.

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 marginal 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. Although this alternative includes drawdown, it is more closely associated with the upstream collection and conveyance alternative.

The relationship used with the existing mathematical models assumes that increasing flows and velocities directly reduces juvenile fish travel time, thereby reducing their reservoir-related mortality and increasing survival. This increase in reservoir survival for the near spillway crest alternative is not enough to overcome other factors reducing survival through the lower Snake (*i.e.*, increased mortality from turbines, spill, and bypass operations). In addition, the fish are then subjected to reservoir and dam mortality through the four dams and reservoirs on the lower Columbia River. Unless actions are taken on the lower Columbia River to significantly reduce reservoir and/or dam-related mortality, the near spillway crest drawdowns on the lower Snake River do not appear to be an effective action to improve system-wide migration conditions for juvenile salmon. The natural river option eliminates the effects of the four lower snake dams, which is enough to potentially offset the increased mortality through the lower Columbia river.

The natural river option was on eof the most expensive alternatives evaluated, and implementation timeframes are long. The estimated construction cost is $4.9 billion (including inflation). The time required to implement this alternative is 17 years, starting from the date authorization is enacted and construction funds are appropriated, to the completion of the construction.

(2) John Day Operation at Elevation 257.

The Corps as initiated, and is continuing, Advanced Planning and Design (AP&D) concurrent with the Phase I SCS study in response to regional (NPPC) and legislative direction. The scope of work includes studies to further evaluate and quantify environmental and user impacts, address mitigation alternatives, develop mitigation plans, and design mitigation measures for the impacted users in anticipation of a decision to implement. The scope also includes biological studies intended to address some of the uncertainties with regard to the biological effects of the proposal and, with completion of a smolt monitoring facility at the project, to obtain baseline flow/survival data prior to potential implementation. The projected date to complete a draft decision document and EIS is 1996. With a positive decision to implement, MOP operation could begin in 1999.

The results of the Phase I study provide little information to reduce uncertainties surrounding the biological effectiveness of the proposed operation. This uncertainty results from general flow/survival issues, as well as the relatively small physical change in pool levels and water travel time that would be achieved by the operation. Uncertainties aside, the operation of John Day at MOP may not provide a sufficient benefit to justify the costs and impacts that have been preliminarily identified. There appear to be two courses of action that may be pursued beyond Phase I for this alternative: 1) continue the AP&D process now underway; or 2) discontinue study of John Day operation at MOP as an alternative. The following paragraphs discuss the premises and options for selection of one of these courses of action.

(a) Continue AP&D.

Under this course of action, biological, environmental, and design studies would continue as described. The prospect of a future negative decision risks sunk engineering and design efforts and costs. Pursuing this alternative would be considered optimistic with regard to the biological effectiveness of the proposed operation relative to costs and impacts. There is a high probability that uncertainties with regard to the biological effectiveness of the alternative may not all be resolved.

This is the course of action for which the Corps has received funding, and which the Corps is currently pursing. The current working estimate for AP&D is about $12 million. Approximately $8 million would be expended prior to a final decision in 1996 under the current schedule. Continuation on this course of action is contingent on regional comment and decisions resulting from the review of this Phase I report.

An option under this course of action would be to proceed to design and construct modifications to implement the drawdown operation without further biological studies. This option is most optimistic; and presumes uncertainties are insignificant, there is little risk, and the proposed operation is biologically effective. Under this option, the study of habitat and other user impacts would be continued toward preparation of an EIS and mitigation plans. The implementation schedule would be approximately the same (*i.e.*, 1999 operation at MOP).

(b) Discontinue Study.

Further evaluation of John Day operation at MOP would be discontinued in this course of action. It presumes that the information to date suggests that the biological effects are, or would likely be shown to be negligible, adverse, or not sufficient to justify incurring the impacts and mitigation costs of implementation. The alternative could be resurrected if new information derived from flow/survival studies, including potential survival studies at John Day upon installation of smolt monitoring facilities, gave cause to reconsider the conclusion.

An option under this course of action would be to continue research studies to evaluate the potential biological effects. Again, uncertainties may not be resolved. Studies of impacts, and design and construction of mitigation measures, could be resumed at some future time if warranted by the research. A delay of at least 2 years in implementation, beyond the current AP&D schedule, would result.

(3) Additional Upstream Storage - Snake River Basin.

The development of additional water storage sites within the Snake River Basin warrants further evaluation in SCS Phase II. This conclusion is based on the potential of these sites as effective and economical means of augmenting streamflows in the lower Snake River. Although additional augmentation storage showed no measurable quantifiable biological benefit in terms of improving salmon survival (as determined using CRiSP), the Phase I analysis may not indicate the true potential of this alternative. The Phase I quantitative evaluation was based on monthly hydroregulation models (HYSSR), rigid flow targets, and lengthy augmentation release periods, which together could understate the benefits to fish migration.

The biological uncertainty inherent in the flow survival relationships used in modeling efforts, as well as other areas of biological uncertainty surrounding the adult and juvenile life cycle, make it extremely difficult to draw definitive conclusions with respect to the biological efficacy of upstream storage for flow augmentation. Additionally, successive years of consultation with NMFS concerning system operation under ESA have continued to result in increasing requirements for flow augmentation. These requirements are driven by the NMFS assessment that incremental flow increases are needed and effective as salmon recovery techniques. The need to provide these flows is stressing the use of Dworshak reservoir storage, and leading to increased demand on upper Snake River storage. Therefore, further consideration of a means to reduce the impact of the water demands on the Columbia River system, particularly existing storage in Idaho, may be prudent.

If public review and regional comment provide compelling support for this approach, there appears to be potential for additional storage to yield benefits in the following areas: 1) benefits to juvenile migration above Lower Granite Reservoir for both spring and fall Chinook; 2) use of additional upstream storage primarily for spring Chinook flow augmentation thus saving Dworshak storage for fall Chinook temperature control and flow augmentation; 3) pulsing reservoir flow releases (during peak migration periods); 4) flow augmentation during critical (low) water years; 5) flow augmentation in combination with upstream collector(s) and barge transport; and 6) flood control storage transfers from Brownlee Reservoir to new storage sites to create additional flow releases from Brownlee. If this alternative is evaluated further, it would be wise to expand the evaluation to examine reallocation of existing storage to fish flow augmentation purposes.

(4) Upstream Collector and Conveyance.

The option of an upstream collector and barge transportation warrants further study in Phase II based on potential anadromous fish survival benefits, cost effectiveness, and NMFS Recovery Team draft findings. The estimated biological benefits associated with the collector, coupled with barge transportation, appear to be the highest of all the alternatives being evaluated. This survival estimate is generally consistent with the analysis prepared by the NMFS Recovery Team (October 1993). The other biological effects (resident fish and wildlife impacts) do not appear to be significant with this alternative. Further study could be pursued in Phase II, provided regional review and comment indicates support for more detailed evaluation.

The option of Lower Granite drawdown with barge transportation was compared to other upstream collector and barge transport options. It would appear that, based on cost effectiveness, further study of this option is not justified. The upstream collector options had much higher juvenile salmon survival rates and lower implementation costs.

The migratory canal and pipeline proposals should be eliminated from further consideration due to biological concerns and uncertainties.

(5) System Improvements--Lower Columbia River.

Qualitative considerations and the preliminary quantitative analysis suggests that there is sufficient justification to continue study of these measures. The FGE improvements at Bonneville first powerhouse warrant further consideration, but only in conjunction with other bypass improvements. The process for moving forward can vary depending on the measure. In general, a separate process for the lower Columbia projects would appear to be the most effective method to move forward beyond the SCS Phase I. This is a preliminary conclusion, subject to regional input, which would allow proceeding in a more timely manner with studies and implementation of feasible measures to improve the passage survival for mid and lower Columbia River stocks. This course of action recognizes the long-term nature of implementation of major modifications on the Snake River. It also recognizes that measures implemented for Columbia stocks would similarly benefit listed Snake River stocks if future decisions led to in-river migration for these stocks.

The John Day extended screens and spill patterns, and the Bonneville DSM and outfall measures, could move forward into design studies as the technology is known and the engineering and biological feasibility would not be in question. There could be a question of alternative technology with regard to extended screens, which should be addressed. The addition of flip-lips at John Day could be evaluated in conjunction with the testing required for spill patterns, and in consideration of the extended-screen measure. The Bonneville outfalls measure would require a research program to optimize the location for placement of the outfalls in conjunction with the design studies. A minimum 2-year research program is anticipated. Testing of alternative outfall strategies (short-haul barging) could also be conducted in association with this research.

The Bonneville first powerhouse FGE measure could be carried forward as a feasibility study. It is believed that there may be advantages to considering the feasibility of alternative bypass technologies in conjunction with studies to modify the existing first powerhouse fish guidance system.

The transport measures (John Day transport and short-haul barging) would require research to ascertain and demonstrate the biological feasibility and determine regional support.

Turbine improvements is a research program that would include laboratory studies, numerical analysis, turbine design, and prototype testing. The purpose would be to study the various casual agents of juvenile fish injury and mortality through turbines, as well as to determine the feasibility of designing modifications or new turbine designs to reduce these effects. The outcome could lead to replacement of all or some of the turbines, either through a specific turbine replacement program to improve turbine passage survival or through incorporation of new designs into future powerhouse rehabilitation programs.

Section 8 - Authorization and Funding Considerations

8.01. Overview.

The SCS is considering numerous alternatives to modify the Snake and Columbia River system in an effort to improve survival of anadromous fish migration. Some of these alternatives may significantly change the operation of the lower Columbia and Snake River projects. The purpose of this section is to identify potential authorization and funding scenarios that could be used to implement SCS alternatives.

Since implementation of many of the SCS alternatives wold constitute significant Federal actions and since threatened and endangered stocks of salmon are involved, it is important to be aware that such implementation must comply with applicable requirements of the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), and other laws. This is true no matter what authority is pursued to implement and fund one or more of the SCS alternatives.

8.02. Authorized and Operating Purposes.

The purposes that a reservoir will serve are set forth in laws that may be grouped into three categories: 1) laws initially authorizing construction of the project; 2) laws specific to the project passed subsequent to construction; and 3) laws that apply generally to all Corps reservoirs. In the latter category, the following laws have the greatest relevance to Corps reservoirs:

- PL 78-534, Flood Control Act of 1944 (add recreation as a purpose and contract for use of surplus water for domestic purposes).
- PL 85-500, Title III, Water Supply Act of 1958 (includes storage for municipal and industrial water supply).
- PL 85-624, Fish and Wildlife Coordination Act of 1958 (modify projects to conserve fish and wildlife).
- PL 92-500, Federal Water Pollution Control Act Amendments of 1972 (establishes goal to restore and maintain the quality of the Nation's waters).
- PL 93-205, Endangered Species Act of 1973 (ensure that actions do not jeopardize listed species and use existing authorities to protect listed species).

In general, project authorizations (categories 1 and 2 above) are found in a variety of public laws, but are most commonly found in a series of Rivers and Harbors and Flood Control acts passed by Congress since 1870. Recent project authorizations have been contained in a series of Water Resources Development Acts. The purposes of a reservoir are generally described in the authorizing law but, specific project purposes and operational criteria are contained in reports of the Secretary of the Army, Chief of Engineers, Board of Engineers for Rivers and Harbors, or other similar reports which are typically referenced in the authorization language. Purposes may be added or deleted by laws passed subsequent to project construction.

8.03. Implementation Authority.

a. General.

Authority for the Corps to construct a project comes from Congress in the form of legislation signed into law by the President. In some cases, existing project authorities can be used; in other cases, continuing authorities may be used; and, in others, new authority must be obtained. Each of these authority mechanisms is discussed below.

b. Continuing Authorities.

For some limited project purposes, previous legislation has given the Corps authority to study and construct projects without going back each time to Congress for project-specific legislation. These authorities are generally termed "Continuing Authorities," and they have provided delegated authority to the Chief of Engineers, through the Assistant Secretary of the Army for Civil Works (ASA-CW), to study and construct single purpose projects within certain Federal cost limits. None of the work envisioned by the SCS would fall into the Federal cost limits associated with the Continuing Authority programs.

c. Existing Authorities.

It is possible that the SCS alternatives that primarily involve only a change in the operation of the projects may be implemented with the Corps existing authorities to operate and maintain those projects to meet the authorized purposes.

(1) Project Construction and Operation.

There are several specifically recognized ways in which projects constructed and operated and maintained by the Corps may be modified within existing authorities: 1) Dam safety assurance; 2) changes in water control plans; 3) addition of water supply; 4) changes to meet water quality needs; and 5) recreation and fish and wildlife enhancement.

Several SCS alternatives would require changes to project Water Control Plans, due to changes in project operation, with respect to existing authority. Existing authorities implies authorities for the allocation and regulation of reservoir storage in projects operated by the Corps are in the acts authorizing the projects. Proposed changes in water control plans must be carefully reviewed to determine the extent of change which may be undertaken consistent with the authorizing legislation. With some specific exceptions, revised plans for purposes not encompassed by the existing project authority require new Congressional authorization.

(2) Section 1135--Environmental Restoration On An Existing Project.

Section 1135 of the Water Resources Development Act of 1986 cites a funding limitation of $25,000,000 to carry out a project modification to improve the environment. The law also states that "no modification shall be carried out under this section without specific authorization by Congress if the estimated cost exceeds $5,000,000."

The intent of the program is to restore fish and wildlife habitat resources to modern historic condition. The area being restored may not have been impacted by a Corps project, but modification of a project can be implemented under this authority to provide improvement to this resource. Environmental restoration is considered to be different from mitigation. In some project cases, mitigation may have not been required or may have been fully completed and impacts still remained. Environmental restoration as been identified by the Corps as a high priority project purpose, equivalent to other traditional purposes such as flood control and navigation.

There are cost sharing requirements associated with section 1135 projects. The Federal government pays 75 percent of the construction-related costs, and the local sponsor pays the remaining 25 percent.

d. New Authority.

New authority can be either specific or general. Specific authority applies to a specific study, a specific project to be constructed, or modification of a completed project, and is most often through an appropriations act. General authority is most often programmatic in nature, setting principals for water resource management or policy. In recent years, major water resources development legislation has been passed by Congress every 2 years. These Acts are called Water Resource Development Acts (WRDA) or omnibus bills.

Project authorization for implementing SCS alternative(s) could be obtained by inclusion in a Water Resource Development Act (WRDA). This is accomplished through submittal to Congress in a Decision Document (Feasibility Report) for approval and inclusion in the next WRDA for authorization. These acts typically are prepared on 2-year cycles. However, congress could choose to include authorization of elements of the SCS in other forms of legislation.

8.04. Funding Options.

a. Overview.

Funding of elements of the SCS raises two general sources of funding: 1) Federal funding, either through specific appropriations by Congress for elements of the SCS or through O&M program appropriations; or 2) direct regional funding, either from BPA or other public or private entities.

b. Federal Funding.

Construction of new projects and the modification of existing projects using Federal funds requires an appropriation of funds from Congress. These funds are provided through appropriations. In addition, appropriations can also be used for the authorization of implementation of new projects and the modification of existing projects. This mechanism is the typical means by which Corps projects are funded.

Currently, the SCS is funded through the annual Appropriations Act under the CRJFMP. Expenditures are allocated to the project purposes, and those expenditures allocated to power (in excess of 85 percent of all expenditures) are billed to BPA and repaid to the Federal treasury by BPA power customers. Congress could appropriate funds for the implementation of elements of the SCS as part of the CRJFMP annual budget, as part of the annual O&M budget, or separately. This could be accomplished without sacrificing appropriate regional and public policy review.

Although O&M program appropriations could be used to implement SCS alternatives involving relatively minor project modifications, use of O&M funds is highly unlikely for a number of reasons. First, in general, the O&M program is developed in recognition of the need to preserve the existing infrastructure. Second, the operations portion of the program is constrained to maximize the proportion of available resources that can be devoted to generate savings that can be applied toward reducing the inventory of unaccomplished maintenance. Third, the goal of the maintenance portion is to place greater emphasis on sustaining the existing infrastructure. Finally, the level of O&M funding has typically been held at a relatively consistent level by Congress. Therefore, using O&M funds for the implementation of SCS alternatives could reduce funds available for O&M activities elsewhere in the nation.

c. Regional Funding.

As stated above, public and/or private entities could provide funds to the Corps for implementation of elements of the SCS.

d. Bonneville Power Administration.

Under provisions of the Northwest Power Planning and Conservation Act (PL 96-501), BPA is authorized and directed to "...use the Bonneville Power Administration fund...to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project of the Columbia River..." In addition, under provisions of the Water Resources Development Act of 1986

(PL 99-662), the Corps is authorized "...to accept funds from any entity, public or private, in accordance with the Pacific Northwest Electric Power Planning and Conservation Act to be used to protect, mitigate, and enhance fish and wildlife in connection with projects constructed or operated by the Secretary [of the Army]."

The Corps has reviewed the provisions of these two Public Laws and has concluded that BPA can provide funds to the Corps and that the Corps can accept funds from BPA to implement elements of the Power Council's fish and wildlife program, so long as the elements are authorized by Congress. Accordingly, to expedite implementation of SCS alternatives, BPA could provide funds directly to the Corps, on a case-by-case basis.

e. Other Public or Private Entities.

As discussed above, the Corps is authorized by PL 99-662 to accept funds from any entity for the purpose of mitigating fish and wildlife resources impacts of Federal water resources projects constructed and operated by the Corps. However, the mitigation measures must be in accordance with the Pacific Northwest Power Planning and Conservation Act, and they must be authorized by Congress. On this basis, other regional sources of funding could be used to expedite implementation of SCS alternatives. Potential sources could include issuance of bonds by one or more of the PNW states. In addition, other public or private funds could be used, but at this time there are no identifiable sources of such funds.

f. Cost Allocation.

Regardless of the funding source for fish and wildlife-related mitigation costs, if the Corps implements an SCS measure on a permanent basis, a new cost allocation may be required to determine if the change in operation and associated benefits to authorized purposes would require a change in the current cost allocation. This could change costs allocated to the existing authorized project purposes and, therefore, to some sponsoring entity or group of cost-sharing entities.

Currently, BPA reimburses the U.S. Treasury for all costs allocated to power on the Columbia and Snake River projects. Anadromous fish facilities at the lower Snake and Columbia River projects are classified as "joint" facilities, and are allocated to hydropower at specific rates for each project, based on the Final Cost Allocations for each project. For example, for joint facilities at John Day, 77.5 percent of the costs are allocated to hydropower and repaid to the U.S. Treasury by BPA. Joint facilities at Lower Granite are allocated 98.4 percent to hydropower.

The objective of the cost allocation is to divide the project costs among the purposes served so that all purposes share equitably in the savings realized from the multi-purpose construction. Project purposes to which costs are allocated are established in authorizing legislation.

8.05. Summary.

Table 8-1 summarizes potential authorities under which the specific SCS alternatives could be implemented and sources of construction funding. As previously discussed, alternatives which involve significant new construction would require specific authorization by Congress. However, once they are authorized, funding could come from Congress or regional funds could be used. During Phase II studies, these options will be studied further.

Table 8-1
Implementation Authority and Construction Funding Options

Alternative	Implementation Authority				Construction Funding	
	Existing Authority	Water Resource Develop Act	Other Leg	Approp Bill	BPA	Other Public Or Private
Lower Snake River Drawdown		X	X	X	X	
John Day at MOP						
Operation	X			X	X	X
Mitigation	X[1]	X[1]	X[1]	X	X	X
Additional Upstream Storage		X	X	X	X	
Collection and Conveyance		X	X	X	X	
System Improvements	X			X	X	X

[1]Subject to case-by-case evaluations.
X = Potential option.

Section 9 - SCS Phase II Plan of Study

9.01. Summary.

a. Overview.

Recommendations as to which alternatives warrant further study in Phase II will not be made until regional input has been received on the draft report. To develop this plan of study (POS), alternatives were chosen that looked as though they warranted further consideration. This POS describes and presents a framework (limited detail) for the various Phase II study tasks, costs, and schedules. A detailed POS will be developed at the end of Phase I which will incorporate regional input received during the draft review process. Based on this review, alternatives could be removed or added to this POS.

The SCS is an element of the CRSMA. The SCS will assess various possible alternatives to the Snake and Columbia River system in an effort to improve the survival of anadromous fish migration. This study is being conducted in two phases. During the first phase, a reconnaissance-level assessment of alternatives was conducted. During this second phase, detailed studies will be conducted for those alternatives that displayed the highest potential of implementation.

b. Authority and Purpose.

The SCS Phase II would be conducted under the same authority as Phase I (see section 1.02). The Phase II purposes and process is discussed in sections 1.03 and 1.06, respectively.

c. Technical Scope.

(1) Study Area.

The SCS will address proposed modifications to Federal facilities on the lower Snake and lower Columbia Rivers. This area extends from the upper end of the Lower Granite reservoir (above Lewiston, Idaho, and Clarkston, Washington) to the estuary below Bonneville Dam (near Portland, Oregon). Sites in the Snake River Basin above Lewiston and Clarkston will be evaluated for potential flow augmentation storage (reservoirs) and juvenile salmon collection.

(2) Level of Detail.

The level of detail will be feasibility-level, unless otherwise noted.

(3) **Types of Studies.**

The Phase II study addresses engineering aspects; particularly design and cost estimates; for constructing the various alternatives and for their continued operation. Analyses of the impacts to fisheries (anadromous and resident), other aquatic and terrestrial resources and habitats; impacts on cultural resources; potential mitigation measures; impacts on hydropower generation; reservoir operation/regulation; and economic costs and benefits will be included. Economic information will be presented to assess the costs and benefits of implementing the alternatives, as well as for a comparison of alternatives. Alternatives to be analyzed include those recommended in the Phase I report for further study. Recommendations made in Phase I were developed with full recognition that a high degree of uncertainty concerning the salmon life-cycle biology exists, and that there is controversy surrounding the relative merits of transport when compared to in-river migration. Knowledge of biological parameters in the estuary portion of the juvenile migration is severely lacking, and could be of significance in evaluating various recovery alternatives. Efforts are continuing to identify and formulate tests and research to reduce these levels of uncertainty. Should the results of these efforts, or any current efforts, yield information that would lead to conclusions different from those drawn here, the Phase II work can be modified to respond in an adaptive management approach.

9.02. A Description of Alternatives.

a. General.

Alternatives in this Phase II feasibility-level study are based on alternatives recommended for further study in the Phase I report. The analyses in Phase II will also evaluate combinations of the following alternatives, recognizing that some alternatives may compliment others, while some may conflict.

b. Lower Snake River Drawdown.

Various proposals have suggested changing the current operation of the lower Snake River projects. These operational changes would focus on decreasing the average water particle travel time through the reservoirs created by the four lower Snake River dams. 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. The proposed operation would occur during the annual juvenile migration period and would replace the existing transportation program, since navigation would not be possible with lowered reservoir water surface elevations. The existing transportation program is aimed at decreasing juvenile migration time and eliminating passage mortality at downstream projects.

The following assumptions are made in this study: 1) all four lower Snake River reservoirs will be operated each year in a drawdown condition during a part of the juvenile fish outmigration period (15 April through 15 June), or the total juvenile fish outmigration period (15 April through 31 August); and 2) following the lowered pool level operation, the reservoirs will be returned to normal operating pool levels. Annual drawdown and other operational constraints will be examined (*i.e.*, early refill, different peak flow design levels, conditions when drawdown would not occur, drawdown duration, timing, *etc.*). Each operational alternative will have associated costs, benefits, and impacts on existing reservoir purposes and uses.

Phase I studies identified two drawdown options for further analysis in Phase II. These two options, the Natural River Option and Lower Granite Drawdown With Barge Transportation, were the only ones to identify any anadromous fish benefit.

c. Additional Upstream Storage in the Snake River Basin.

Potential new upstream storage is addressed in section 3.6, paragraph B, page 33, of NPPC's *Strategy for Salmon - Volume II*, dated December 11, 1991. This alternative will examine the possibility of providing additional upstream storage for flow improvements during anadromous fish migration periods. The study will utilize existing information on previously proposed storage sites. Information on site locations, storage, possible flows, types of structures, preliminary design and costs, and estimated implementation schedules will be presented. In addition, the estimated biological benefits to juvenile fish passage will be provided.

Phase I studies recommended the Galloway site on the Weiser River (upstream of Weiser, Idaho) for further detailed studies. The State of Idaho has also indicated strong interest in development of this particular dam and reservoir.

Offstream storage sites identified by the BOR investigation, and recommended for further study, will be included in the Phase II study.

d. Upstream Collection and Conveyance.

The upstream collection and conveyance of downstream migrating salmon and steelhead is addressed in section 3.9, page 40, of NPPC's *Strategy for Salmon.* Several options for collecting and transporting downstream migrants were examined in the Phase I studies.

Phase II studies will investigate collection methods for a collection facility to be located on the Lower Granite reservoir that would utilize the existing barge transportation system.

e. Existing System Improvements.

This element of the study will define and evaluate potential improvements to the existing systems (both adult and juvenile) that may enhance fish survival. It will be limited to those measures not currently scheduled for implementation. Potential juvenile facility improvements are identified in NPPC's *Strategy for Salmon*, as well as by the Corps.

Existing system improvements recommended for further detailed study will be determined following completion of the Phase I biological effects analysis.

9.03. Coordination.

The formal exchange of information and views among the Corps and other agencies will be performed as required by, and in accordance with, the purposes and procedures established by Federal policy.

a. Columbia-Snake River Drawdown Committee.

The Columbia-Snake River Drawdown Committee serves in an advisory capacity to NPPC, and is chaired by a member of NPPC. Its members include a representative from each of the following: the Corps, BPA, BOR, the States of Idaho, Montana, Oregon, and Washington, the Columbia River Inter-Tribal Fish Commission, and the Shoshone-Bannock Tribe. Originally, this committee was responsible for monitoring and overseeing studies related to long-term drawdown on the lower Snake and Columbia Rivers.

b. The TAG.

The assessment of biological impacts, and the effectiveness of alternative measures studied as part of the SCS, will be conducted under the direction of the TAG. This group was established by CENPW for the 1992 Flow Improvement Measures OA/EIS. The TAG is chaired by CENPW, and will include representatives from other Federal and state agencies, interest groups, and the biological community.

9.04. Lower Snake River Drawdown Tasks and Activities.

a. General.

The study of the drawdown of the lower Snake River projects will be conducted by CENPW. Lowering pool levels at the four lower Snake River projects is under consideration to improve the downstream migration of juvenile fish. The objective is to increase river velocities to potentially reduce the travel time 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 study is: 1) to identify and evaluate the technical feasibility and environmental acceptability of long-term modifications to the lower Snake River dams in order to allow the projects to operate at pool elevations below current MOP elevations, while still maintaining safe and effective juvenile and adult fish passage; 2) to evaluate the impacts of drawdown on existing project purposes and uses; 3) to identify and evaluate measures to mitigate the impacts of drawdown; and 4) to identify the process, biological benefits, and approximate cost of implementing each of the technically feasible alternatives.

The ability to maintain existing project uses under these conditions will be assessed. The primary uses include navigation, irrigation, hydropower generation, fish and wildlife, recreation, and municipal and industrial water supply. Modifications required to protect structures, levees, railroads highways, and drainage systems while the projects are operating under the drawdown conditions will be examined. The study will be limited to Federal and non-Federal facilities at the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor projects. Concept designs, construction cost estimates, implementation schedules, operational descriptions, environmental considerations, cost effectiveness evaluations, and economic effects evaluations will also be presented.

b. Phase I Findings.

Twenty drawdown alternatives were identified and screened in the Phase I study 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 proposed spillway-only operations were found not to be 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 in the Phase I study. Based on the known potential negative impacts of drawdowns, results of fish modeling, and the likely inability of a test drawdown to obtain information that will increase the likelihood of potential benefits for a near spillway crest drawdown, the Phase I studies identified two drawdown options for further analysis in Phase II. These two options were the only ones to identify any anadromous fish benefit. The options are: 1) the Natural River Option; and 2) Lower Granite Drawdown with barge transportation.

c. Tasks and Activities.

(1) Operation Analysis.

The study will assume that the reservoirs will be operated each year at a near-natural river condition during the annual juvenile migration period. Two separate periods of drawdown duration will be evaluated: a 2-month period, extending from mid-April to mid-June; and a 4.5-month period, extending from mid-April through August 31. These periods do not include the ramping or lowering of the pools below MOP, or refilling. It is assumed that the reservoirs will be returned to the normal operating pool elevations for the remainder of the year. The tailwater at Ice Harbor will be assumed to be at the normal operating pool range (elevation 335 to 340) for McNary.

The operations analysis consists of a detailed program for the implementation of reservoir drawdown. This analysis is consistent with the items outlined in NPPC's *Operations Plan*. These items include, but are not limited to, the following elements:

- Criteria for depth and duration of drawdown;
- the sequence for lowering and refilling reservoirs;
- rates of drawdown and refill;
- provisions for refilling mainstem reservoirs;
- the impacts of refill on adult anadromous fish passage and on lower river target flows;
- plans for using water evacuated from the mainstem reservoirs to enhance downstream flows for fish migration;
- operations required for juvenile fish passage;
- operations required for adult fish passage;
- evaluation of shifting flood control responsibilities from Dworshak, Brownlee, and other storage projects on the Columbia River, to the lower Snake River projects during the drawdown period in order to allow the storage projects to be operated at higher pool elevations;
- impacts of a flood control shift on anadromous fish, resident fish, and wildlife;

- procedures for planning, coordinating, and implementing reservoir operations; and
- evaluation of the reduction of Columbia River storage releases during the period when the lower Snake projects are being lowered.

The assessment of the physical performance (in the form of frequency curves) of system operation, and configuration alternatives, will include the determination of flow velocity and the duration of the drawdown. The analysis will be conducted using the 50-year hydrologic record used for operations planning on the Columbia/Snake River system (from 1928 to 1978). In addition to the primary measures of velocity and duration of the drawdown, water quality parameters will also be assessed.

(2) Hydroregulation Modeling.

Re-regulation studies/modeling will be performed by the Corps, using the best available simulation models.

(3) Design and Cost Estimates.

(a) General.

This task will consist of a technical feasibility analysis and preliminary cost estimates for structural modifications needed to implement the various operations. Measures to permit the operation of dam facilities at lower reservoir elevations will be considered. This work is consistent with the items outlined in NPPC's *Design Plan*. These evaluations will be prepared by CENPW, unless otherwise noted.

(b) Preliminary Design.

This task consists of developing design criteria, and preparing feasibility designs and layouts for structural modifications to the following: adult fishways; turbines and associated facilities; turbine intake screens and fish bypass facilities; collection and transportation facilities for juvenile migrants; physical devices and other measures used to control dissolved gas supersaturation and other conditions; any additional design activities necessary to evaluate the modifications needed to facilitate implementation of the mitigation provisions; and backwater analyses, historical flow summaries and frequencies will be required.

An inventory for each project of miscellaneous facilities requiring modification prior to reservoir pool drawdown will be developed. This inventory will include such items as the floating navigation lock guide walls, and the debris shear booms.

Construction drawings and design documents on the existing Corps facilities are available, and will be used in these evaluations. Also, Phase I preliminary designs, results of the June 1991 spill test, and the March 1992 drawdown test at Lower Granite are available, and will be used.

(c) Waterways Experiment Station (WES) Model Studies.

A general three-dimensional model of Lower Granite Dam, and a sectional model of the Lower Granite spillway, have been constructed at WES in Vicksburg, Mississippi. They will be used to evaluate the identified alternatives for operability, and as a demonstration tool. General models of Little Goose, Lower Monumental, and Ice Harbor Dams will be constructed and tested to determine design information. Likewise, spillway sectional and FGE models will be constructed and tested. The WES will conduct the physical model study work.

(d) Turbine Studies.

The Hydroelectric Design Center (HDC) at North Pacific Division will conduct a study to evaluate the effects of turbine operation on the lower Snake River under drawdown conditions. Alternative turbine/generator modifications, or replacements, will be evaluated to minimize impacts to juvenile fish during the drawdown period.

(e) Geotechnical Studies.

An inventory of structural features requiring erosion protection will be developed. Features such as railroad and highway fills, levees, dam embankment sections, bridge piers, water supplies, groundwater wells, and culvert outfalls will be developed. Modification costs and implementation plans will be addressed.

(f) Real Estate Studies.

Any real estate requirements necessary to implement any of the modifications required for the drawdown options will be identified.

(g) Quantity and Construction Cost Estimate.

Quantities and construction costs will be estimated along with the costs for additional research and development, engineering and design, construction supervision and administration, O&M, and replacement costs. Costs will be estimated at a general feasibility level for all alternatives. Life-cycle costs will be developed for each alternative considered.

(h) Implementation Schedule.

Schedules will be developed for the design and construction of the modifications necessary to successfully implement drawdown. These schedules will assume unlimited resources (*i.e*., manpower, money, or materials). The schedules will include normal research, design, and construction periods. At least one schedule will be prepared assuming that all four projects will be modified simultaneously.

(4) Environmental Studies.

(a) General.

Environmental studies will include the assessment of the biological effects of alternative conceptual designs/assessment of the impacts of construction activities; and assessment of the biological positive and negative impacts of the operation of alternatives on anadromous and resident fish and wildlife.

(b) Biological Drawdown Test.

Although a drawdown test is not considered necessary for the implementation of the natural river option, the Corps is still proposing a biological test pending regional concurrence. A drawdown test, to be conducted on the lower Snake River, is proposed to obtain vital information on the biological response to drawdown. The drawdown test will better determine the economic and environmental costs and benefits of drawdown--particularly the biological effects. Major tasks and activities would include: collecting data on juvenile fish survival in dam passage; collecting data on juvenile fish travel time and reservoir survival; and providing timely feedback on the drawdown test results to expedite, rather than delay, the evaluation process.

A drawdown test plan, detailed activities, schedules, and costs are being prepared under a separate document. Also, NEPA documentation is in progress for the proposed drawdown test.

(c) Fish and Wildlife.

These studies will analyze the effects of reservoir drawdown on salmon, steelhead, resident fish, and wildlife. This will include the analysis of available information, as well as any new information resulting from the biological drawdown test. The effects of drawdown on fish survival will be compared to alternative means of enhancing survival. The studies will be coordinated with the preliminary project modifications and operational constraints, particularly in regard to the development of drawdown alternatives. The process to be used in developing this plan will consist of the following:

- A literature search of existing data to collect all pertinent biological information available;
- a qualitative analysis of biological effects, based on existing data and drawdown testing;
- a quantitative analysis of biological effects using available models;
- an identification of uncertainties that surfaced in the qualitative and quantitative analysis; and
- the development of a plan to resolve any uncertainties that surfaced in the qualitative and quantitative analyses. This will consist of risk analyses and the development of biological tests.

Effects to anadromous fish will be measured in terms of adult returns to Lower Granite and their spawning grounds, if possible. If adult returns are not quantifiable, the fallback position will be to measure effects in terms of the juveniles arriving below Bonneville Dam. The effects will be identified by special stock.

The analysis will determine the biological effectiveness and acceptability of the alternative(s). This biological analysis will be coordinated with the TAG. The TAG will develop the scope of the biological analysis, including the effects of the implementation of the alternatives on anadromous fish, resident fish, and wildlife. This scope will also serve as the Biological Plan called for in NPPC's Phase Two Amendments. The TAG will also identify specific tasks that must be performed to assure an adequate qualitative and quantitative analysis.

(5) Fish and Wildlife Coordination Act Requirements.

Under the Fish and Wildlife Coordination Act, CENPW will contract with USFWS (and others, if necessary) for the preparation of a Coordination Act Report (CAR)k, normally prepared during feasibility-level studies. The CAR will consist of the following:

- Description of resources (identified above) impacted during construction and operation;
- measures to eliminate, reduce, or mitigate impacts; and
- enhancement opportunities.

In addition, provisions for coordinating and administering the necessary contract(s) will be included.

(6) Cultural Resources Studies.

An assessment of potential impacts to cultural resources will be conducted. The following tasks will be completed:

- Consultation with appropriate Native American Tribes, Historic Preservation Offices, and other interested parties;
- preparation of an inventory of cultural resource sites;
- identification of potential impacts;
- development of a cultural resources mitigation plan and an estimation of costs to mitigate for expected impacts; and
- qualitative and quantitative analyses based on existing data and drawdown testing.

(7) Economic Effects Analysis.

(a) General.

Studies will be conducted to identify and quantify impacts to existing project facilities and uses, both Federal and non-Federal. Also, measures to mitigate impacts will be identified. The existing uses include hydropower, navigation, irrigation/water supply, and recreation. Benefits foregone from existing project functions (opportunity costs) will be evaluated from an NED perspective, as defined in the Water Resources Council Principles and Guidelines. The economic impacts to regions and communities will also be evaluated from a Regional Economic Development (RED) perspective.

(b) Hydropower.

The analysis will include consideration of turbine operability and potential modifications at lowered pool levels. Economic effects on power generation, in terms of increased system production costs [Firm Energy Load Carrying Capability (FELCO), non-firm power, and capacity costs] will be assessed. Effects will be presented in terms of system production costs.

(c) Recreation.

An inventory of recreational facilities, including parks and marinas, will be provided. Information on the number of annual users, types of facilities, number of boat ramps, and concessionaires will be presented. Modifications to facilities will be examined, and alternatives will be developed to address the feasibility of continued usage.

Costs or modifications, relocations, and implementation schedules will be developed. Visitation impacts will be analyzed by using pilot models employed in the OA/EIS. Willingness-to-pay values for application to visitation data with, and without, recreation area modifications will be estimated in consultation with North Pacific Division. Benefits foregone will be compared to mitigation costs, based on available data. Phase II studies will attempt to compare benefits foregone with mitigation cost for individual facilities within the recreation area (*e.g.*, boat ramps).

(d) Navigation/Transportation.

Tasks and activities are yet to be determined.

(e) Irrigation/Water Supply.

The inventory of pumping plants that will be affected, prepared by Anderson Perry and Associates for CENPW, will be verified and updated. Information such as discharge, average annual water usage, plant size, period of usage, and plant location will be presented. Irrigation systems of wildlife areas, parks and private and municipal pumping facilities will be included. The estimated cost of modifications and implementation schedules required for the continuation of pumping will also be presented. Permit process, design, and construction schedules will be addressed as well.

An approximate estimate of the reduction in net farm income, with drawdown and pump modifications due to head increases, will be made by CENPW. Mitigation costs will be compared to benefits foregone on an overall basis. The OA/EIS showed that loss of farm income, if water deliveries are interrupted, generally far exceeds pump modification costs. There may be individual situations where that would not be true (*i.e.*, small acreage and high pump modification cost). Detailed analysis of this sort will be conducted in Phase II studies.

(f) Flood Control.

Flood control is not currently a function of the lower Snake River projects, but system flood control could be shifted from Dworshak Dam to take advantage of space available in drawdown reservoirs. This shift will be included in hydroregulation model studies using flood control rule curves previously established by SOR. Phase II studies could evaluate a similar shift of system flood control from Brownlee to the lower Snake River.

(g) Regional (Indirect) Impacts.

Indirect impacts (the economic effects on local and regional economies resulting from direct impacts) will be determined using the IMPLAN input-output model. The CENPW will set up a contract for developing the indirect impacts, using the available model. North Pacific Division will provide technical support for this contract. Successful completion of indirect impacts analysis hinges on the receipt of direct effects input.

(8) Mitigation Analysis.

Studies will identify measures to mitigate the adverse impacts of reservoir drawdown. Mitigation of these impacts is an integral and necessary part of any overall changes involving the drawdown of the lower Snake River projects. Consistent with the mitigation section of the amendments to NPPC's Fish and Wildlife Program (section VIII), development of the mitigation measures will address the incidence of costs of mitigating impacts with the view that they should be shared regionally, and/or nationally, so that local communities, industries, businesses, and other entities that depend on the Snake River do not bear a disproportionate share of the burden.

An incremental justification of mitigation measures will be required.

(a) Recreation.

Recreation facilities along the Snake River are water-oriented. A reservoir drawdown will make existing beaches, docks, and boat-launching ramps unusable. Analysis of measures to mitigate these detrimental impacts will include the following tasks"

- Update the inventory of recreational facilities, including parks and marinas. The inventory will identify types of facilities and the number of boat ramps;
- formulate mitigation measures that include modifications or relocation alternatives;
- determine initial construction and life-cycle costs for proposed construction alternatives;
- determine an implementation schedule; and
- evaluate the reduction in recreation visitation, in the absence of modifications to mitigate the impacts of drawdown. The number of annual users, as well as impacts to concessionaires, will be evaluated.

(b) Resident Fish and Wildlife.

The environmental impacts of drawdown, and its effect on resident fish and wildlife, will be evaluated and mitigation measures will be formulated. Proposals will be consistent with recommendations in the USFWS Coordination Act Report.

(c) Navigation.

Phase II studies will investigate the possibility of modifying existing port facilities to ship by rail or truck.

(d) Cultural Resources.

A number of cultural resource sites will be exposed during drawdown operations, and will require measures to protect them from erosion, vandalism, and disturbance by livestock.

An inventory of known cultural resource sites is available. Methods of protection, construction costs, and implementation schedules are presented in this report, entitled *Lower Snake River Archaeological Study: Site Protection and Preservation Project Cost Estimates and Schedule*, dated February 1992. This report is the basis for the formulation or potential mitigation measures for cultural resource impacts.

The analysis of measures to mitigate the detrimental impacts to cultural resources during reservoir drawdown will include a review of published consultant reports and data; formulation of potential mitigation measures based on consultant reports and available data; determination of preliminary costs, based on consultant reports and available data; and consultation with appropriate Native American Tribes, Historic Preservation Offices, and other interested parties.

(e) Irrigation.

Reservoir levels behind the four dams on the Snake River have relatively stable pool elevations, and fluctuate only 3 to 5 feet. The existing pumping facilities along the reach of the Snake River will not operate below MOP.

An inventory of affected pumping facilities, proposed modifications, and estimated costs, is presented in *Investigation of Pumping Facilities, Lower Snake River*, prepared by Anderson Perry and Associates in 1991. This report is the basis for the formulation of potential mitigation measures to identify the impact to pumping facilities.

An analysis of impacts to pumping facilities will include the following tasks: the compilation of an inventory of affected pumping plants; the compilation of information such as discharge, average annual water usage, plant size, period of usage, and plant location (Irrigation systems of wildlife areas, parks, and private and municipal pumping facilities, will be included); the formulation of mitigation measures, and determination of the estimated cost of alternatives; the development of O&M costs; and the development of schedules that include the permit process, design, and construction.

(f) Hydropower.

The construction of specific mitigation features to mitigate lost hydropower is not anticipated. However, mitigation will be investigated on the basis of generation system costs and a determination of who will be responsible for the payment of these costs.

(9) Report Preparation.

A technical appendix will be prepared for this alternative. It will identify the evaluations conducted (as outlined above), and the results of those evaluations.

9.05. Additional Upstream Storage and Activities.

a. Phase I Findings.

Of the alternative projects that were evaluated, the Galloway Project was found to be the most cost-effective alternative. However, barge transport of juvenile salmonids is a necessary program, in combination with upstream storage.

Offstream storage sites identified by BOR, and recommended for further detailed studies, will be included in the Phase II analyses.

b. Tasks and Activities.

(1) General.

The SCS study of upstream storage in the Snake River Basin will include feasibility-level studies in two distinct sections: 1) the Galloway damsite; and 2) offstream damsites identified in the Phase I BOR interagency upstream storage study. The following paragraphs describe information that will be included in the Phase II report.

(2) Operations Analysis.

Operation studies will be performed on the identified storage sites to determine the effectiveness of the reservoir(s) in meeting regional flow augmentation objectives, both alone and in combination with the operation of other storage and drawdown strategies. Studies and modeling will be performed by the Corps using the best available simulation models.

(3) Design, Construction Cost Estimates, and Schedules.

Layouts of the Galloway project, as well as design/construction schedules, will be reviewed and updated. The construction cost will be revised and updated to reflect current conditions and needs. Feasibility-level design, cost, and schedules will be developed for identified offstream storage sites.

(4) **Environmental Studies.**

Environmental studies will identify significant environmental issues. Issues that will be addressed in these studies include the following:

(a) **Impacts and Mitigation.**

Environmental studies will identify potential significant site impacts and potential site mitigation measures. Resource areas to be evaluated include: anadromous fish; resident fish and aquatic ecology; terrestrial ecology; and water quality.

(b) **Biological Benefits Analysis.**

The analysis will estimate the biological effectiveness and acceptability of the alternative(s), including the effects of implementation of the alternatives on anadromous fish. This biological analysis will be coordinated with the TAG. The TAG will develop the scope of the biological analysis, and will identify the specific tasks that need to be performed in order to assure an adequate qualitative and quantitative analysis.

(c) **Fish and Wildlife Coordination Act.**

Under the Fish and Wildlife Coordination Act, CENPW will contract with USFWS (and others, if necessary) for the preparation of a CAR, normally prepared during feasibility-level studies. Provisions for coordinating and administering the necessary contract(s) will be included. The CAR will evaluate and attempt to quantify the following:

- A description of resources (identified above) impacted during construction and operation;
- measures to eliminate, reduce, or mitigate impacts; and
- enhancement opportunities.

(d) **Mitigation Analysis.**

The mitigation analysis will identify any adverse impacts to existing resources, and include measures to mitigate the impacts associated with each potential site development. Proposed features will be consistent with the recommendations in the CAR. Mitigation will include, but not be limited to, the following resource functions: cultural resources; irrigation and water supply, resident fish, wildlife, and recreation.

(5) **Determine Real Estate Requirements.**

Real estate requirements for each storage site will be identified, and acquisition and administrative costs will be determined.

(6) **Report Preparation.**

A technical appendix will be prepared that addresses the technical evaluations and results, as outlined in the tasks identified above.

9.06. Upstream Collection and Conveyance.

a. Phase I Findings.

Alternatives that required the use of migratory canals or pipelines were eliminated from further consideration, due to biological concerns and uncertainties. Phase I alternative 3 (Barge Transport System Option) would provide for fish collection, sorting, and transfer into existing barges. Collected fish would then be transported downstream to below Bonneville Dam. This option is recommended for further detailed study.

b. Study Tasks and Activities.

(1) Develop Design and Cost Estimates.

Based on the plan recommended for further study, the following tasks will need to be completed:

(a) Diversion/Collection Structures.

Identify location(s), and design typical water diversion/collection structures. Develop methods for juvenile collection at the structure, and for key tributaries. Identify features required to accommodate holding and loading facilities for barge transportation. Considerations for diversion/collection structures will include navigation, debris, sedimentation, and adult and juvenile fish passage. Other biological effects will be evaluated. Layout facilities for transporting juveniles collected at existing lower Snake River and Columbia River dams to the migratory canal/pipeline.

(b) Barge Transport Facilities.

Maintain existing barge/truck capability at the lower Snake and Columbia River projects. In addition, develop the capability for barge-truck transport for the new collector(s).

(c) Quantities and Cost Estimates.

Estimate quantities and develop construction cost estimates for all facilities. Estimate costs for additional research and development, engineering and design, construction supervision and administration, O&M, and replacement costs.

(d) Design and Construction Schedule.

An estimate of the time required to design (including additional research requirements) and construct the migratory canal and upstream collector will be provided.

(2) Supplemental Evaluation, Design and Cost Estimate.

The expanded Phase II evaluation of multiple upstream collection and barge transport system concepts would proceed in three basic stages:

(a) Stage 1.

Stage 1 of the study will explore, develop, and evaluate (at conceptual levels) innovative and creative designs for a juvenile fish collection and transport system upstream of Lower Granite Dam. This effort will require further development of design criteria related to such things as river design flows, screen approach velocities, screen types, and behavioral devices. Alternative sites, and possibly multiple sites for a collection system, will also be further explored. Ideas and methods related to how biological and engineering-related testing might proceed will be formulated. Preliminary development of sketches for selected options will be developed as part of this stage.

(b) Stage 2.

Stage 2 of the study will coordinate the results of the Stage 1 studies with the TAG, agencies, tribes, and other miscellaneous groups. Based on input from the various groups, modifications or refinements will be made to the concepts developed in Stage 1. It is possible that entirely new conceptual designs could be initiated in this stage.

(c) Stage 3.

Stage 3 of the analysis will further develop concepts and designs from the Stage 1 and 2 phases of the study. Preliminary cost estimates, including a tentative plan and schedule to design and construct an upstream collection system, will be developed for selected concepts.

(3) Determine Real Estate Requirements.

Identify real estate requirements associated with construction of the above facilities (including preliminary cost estimates).

(4) Conduct Environmental Studies.

(a) Biological Benefits Analysis.

The analysis will estimate the biological effectiveness and acceptability of the alternative(s). Coordination of this biological analysis will be with the CRSMA TAG.

The TAG will develop the scope of the biological analysis. This analysis will include the effects of implementation of the alternative on anadromous fish, resident fish, and wildlife. The TAG will also identify specific tasks that need to be performed to assure an adequate qualitative and quantitative analysis.

A quantitative analysis will be performed. The assumptions and parameters used will be developed by the TAG.

(b) Fish and Wildlife Coordination Act.

Under the Fish and Wildlife Coordination Act, CENPW will contract with the USFWS (and others, if necessary) for the preparation of a CAR consisting of the following:

- A description of resources impacted during construction and operation;
- measures to eliminate, reduce, or mitigate impacts; and
- enhancement opportunities.

In addition, provisions for coordinating and administering the necessary contract(s) will be included.

(5) Mitigation.

Estimates will be made of mitigation costs due to habitat disturbance, as well as for navigation passage at the main fish collection facility.

(6) Operation.

The operation plan will evaluate all operation requirements and/or changes to existing operations for the alternative(s). This will include hydroregulation modeling (as necessary), and the identification of the period of operation.

(7) Report Preparation.

A technical appendix will be prepared addressing the technical evaluations and results, as outlined in the tasks identified above.

9.07. Existing System Improvements.

a. General.

This analysis element of the study will define and evaluate potential improvements to existing systems (both adult and juvenile) that could enhance fish survival. This study will be limited to those measures not currently scheduled for implementation.

Potential improvements will be prioritized in consultation with the TAG. The factors to be considered in the prioritization process will include the dependency of the items on implementation of other project modifications; potential biological benefits; and estimated relative cost-effectiveness.

b. Phase I Findings.

The improvements and modifications considered in the Phase I study are categorized, and briefly explained below. This section will be revised and updated following the completion of the biological effects analysis.

(1) Improvements to Juvenile Fish Collection and Bypass.

- To reduce perdition losses, provide dispersed release at the outfalls of the existing juvenile bypass systems at Little Goose, Lower Monumental, and McNary Dams.
- Provided extended STS's for the existing juvenile fish collection systems at Lower Monumental and Ice Harbor Dams to improve FGE's.
- Replace the pressurized bypass pipe at Lower Granite Dam that runs from the dam to the separator with a flume system similar to that being used at Little Goose and Lower Monumental Dams. Replace the fish separator, raceways, and raceway flume system, and provide shading of project features. These changes are required to improve the bypass, holding and loading facilities.
- Provide short-haul barges for the Lower Granite, Little Goose, Lower Monumental, and McNary Juvenile Fish Facilities to reduce predation losses at the river release points.
- Provide a surface-oriented system to attract, collect, and bypass juvenile fish from higher forebay depths in front of the dams. This alternative is intended to improve juvenile fish survival by reducing migration delay, predation, and fish stress.

(2) Improvements to Juvenile Fish Transportation Systems.

- Provide a means of reducing and controlling water temperatures in the fish barges in order to improve conditions in the barges.
- Increase the size of the fish release exits on the barges to reduce fish stress during release.
- Provide new fish barges to supplement the existing fleet in order to increase direct-loading capability and improve transport capability.

(3) Improvements to Adult Fish Passage Systems.

- Control the fish ladder water temperatures to reduce the impact to adult fish passage caused by water temperature differences between the forebay, fish ladder, and tailrace.
- Provide north shore fish ladders at Lower Granite and Little Goose Dams to enhance adult fish passage, and provide a backup fish ladder at each dam in the event of problems with the existing fish ladder.
- Improve the adult fish collection system to operate more effectively by enhancing performance and attraction flows.
- Improve hydraulic control of the exit gates at the McNary Dam fish ladders.
- Eliminate the low velocity area in the adult fish collection channel at McNary Dam to enhance adult passage.
- Extend the collection channels and entrances serving the north shorelines at Lower Granite and Little Goose Dams to improve adult fish passage during spill.

(4) Dam Modifications.

Modify the spillway/stilling basin to reduce levels of dissolved gasses in the downstream flow when spilling operations are required.

(5) Other Potential Improvements.

Replace old turbines with new and more efficient units that will improve juvenile survival during downstream migration.

c. Evaluation of Potential System Improvements.

(1) Phase I Ranking of Potential Improvements.

Improvements listed above will be ranked and grouped at the completion of the Phase I biological effects analysis. This process will determine the improvements that can be evaluated and implemented in isolation from other improvements or system configuration modification alternatives. Improvements that are dependent on another alternative will be studied along with the alternative upon which they are dependent.

(2) **Evaluation Criteria.**

Potential independent improvements will be evaluated on the basis of potential biological benefits and estimated costs. Implementation of improvements will be based on cost effectiveness. Opportunity costs, in terms of reduced outputs of existing project functions, are expected to be negligible, and will not be evaluated. If it becomes apparent that there are benefits foregone, they will be evaluated in the same manner as the lower Snake River drawdown alternatives.

d. Tasks and Activities.

(1) **Develop Design and Cost Estimates.**

(a) **Layout and Design.**

Feasibility-level designs will be required for each identified improvement.

(b) **Cost Estimates.**

Cost estimates will include research and development costs, engineering and design costs, construction costs, O&M, and replacement costs.

(c) **Design and Construction Schedule.**

A preliminary implementation plan, including a design and construction schedule, will be developed.

(2) **Conduct Environmental Studies.**

Environmental studies will identify and attempt to quantify significant environmental issues prior to implementation. Issues that will be addressed in these studies will include the following:

(a) **Impacts Assessment.**

Environmental studies will identify any potential significant environmental impacts. If appropriate, mitigation measures will be identified.

(b) **Biological Benefits Analysis.**

The analysis of biological benefits will estimate the biological effectiveness and acceptability of the alternative(s). This biological analysis will be coordinated with the TAG. The TAG will develop the scope of the required biological analysis, and will assist in the determination of the effects of implementation of potential improvements on anadromous fish, resident fish, and wildlife. The TAG will also identify specific tasks that must be performed to assure an adequate qualitative and quantitative analysis.

(3) Determine Real Estate Requirements.

Identify real estate requirements associated with the construction of any of the above facilities.

(4) Operation Analysis.

The operation plan will evaluate all operation requirements, and/or changes to existing operations for each alternative. This will include hydroregulation modeling (as necessary), and the identification of the period of operation.

(5) Agency Coordination.

Potential system improvements will be coordinated with relevant Federal and state agencies through coordination meetings and workshops. They will also be coordinated with NPPC to ensure that any recommended actions are consistent with regional fisheries goals and objectives. To the greatest extent possible, these activities will be conducted jointly with other SCS agency coordination activities.

(6) Fish and Wildlife Coordination Act.

Because the system improvements identified are modifications to existing facilities, there are no specific actions that need to be completed for the Fish and Wildlife Coordination Act.

(7) Report Preparation.

A technical appendix will be prepared addressing the technical evaluations and results, as outlined in the tasks identified above.

9.08. Other Tasks and Activities.

a. Public Involvement.

A public involvement strategy will be prepared to respond to the level of interest and concern expressed by the public. The approach to public involvement will be visible and understood and designed as an integral part of the planning and decision-marking process.

Formal exchange of information and views among the Corps and other agencies will be performed as required by, and in accordance with, the purposes and procedures established by Federal policy.

Public involvement activities will be conducted jointly with other SCS public involvement activities. Public involvement will be implemented, as needed, through the use of public workshops, public information meetings, and bulletins (*i.e., Salmon Passage Notes*). Media briefings will be used to announce significant study findings.

Public Information Meetings will be held, in cooperation with NPPC, throughout the region. The purpose of these meetings is to present the results of the SCS Phase II evaluation, as well as to gain public input. The exact dates and locations have not yet been determined. Following the Public Meetings, a Regional Review conference will be held to discuss the study results and the public's opinions of the SCS Phase II.

b. Institutional Studies.

Institutional studies, if appropriate, will address authority and liability issues involved with the implementation of any improvements that might be recommended. For example, to implement the lower Snake River drawdown alternative, the existing project authorities will need to be changed by Congressional action. The Corps is currently authorized to operate only within the existing limits, but they have some discretionary authority to change operation under extenuating circumstances (*e.g.*, the March 1992 drawdown test).

c. The NEPA Documentation.

Documentation needed to comply with NEPA will be prepared. It is anticipated that an EIS will be published as a separate document because of the complex environmental issues. Preparation of the environmental impact statement will perform the following objectives:

- Explain the need for, and objectives of, the proposed action(s);
- identify the alternatives;
- describe the effected environmental consequences;
- document public involvement;
- document agency review and consultation; and
- fulfill and document the required consultation with NMFS under Section 7 of the Endangered Species Act.

d. Coordination Act Report.

The USFWS will be contracted to complete a CAR for the Phase II studies. The primary purpose of the CAR is to assure that fish and wildlife is considered in plan selection, and that all justifiable fish and wildlife conservation measures are included as integral parts of the selected plan. Activities will include the following:

- A full description of the significant impacts associated with each alternative;
- linking of impacts as specifically as possible to the features of the various alternatives responsible for the impacts, and their incidence (location, timing, and duration) specified;
- identify the fish and wildlife trade-offs associated with each alternative;
- fully describe and justify those fish and wildlife conservation measures that should be included as integral parts of the recommended plan; and
- prepare the coordination act report.

e. Report Preparation.

Draft and final SCS Phase II summary reports will be prepared. These reports will summarize and incorporate the technical appendixes prepared for each specific alternative. The summary report will present the results of the evaluations, as well as the recommended plan. The draft report will be reviewed by the Drawdown Committee, NPPC, and the Corps. The final report will be revised to incorporate comments received on the draft, and will then be submitted to the Corps' higher authority for review and approval.

f. Project/Study Management.

The study management activity includes the day-to-day management of study activities, coordination, meetings, correspondence, budget data, work requests, and report preparation. Coordination includes internal coordination as well as coordination with contractors, higher authority, and other involved Corps offices. An initial project management plan will be developed for the start of Phase II activities.

9.09. Selection of the Recommended Plan.

a. General.

The objective of this section is to describe the process for developing, comparing, and selecting the recommended plan.

b. Evaluation Criteria.

(1) General.

Typically, the Corps bases plan selection on the Federal objective established in the Water Resource Councils' *Economic and Environmental Principles for Water and Related Land Resources.* The Federal objective is to select the plan that maximizes contributions to NED, consistent with protecting the nation's environment. The strict use of NED analysis is not considered appropriate when dealing with endangered and threatened species. Any attempt to assign a monetary value to endangered fish, given current techniques, would not account for its full value to society. However, benefits foregone from existing project functions (opportunity costs) will be evaluated from an NED perspective.

The criteria for evaluating the alternatives analyzed in the SCS Phase II includes: 1) salmon survival rates; 2) cost effectiveness; 3) regional acceptability; and 4) other environmental effects. These criteria are discussed further in subsequent paragraphs.

(2) Biological Objective.

The effects of each alternative, or combinations of alternative, on salmon survival will be analyzed and estimated. Both qualitative and quantitative procedures will be used in an effort to estimate survival. Quantitative estimates will use available salmon life-cycle models. These life-cycle models have accompanying juvenile passage models. There are several models available within the region that will be used in this analysis. The goal is to estimate the effects on survival by measuring returning to the spawning grounds. Returning adults will be estimated in terms of range of survival. However, expected values will be estimated. These effects will be estimated by species and/or stocks.

Developing a comparison of the results of the various life-cycle models will be difficult, because the models use different parameter values for some actions. These differences will be documented in the Biological Plan.

(3) Cost-Effectiveness Analysis.

Cost effectiveness is an evaluation tool, calculated in terms of relative costs needed to achieve a change in salmon survival (adults to spawning grounds). The analysis will look at each species/stock separately. The cost-effectiveness approach avoids the issue of assigning monetary values to endangered species, by comparing alternatives in an attempt to identify the least-cost way to increase survival. This approach does not determine how much improvement of the environmental objective is economical justified but, rather, it provides information regarding the cost of action for various levels of salmon survival improvement. Since salmon survival will be expressed as a range, the cost effectiveness of each alternative will also be shown as a range.

Costs will be estimated at a general feasibility-level, for all alternatives, in two basic categories: 1) construction and mitigation costs; and 2) opportunity costs. All costs will be presented as an average annual equivalent cost over a 50-year period. To the greatest extent possible, the sources of cost uncertainty will be identified, and the decision process will recognize the significance of this uncertainty. The construction/mitigation costs will include the engineering and design costs, construction outlays over time, interest during construction, O&M, and replacement costs. The opportunity costs will include the existing economic benefits that will be foregone with the construction and operation of the proposed alternatives. The basis for defining the opportunity costs will be NED costs and benefits, as defined in the Water Resources Council's Principles and Guidelines.

(4) Environmental Effects.

Environmental effects (both positive and negative), other than those to anadromous fish, will also be used in the decision/selection process. These effects do not have quantifiable monetary values, but may have significant effect on the selection process.

(5) Regional Accessibility.

Regional acceptability of these alternatives will be assessed. The primary entity for determining regional acceptability is NPPC. In addition, public information meets will be held throughout the region to present the recommended plan, and gather public input.

c. Selection of the Recommended Plan.

The range of potential actions will be compared against each other by using the criteria identified above. This evaluation will also look at combinations of alternatives in the selection of the recommended plan.

Cost-effectiveness results will be used to rank alternatives in terms of biological improvement and cost. This cost effectiveness criteria, combined with other criteria (*i.e.*, regional acceptability and impacts to other environmental resources) will serve to guide the decision of selecting the recommended plan. This information will provide a basis for a decision process that will involve the region (through NPPC), the nation (through the Corps), and NMFS's ESA responsibilities. It must be recognized that each of these entities may arrive at a different decision The Corps process, however, will include HQUSACE-level review, and will not doubt be influenced by decisions made by NPPC and NMFS. The HQUSACE will have the final approval of the Phase II report.

9.10. The Recommended Plan.

The Phase II summary report will present the recommended plan. If the recommended plan is not the NED plan, the rationale for departure from the NED plan will be presented.

The report will document that the affected states, other non-Federal interests, and Federal agencies have been consulted in the development of the recommended plan.

A description of the recommended plan will include:

- Plan components, including mitigation.
- Design and construction considerations.
- Operation and maintenance considerations.
- Plan accomplishments.
- A summary of economic, environmental, and other social effects.
- An implementation plan.

The baseline cost estimate will be developed for the recommended plan. The October base and fully-funded estimates will be shown. Uncertainty associated with the significant cost features of the recommended plan will be discussed, along with how these uncertainties will be addressed in future project development.

9.11. Study Schedule and Costs.

Phase II studies are scheduled to begin August 1994. Activities in preparation for a biological drawdown test in 1996 are scheduled to begin in mid-1994.

The biological drawdown test is scheduled over a 4-year period. Test findings will greatly influence the overall timeframe for completion of the Phase II report. Interim progress reports are anticipated.

Components of the Phase II study are listed in table 9-1. Costs are shown for fiscal years 1994 through 1999. The estimated total Phase II study cost is $141,680,000.

Table 9-1
System Configuration Study
Phase II, Estimated Costs
($1,000) October 1993 Price Levels

	FY 94	FY 95	FY 96	FY 97	FY 98	FY 99	FY 00/01
Lower Snake River Drawdown							
WES Model Studies	1,100	825	825	800	500	100	
Operational Model Studies	120	200	150	25	25	25	
Engineering/Design/Costs	400	500	500	330	350	350	
Other Biological Tests/Studies	20	20	150	50	50	125	
Subtotal	1,640	1,545	1,625	1,225	925	600	
Biological Drawdown Testing							
NEPA Documentation	347	40	40	40	40	40	
Engineering	250	800	800	800	250	250	
Gatewell Tank	300	3,000	100	200	100	100	
Adult Fish Ladder	100	1,000	100	100	50	50	
Const Riprap, Debris Bm Misc	250	2,376	3,320	3,591	956	865	
Gatewell Tank Prototype	200	150	0	0	0	0	
Drawdown Operations	0	0	10,000	10,000	9,500	9,500	
Subtotal	$1,447	$7,366	$14,360	$14,731	$10,896	$10,805	$37,194
Upstream Collector/Transport							
WES Model Studies	400	1,215	1,033	300	100	291	
Engineering/Design/Costs	500	1,200	1,200	700	750	500	
Biological Tests/Misc Studies	100	20	250	1,458	809	134	
Subtotal	$1,000	$2,435	$2,483	$2,458	$1,659	$925	$450
Additional Upstream Storage							
WES Model Studies	0	200	150	100	100	0	
Operational Model Studies	0	50	100	100	25	25	
Engineering/Design/Costs	164	300	300	300	551	100	
Econ, Cult., and Misc Studies	20	20	20	100	100	100	
Subtotal	$184	$570	$570	$600	$776	$225	$440
CENPW System Improvement							
WES Model Studies	150	350	500	100	50	50	
Operational Model Studies	0	80	0	0	0	0	
Engineering/Design/Costs	800	1,500	500	750	100	200	
Misc Studies and Research	20	120	100	100	100	100	
Subtotal	$970	$2,050	$1,100	$950	$250	$350	$450
General Support							
Supervision/Management	350	1,184	1,426	1,136	712	704	
Program Management	240	300	300	300	300	250	
NPD Support	173	300	300	300	300	175	
Subtotal	$763	$1,784	$2,026	$1,736	$1,312	$1,129	$4,212
Fiscal Year Totals	$6,004	$15,750	$22,164	$21,700	$15,818	$14,034	$42,746

9.12. John Day Advanced Planning and Design (AP&D).

a. General.

Further study of the John Day operation at MOP is being conducted under AP&D, separately from the SCS Phase II. The following paragraphs outline the preliminary POS for this work.

b. Biological Studies (Anadromous Fish).

Studies would involve the collection of baseline data and conduct of model studies and tests to establish without project conditions, and to assess and predict the effects that operation at MOP will have on anadromous fish. Studies will be coordinated with NMFS. The following studies and testing are anticipated, as summarized:

- Travel time/survival relationships.
- Turbine survival studies: model studies and direct survival tests.
- Effects on FGE.
- Effects on spill conditions at McNary Dam.
- Effects on fish passage and bypass systems: juvenile bypass system and orifice passage efficiency; and adult ladders.
- Effects on predation (no protocol established).
- Effects on shallow water fish habitat.
- Biological assessments for listed anadromous fish species.

c. Habitat Impacts.

The following study and design efforts would be required to establish without project conditions and assess the impacts of any mitigation requirements for the effects of MOP operation on habitats for resident fish and wildlife. The overall project shoreline and lands will be considered, but studies will focus on the Umatilla National Wildlife Refuge, operated by USFWS; and two wildlife management areas operated by the State of Oregon on project lands. This work would be conducted in cooperation with USFWS and state agencies. It would include the following:

- HEP analyses.
- Wildlife field studies.
- Submergent plant communities.
- Develop/evaluate mitigation alternatives.

- A coordination act report will be provided by USFWS.
- Biological assessments for listed fish and wildlife species potentially impacted by the drawdown operation.
- Design. Detailed requirements for offsite acquisition, as required, and designs for initial site development.
- Real Estate Design Memorandum for the acquisition of off-project lands required for mitigation.
- P&S for initial development of mitigation sites in accordance with the approved mitigation plan.

d. Water Supply Impacts.

(1) Umatilla and Irrigon Hatcheries.

Investigate and develop alternative methods for mitigating the additional increment of water supply shortfall that would be caused by the drawdown (in coordination with CENPW). This would include:

- Explorations and test wells.
- Test and demonstrate the feasibility of alternatives to provide treatment of river water or recycled hatchery water.
- Prepare a feature design memorandum for review and approval.
- Preparation of final designs, plans, and specifications will be initiated with approval of the feature design memorandum.

(2) City of Boardman Municipal Water Supply.

- Negotiate agreement with owner.
- Conduct studies to assess the impact, need, and alternatives for additional water to supplement existing municipal capacity.
- Prepare plans and specifications for the modifications/additions.
- Prepare draft relocation agreement for execution with authorization, as determined necessary, and funding for construction.

e. Public and Private Groundwater Supplies.

- Conduct studies to tabulate existing groundwater well locations, year of construction, depth, type, capacity, *etc.* Estimate potential physical and financial impacts that will result from the drawdown.

- Develop instrumentation and monitoring criteria and preliminary plan for installation prior to drawdown. Develop a contingency plan to deal with short-term groundwater supply problems that may result from the drawdown.

- Prepare contract documents for instrumentation, monitoring, and contingency program.

f. Irrigation Pump Stations.

- Negotiate preliminary agreements with each owner to conduct studies and prepare designs, plans, and specifications.

- Conduct hydrosurveys to provide bottom contour information in the vicinity of each station.

- Conduct explorations to determine rock contour locations at each station where the potential for encountering rock is anticipated.

- Establish existing as-built pump installation design and operation.

- Prepare plans and specification packages for the required modifications and additions to the impacted facilities.

- Negotiate draft relocation agreement with each owner.

g. Recreation Sites (And Existing Treaty/Access Facilities.

- For the non Corps-owned facilities, negotiate a preliminary agreement with each owner.

- Conduct hydrosurveys to provide bottom contour information in the vicinity of boat ramps, beaches, access channels, and moorages.

- Develop alternative solutions to modify or replace existing facilities to mitigate the impacts of the drawdown, as appropriate. Provide incremental analysis where various levels of serviceability may be restored or replaced with alternative measures.

- Prepare plans and specification packages for the required modifications and additions to the impacted facilities.

- Negotiate draft relocation agreements with each owner.

h. Adult Passage Facilities.

Prepare a letter report, and plans and specifications detailing the design of the remedial measures.

i. Cultural Resources.

- SHPO Coordination.

- Develop monitoring and contingency plans.

- Prepare monitoring and contingency contracts.

j. Miscellaneous Impacts.

Reconnaissance studies indicated several other physical modifications and areas of concern that need to be addressed prior to the implementation of MOP operation.

k. Economic Studies.

- Evaluate economic impacts to hydropower and navigation for operation at MOP for the alternative periods.

- Evaluate direct and indirect economic impacts, and provide incremental analyses to support recommendations with regard to restoration of serviceability of the impacted facilities.

l. Decision Document, EIS, and Baseline Cost Estimate.

In addition to the products discussed in the various sections above, the following reports and documents will be prepared:

- Draft decision document (feasibility report) and EIS.

- Final decision document (feasibility report) and EIS.

- Draft baseline cost estimate.

m. Legal Analysis.

Conduct legal analysis to assess compensable interest of the owner, and Federal liabilities in regards to the proposed drawdown operation.

The preliminary estimate for the AP&D studies is about $12 million. The current schedule would provide for a decision document and draft EIS in Fiscal Year 1996. Facility modifications to allow operation at MOP would be completed by Fiscal Year 1999. The expenditure schedule for AP&D is estimated as shown in table 9-2.

Table 9-2
Estimated Fiscal Year Expenditures for John Day AP&D
($1,000,000)

Fiscal Year	Estimated Expenditures
1994	$1.7
1995	$3.0
1996	$3.3
1997	$2.5
1998	$1.0
1999	$0.5

9.13. Lower Columbia System Improvements.

As discussed in section 7, potential separate tracks from the general SCS Phase II study and packaging of these measures based on study requirements is anticipated, subject to regional review and consideration. All measures will require more detailed development of engineering, design, and cost information. The following paragraphs present a preliminary outline of the major efforts anticipated for these measures beyond the Phase I SCS.

a. Extended Screens at John Day.

This course of action assumes continuation of the activities on this measure initiated due to the Fiscal Year 1994 Congressional addition to the budget. Biological testing, hydraulic model studies, and a prototype screen contract will be required to develop designs. The work will be documented in a Feature Design Memorandum for the project, and includes the following:

(1) Biological Studies.

- FGE testing of extended prototype screens.
- Orifice passage efficiency testing.

(2) Hydraulic Model Studies.

- Sectional model--1:25 models for evaluating screens.
- VBS model--1:12 model to evaluate the increased flows diverted up the bulkhead slot.
- Orifice model--1:4 model for determining the optimum location and configuration for the orifice.
- Turbine models: 1) WES turbine model for evaluating flow directions and velocities; and 2) manufacturer's turbine efficiency model for developing new efficiency data.

(3) Prototype Studies.

Three ESTS's and three ESBS's will be constructed for prototype testing.

b. John Day Spill/Flip-Lips.

Biological and hydraulic model studies will be employed in this phase of the study to develop designs. The studies will consist of the following:

(1) Biological Studies.

- Hydroacoustic evaluation of the efficiency of the juvenile spill patterns.
- Radio tracking of adults.

(2) Hydraulic Model Studies.

- Sectional spillway model: model design would involve two bays at 1:24 scale. Model testing would include flip-lip development by visual observation and iteration with the general model.
- General model: model design would consist of the entire project and 2.5 miles of river, both upstream and downstream, at 1:80 scale. Model testing would be used to develop optimum spill patterns both with and without flip-lips.

c. Juvenile Transportation at John Day.

Biological testing and hydraulic model studies will be employed to evaluate the feasibility of the measure, as well as to develop designs. The testing and studies will be documented in a feasibility report, and will include the following:

- Biological studies would include juvenile marking and release studies.

- Hydraulic model studies. The general 1:80 model to be constructed for the spill optimization study will be used for selecting a new outfall site and navigation conditions for a new fish barge dock.

d. Bonneville First Powerhouse FGE.

Biological and hydraulic model studies will be employed to evaluate approach conditions, identify problem areas, and develop alternatives. The studies will consist of the following:

(1) Biological Studies.

Biological studies would evaluate current FGE.

(2) Hydraulic Model Studies.

- Sectional model. Model design would be of one unit at 1:12 scale. Testing would be to obtain three-dimensional flow information via laser velocimeter.

- General model. Modify existing WES model to perform fisheries studies. Testing would include forebay elevations and the verification of unit approach conditions.

e. Bonneville DSM.

Biological studies consisting of juvenile release studies will be required in this phase of the study to develop designs for bypass modifications.

f. Bonneville Outfalls.

Biological testing and hydraulic model studies will be employed to develop designs. The testing and studies will be documented in a feature design memorandum, and will include the following:

- Biological testing will include a program of juvenile release studies to test release location sites.

- Hydraulic model studies. The existing 1:100 general model will be modified for testing new outfall locations.

g. Short-Haul Barging.

Biological testing and hydraulic model studies will be employed to test the feasibility of the concept and to develop facility designs. The Phase I work has provided a preliminary estimate of costs and biological benefits for this measure at Bonneville, and study cost estimates currently only include that project. The testing and studies will consist of the following:

- Biological studies--juvenile coded wire tag marking and release studies.
- Hydraulic model studies--the existing general model of Bonneville will be used for studying the navigation conditions for a fish barge dock.

h. Turbine Passage Improvements.

Phase II would consist of a research program to determine whether the causes of juvenile turbine mortality can be isolated, measured, and modified through advanced turbine design. Included in the research program would be model studies, numerical analysis, laboratory studies, and video imaging. If determined to be feasible, a prototype turbine would be constructed for field tests. A task force comprised of engineers, turbine designers, and fish passage experts would be assembled to conduct the studies, which would address the following potential causes of turbine mortality:

(1) Strike.

Video imaging using neutrally-buoyant particles in the turbine models.

(2) Pressure.

Laboratory research and testing with various sizes and species.

(3) Cavitation.

Numerical analysis of existing turbine configurations as part of a hydraulic model study.

(4) Shear.

Laboratory study to test tolerance levels.

(5) Stress.

This would involve two stages: 1) initial laboratory investigations to define levels of stress; and 2) prototype turbine design to field test stress parameters.

(6) Grinding.

Video imaging of prototype conditions.

(7) Efficiency.

Prototype investigations involving the relationship between efficiency and fish passage survival.

(8) Intake System Effects.

Numerical analysis, and turbine model and prototype testing.

The task force would develop new turbine designs for testing. Prototype testing would evaluate fish survival, stress, power production, and efficiencies.

Preliminary cost estimates have been developed to provide an indication of the magnitude of costs involved in Phase II studies for the lower Columbia system improvements. The overall estimate by fiscal year, and the major category of study, is shown in table 9-3. This summary is based on preliminary costs that will be expected to be modified with detailed scoping of the Phase II program following regional review of the Phase I reports.

Table 9-3
Preliminary Cost Estimate Summary for Phase II Studies
Lower Columbia System Improvements
($1,000,000)

	Fiscal Year Costs						
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000 to 2002**
Model Studies	0.3	1.7	2.2	0.9	0.1		
Biological Studies	--	0.9	2.3	3.4	0.4		
Engineering and Design Costs	0.4	1.3	2.3	1.0	0.4	0.4	
Prototype Construction/Testing	--	--	1.2[1]	1.2[1]			5.8[2]
Total	0.7	3.9	8.0	6.5	0.9	0.4	

[1]John Day Extended Screens Prototype
[2]Turbine Prototype