US Army Corps
of Engineers®
Walla Walla District

Columbia River Salmon Mitigation Analysis
System Configuration Study
Phase I

Appendix C
Additional Snake River Basin Storage
Technical Report

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

April 1994
DRAFT

Executive Summary

1. Background

The Northwest Power Planning Council (NPPC), created by the Northwest Power Act (Public Law 96-501), implemented the Water Budget as a key part of its Fish and Wildlife Program. The Fish and Wildlife Program is based on the concept that anadromous fish are an important resource to both the Pacific Northwest and the nation.

During the Salmon Summit, the U.S. Bureau of Reclamation (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 the NPPC Phase Two amendments), BOR is facilitating an interagency committee effort to inventory and screen potential storage sites for further development. The committee is made up of representatives from BOR, the Corps, and Bonneville Power Administration (BPA), as well as from the states of Washington, Oregon, and Idaho. The sites will be 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 NPPC by a 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 is an alternative being evaluated for the System Configuration Study (SCS) conducted by the Corps. This alternative will examine the possibility of providing additional upstream storage for flow and temperature improvements during anadromous fish migration periods. The study will utilize existing information on previously proposed storage sties, 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 will be presented. In addition, benefits to juvenile fish passage will be provided.

The SCS consists of two phases. During this first phase, a reconnaissance-level assessment of alternatives occur. During the second phase, detailed studies of the most likely alternatives will be conducted. The other alternatives being evaluated under the SCS include: 1) drawdown of the lower Snake River reservoirs; 2) collection of juveniles above the Lower Granite reservoir and conveyance to below Bonneville Dam; 3) system improvements for existing fish passage and transport facilities; and 4) operation of the John Day reservoir to elevation 257. The first phase of this study is scheduled to be completed in June 1994.

The SCS Phase I Upstream Storage Study includes two main components: 1) a report on the Galloway Project (located on the Weiser River; and 2) a summary/status report on the BOR-led Interagency upstream storage study. The Phase I study is scheduled to be completed in June 1994.

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.

2. Galloway Evaluation

The Galloway site received strong support early in the inventory process. One of the reasons for this support is a feasibility study recently conducted on this site by the Corps. This study was terminated prior to completion, due to a lack of Corps interest in developing the site for hydropower, fish, and wildlife enhancement (due to budgetary priorities). The feasibility study provided a substantial amount of information on this site and, therefore, the information presented for Galloway is much more detailed (feasibility-level) than the information for the other sites (pre-reconnaissance level).

The Galloway plan calls for the construction of a 300-foot-high earth and rockfill embankment dam on the Weiser River approximately 13.5 miles above the mouth of the river. The dam impounds up to 900,000 acre-feet (AF) of water, and 715,000 AF of active storage, forming a 6,900-acre reservoir. Camping, day-use, and reservoir access is provided for recreation. The project would include an at-site powerplant, with an installed capacity of 4.6 megawatts. Channel protection is provided for areas along the downstream channel that are prone to bank erosion and overbank flooding in order to facilitate the release of stored water. Environmental concerns include reservoir water quality, cultural resource mitigation, wildlife mitigation, and resident fishery mitigation. Fish and wildlife mitigation measures include habitat and stocking for the downstream and reservoir fisheries, as well as acquisition and development of 4,384 acres of land for wildlife.

A storage exchange agreement with Idaho Power Company may be necessary to facilitate the transfer of flows through Brownlee Reservoir to below Hells Canyon Dam, as well as to assure compensation to Idaho Power Company for impacts to hydropower operations. Some flood control storage responsibility could be transferred from Brownlee Reservoir to Galloway Reservoir, resulting in increased hydropower generation at Brownlee. This generation would somewhat decrease the net compensation currently provided by BPA for Brownlee's participation in the Water Budget. Also critical to the project is the status of the branch railroad running from the city of Weiser, through the project site, to Rubicon, Idaho. In the most recent analysis, a relocation of the railroad was not economically feasible. The decision of whether or not to abandon and relocate the railroad will have a tremendous impact on the economic feasibility of the Galloway project. In November 1993, the Union Pacific Railroad sold the branch line to the Idaho Northern and Pacific Railroad. However, reformulating the project to mitigate for, or recover, lower Snake River anadromous fishery losses may diminish the significance of this economic issue. This issue will be explored further in the Phase II studies, if the region chooses to pursue Galloway as a contributing alternative.

The total estimated project cost at the 1 October 1992 price level is $189 million. The current fully-funded cost (cost escalated to midpoint of construction) of the project is estimated to be about $215 million. The following is a summary of the total annual cost of the project, as included in the August 1990 Technical Report. Due to limited inflation, the 1 October 1993 price level was assumed to be the same as the 1 October 1992 price level. An interest rate of 8 percent was used in computing interest during construction, and interest and amortization.

Interest and Amortization	$18,340,000
Operation and Maintenance, and Replacement	750,000
Increased Cost to Shippers	750,000
Increased Highway Maintenance	230,000
Total	**$20,050,000**

System operation studies were conducted to evaluate the impacts of adding the Galloway Project toward meeting flow targets at Lower Granite Dam, and impacts on the northwest power generation system. The analysis was completed as part of the BOR-led Interagency Upstream Storage Study. The studies were conducted using the Hydrologic System Seasonal Regulation (HYSSR) computer model, which simulates the operation of each independent project in the Columbia River system based on predetermined operation criteria for each project. The computer model was run both with and without the Galloway Project for flow targets of 85,000 cubic feet per second (cfs) and 120,000 cfs, and evaluated over a 2½-month (16 April to 30 June), and 4½-month (16 April to 31 August) flow period. Output from this study was then used to evaluate the impacts of the Galloway Project on improving juvenile anadromous fish survival as well as costs to power generation.

The impact of the Galloway Project on increasing the survival rate for juvenile anadromous fish through the Columbia and Snake River system 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 the System Operation Review

(SOR) process. The effect of the Galloway Project on increasing the survival rate was evaluated under two conditions, including both with and without fish transportation. For each transportation condition, four cases were evaluated; including combinations of flow targets of 85,000 cfs and 120,000 cfs, and flow duration periods of 2½ and 4½ months.

The evaluation of the economic impacts of alternative storage options for flow augmentation on Pacific Northwest power system costs 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. The SOR spreadsheet was designed to calculate the total system cost for alternative operation strategies. The primary output of the model is the total annual cost of operating the entire power system under each condition evaluated.

Benefits for flood control, recreation, and employment as related to the Galloway Project, were evaluated in the 1990 Technical Report and updated.

The following is a summary of the economic analysis of the Galloway Project:

Economic Analysis of Galloway Project
($1000, Except as Noted)

	Flow Target			
	85,000 cfs		120,000 cfs	
	Flow Duration, Months		Flow Duration, Months	
	2.5	4.5	2.5	4.5
Average Annual Costs				
Implementation	20,050	20,050	20,050	20,050
Economic				
Power	(63,000)	(49,000)	(48,000)	(26,000)
Recreation	(196)	(196)	(196)	(196)
Employment	(78)	(78)	(78)	(78)
Flood Dam Reduction	(110)	(110)	(110)	(110)
Total	**(43,334)**	**(29,334)**	**(28,334)**	**(6,334)**

The following is a summary of the median survival rates over the 50 years of record, by species, for the 85,000 cfs and 120,000 cfs flow targets for both the 2½- and 4½-month flow duration periods. The results are presented for both with and without the transportation program.

Dworshak (Base) With Galloway Added Median Smolt Survival (Standard Deviation)				
	Flow Target			
	85,000 cfs		120,000 cfs	
	Flow Duration, Months		Flow Duration, Months	
	2.5	4.5	2.5	4.5
Species, Without Transportation				
Spring Chinook				
Base Condition	25	24	25	24
With Galloway	23	24	24	25
Summer Chinook				
Base Condition	28	27	28	29
With Galloway	28	28	27	28
Fall Chinook				
Base Condition	11	11	09	10
With Galloway	09	11	09	11
Dworshak Steelhead				
Base Condition	28	27	26	29
With Galloway	28	27	27	29
Species, With Transportation				
Spring Chinook				
Base Condition	38	37	38	37
With Galloway	37	37	37	37
Summer Chinook				
Base Condition	39	38	39	38
With Galloway	38	38	38	39
Fall Chinook				
Base Condition	42	41	42	40
With Galloway	38	42	37	40
Dworshak Steelhead				
Base Condition	45	44	45	44
With Galloway	44	44	43	44

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

The final report, titled *Snake River Basin Storage Appraisal Study,* dated January 1994 was submitted to NPPC, by letter dated 11 February 1994. 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.

As the first step of the study process, BOR 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*(addendum E of final report).

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

- Wild and scenic river designation
- State 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 Storage Appraisal Study Work group reduced the large number of potential sites to a workable quantity, based on discretionary application of the 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. The following is a list of damsites that were chosen for further appraisal evaluation:

- Onstream:

  Galloway site, Oregon
  Teton River, Idaho
  Owyhee Dam and Reservoir Enlargement, Oregon
  Thief Valley Dam, Oregon; replace existing dam

- Offstream:

  Moores Hollow, Oregon
  Jacobsen Gulch, Oregon
  Succor Creek Basin, Idaho-Oregon
  Saylor Creek, Idaho
  Rosevear Gulch, Idaho
  Bissel Creek, Idaho
  Conant Creek, Idaho

Appraisal level cost estimates were conducted for all project sites except the Galloway and Teton sites, using a cost-estimating computer model designed for planning studies. Costs for the Galloway and Teton projects were based on existing reports. Total average annual cost of the projects was then computed in terms of cost per AF of water released from storage.

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 abandoned mercury mines. However, it is estimated that the problem will diminish over the first years of operation.

Through a combination of the water availability studies, the cost of developing and operating the project, and 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.

The following is a summary showing reservoir storage capacity, average annual water that could be released from each reservoir, and the total cost per AF of water released:

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	1,152,070	

[1]Upper Site. Minimum water released would be about 32,000 AF.

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.

System operation studies were conducted to evaluate the impacts of adding the Galloway and Rosevear/Jacobsen Gulch Projects for flow augmentation. The projects were evaluated for two duration periods of 2½ months (16 April to 30 June), and 4½ months (16 April to 31 August), and two target flows of 85,000 cfs, and 125,000 cfs at Lower Granite Dam. Studies were also conducted to evaluate the impacts (added costs) of operating the Pacific Northwest Power System for flow augmentation. The following is a summary of the cost analysis for the two scenarios:

Cost Analysis
Average Annual Costs
Galloway and Rosevear/Jacobsen Gulch Projects

	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)	(4,456)
Galloway, Rosevear Gulch, and Jacobsen Gulch				
Implementation Cost	207,407	207,407	207,407	207,407
System Power Cost	(58,000)	(65,000)	(63,000)	(42,000)
Total	149,407	142,407	144,407	165,407

[1]As updated and computed by BOR.

Studies on fish survival were conducted by the Center for Quantitative Studies at the University of Washington, using the CRiSP model. The model used average monthly streamflow data output from the HYSSR system operation studies that was modulated to average daily flows. The following is a summary of the estimated median smolt survival rates, by species:

Median Smolt Survival[1]				
	Flow Target			
	85,000 cfs		120,000 cfs	
	Flow Duration, Months		Flow Duration, Months	
	2.5	4.5	2.5	4.5
Dworshak (Base) With Galloway Added				
Spring Chinook				
Base Condition	25	24	25	24
With Galloway	23	24	24	25
Summer Chinook				
Base Condition	28	27	28	29
With Galloway	28	28	27	28
Fall Chinook				
Base Condition	11	11	09	10
With Galloway	09	11	09	11
Dworshak Steelhead				
Base Condition	28	27	28	29
With Galloway	28	27	27	29
Dworshak (Base) With Galloway and Rosevear/Jacobsen Gulches Added				
Spring Chinook				
Base Condition	25	24	25	24
With Galloway	24	23	25	25
Summer Chinook				
Base Condition	28	27	28	29
With Galloway	28	28	29	29
Fall Chinook				
Base Condition	11	11	09	10
With Galloway	09	11	10	11
Dworshak Steelhead				
Base Condition	28	27	28	29
With Galloway	29	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 base conditions. However, most 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 specified flows over long time periods (2½ and 4½ 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 if the additional supplies were used in conjunction with an in-season water management process to provide improved flows during the time of greatest smolt movement, a more significant increase in smolt survival could be obtained.

4. Discussions.

Based on studies completed to date, it has been found that benefits attributable to upstream storage for increasing anadromous fish survival appears to have limited benefits. 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.

In spite of the marginal findings, the Galloway Project, and possibly other upstream storage sites, could still have high potential for being feasible alternatives for fish survival. Although the increased survival rates were estimated to be minimal and sometimes even negative, 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.

By allowing the upstream storage sites to operate on a first priority basis for flow augmentation, the Dworshak Project can be operated on an as-needed basis to supplement flows. By doing so, the Dworshak Reservoir can be maintained at a higher reservoir level and consequent higher head, allowing a higher power production level for the system. In doing so, the total cost to the power generation system was actually reduced in every case with the Galloway Project. As an example, under the 85,000 cfs target flow and 2½-month flow duration period, the total average annual cost, including implementation costs and reduced cost of system power generation, was estimated to be a negative $43,000,000 per year. Since the cost is negative, the cost is actually a benefit.

Offstream storage sites such as the Rosevear and Jacobsen Gulch Projects could also be justified if the benefits could justify the costs. The Moores Hollow site could also be a consideration because of its high water supply potential.

The onstream Owyhee enlargement and Thief Valley sites, although they are much smaller reservoirs, have costs per AF of water released from storage about the same as those of the Galloway Project. Development of these sites may also be a consideration.

5. Preliminary Findings and Conclusions.

Based on the evaluation completed as part of the Phase I study, it has been determined that there are no quantifiable benefits of adding new upstream storage for the purpose of increasing fish survival in the lower Snake and Columbia Rivers. The estimated benefits to fish survival were found to be marginal, and fall within the margin of effort in the analysis. Although additional storage showed no measurable quantifiable biological benefit. In terms of improved salmon survival (as determined using CRiSP), the Phase I analysis probably does 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 in all probability understate the benefits to fish migration.

Of the alternative projects that were evaluated, the Galloway Project was found to be the most cost-effective alternative. By supplementing the flow augmentation from the Dworshak Project with the Galloway Project, the Dworshak Project would be able to operate at a higher head for hydropower generation, resulting in a reduction in system power generation costs. This benefit results in an economically cost-effective project.

Sensitivity studies indicate that barge transport is a beneficial program in delivering the maximum number of juvenile salmon to below Bonneville Dam. Additional flow augmentation, through upstream storage, may be beneficial in delivering more juvenile salmonids to the collector at Lower Granite Dam.

In spite of the marginal benefits of upstream storage, there are numerous qualitative reasons that have been identified for keeping additional upstream storage as a viable alternative in the Phase II evaluation. The following is a list of those reasons:

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

- Upstream storage could improve water temperature control to aid in fish passage. 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.

- Water from upstream storage could be used for pulsation purposes to aid the migration process during high migration periods.

- Water released from upstream storage could benefit fish survival in the low-flow critical years. To date, only the median survival over the 50-year period of record has been evaluated.

- In the event that water from upstream storage was highly managed, and releases were made to coincide with known high migration periods of specific species, the effectiveness of the stored water could be greatly increased. Releases could be made over a 1- to 3-week period, as opposed to the 2½- or 4½-month period assumed in the Phase I study. In addition, only flows needed at the time would be released, rather than trying to meet a specified flow target of 85,000 cfs. This would tend to increase the efficient use of the stored water and, consequently, increase benefits dramatically.

- Upstream storage could be an effective alternative, in combination with other improvements (*e.g.*, a surface-oriented 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 overall increased efficiency.

- The feasibility of transferring the flood control storage space from the Brownlee Project to the Galloway Project could improve the effectiveness of upstream storage, and should be considered further.

- 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.

- Although preliminary studies by the BOR-led interagency team concluded that lower Snake River reservoirs would normally refill within 1 month (one time-step in the HYSSR model), using just natural inflow, earlier refill using stored water could result in benefits to power and navigation interests.

Table of Contents

Executive Summary

Section 1 - Introduction

Section 2 - Galloway Storage Project Evaluation

2.08. Other Environmental Effects
- a. General
- b. Water Quality
- c. Cultural Resources
- d. Vegetation
- e. Resident Fish
- f. Wildlife
- g. Future Mitigation Study Needs
- h. Future Evaluation Needs
- i. Summary

2.09. Implementation Schedule

2.10. Cost Estimates
- a. General
- b. Construction
- c. Railroad Abandonment
- d. Mitigation
- e. Operation, Maintenance, and Replacement (OM&R)
- f. Cost Summary

2.11. Economic Effects
- a. Power
- b. Recreation
- c. Employment
- d. Flood Damage Reduction
- e. Summary

Section 3 - Status/Summary of BOR-Led Interagency Upstream Storage Study

3.01. Background

3.02. Purpose and Scope

3.03. Inventory

3.04. Site Screening

3.05. Site Evaluation
- a. Reservoir Sizing
- b. Dam and Reservoir Cost Estimates
- c. Environmental Impacts
- d. Scenarios Defined
- e. System Operation Studies
- f. System Power Cost Studies
- g. Fish Survival Evaluation

3.06. Conclusions

Plates

Appendixes

Section 1 - Introduction

1.01. Background

a. General

The Northwest Power Planning Council (NPPC), created by the Northwest Power Act [Public Law (PL) 96-501], implemented the Water Budget as a key part of its Fish and Wildlife Program. The Fish and Wildlife Program is based on the concept that anadromous fish are an important resource to both the Pacific Northwest and the nation. The Water Budget provides for flow augmentation on the Snake and Columbia Rivers during the spring migration of juvenile anadromous fish (salmon and steelhead) to the ocean. Flow augmentation on the Snake River, as measured by the flow at Lower Granite Dam (near Lewiston, Idaho), is currently accomplished through modified operation of the U.S. Army Corps of Engineers' (Corps) Dworshak Dam, located on the North Fork of the Clearwater River; and Idaho Power Company's Brownlee Dam, located on the Snake River. Augmented flows increase the velocity of the water in the river and, thereby, increase the survival of the juvenile anadromous fish by decreasing the length of time required for them to complete their migration to the sea.

b. Interagency Upstream Storage Appraisal Study

During the Salmon Summit, the U.S. Bureau of Reclamation (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 in an effort to aid migrating salmon and steelhead. This element was incorporated in the Governor's Report to Senator Hatfield on May 1, 1991. The following quotation is an excerpt from the Governor's Report that applies to additional storage:

> "Beginning in 1992 and concluding by the end of 1993, conduct a cooperative appraisal study of the potential for new Snake River Basin storage to provide additional water for lower Snake River flow augmentation to aid migrating salmon and steelhead. Identify and make preliminary evaluation of engineering, hydrologic, economic, and environmental aspects of potential sites. In addition, expeditiously explore short-term options to develop storage capacity for at least 200,000 acre-feet of water. The Bureau and others should give highest priority to potential new storage opportunities that: a) have highest refill probability; b) are or can be associated with new water supplies made available by the Council-mandated Bureau water conservation projects under this program; c) are located such that they provide opportunities to share flows to benefit fish migration (without intervening barriers); d) are located such that they provide opportunities to moderate instream temperatures where this will benefit migration; e) are not subject to state or other regulations that will preempt stored water or otherwise substantially impair employment of the projects to benefit fish migration."

The above language was included on page 49 of the NPPC's *Amendments to the Columbia River Basin Fish and Wildlife Program (Phase Two),* dated December 11, 1991.

As a result of commitments made at the Salmon Summit (and reiterated in the NPPC Phase Two amendments), 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 Bonneville Power Administration (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 report, dated January 1994, was submitted to NPPC, by letter dated 11 February 1994 (see exhibit 3). Participation in this process, by the Corps, was initiated by a letter, dated October 11, 1991, from BOR (see exhibit 1).

c. The System Configuration Study (SCS)

The development of additional Snake River basin storage is an alternative being evaluated for the SCS by the Corps. This alternative will examine the possibility of providing additional upstream storage during anadromous fish migration periods, in an effort to improve both flow and temperature. The study will utilize existing information on previously proposed storage sites. Information on site location, storage, possible flows, type of structures, preliminary design and costs, and estimated implementation schedules will be presented. In addition, benefits to juvenile fish migration will be described.

The SCS will be conducted in two phases. During the first phase, a reconnaissance-level assessment of alternatives will occur. During the second phase, detailed studies of the most likely alternatives will be conducted. The other alternatives being evaluated under the SCS include: 1) drawdown of the lower Snake River reservoirs; 2) collection of juveniles above the Lower Granite reservoir and conveyance to below Bonneville Dam; 3) system improvements for existing fish passage and transport facilities; and 4) operation of the John Day reservoir at elevation 257.

1.02. The SCS Phase I Upstream Storage Study

The SCS Phase I Upstream Storage Study includes two main components: 1) a report on the Galloway Project (located on the Weiser River); and 2) a summary report on the BOR-led Interagency upstream storage study. Each component of this study is further discussed in the following paragraphs.

The Corps terminated a feasibility-level study, and released a technical report in August 1990. Information on the Galloway Project, from the technical report, is summarized in this report. Since the feasibility-level effort was not entirely completed, a plan of study (POS) estimating the study efforts necessary to update the pertinent feasibility study findings, complete terminated analyses, and complete Environmental Impact Statement (EIS) for the site is needed. The actual Galloway study/EIS completion will occur during Phase II, if recommended by the region.

As mentioned above, the final report on the BOR-led interagency upstream storage study, titled *Snake River Basin Storage Appraisal Study,* and dated January 1994, was submitted to NPPC by letter dated 11 February 1994 (see exhibit 3). This SCS report is based on the final BOR report.

1.03. Purpose.

The purpose of this report is to present the status of the Galloway Project study. The report also presents a summary of the findings from the BOR-led interagency upstream storage study.

The studies identify and evaluate potential Snake River storage sites that could provide additional water to aid migrating salmon and steelhead either through augmentation of flow or refill of lower Snake River reservoirs following drawdown. The information presented in this report will be used for the SCS Phase I being conducted by the Corps.

1.04. Scope.

The identification of storage sites is limited to the Snake river Basin. This evaluation includes enlarging existing sites, and new onstream and offstream site development.

The evaluations include economic engineering and environmental effect aspects; hydrology, preliminary designs and costs, analysis of impacts to system power costs, and anadromous fisheries. Other aquatic and terrestrial ecology resources and habitats were addressed in the SCS study to determine the positive and negative impacts of design, construction, and operation. Also, impacts on cultural resources were assessed, and potential mitigation measures identified. There is not always enough time to fully evaluate impacts and mitigation measures. In these specific cases, significant potential problems were identified for future study. This information, where appropriate, was based primarily upon existing information gathered from previously studied storage sites.

Section 2 - Galloway Storage Project Evaluation

2.01. General.

The Galloway site received strong support early in the inventory process. One of the reasons for this support is a feasibility study, recently conducted on this site by the Corps. This study was terminated prior to completion, due to a lack of Federal interest in developing the site for hydropower, fish, and wildlife enhancement purposes. However, the feasibility study provided a substantial amount of information on this site. Therefore, the information presented for Galloway is much more detailed (feasibility-level) than the information for the other sites (reconnaissance- or prereconnaissance-level).

Information presented in this report for the Galloway Project is based on a Technical Report prepared for the Galloway Dam and Reservoir Study, dated August 1990, except as noted. Exceptions include studies that were accomplished subsequent to the Technical Report as part of the SCS, System Operation Review (SOR), and the Snake River Basin Storage Appraisal Study conducted by BOR in cooperation with the Corps and other interested state agencies. A summary of BOR's report is included in section 3 of this report.

2.02. Galloway Site Location.

The Galloway damsite is located at river mile (RM) 13 of the Weiser River in western central Idaho (see plate 1). The Weiser River Basin is an irregular-shaped drainage area of about 1,660 square miles. It is located in western central Idaho between latitudes 44 and 45 degrees north, and longitudes 116 and 117 degrees west. The area is drained by the Weiser River, which enters the Snake River just above the city of Weiser. Its headwaters are in the Seven Devils Range on the west and north, and in the West Mountains to the east. The Little Salmon River Basin lies to the north, the Payette River Basin to the east and south, and minor stream basins to the west, all of which drain directly, or indirectly, into the Snake River. The basin's north/south length is about 66 miles, with a maximum east/west width of approximately 36 miles.

The Galloway site takes advantage of at least two river basin characteristics that encourage water resource development. The first characteristic is the fact that the average basin runoff [843,000 acre-feet (AF)] exceeds basin needs and use. The Galloway site passes about 742,000 AF of basin runoff. The second characteristic is a result of the basin's low elevation in relation to the rest of the upper Snake River Basin. The basin runoff tends to precede that of the rest of the upper Snake River Basin by a month or more. This provides an opportunity to trap flows for use later in the spring.

The Galloway site also offers the combination of a narrow canyon damsite and a wide, flat, upstream valley. Just downstream of the proposed damsite, the canyon opens into a broad floodplain that extends to the mouth of the Weiser River. Above the damsite, the canyon leads into an 8-mile-long, 2-mile-wide valley, with some floodplain and low rolling foothills. Above this, the river emerges from a narrow canyon that stretches upstream for about 11 miles.

2.03. Alternative Weiser Basin Sites Investigated

During previous reconnaissance-level studies on potential water resource development in the Weiser River Basin, the Corps and the State of Idaho screened 49 reservoir storage sites. These sites were screened, based on storage capacity, water supply, and cost per AF of storage. Five sites were determined to be potentially feasible, and survived the screening process: Vista, Lost Valley, Tamarack Valley, Goodrich, and Galloway. Reconnaissance studies of these sites established that, of all the potential storage sites within the Weiser River Basin, the Galloway site provides the best opportunity for economically feasible storage development.

The Vista, Lost Valley, and Tamarack Valley sites all lacked economic justification, and did not warrant further investigation. A flow augmentation project located at the Goodrich site does not appear feasible if the Galloway project is built. If the Galloway project is built an operated to augment anadromous fish flows, the Goodrich project could not augment flows because of the relative location of the two projects. The Corps deferred study at the Goodrich site indefinitely.

2.04. Physical Features of Galloway Project

a. General Description

Pertinent data for the proposed Galloway project is summarized in table 1. The project includes a 300-foot-high earthfill dam and 900,000-AF total storage reservoir project located at RM 13.5 on the Weiser River. The conservation pool storage is 185,000 AF, with a 3,400-acre surface area. Outlet facilities include a small outlet equipped with a selective withdrawal tower to meet downstream stream maintenance and irrigation requirements, and a large outlet to control releases for augmentation. A 4.6-megawatt (MW) powerhouse utilizes discharges from the smaller outlet. The project includes features to provide irrigation flows to the Sunnyside Canal, since the canal would be severed by the dam. No new irrigation development or storage allocation will be included. Downstream channel modifications are included to protect against bank erosion and overtopping during augmentation operations. Recreational facilities will include camping, boating, day-use, and parking facilities. The project operation and maintenance boat ramp will provide public access to the reservoir. No major relocations are necessary, although purchase of the branch line of the Union Pacific Railroad is recommended. Fish and wildlife mitigation features are included.

b. Foundation Investigations

(1) Site Collection

The Galloway damsite is located in a short section of canyon between wide valleys, both upstream and downstream. The canyon is V-shaped, with walls that generally slope at 35 degrees. There is no floodplain at the damsite. Three core holes were drilled, one in each abutment and one in the valley bottom. The core holes indicate that Columbia River basal underlies the site at about the valley bottom elevation. The abutments consist of interbedded basalts, breccias, and tuffs. Both abutments have basalt slump blocks. There are normal faults both upstream and downstream of the site. The Crane Creek fault system runs through the reservoir site and may be an avenue for the loss of reservoir water. The damsite lies in seismic Zone 2 (moderate damage probability).

(2) Engineering Considerations

Roller compacted concrete (RCC) and earthfill designs were considered for the dam. The earthfill design is preferred because the weaker interbed zones found in both abutments are not adequate to support a concrete structure. An RCC structure may be feasible, but additional site investigations are necessary. Project scoping studies analyzed reservoirs with capacities ranging from 600,000 AF, at pool elevation 2,440; to 1,220,000 AF, at pool elevation 2,520. However, due to the abutment conditions, pool elevations above 2480 are not recommended.

(3) Future Site Investigations

The design phase of the Galloway project should include the following minimum geologic investigation programs: exploratory core borings; geological and seismological review; explorations for construction materials; and seepage analysis.

c. Reservoir

Galloway Dam will form a reservoir with a capacity of 900,000 AF when full (elevation 2480). The reservoir will be approximately 18.2 miles long and, when full, will have a surface area of approximately 6,900 acres (see area-capacity curves on plate 2). The reservoir will fluctuate between elevation 2480 and elevation 2340 during operation. Existing trees, structures, and fences must be cleared down to elevation 2330. Borrow areas for dam embankment materials are located upstream of the damsite, and will be flooded by the reservoir conservation pool when the dam is completed. The stability of the reservoir rim during drawdown should be analyzed during the design phase.

d. Embankment

A zoned rockfill embankment is shown on plate 3. The embankment has a top width of 40 feet, 1 vertical on 2 horizontal side slopes, a maximum height of 300 feet (based on the foundation rock elevation of 2,198 feet encountered in the drill hole), and a top elevation of 2,495 feet mean sea level (msl). The impervious core section is composed of silt. Upstream of the core section is a 10-foot-wide sand and gravel filter, and a 10-foot-wide zone of rock spalls. The upstream and downstream sections of the impervious core are both composed of a 10-foot-wide sand filter, a 10-foot-wide gravel filter, and a 10-foot-wide section of rock spalls. Rockfill shells support the core and filter materials, both upstream and downstream.

The embankment foundation area will be stripped to bedrock prior to the placement of core or filter materials. Under the core section is a 3-foot-deep foundation blanket of silty sand. The basalt foundation area under the core section must be grouted. Riprap is required on the upstream face of the embankment, from a point 5 feet above maximum pool elevation to 3 feet below normal low pool. Riprap is also required on the downstream tow of the embankment (from the toe to elevation 2225, approximately).

The stability of the embankment during reservoir drawdown should be analyzed in any further studies.

e. Spillway

A gated spillway will be located in the right abutment. The spillway will have two radial gates, each 42 feet wide by 55 feet high, and will be designed to pass a maximum of 112,400 cubic feet per second (cfs). This flow, plus 11,000 cfs from the outlet works, will pass the spillway design flow of 123,400 cfs. The crest of the spillway will be at elevation 2427. The freeboard for wind-wave action is considered to be 5 feet above the maximum elevation of the spillway design flood (see plate 3 for the spillway location and section).

The spillway design flood was developed by routing the standard project flood through the reservoir and, 5 days later, routing the probable maximum flood through the reservoir after it had been drawn down as a result of volume forecasting. Because of their close proximity to the dam embankment, consideration should be given to designing the spillway and stilling basin to accommodate the probable maximum flood routed through the reservoir when it is full.

f. Outlet Works

The intake structure will be a freestanding tower located in the reservoir at the upstream toe of the embankment, near the left abutment (see plate 3). The intake tower will include controls to regulate the flow of water into the low-level regulating outlet and the power penstock. Trash barriers at the regulating outlet entrance will protect two service gates that control flows into the regulated outlet conduit. The intake tower will include emergency gates, bulkhead slots for maintenance dewatering, and an air vent. This vent will be designed to supply air, downstream from the control gates, for the regulating outlet conduit. At the time of year when large volumes of water will normally be released through the regulating outlet, there will be no temperature stratification in the reservoir. Therefore, the regulating outlet does not require a water quality-type intake. The intake will release water down to reservoir elevation 2220.

The regulating outlet conduit will measure 18 feet wide by 20 feet high, and will be approximately 1,300 feet long (see plate 3 for location in plan view). It is designed with upstream gate control, to carry 11,000 cfs under open channel flow conditions when the pool elevation is at conservation level (2,344 feet). This regulating outlet meets the requirements of Engineer Regulation (ER) 1110-2-50, *Low-Level Discharge Facilities for Drawdown of Impoundments.* This ER requires an average flow of 8,740 cfs for 4 months, to draw the reservoir down to a level equal to 10 percent of full pool storage.

There exists a high probability for the reservoir to stratify thermally during the summer months. This will result in a warm surface water layer (epilimnion) of about 25 to 50 feet in thickness, and a cooler bottom water layer (hypolimnion) below it. In the hypolimnion, severe depletion of dissolved oxygen may occur, along with the subsequent release of nutrients, trace and heavy metals, and other contaminants. Releases of water from the hypolimnion during the summer months would not meet State of Idaho requirements for dissolved oxygen and ammonia concentrations. Multiple level intakes would allow for water to be released from the epilimnion (where oxygen concentrations are more favorable to downstream uses), or to be blended with water from the hypolimnion. This will provide a control for the dissolved oxygen/nutrient levels and water temperatures.

g. Channel Improvements

Channel improvements are necessary to increase channel capacity for flow augmentation operations. Improvements include levees and riprap or rockfill bank protection at selected areas downstream of the damsite. Coordination with the US Fish and Wildlife Service (USFWS) and the State of Idaho will be required for specific determinations of improvement locations. Pump stations are required to drain areas cut off by levee improvements.

h. Power Facilities

The following descriptions assume that the power facilities will be installed by a non-Federal entity to be determined by the Federal Energy Regulatory Commission (FERC). A single 4.6-MW generating unit will be located in a powerhouse below ground on the left bank downstream of the dam and regulating outlet stilling basin (see plate 3). The penstock connects the dual intake columns under the upstream end of the regulating outlet conduit to a butterfly valve at the turbine. The generating unit will operate on 100 to 225 cfs, at heads ranging from 142 to 282 feet. A single vertical-shaft Francis turbine, with wicket gates at 215 feet of head, produces 4,940 horsepower (hp) (85-percent efficiency).

Based on system operation studies discussed in paragraph 2.05, below, at-site power generation varies from about 8,800,000 to 18,000,000 kilowatt hours (kwh) of energy each year, depending on the target flow at Lower Granite Dam and the flow duration period. The powerhouse will operate unattended after manual startup.

It is assumed that electrical power generated at the Galloway site will be transmitted to Idaho Power Company (IPC) transmission lines near Weiser, Idaho. Approximately 10 miles of new 69-kilovolt (kV), three-phase power lines, with main power transformer and disconnect switch, are required to make this tie-in. Onsite power will be provided by a station service transformer. This transformer will connect the generator breaker and the main power transformer.

Due to the elevation of the powerplant, irrigation flows for the Sunnyside Canal will be pumped from the tailwater. If non-Federal interests choose not to develop the at-site power facilities, the penstock can be reduced in size and discharge through a small stilling basin into the Sunnyside Canal, negating the need for the pumping plant.

i. Recreation

Approximately 48,385 visitor days for day use, and 5,957 visitor days for camping, were included in the August 1990 Technical Report. If non-Federal cost sharing for recreational features does not materialize, only minimum facilities will be provided under section 3.(a) of PL 89-72. These facilities will consist of access, a turnaround, and a kiosk. Access will be provided by the project boat launching ramp. The access, the turnaround, and the boat ramp are necessary for project operations. Should non-Federal cost sharing materialize, the double-lane boat ramp will accommodate about 40,000 visitor days. In addition, 18 camping spaces, 24 picnic tables, and parking for 72 vehicles will be provided. Water and toilet facilities will be provided to support these recreational facilities.

j. Relocations and Real Estate

(1) Railroad

Galloway Reservoir will inundate approximately 18 miles of branch line run by the Union Pacific Railroad. Both relocation and abandonment were examined. A study, done in 1983 by Roger Creighton Associations, estimated the economic impacts to the upper Weiser River Basin that would result from the abandonment of the branch line. The study indicated that abandonment costs are about a tenth of the costs of relocation. Based on the cost differential between abandonment and relocation, the branch line will probably be abandoned if the Galloway project is constructed, The branch line was sold to the Idaho Northern and Pacific Railroad in November 1993.

(2) Roads

The reservoir will also inundate a system of local roads that serve many ranches in the valley. Only one of the roads, besides the primary access road that goes through the damsite, connects to roads outside the valley. This road travels up Bear Creek, and provides access from the valley to a larger road that connects with Crane Creek. Since the entire valley will be inundated and, since Bear Creek Road's function was access to and from the valley, no roads or highways will be relocated or rerouted as part of the Galloway project. The remaining portion of the Bear Creek Road will provide access to the reservoir from Crane Creek Road.

(3) Land

Approximately 8,751 acres will be required for the reservoir, and an additional 4,384 acres will be required for two wildlife mitigation areas. Approximately 5,661 acres of the reservoir area are privately owned. About 1,200 acres are irrigated cropland, 450 acres are dry cropland, and 4,011 acres are rangeland. The wildlife mitigation areas include 3,759 acres of private land. Approximately 117 acres of this land are irrigated cropland, 100 acres are dry cropland, 3,365 acres are rangeland, and 177 acres are riparian. Approximately 625 acres of the mitigation lands are state-owned. About 55 acres will be required for downstream channel modifications, including 39 acres of private cropland.

(4) Irrigation

Irrigation water is currently diverted from the Weiser River by the Galloway and Sunnyside Canals, in the proximity of the Galloway damsite. Galloway Canal begins at an existing diversion dam, approximately ¼ mile downstream of the Galloway damsite, and runs along the right bank. The proposed dam will not affect Galloway Canal. The Sunnyside Canal diversion is approximately ½ mile upstream of the damsite and runs along the left bank. It will be cut off by the new dam and will need to be supplied with irrigation water. Pumping water from the tailrace is more economical than supplying water from the forebay. A pump station capable of pumping 75 cfs, at a head of 15 feet, will be provided to lift water into Sunnyside Canal from the tailrace.

k. Cultural Resource Mitigation

To date, no systematic archaeological survey has been undertaken of the Galloway project, nor has testing and evaluation to determine site significance been accomplished. These investigations, together with n assessment of project impacts, will be needed in Phase II to determine cultural resource mitigation needs.

2.05. System Operation Studies

System operation studies were conducted to evaluate the impacts of adding the Galloway Project on the system's ability to meet flow targets at Lower Granite Dam. The system studies were conducted as part of the BOR-led Interagency Upstream Storage Study, as addressed in section 3 of this report. The studies were conducted by the Corps, using the Hydrologic System Seasonal Regulation (HYSSR) computer model, which was developed to analyze the operation of the Columbia/Snake River System. The model includes projects on the lower Snake River up to, and including, the Brownlee Project. The model also includes provisions for a project on the Weiser River. It is capable of simulating hydrology, power generation, and flood control operations as carried out under the terms of the Pacific Northwest Coordination Agreement and the Columbia River Treaty between the United States and Canada. It also accounts for a variety of non-power operating requirements.

The HYSSR program simulates the operation of each project in the Columbia/Snake River System, based on predetermined operating criteria for each project. For this study, the model was run for different flow targets and flow durations, both with and without the Galloway Project, to determine the impact that the Galloway Project has on flows at Lower Granite Dam and system power generation. The program uses average monthly flows over the period of record extending from years 1928 to 1978, with the months of April and August being split in two, for a total of 14 time steps per year. The program consecutively routes the flow data through the system on a time-step basis over the period or record, according to the assumed criteria.

In all cases, including the base case, the Brownlee Project was assumed to operate to meet target flows at Lower Granite Dam in the same manner that it is currently operated (1993 operation) to meet water budget flow targets. It was assumed that discharges from the Galloway Project into the Hells Canyon Complex (includes the Brownlee, Oxbow, and Hells Canyon Projects, proceeding downstream) would be passed as received, with no shaping.

The volume of water to be released for augmentation from Brownlee is constrained by the active storage available in Galloway at the start of augmentation, Galloway inflows during augmentation, the channel capacity of the lower Weiser River, the powerhouse capacity at IPC's Hells Canyon projects, and the target flow at Lower Granite Dam.

The maximum active storage volume in Galloway Reservoir is 715,000 AF. The limiting powerhouse capacity at IPC's projects is 26,365 cfs. Augmentation operations are constrained by the IPC powerhouse capacity to minimize impacts on IPC power generation. Augmentation flows cannot be temporarily stored in Brownlee Reservoir due to flood control constraints.

The operation of the three IPC projects downstream from the confluence of the Snake and Weiser Rivers could be impacted in three ways: 1) high-flow discharge from the Weiser River, which normally occurs during the months of March through May, will be postponed until later in the spring; 2) because of the channel constraints on the Weiser River, it may be necessary to draft Brownlee Reservoir during the flow augmentation period to maximize flow augmentation benefits to fish; and 3) up to 130,000 AF of flood control storage may have to be transferred, on a forecast basis, from Brownlee Reservoir to Galloway Reservoir during the months of March, April, and May.

At the Dworshak Project, the flood control storage will be shifted to the Grand Coulee Project, if the April to July runoff forecast at Dworshak is 3 million AF or less. Minimum and maximum flows of 1,20 cfs and 25,000 cfs, respectively, were assumed for the Dworshak Project. The Dworshak Reservoir was maintained as full as possible be releasing minimum flows, or releases required for flood control (except when drafts were necessary to meet flow targets at Lower Granite Dam). All other projects in the system were set and maintained at a constant operation in all cases.

For each alternative run, the Galloway project was added and operated in conjunction with the Dworshak Project to meet flow targets at Lower Granite Dam. The Galloway Project was operated on a fill-and-spill basis, with no consideration for flood control. It was assumed that the Galloway Project will be operated first to meet the flow objective, with the Dworshak Project being drafted to provide additional water as needed. The analysis was conducted at a reconnaissance-level of detail, and must be refined in Phase II of the study.

Target flows of 85,000 cfs and 120,000 cfs at Lower Granite Dam were evaluated over a 2½-month (16 April to 30 June) and 4½-month (16 April to 31 August) flow period. The results of the system operation study are presented in paragraph 2.06, below, under the respective subparagraphs. The numbers in parentheses (*e.g.*, SOS2AX0) correspond to the HYSSR run number for that particular alternative run. The following is a summary showing the accomplishments of the Galloway Project in meeting flow targets at Lower Granite Dam for the various flow targets and flow duration periods, as analyzed in the system operation studies as discussed above. The flow data are based on average monthly flows over the period of record.

Target Flow at Lower Granite Dam: 85,000 CFS Flow Duration: 2.5 Months					
Alternative (HYSSR) Run Number	**Average Flow at Lower Granite Dam, 1000 cfs (Number Years Target Met/Over Period)**				
	April 16-30	**May**	**June**	**July**	**August**
Dworshak Only (Base Condition) (SOS2AX3)	92.4 (30/50)	105.8 (47/50)	100.4 (37/50)	n/a n/a	n/a n/a
Dworshak With Galloway Added (SOS2AX4)	96.8 (33/50)	105.4 (48/50)	101.3 (38/50)	n/a n/a	n/a n/a
Target Flow at Lower Granite Dam: 85,000 CFS Flow Duration: 4.5 Months					
Alternative (HYSSR) Run Number	**Average Flow at Lower Granite Dam, 1000 cfs (Number Years Target Met/Over Period)**				
	April 16-30	**May**	**June**	**July**	**August**
Dworshak Only (Base Condition) (SOS2AX3)	90.8 (30/50)	104.6 (44/50)	99.6 (37/50)	55.1 (4/50)	28.6 (0/50)
Dworshak With Galloway Added (SOS2AX4)	93.2 (33/50)	103.6 (44/50)	99.2 (38/50)	59.9 (7/50)	29.8 (0/50)
Target Flow at Lower Granite Dam: 120,000 CFS Flow Duration: 2.5 Months					
Alternative (HYSSR) Run Number	**Average Flow at Lower Granite Dam, 1000 cfs (Number Years Target Met/Over Period)**				
	April 16-30	**May**	**June**	**July**	**August**
Dworshak Only (Base Condition) (SOS2AX3)	95.4 (10/50)	14.0 (22/50)	103.6 (19/50)	n/a n/a	n/a n/a
Dworshak With Galloway Added (SOS2AX4)	101.7 (14/50)	115.3 (22/50)	104.4 (21/50)	n/a n/a	n/a n/a

Target Flow at Lower Granite Dam: 120,000 CFS Flow Duration: 4.5 Months					
Alternative (HYSSR) Run Number	**Average Flow at Lower Granite Dam, 1000 cfs (Number Years Target Met/Over Period)**				
	April 16-30	**May**	**June**	**July**	**August**
Dworshak Only (Base Condition) (SOS2AX3)	94.5 (10/50)	112.5 (22/50)	103.4 (19/50)	48.2 (0/50)	22.8 (0/50)
Dworshak With Galloway Added (SOS2AX4)	100.1 (14/50)	112.6 (22/50)	103.9 (21/50)	50.8 (0/50)	23.0 (0/50)

2.06. Project Operation

a. General

Galloway Reservoir will inundate 6,900 acres of land at full pool elevation (2,480 feet). At conservation pool elevation (2,340 feet), the reservoir will inundate 3,400 acres. The maximum drawdown could be 140 feet, and could occur over periods of from 2½ to 4½ months, depending on the target flow and duration period.

During most years, the reservoir will start the summer slightly above, or near, conservation pool elevation. During the summer and fall, the pool will generally drop slightly, as storage is used to meet minimum stream flow requirements. During the late fall and winter, the pool will raise as basin runoff increases. It will continue to rise during the early spring. From summer through early spring, however, the reservoir will only release minimum and irrigation flows when it is not full. If the reservoir is full, it will pass inflows. During the late spring augmentation period, the reservoir contents (active storage) will be released, in most years, at a rate of 11,000 cfs.

As an example, the Galloway Reservoir is expected to be drawn down to minimum levels in about 24 percent of all years by the end of June, for the 85,000-cfs flow target and the 2½-month flow duration period, based on historical flow data. During 36 percent of the years, a partial drawdown will be required. No drawdown will be required during the other 40 percent of the years, because discharges at Lower Granite Dam will be sufficient for fish passage. The following is a summary of the average and median end-of-month pool elevations for the Galloway Project for the various flow targets and flow duration periods, as analyzed:

Galloway Project End of Month Median Reservoir Elevation[1]				
	Flow Target			
	85,000 cfs		120,000 cfs	
	Flow Duration Months		Flow Duration Months	
	2.5	**4.5**	**2.5**	**4.5**
October	2469	2343	2350	2343
November	2470	2346	2363	2346
December	2477	2350	2377	2350
January	2480	2361	2390	2361
February	2480	2380	2407	2390
March	2480	2403	2431	2403
1 to 15 April	2480	2420	2446	2420
16 to 30 April	2442	2402	2401	2365
May	2454	2426	2340	2340
June	2465	2435	2340	2340
July	2467	2340	2344	2340
1 to 15 August	2467	2340	2346	2340
16 to 31 August	2468	2340	2347	2340
September	2468	2340	2349	2342
[1]Full Pool: Elevation 2480 Minimum Pool: Elevation 2340				

(1) Flood Discharges

The standard project flood (SPF) at the Galloway site is 130,200 cfs, and the probable maximum flood (PMF) is 190,000 cfs. The spillway design flood (SDF) is 123,400 cfs, based on 200,000 AF of flood control spaced provided on a forecast basis. It results in a maximum pool elevation of 2,480.3 feet.

The SDF was developed by routing the SPF through the reservoir and, 5 days later, routing the PMF through the reservoir (already drawn down as a result of volume forecasting). Because of the close proximity of the spillway and stilling basin to the dam embankment, consideration should be given to designing them to accommodate the PMF routed through the reservoir when it is full.

(2) Sedimentation

For the 100-year life of the project, about 15,000 AF of reservoir space is reserved for sediment accumulation. Since the project will trap nearly all of the incoming sediment, the downstream channel will potentially degrade, while the upstream channel will potentially aggrade. Downstream degradation may require additional channel bank protection in the future, if erosion progresses below the toe of the protection works. Upstream aggradation may reduce flood-carrying capacity and channel stability if it extends upstream several miles.

(3) Ice Jams

The Galloway project will affect winter ice regimes in the reservoir area, both downstream and upstream for some distance. The project will not increase flood problems during the winter freeze up, and should eliminate all downstream ice-related flooding from breakup jams except, that resulting from ice jams on the Snake River. The project could increase the frequency and duration of flooding on agricultural lands between the project and Midvale by providing an additional jam initiation point at the upstream end of the reservoir. Winter drawdown will probably prevent jams from extending to Midvale in most years, but they might occasionally extend that far upstream. Changes in the frequency or severity of flooding at Midvale are difficult to demonstrate, since jams typically form at several locations near the city during severe winters, even without the project. Longer periods of flooding could be the primary impact, since it may taken longer for the ice to clear out of the Weiser River (upstream of the project) during the spring breakup. The additional ice backed up behind the reservoir could interfere with, and even delay, the downstream movement of upstream ice.

Even with a full pool at the time of ice breakup, the reservoir is expected to eliminate most of the ice delivery to the downstream reach. Warmer releases from the reservoir during the winter period, combined with the elimination of frazil ice production in the canyon above the dam, should eliminate ice-jam flooding that originates in the Weiser River (which accounts for all of the ice-jam flooding between the Galloway site and the city of Weiser). However, the city of Weiser will remain subject to flooding from Snake River ice jams that build across the mouth of the Weiser River.

b. Storage Allocations

The total volume of the reservoir will be 900,000 AF at the normal maximum pool elevation of 2,480 feet msl. The active storage volume will be 715,000 AF. The remaining 185,000 AF will form a conservation pool at elevation 2,340 feet msl. This pool will provide for resident fish mitigation, sediment storage (15,000 AF), and minimum head for power generation. Incidental benefits will include aesthetics, recreation, and resident sport fishing. No storage space is allocated to irrigation, but the project will pass part, or all, of the inflow needed to meet existing downstream diversion rights. All 715,000 AF of active storage was assumed to be used to provide augmentation flows for downstream anadromous fish and system power generation. Recreation may occur at all pool elevations.

(1) Flood Control Operation

Flood control operational criteria will be developed during the design phase. During flood events, the outlet works release up to 11,000 cfs (the improved downstream channel capacity) to pass the flood and eliminate surcharge. The spillway is capable of passing the SDF of 123,400 cfs, with a surcharge at elevation 2,480.3 feet msl.

(2) Normal Operation

Within the constraints and operations described above, the project will pass the portion of inflows necessary to meet downstream irrigation requirements and minimum stream maintenance flows. Irrigation flows will be required between April and October, and will range up to 268 cfs in July. Minimum stream maintenance flows will be 50 cfs between May and October, and 100 cfs between November and April. No releases will be made explicitly for power. Power will be generated from releases made through the small outlet for irrigation, stream maintenance, and flood control. Between July and April, selective withdrawal will be used with the small outlet to optimize downstream water quality. Cooler water will be released to benefit the fishery during warm weather, and warmer water will be released in the winter to control ice formation. If at-site power facilities are not built, the small regulating outlet will discharge through a small stilling basin into Sunnyside Canal, negating the need for the pumping plant. No operational criteria would change.

(3) At-Site Power

The project would have the capability to generate up to approximately 18,000,000 kwh (85,000 cfs flow target and 2½-month flow duration) of hydroelectric power at-site annually, with a 4.6-MW powerhouse, depending on the flow targets and flow duration periods. This is approximately the amount of energy required to supply 1,400 homes in the region. Operation for hydropower generation will have to be consistent with operations for fish and flood control purposes. Further studies to determine the economics associated with hydropower development at this site will be required.

2.07. Anadromous Fishery Effects

a. Analysis Description

The estimates of survival of the anadromous fishery was analyzed using the Columbia River Salmon Passage Model (CRiSP), in conjunction with output from the HYSSR model. The CRiSP model is a downstream passage model that tracks the downstream migration of wild and hatchery stocks of salmon and steelhead through the Columbia and Snake River mainstem and dams to below Bonneville Dam (Anderson *et al.*, 1993) and the estuary. The model is used to compare the relative changes in survival of various management alternatives or scenarios involving fish release schedules, transportation, flows, and dam and reservoir passage conditions. It is not intended to develop actual survival information.

The reservoir- and dam-related mortality parameter values used in CRiSP 1.4 for this evaluation are consistent with those used for the System Operation Review (SOR) base case (SOR SOS2A). Only the respective flow files, as generated by the HYSSR hydroregulation model, differ between the upstream storage alternatives and SOS2A (base case). The HYSSR output includes average monthly streamflows, over a 50-year period of record. The CRiSP model requires daily flow estimates, because proportions of juvenile salmon populations are moved within the model on a daily time step and, for some parameters, in 2-hour increments. In order to accommodate this greater resolution, the average monthly flows over the 50 years of record (from the HYSSR output) were modulated to generate consecutive daily flow shaping data for historical weekend and weekday power operations. This modulation would not be optimal for fish flow benefits and maintaining the flow shaping limitations imposed by historical power operations.

The CRiSP 1.4 is not highly sensitive to, or directly dependent on, a specific flow/survival relationship such as the Sims and Ossiander (1981) data set for spring/summer Chinook salmon (yearling Chinook salmon). However, the effects of modified flow scenarios are evident in the output. Flow is treated in CRiSP 1.4 as a dominant covariant acting to influence reservoir predator activity and distribution in relation to smolt travel time, as modified by flow.

The CRiSP 1.4 differs from the other mainstem passage models used throughout the region [the Passage Analysis Model (PAM) (McConnaha, 1992); and the Fish Leaving Under Several Hypothesis (FLUSH) model (Weber and Petrosky, 1992; and Weber *et al.*, 1992)] with respect to its degree of flow sensitivity. The primary difference between the models is the resultant magnitude of the absolute system survival estimates (*e.g.*, PAM and FLUSH predict lower survivals for low flow years and higher survivals for high flow years compared to CRiSP 1.4).

In this evaluation, the CRiSP 1.4 model outputs the median system survival estimates for wild Snake River salmon stocks and Dworshak hatchery steelhead, from the top of the Lower Granite reservoir to below Bonneville Dam, based upon the compilation of 500 individual runs. The analysis was made for both "with" and "without" the smolt transportation program.

b. Study Results

The following is a summary of the median survival rates over the 50 years of record, by stock, for the 85,000 cfs and 120,000 cfs flow targets for both the 2½- and 4½-month flow duration periods. Individual model runs for any of the respective salmonid stocks exhibited standard deviations that were maintained consistently within the stock across the whole gamut of flow augmentation alternatives. The standard deviations indicate that the variability contained within the simulated 50-year flow record for each alternative can be large for the alternatives when juveniles are not transported, and lower for those same alternatives when juveniles are transported. Standard deviations are included in parentheses.

Dworshak (Base) With Galloway Added Median Smolt Survival Percent (Standard Deviation)				
	Flow Target			
	85,000 cfs		**120,000 cfs**	
	Flow Duration Months		**Flow Duration Months**	
	2.5	**4.5**	**2.5**	**4.5**
Species, Without Transportation				
Spring Chinook				
Base Condition	25 (9)	24 (9)	25 (9)	24 (9)
With Galloway	23 (9)	24 (9)	24 (9)	25 (10)
Summer Chinook				
Base Condition	28 (9)	27 (9)	28 (9)	29 (8)
With Galloway	28 (8)	27 (8)	27 (8)	28 (9)
Fall Chinook				
Base Condition	11 (6)	11 (6)	09 (5)	10 (6)
With Galloway	09 (5)	11 (6)	09 (5)	11 (6)
Dworshak Steelhead				
Base Condition	28 (11)	27 (11)	28 (11)	29 (11)
With Galloway	28 (11)	27 (11)	27 (10)	29 (11)
Species, Without Transportation				
Spring Chinook				
Base Condition	38 (4)	37 (4)	38 (4)	37 (4)
With Galloway	37 (4)	37 (4)	37 (4)	37 (4)
Summer Chinook				
Base Condition	39 (3)	38 (3)	39 (3)	38 (4)
With Galloway	38 (3)	38 (3)	38 (3)	39 (4)
Fall Chinook				
Base Condition	42 (7)	41 (7)	42 (7)	40 (7)
With Galloway	38 (6)	42 (7)	37 (6)	40 (7)
Dworshak Steelhead				
Base Condition	45 (4)	44 (5)	45 (5)	44 (5)
With Galloway	44 (5)	44 (5)	43 (5)	44 (5)

Based on the assumptions and evaluation completed as part of the Phase I study, there are no quantifiable benefits of adding new upstream storage for the purpose of increasing fish survival in the lower Snake and Columbia Rivers. The estimated benefits to fish modeling survival were found to be marginal, and fall within the margin of error in the analysis. Although additional storage showed no measurable quantifiable biological benefit, in terms of improved salmon survival (as determined using CRiSP), the Phase I analysis probably does 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 in all probability understate the benefits to fish migration.

Of the alternative projects that were evaluated, the Galloway Project was found to be the alternative with the most potential for increasing juvenile fish survival.

Sensitivity studies indicate that barge transport is a necessary program, in combination with upstream storage.

In spite of the marginal benefits of upstream storage, there are numerous qualitative reasons that have been identified for keeping additional upstream storage as a viable alternative in the Phase II evaluation. The following is a list of those reasons:

- Upstream storage, including the Galloway Project, 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. The Galloway Project could be used to augment flows for spring Chinook, allowing the water in the Dworshak Project to be saved for water temperature control in the Snake River for fall Chinook.

- Water from upstream storage could be used for pulsation purposes to aid the migration process during peak migration periods.

- In the event that water from upstream storage could be effectively managed, and releases 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 2½- or 4½-month periods, assumed in the Phase I study. In addition, optimization of flows would 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 fish collector). Benefits from such a combination would be limited to the reach of river between the alternatives, but could increase fish survival for the total system due to cumulative increased efficiency.

- The feasibility of transferring the flood control storage space from the Brownlee Project to the Galloway Project could improve the effectiveness of upstream storage, and should be considered further.

- 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.

c. Discussion

Transportation has the most influential effect on modeled juvenile survival for all stocks, especially for wild Snake River subyearling (fall) Chinook salmon. The transport assumptions, based upon the 1986 Transport Benefit Ratios (TBR) for spring and fall Chinook salmon used in the SOR, were used for these SCS CRiSP 1.4 runs in order to remain consistent with SOR. The response to transportation is based upon the sensitivity to transport assumptions shared by all of the mainstem passage models used in the region. Wild spring and summer chinook salmon and Dworshak hatchery steelhead benefit consistently, with about a 10-percent increase in estimated median survival across all alternatives, due to maximizing transport compared to leaving all fish in the river to continue their migration. The most dramatic increased benefit attributable to maximizing transportation occurs with wild subyearling Chinook, who show a consistent increase of around 25-percent estimated actual survival. Subyearling Chinook transport assumptions that are consistent with the SOR utilize the 1986 mean TBR of 2.4 (established at McNary). This is held constant for the upstream Snake River collection dams, as opposed to scaling either the TBR or the associated transport survival estimate for the upstream collector dams. A substantial contributing factor for this increased survival (due to transportation) is the observable hypothesis that transport physically removes small-sized juvenile subyearling Chinook from relatively poor in-river conditions where higher temperatures contribute to greater predator activity during the later summer months of the smolt outmigration season. This effect is more substantial during low flow years and conditions.

The CRiSP 1.4 runs are fairly consistent with the results of a HYSSR flow analysis, except for spring Chinook. In this case, CRiSP shows a decrease for an augmentation period of 2 months, while HYSSR shows increased flows. Generally, survival would tend to increase with an increase if flow. Other minor discrepancies are explainable by model behavior, with respect to factors such as the volume and rate of water spilled and/or migration timing of the respective salmonid stocks. The HYSSR analysis support CRiSP 1.4 in indicating that Galloway strains to adequately trap and store a sufficient volume of water for summer flow augmentation after supplying the release requested during the earlier spring Chinook salmon passage, especially during naturally-occurring, critical low flow years. As designed with respect to flow shaping, augmentation in the spring is aided by the higher natural spring runoff contributed by the subbasins, and would principally benefit spring Chinook salmon at the expense of fall Chinook salmon. Natural flows diminish as the summer days pass and temperatures increase. Therefore, any assumed flow/survival relationship for wild subyearling Chinook salmon could hypothetically become increasingly important to survival, as greater flow volumes could be augmented through August (*e.g.*, increasing duration from 2½ to 4½ months).

Evolutionarily wild subyearling fall chinook salmon should be better adapted to the naturally-occurring, lower flow conditions that occurred during the summer and early fall of pre-dam conditions. Based on this hypothesis, one should not entirely expect the critical need to physically meet the 85 thousand cfs (Kcfs) or 120 Kcfs flow targets in near average flow years that are assumed to be most beneficial for spring Chinook salmon, even though the higher velocity and turbidity would benefit subyearling Chinook salmon by handicapping the search efficiencies of predators (*e.g.*, smallmouth bass). The National Marine Fisheries Service estimates that about 55 Kcfs is the minimal flow required to stabilize Snake River fall Chinook populations (NMFS, 1993 and 1994). In fact, the attempt to augment for target flows for 4½ months instead of 2½ months only slightly benefits median subyearling Chinook salmon by a 1-percent relative increase as Galloway is added. This slight increase is well within the statistical variability of CRiSP 1.4, because average flow augmentation of about 50 Kcfs could be provided during the peak subyearling Chinook passage month (July). The HYSSR model indicates that, by adding Galloway flows, the 85 Kcfs or 120 Kcfs targets requested for spring Chinook salmon can never be achieved during August under any of the proposed alternatives. The slight increase that could be provided by targeting for 120 Kcfs, but only being able to achieve near 60 Kcfs during July in the 4½-month-long scenarios, was enough of a proportional increase in flow (due to the addition of Galloway) to result in a near 10-percent increase in relative change in percent survival for fall Chinook salmon.

Neither spring or summer Chinook salmon benefit from any flow augmentation alternative when transportation is maximized. If fish were to remain in-river, there are only slight benefits (<5-percent relative change in survival) to spring Chinook salmon only when flows near 100 Kcfs are provided in an attempt to meet the 120 Kcfs target for the 4½-month-long alternative. The same effect seen in the subyearling Chinook salmon analysis is evident for spring Chinook salmon. These high flows near 100 Kcfs can be provided by the addition of Galloway to Dworshak up near 40 to 50 percent of the flow years (HYSSR analysis).

This same effect is also evident for summer Chinook salmon if they are left in-river, or are returned to the river to continue their migration. The exception is the 2½-month, 120K-kcfs target alternative for both wild summer Chinook salmon and Dworshak hatchery steelhead, where the desire to achieve the target flow for spring Chinook salmon forced HYSSR to spread the near 60 Kcfs of additional flow that was allocated during June for 4½ months into the supplementation of June flows for the 2½-month scenario (HYSSR analysis).

If the more flow-sensitive passage models (PAM and FLUSH) were run for this analysis, it would be expected (with a fair degree of confidence) that slight increases in the magnitude of benefit proportional to the scheduled duration and increasing flow target volumes would occur compared with CRiSP 1.4. The absolute survival estimates for the in-river scenarios would proportionally increase under all flow years with additional augmentation, due to the flow/survival critical assumption incorporated into both PAM and FLUSH; especially for individual low flow years where the target flow could be achieved. The median hydrosystem survival estimates to below Bonneville Dam for low flow years would be less than that estimated by CRiSP 1.4, but the relative change in percent survival would likely indicate a slightly greater benefit with proportionately greater flow augmentation.

2.08. Other Environmental Effects

a. General

The environmental effects described in the subsequent paragraphs are a summary of the more significant effects identified in the Galloway terminated feasibility study, and subsequent efforts.

b. Water Quality

Estimated water quality conditions, and trends within the Galloway Reservoir, are based on conditions in nearby similar reservoirs. Land-use activities and Galloway operations are considered. Mathematical modeling enables more precise quantification, as well as an understanding of the processes and nature of the various changes and concentrations of water quality constituents. Such investigative modeling efforts may be necessary in the design phase of this project.

Galloway Dam operation, especially the potentially high volume discharges for downstream fish passage during the spring, will significantly affect and determine reservoir water quality conditions. It is assumed, in the general discussion of water quality that follows, that the filling of the pool during the winter and early spring will result in a full pool by mid-April. Projected reservoir elevations based on the previous 50-year record, indicate that this will occur roughly every other year. It is also assumed that the entire volume of water necessary for fish passage (715,000 AF) will be withdrawn for flow augmentation, as needed. All other analyses included in this document are based on expected pool elevations derived from the analysis of 50 years of hydrologic data.

During the release of water for anadromous fish, it is unlikely that stratification of the reservoir will occur. The ability of the reservoir to clarify inflows is suspect. Most of the inflowing sediment is presently composed of fine silts and clays and, therefore, settling rates are slow. With a bottom discharge, much of the suspended solids could pass downstream.

Loading of nutrients will be high, with probably 80 percent of the phosphorus load coming from streambank erosion [Weiser River Soil (WRS) Conservation District]. Most of this phosphorus is probably in the particulate phase and strongly bonded to sediments and, therefore, not available to the water column. However, a high amount of dissolved phosphorus will still exist to allow algal production, and not be a limiting factor.

The land area to be inundated and drained by Galloway Reservoir contains mercury deposits and formerly active mercury mine. An investigation to predict the levels of mercury to be expected in Galloway Reservoir fish (Buhler, Reed, and Caldweld, 1984) indicated that the average mercury concentrations will fall within the range of 0.17 and 1.32 milligram/kilogram (mg/kg) wet weight. The Food and Drug Administration's (FDA) present action level for methyl-mercury is 1.0 mg/kg. The potential for mercury contamination of the water and associated effects should be evaluated in detail in Phase II.

Water quality conditions within Galloway Reservoir, as with most reservoirs, will be at their worst during the first 3 to 4 years after filling. During this tie, decomposition of vegetative material and organic sediments occurs, reducing dissolved oxygen concentrations and increasing the levels of ironically-reduced constituents (*i.e.*, iron and manganese). Because of the small amount of vegetation in the watershed, these adverse conditions will probably not be as severe as noted in other reservoirs. Following this initial period, water quality conditions will improve and stabilize.

Downstream impacts will depend on reservoir water quality conditions and discharge operations (*e.g.*., the use of selector gates). Of utmost concern in the lower Weiser River will be the temperature and dissolved oxygen levels, with turbidity and nutrients of lesser concern. During most summers, hypolimnion dissolved oxygen concentrations will be low, and will possibly be inadequate for downstream use by fish species. Because of the relatively high gradient of the lower river (8 feet per mile) and the presence of riffles, progressive reaeration will occur as the water flows downstream.

Impacts to the Snake River, from Weiser River impoundment, will be minimal. The Weiser River accounts for approximately 9 percent of the total flow to the Snake River, and little difference in water quality or sediment loading is expected due to the impoundment of the Weiser River upstream. During flow augmentation with 11,000 cfs, the Weiser River will be from 30 percent to 50 percent of the total flow in the Snake River at Weiser. Water quality changes downstream can be adequately evaluated by the detailed modeling of reservoir and discharge water quality.

c. Cultural Resources

The area will greatly change with the construction of Galloway Dam. Cultural sites located at lower elevations within the proposed reservoir area will be totally inundated, and will be lost to further study. Other sites may be partially inundated and subject to loss from erosion and deterioration. An increased human presence in the area will increase the changes of human activity impacting cultural properties.

To date, no systematic cultural resource survey has been undertaken for the Galloway Project. Approximately 12 sites have been recorded within the project area. However, based on the results of previous work, the prehistoric potential in the Galloway area is considered fairly great, and could range as early as 7,000 years ago to historic times. Testing and evaluation work is also needed to determine site significance and National Register of Historic Places eligibility. These investigations, together with the assessment of project impacts will be needed in Phase II to determine cultural resources mitigation needs.

d. Vegetation

The obvious impact to vegetation is the loss caused by inundation from the reservoir. More subtle impacts are land-use changes and consequent impact to vegetation in the lower Weiser River below the project. In the reservoir area, nearly 6,900 acres of riparian and upland vegetation will be inundated. The project will likely induce change in cover types, along the Weiser River, below the damsite. Because of project channel work and bank protection measures, landowners bordering the river will be enabled to convert some riparian and wetland areas to crop and pasture, since flooding in these areas will be reduced. No change in vegetation is expected below the mouth of the Weiser River.

e. Resident Fish

(1) Species Impacts

Project impacts to resident fish resources will occur in three locations: the reservoir area; the lower Weiser River; and potentially in the Snake River below the mouth of the Weiser River. Existing stream fisheries for rainbow trout and smallmouth bass will be eliminated in the permanent inundation area. Stream fisheries in the upper reservoir area will also be degraded, due to annual inundation as the reservoir refills after the previous year's drawdown. Indirect impacts may occur from stream habitat deterioration above the reservoir, and from the proliferation of nuisance fish species. Stream habitat may be adversely affected by silt accumulation in the streambed just above the reservoir. Although no data is available to estimate this effect, it is likely to be a minor loss. Nuisance fish (*e.g.*, squawfish) may thrive in the reservoir, and migrate above the reservoir to spawn. They could compete with, and feed on, populations of more desirable nongame and game species. However, the effect may be minor if existing squawfish populations in the river are fully using spawning habitat.

The reservoir may possibly provide suitable conditions for game fish populations. However, extensive annual drawdown and potentially unsuitable temperature and turbidity conditions severely limit fishery potentials. Model studies indicate that habitat suitability will be low to moderate for black crappie, yellow perch, smallmouth bass, and rainbow trout, provided these species could even survive the large volume water releases.

Below the project, fish populations in the Weiser River will be affected by changes in flow regimes and temperature, as well as by potential changes in stream substrate. Model studies indicate that warmwater species use will be reduced because of decreased flows and habitat during the winter months. Habitat suitability for cold-water species will remain similar, or will increase slightly. However, with probably channel degradation and the loss of suitable spawning areas, it is assumed that the spawning run of rainbow trout that enter from the Snake River will decline. Spawning of bass in the Brownlee reservoir could also be a concern.

(2) Species Mitigation

Because of the extremely limited information on fish abundance and the impacts of the proposed project, angler days will be the focus of mitigation rather than a one-for-one replacement of habitat and/or fishery losses. A breakdown between cold- and warmwater fishing effort is not possible for existing conditions. Therefore, efforts were made to mitigate for the total fishery, without regard to cold- or warmwater activity. Although reservoir fishing activity is used to mitigate for lost stream fishing activity, it is widely accepted that stream fishing activity is more valuable (and limited within the State).

For the entire project, it is anticipated that an annual deficit of 1,325 stream angler days will result from the installation of the dam and reservoir. The goals for mitigation, therefore, will be to completely replace those 1,325 days of fishing activity, with emphasis on the stream fishing activity.

It is recommended that stocking rainbow trout and placing boulder fields/riparian vegetation complexes in the lower river, and stocking trout in the reservoir, be implemented to mitigate for the project-related decreases in the fishery.

f. Wildlife

(1) Goals

The following goals were defined by the Habitat Evaluation Procedure (HEP) terrestrial evaluation team to offset the significant losses of wildlife resources in the reservoir basin and the lower Weiser River:

- The long-billed curlew is recognized by both state and Federal agencies, as well as private organizations, as an important species (declining species of special concern) whose habitat losses should be minimized. A project goal is to recover unavoidable curlew habitat losses in-kind or with out-of-kind resources. The Columbia sharp-tailed grouse, a species with a limited, dwindling range and declining population (identified as a sensitive species in Idaho), was identified as a potential out-of-kind resource to offset curlew habitat losses.

- The Idaho ground squirrel is also an important species recognized by state and federal agencies and others (Idaho Sensitive Species, Federal Candidate Species for the Endangered and/or Threatened Species List). A project goal is to minimize habitat losses and, if possible, encourage the establishment of new colonies in a suitable habitat.

- Upland game bird habitat losses will be significant and unavoidable with any alternative. A project goal is to compensate for pheasant and quail losses by improving management on compensation lands adjacent to the reservoir, and/or adjacent to the lower river. Chukar losses should also be offset with improve management on compensation lands. Net gains in chukar habitat value will be acceptable for offsetting the losses of pheasant and quail.

- Big game (species that are economically "significant") winter habitat loses will result from any reservoir alternative. A project goal is to select and manage areas for compensating other species and habitat losses that provide winter game range improvements (as management for sharp-tailed grouse and meadowlark will improve upland/rangeland).

- Among affected habitats, wetland cover types (wetland, riparian, and woody draw cover types) were identified as those whose losses should be replaced. These habitats are considered Resource Category 2 under the USFWS Mitigation Policy [Federal Register, Vol. 46 (15). 7644-7663] and, as such, the USFWS goal is no net loss of in-kind value. Other cover types are considered Category 3 and 4 resources and, as such, the goal is to fully compensate their losses.

- A final goal is to improve conditions wherever possible for any threatened or endangered species, or any other species of special state, local, or Federal concern. For example, compensation lands or land management practices of any project lands that might prove conditions for bald eagle use will be favored, particularly if the lands or practices meet other mitigation needs.

(2) Mitigation Measures

Approximately 4,384 acres of private land, in two locations, will also be acquired for project wildlife habitat mitigation. The locations of these areas are: 202 acres along the lower Weiser River, and 4,182 acres in the Pole Creek area. Public land of about 625 acres (all state-owned) in the Pole Creek area will be included in the wildlife unit, in addition to private land. Further studies on this mitigation will be required to determine whether the procedures used in this evaluation are acceptable under newly established procedures.

g. Future Mitigation Study Needs

(1) Refinement of HEP Analysis

Because of recent requirements of the incremental analysis procedure, additional field efforts are needed to refine the HEP analysis, such that techniques inherent in the HEP are compatible with the incremental analysis procedure. Modifications to the mitigation measures may be necessary, but are not expected to significantly change the magnitude of the acreage or cost requirements for mitigation.

(2) Wetland Species

Although the acquisition of the Lower River and Pole Creek Units will provide about 90-percent compensation for significant species overall, the units will only replace 70 percent of the total losses for wetland species. The USFWS Mitigation Policy is to accept no out-of-kind replacement for wetland/riparian habitat values because of the scarcity and importance of this habitat in the Great Basin. The Corps supports full compensation of wetland/riparian habitats.

Within the Thousand Springs Unit (one of the units recommended for mitigation by USFWS), 25 percent of total Average Annual Habitat Unit (AAHU) losses for wetland/riparian species can be gained with riparian rehabilitation management and the development of two wetlands recommended by USFWS. Applicable portions of this unit should be studied for possible incorporation into the mitigation plan. It will also be possible to "fine-tune" this plan to achieve 100-percent mitigation for wetland species by evaluating portions of other recommended units, along with the gathering of additional habitat and resultant management data.

(3) Goose Nesting

Goose nesting islands will be affected by the project, due to altered Snake River flows and changes in Brownlee Reservoir water levels. The changes may result in the flooding of some goose nests. A study should quantify these impacts by incorporating BPA's water budget investigations, and determining the degree of impact and the amount of compensation necessary. The study should include a determination of flow/water elevation relationships at specific Snake River islands, concurrent with an intensive nesting study. Data collection should continue during the 2 years prior to project construction, and for 2 years after completion and operation of the project.

h. Future Evaluation Needs

The USFWS has review their past Coordination Act Report (1985) for the Galloway Project relative to current conditions. The USFWS has provided, in a letter dated 14 October 1992 an initial list of study needs that will be required as part of the SCS upstream storage study (see exhibit 2).

A follow-on letter was received from the USFWS, dated 27 May 1993 (see exhibit 3), regarding the evaluation of the anadromous and resident fish and wildlife benefits as a result of the Galloway Project. It was decided that, for the Phase I portion of the study, coordination will be accomplished through the Technical Advisory Group (TAG). The TAG includes representatives from the USFWS, as well as from several other agencies. In the event that the Galloway Project is recommended for further study in Phase II, normal Coordination Act Report procedures through the USFWS will be followed.

i. Summary

Since there are no remaining stocks of anadromous fish above Hells Canyon Dam on the Snake River, there are not likely to be any negative impacts as a result of construction of the Galloway Project.

The land area to be inundated and drained by Galloway Reservoir contains numerous mercury deposits and a formerly active mercury mine. Consequently, following initial filling, fishing will have to be prohibited for a period of 2 to 5 years. Impacts to the Snake River, from the Weiser River impoundment, will be minimal. However, further studies are needed.

Approximately 12 cultural resource sites have been recorded within the reservoir area. However, the prehistoric potential in the Galloway area is considered fairly great, and could range from as early as 7,000 years ago to historic times. Testing and evaluation work is needed.

Nearly 6,90 acres of riparian and upland vegetation will be inundated. The project will induce change in cover types along the Weiser River (below the damsite). No change in vegetation is expected below the mouth of the Weiser River.

The reservoir may possible provide conditions for game fish populations, but extensive drawdown and possible unsuitable temperature and turbidity conditions will severely limit the potential. Below the project, the fish population will be affected by changes in flow regimes and temperature.

The Coordination Act Report provided by the USFWS (1985) for the Galloway Project included an initial list of study needs that will be required as part of the SCS upstream storage study.

2.09. Implementation Schedule

It is assumed that the SCS Phase II will complete the terminated feasibility study of Galloway in a Re-Evaluation Report and Environmental Impact Statement. If Galloway were to be recommended for construction as a Federal project following the completion of the SCS, the project would require Congressional authorization and appropriations prior to implementation.

The first step in the implementation plan for Galloway calls for the preparation of Design Memorandums (DM's), followed by Plans and Specifications. Land acquisitions will have to be completed prior to the initiation of actual construction. The DM's will require approximately 2 years to complete, and the preparation of plans and specifications will require another 2 years. Land acquisitions, advertising, and the awarding of a construction contract will require another year. After awarding a construction contract, it is estimated that construction will require 4 years to complete. In all, the time required to implement this project is 11 years.

A conceptual breakdown of the construction effort for each of the respective years is shown below. The actual schedule will depend on several factors and may vary from this general outline.

Year 1
Develop borrow sources Being processing materials Begin penstock and diversion/outlet channel construction Strip abutments Construction access roads and temporary facilities Construct fire breaks Begin spillway and stilling basin construction
Year 2
Clear shorelines Fence mitigation units Complete penstock and diversion/outlet channel Complete processing materials Complete stilling basin Continue spillway construction Construct cofferdams and divert river into completed diversion/outlet channel Complete foundation preparation Begin powerhouse construction Construct dam embankment to elevation 2300
Year 3
Continue spillway and powerhouse construction to completion, if possible Construct wetland mitigation units upstream of dam Begin downstream improvements
Year 4
Complete spillway and powerhouse Complete dam embankment, if not completed in Year 3 Complete downstream improvements Construct wetland mitigation units downstream of dam Construct low-level outlet gates and intake tower Burn and seed rangeland Plan riparian and wetland areas Complete recreational facilities

During the construction of the embankment section, the Weiser River will be diverted through the regulating outlet conduit. In the first construction season, the regulating outlet and penstock will be constructed. This is possible without diverting the river because the regulating outlet and penstock are located above the normal river level. Physical hydraulic model studies in the design phase will address the feasibility of combining the diversion works and the augmentation outlet into one structure, as well as defining the resulting design requirements for the downstream stilling basin. The combination of a narrow canyon site, fill material quantities, historical flood frequency, and construction time requirements may leave the partially-completed fill vulnerable to overtopping. Additional risk analysis may be warranted to ensure that the diversion scheme adequately fits the seasonal phasing of the construction sequence.

At the beginning of the second construction season, both upstream and downstream cofferdams will be constructed (these cofferdams will eventually become a part of the completed dam embankment), and water will be diverted through the ungated regulating outlet conduit. The conduit will be capable of discharging 9,000 cfs under open channel flow conditions, or up to 18,000 cfs with 100 feet of pressure head. This will permit the dewatering of the work area so that the embankment section can be constructed. At the end of the second construction season, the embankment must be completed to elevation 2300, but no higher than elevation 2310.

The embankment at elevation 2300 will have adequate capacity to prevent overtopping the partially-completed dam for all floods up to, and including, the 100-year flood. At elevation 2310, the reservoir will store approximately 90,000 AF of water, which is approximately 10 percent of the completed full pool storage.

At the end of the third construction season, the embankment must be completed to elevation 2470 or higher. The spillway section, except for gates, must be functionally complete in order to pass a SDF without overtopping. During the fourth construction season, the embankment will be topped out at elevation 2495, if not completed previously, and the gates will be installed in the regulating outlet, intake, and spillway. When it is necessary to work inside the intake or regulating outlet conduit, water will be diverted through the penstock.

2.10. Cost Estimates

a. General

The cost estimates prepared for this project are intended to be used in the planning process for comparison purposes only. These costs are not of sufficient detail for use in obtaining project authorization and appropriations. Estimates contained in this report reflect costs from the terminated feasibility study, updated to current price levels. Costs were updated using Engineer Manual (EM) 1110-2-1304, *Civil Works Construction Cost Index System.*

b. Construction

The cost estimate for the Galloway Project includes all costs incurred in constructing the project, including the acquisition of real estate. The cost estimate assumes that the portion of the Union Pacific Railroad inundated by Galloway Reservoir will be purchased, rather than relocated. An executive cost summary for Galloway Dam and reservoir is shown in table 2. All estimates are based on October 1992 cost levels and the requirements of EM 1110-2-1301. Since inflation was nil, the October 1992 cost level was assumed to be the same as the 1993 cost level. The total estimated project cost, with inflation (fully-funded), is $215 million.

c. Railroad Abandonment

Although Galloway Reservoir will not inundate the entire length of the branch railroad, it will cut off the traffic sources that are located above the reservoir. As a result, Galloway will eliminate the entire branch line as a viable economic unit. The Galloway project will be responsible for acquiring the railroad property and facilities within the project bounds.

The loss of the railroad will eliminate a transportation alternative for two mills, as well as other branch line customers. By switching from rail to trucks, annual transportation costs will increase about $730,000 for these customers. Due to increased truck traffic, highway maintenance costs will increase $230,000 annually. These increased costs for shippers and highway maintenance are economic costs of the project, but shippers and the state will not be compensated.

d. Mitigation

Mitigation costs will include $1.2 million for downstream water quality and wildlife, and $640,000 for land. These costs are included in the construction cost estimate.

e. Operation, Maintenance, and Replacement (OM&R)

The project will require a staff, and appropriate equipment for O&M. The estimated annual cost for operation, maintenance, and replacement (OM&R) is $750,000. The estimated cost for OM&R of the dam and reservoir include labor, supervision, clerical, equipment operating costs, and vehicle operating costs. The OM&R estimates for the levees include labor, supervision, power for and operation of drainage pumping plants, equipment operating costs, and vehicle operating costs. Powerhouse OM&R includes labor and equipment required to operate and maintain the powerhouse facilities.

Mitigation for lost fish habitat at the Galloway Project will require annual maintenance of instream habitat in the Weiser River downstream of Galloway Dam. Fish stocking for the Weiser River and Galloway Reservoir will also be required. Wildlife mitigation will require a full-time biologist/manager, and maintenance costs for fences, equipment, and roads. The total annual cost for O&M of fish and wildlife mitigation features is estimated to be $130,000.

f. Cost Summary

Total initial costs are summarized below. The project cost is at a 1 October 1992 price level. However, since the rate of inflation is nil, it is comparable with other costs and benefits for comparison purposes. Interest during construction is compounded monthly, and applied to anticipated payout of project costs during land acquisition, and over a 4-year construction schedule. The interest rate is 8.0 percent.

Project Cost:	
1 October 1992 Price Level	$189,000,000
Fully-Funded[1]	$215,000,00
Interest During Construction	$40,100,000
Investment Cost	$229,100,000
[1]Reflects inflation to midpoint of construction.	

Annual costs are summarized below. Interest and amortization charges are based on an 8.0-percent interest rate and a 100-year project life. Transportation damages will not be an actual expenditure, but are a cost of the project.

Interest and Amortization	$18,340,000
OM&R	$750,000
Increased Cost to Shippers	$730,000
Increased Highway Maintenance	$230,000
Total Annual Cost	**$20,050,000**

2.11. Economic Effects

a. Power

The evaluation of the impacts of alternative storage options for flow augmentation on system power generation and costs was completed using the HYSSR model, in conjunction with a spreadsheet model developed by the SOR Power Work Group. The HYSSR model, as explained above, simulates the operation of the Columbia/Snake River system over a 50-year hydrologic period of record. System power generation is one output report produced by the model. This report shows how much power the system can generate, but does not calculate system generation costs.

The analysis of system generation costs for each alternative, including the use of existing storage in the Dworshak Reservoir to meet flow objectives, was done with the SOR Power Work Group's spreadsheet model. The results for each alternative were then compared to the base condition to determine the change in system generation costs relative to the base condition.

The SOR spreadsheet model was designed to calculate the total system cost for alternative system operating strategies. Many simplifying assumptions were made regarding resource acquisition, resource dispatch to meet regional and out-of-region power loads, power purchase costs, and other related input to the model. However, during development of the model, results were validated by comparison of results with the results of BPA's System Analysis Model (SAM). The SAM model is used by BPA and others to analyze power system operations in much greater detail.

Input to the spreadsheet model includes system power generation from the HYSSR model studies of the alternatives, along with information on monthly power loads, other hydro and thermal resources, fixed and variable costs of operating thermal resources, the cost of purchased power, the value of energy exported from the region, thermal plant maintenance schedules, the demand for surplus power, and the capacity of the Pacific Northwest/Pacific Southwest intertie. Power loads used in the model are for the 1993 operating year, and costs are in 1993 dollars. Using these inputs, the model acquires new resources, or makes purchases, if existing Pacific Northwest hydro and thermal generation is insufficient to meet regional loads. It also displaces regional thermal plants, if possible, and sells power to the Pacific Southwest region if there is excess generation in the Pacific Northwest.

The primary output of the model is the total annual cost of operating the entire Pacific Northwest power system in millions of 1993 dollars. Costs include the capital cost of new resources, as appropriate, and the operating cost of both existing and new resources, less revenues from the sale of power to the Pacific Southwest region.

Power system generation cost results from the SOR Power Work Group spreadsheet model consist of total annual system costs in 1993 dollars. Costs include the cost of operating existing resources, as well as the cost of acquiring and operating any new resources that would be required to meet Pacific Northwest loads: 1) assuming new combustion turbines would be acquired and operated to meet loads; and 2) assuming energy could be purchased from sources outside of the region on the sport-market. However, only the results for the combustion turbine option are presented. The results of the purchase options are not shown because the analysis required to demonstrate that surplus generation outside the region would continue to be available over the long-term was not conducted.

The analysis was conducted to evaluate the impact of adding the Galloway Project to the hydropower system. The analysis was made based on four different base conditions; reflecting the 85,000 cfs and 120,000 cfs flow targets, and the 2½-month and 4½-month flow duration periods. In each analysis, the base condition consists of operating existing storage, namely the Dworshak project, to meet the specified flow targets at Lower Granite Dam. The results of the analysis are summarized below. The number in parentheses (*e.g.*, SOS2AX0) correspond to the HYSSR run number.

Target Flow at Lower Granite Dam: 85,000 CFS Flow Duration: 2.5 Months				
Alternative (HYSSR) Run Number	**System Generation (annual MW)**	**New Combustion Turbines (annual MW)**	**Total System Costs ($1,000)**	**Change From Base Condition ($1,000)**
Dworshak Only (Base Condition) (SOS2AX3)	15,504	4,100	1,657,000	Base Condition
Dworshak With Galloway Added (SOS2AX4)	15,509	3,650	1,594,000	(63,000)
Target Flow at Lower Granite Dam: 85,000 CFS Flow Duration: 4.5 Months				
Alternative (HYSSR) Run Number	**System Generation (annual MW)**	**New Combustion Turbines (annual MW)**	**Total System Costs ($1,000)**	**Change From Base Condition ($1,000)**
Dworshak Only (Base Condition) (SOS2AX3)	15,428	4,600	1,756,000	Base Condition
Dworshak With Galloway Added (SOS2AX4)	15,432	4,250	1,708,000	(49,000)
Target Flow at Lower Granite Dam: 120,000 CFS Flow Duration: 2.5 Months				
Alternative (HYSSR) Run Number	**System Generation (annual MW)**	**New Combustion Turbines (annual MW)**	**Total System Costs ($1,000)**	**Change From Base Condition ($1,000)**
Dworshak Only (Base Condition) (SOS2AX3)	15,453	4,700	1,746,000	Base Condition
Dworshak With Galloway Added (SOS2AX4)	15,456	4,350	1,698,000	(48,000)

Target Flow at Lower Granite Dam: 120,000 CFS Flow Duration: 4.5 Months				
Alternative (HYSSR) Run Number	**System Generation (annual MW)**	**New Combustion Turbines (annual MW)**	**Total System Costs ($1,000)**	**Change From Base Condition ($1,000)**
Dworshak Only (Base Condition) (SOS2AX3)	15,415	4,900	1,793,000	Base Condition
Dworshak With Galloway Added (SOS2AX4)	15,417	4,700	1,767,000	(26,000)

At-site power generation is included in the total system power generation. At-site generation appears to be marketable, since significant amounts of desirable energy will be produced during the high load months of December and January.

As indicated above, under each flow and flow duration, the system power costs are reduced when compared to the base condition. The reduced system power cost in each case can be attributable to allowing the Dworshak Project to operate at a higher head and, therefore, produce more electrical energy than can be generated in the base case.

b. Recreation

The Galloway project will impact recreation on the Weiser River, from the reservoir area to the river mouth; and the Snake River, from the mouth of the Weiser River to the Lower Granite reservoir. Galloway Reservoir will provide substantially different recreational opportunities than those currently existing on the Weiser River. Galloway will slightly impact recreation on Brownlee Reservoir, due to changes in pool elevations caused by the storage exchange (if implemented) for augmentation. Recreational impacts at, and below, Brownlee Dam are relatively minor and were not estimated. It was estimated, in updated from the August 1990 Technical Report, that the Galloway Reservoir would provide water-based recreational opportunities worth about $196,000 annually to the national economy. The impact on local economy would be significantly greater. Since recreational benefits are substantially less than the total project's net benefits, project feasibility is not sensitive to the range of potential water quality conditions in the reservoir.

c. Employment

Labor requirements of the Galloway project far exceed unemployed labor available in the area, and will result in the employment of 28 unemployed construction workers. The present value of wages that would be paid to otherwise unemployed labor is $880,000. The annual equivalent benefit is $78,000.

d. Flood Damage Reduction

In the August 1990 Technical Report, average annual damage remaining after a reservoir is in operation at the Galloway site was calculated by substituting the regulated frequency curve for the frequency curve under natural conditions in the damage-frequency integration process, and considering the effect of channel improvements. In the technical report, it was estimated that flow regulation by the Galloway Reservoir would reduce the frequency of flows greater than 11,000 cfs for a 500-year flood. Channel protection measures would essentially prevent all damages up to a 500-year flood. Average annual flood damage reduction benefits attributable to the project are estimated at $110,000. Since the channel protection measures will be required for flow augmentation operations rather than for flood control, the flood control benefits were fully attributed to the reservoir operation.

e. Summary

The average annual economic costs and benefits for various project impacts are summarized in the following table:

Economic Analysis of Galloway Project ($1,000)				
	Flow Target			
	85,000 cfs		120,000 cfs	
	Flow Duration Months		Flow Duration Months	
	2.5	4.5	2.5	4.5
Average Annual Costs				
Implementation	20,050	20,050	20,050	20,050
Economic				
Power	(63,000)	(49,000)	(48,000)	(26,000)
Recreation	(196)	(196)	(196)	(196)
Employment	(78)	(78)	(78)	(78)
Flood Damage Reduction	(110)	(110)	(110)	(110)
Total	**(43,334)**	**(29,334)**	**(28,334)**	**(6,334)**

Section 3 - Status/Summary of BOR-Led Interagency Upstream Storage Study

3.01. Background

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 to aid migrating salmon and steelhead. This element was incorporated in the Governor's Report to Senator Hatfield on May 1, 1991. Language was included in page 49 of the NPPC's *Amendments to the Columbia River Basin Fish and Wildlife Program (Phase Two)*, dated December 11, 1991.

As a result of commitments made at the Salmon Summit (and reiterated in the NPPC Phase Two amendments), BOR facilitated an interagency study of 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. Sites evaluated b the Corps and BOR depended on prior involvement at the specific sites. The final report, titled *Snake River Basin Storage Appraisal Study,* dated January 1994, was submitted to NPPC by letter dated 11 February 1994 (see exhibit 3). A copy of the Executive Summary of the report is included in appendix A of this report.

3.02. Purpose and Scope

The purpose of the study was to review the economic feasibility of potential upstream storage as a possible solution to improve the anadromous fish runs in the lower Snake and Columbia Rivers. The study is of an appraisal level of detail based on existing information.

3.03. Inventory

As the first step of the study process, BOR 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, and titled *Snake River Basin Damsite Review.*

3.04. Site Screening

To reduce the large number of sites to a more workable number, the work group evaluated the sites in July 1992 according to agreed-upon screening criteria, as summarized below:

- Wild and scenic river designation
- State scenic waterway(s)
- Northwest Power Planning Council 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

Twelve areas (some with more than one damsite)were selected to receive further evaluation regarding potential water supplies. The 12 areas are listed below:

- Burnt River Basin, Oregon (Hardman and Dark Canyon Sites - onstream)
- Malheur River Basin, Oregon (Warm Springs and other sites
- Upper Malheur River Basin, Oregon (various sites - onstream)
- Owyhee River Basin, Oregon (Owyhee enlargement and other sites - onstream)
- Powder River Basin, Oregon (Thief Valley and other onstream sites, including the North Powder River Basin)
- Bruneau area, Idaho (Sailor Creek, Grindstone Butte, Pilgrim Gulch, and other sites south of the Snake River near Bliss an Glenns Ferry - offstream)
- Payette River Basin, Idaho (offstream sites on north side of river between Emmett and Payette)
- Teton River Basin, Idaho (Teton site - onstream)
- Weiser River Basin, Idaho (Galloway site and Lost Valley enlargement - onstream)
- Jump Creek Basin, Idaho (offstream)
- Succor Creek Basin, Idaho-Oregon (offstream)
- Potlatch River Basin, Idaho (various sites - onstream)

To evaluate the water availability potential for each area, water availability studies were conducted. The studies were accomplished as a joint effort by BOR and the Corps. For each site, the water availability was evaluated, reflecting downstream commitments such as water rights and minimum streamflow requirements. Water availability was based on available water after meeting downstream commitments. As part of the study, it was assumed that excess water during the flow augmentation period of 16 April to 31 August was not available for storage, since it would already be used for flow augmentation.

Based on the water availability of the 12 storage areas, 11 specific sites were identified for an appraisal-level cost and environmental impact evaluation. The sites selected include both offstream and onstream sites, and all are located in the Snake River Basin above Lower Granite Dam. The sites selected for the appraisal study are as follows:

- **Onstream:**
  Galloway site, Oregon
  Teton River, Idaho
  Owyhee Dam and Reservoir Enlargement, Oregon
  Thief Valley Dam, Oregon; replace existing dam

- **Offstream:**
  Moores Hollow, Oregon
  Jacobsen Gulch, Oregon
  Succor Creek Basin, Idaho-Oregon
  Saylor Creek, Idaho
  Rosevear Gulch, Idaho
  Bissel Creek, Idaho
  Conant Creek, Idaho

3.05. Site Evaluation

Damsite locations for the new sites not already established were determined based on field observations, U.S. Geological Survey (USGS) quadrangle maps, and existing studies and reports. A map showing the damsite locations is included in plate 4.

a. Reservoir Sizing

The total reservoir storage for each site, except for the Galloway and Owyhee Dam enlargement, was to be twice the average annual water supply (active storage); plus dead storage for each site or the maximum site storage capacity, limited by geographic constraints (whichever was larger). With the exception of the Teton and Owyhee damsites, each site was limited by geographic constraints, rather than water availability. The Galloway site was based on the August 1990 Technical Report. Table S-1 in appendix A shows the total reservoir capacity of each site, and the average annual water available for release from each reservoir.

b. Dam and Reservoir Cost Estimates

Costs estimates were developed for all selected sites, with the exception of the Galloway and Teton sites, using BPA's Hydropower Analysis Model (HAM) computer model. Costs for the Galloway and Teton sites were based o existing reports, and updated to be consistent with other cost estimates. The HAM model determines cost for potential hydropower projects, and allows cost comparisons to be made between each of the sites. Dam enlargement costs were determined separately from the new sites, because dam enlargement and new site cost comparison would not be compatible due to inconsistent methods of estimating. Table S-1 in appendix A shows the total construction cost, investment cost, OM&R cost, and power costs (for pumping water to offstream storage projects) for each of the sites that were evaluated. The costs are also presented in terms of dollars per AF of average annual water released from the reservoirs.

c. Environmental Impacts

Preliminary environmental evaluations were made of each site. It was determined that the Rosevear Gulch, Jacobsen Gulch, Bissel, and Moores Hollow sites had minimal environmental impacts that could be mitigated. Environmental comments associated with each potential site are presented in a separate table on page S-17 of appendix A.

d. Scenarios Defined

A total of three scenarios were identified for further study, based on a combination of water availability, costs, and location with respect to the lower Snake River, including different combinations of the sites. Each scenario is defined below:

- Scenario 1. (Onstream Sites)
  Galloway Site, Idaho
  Teton Site, Idaho
  Thief Valley Dam Replacement, Oregon
  Owyhee Dam Enlargement, Oregon

- Scenario 2. (Offstream and Galloway
  Galloway Project, Idaho
  Rosevear Gulch, Idaho
  Jacobsen Gulch, Oregon

- Scenario 3.
  Galloway Project, Idaho

The following is a summary showing reservoir storage capacity, average annual water that could be released from each reservoir, and the total cost per AF of water released:

Project Name	Gross Storage AF	Active Storage AF	Average Water Released AF/Yr	Cost Per AF ($/AF/Yr)
Galloway Project	900,000	715,000	335,650	61
Rosevear Gulch Project[1]	675,300	607,800	607,740	224
Jacobsen Gulch Project	208,600	188,600	188,680	269
Total	**1,784,900**	**1,511,400**	**1,152,070**	
[1]Upper Site.				

Since the water availability for the Teton, Thief Valley, Powder River, and Owyhee enlargements was relative small (see page S-6 of appendix A), scenario 1 was eliminated, and only scenarios 2 and 3 were further analyzed and compared to a base condition.

e. System Operation Studies

To evaluate how the new storage could meet salmon flow needs in the lower Snake River, system operation studies were conducted using the HYSSR computer model, described in paragraph 2.05 of this report. Through further screening, only scenarios 2 and 3 (as defined above) were evaluated using the HYSSR model. Two target flows of 85,000 cfs and 120,000 cfs at Lower Granite Dam; and two flow duration periods of 2½ months (16 April to 30 June), and 4½ months (16 April to 31 August) were evaluated.

A total of 12 alternative HYSSR runs were made to evaluate the impacts of adding the Galloway and Rosevear/Jacobsen Gulch sites for each target flow and flow duration period. An additional three runs were made to evaluate the capability of using upstream storage for refilling the lower Snake River reservoirs in the event of a drawdown. A list of alternative HYSSR runs and descriptions is included in table S-2 of appendix A. The following is a summary of the results of the HYSSR runs in terms of average flows for each alternative, showing how each can contribute to flow augmentation at Lower Granite Dam:

Target Flow at Lower Granite Dam: 85,000 CFS Flow Duration: 2.5 Months					
Alternative (HYSSR) Run Number	**Average Flow at Lower Granite Dam, 1000 cfs (Number Years Target Met/Over Period)**				
	April 16-30	**May**	**June**	**July**	**August**
Dworshak Only (Base Condition) (SOS2AX3)	92.4 (30/50)	105.8 (47/50)	100.4 (37/50)	n/a n/a	n/a n/a
Dworshak With Galloway Added (SOS2AX4)	96.8 (33/50)	105.4 (48/50)	101.3 (38/50)	n/a n/a	n/a n/a
Dworshak With Galloway and Rosevear/Jacobsen Gulches Added (SOS2AX2)	101.1 (36/50)	109.2 (48/50)	106.7 (44/50)	n/a n/a	n/a n/a
Target Flow at Lower Granite Dam: 85,000 CFS Flow Duration: 4.5 Months					
Alternative (HYSSR) Run Number	**Average Flow at Lower Granite Dam, 1000 cfs (Number Years Target Met/Over Period)**				
	April 16-30	**May**	**June**	**July**	**August**
Dworshak Only (Base Condition) (SOS2AX3)	90.8 (30/50)	104.6 (44/50)	99.6 (37/50)	55.1 (4/50)	28.6 (0/50)
Dworshak With Galloway Added (SOS2AX4)	93.2 (33/50)	103.6 (44/50)	99.2 (38/50)	59.9 (7/50)	29.8 (0/50)
Dworshak With Galloway and Rosevear/Jacobsen Gulches Added (SOS2AX2)	95.6 (35/50)	105.7 (46/50)	102.1 (40/50)	63.1 (7/50)	33.5 (0/50)
Target Flow at Lower Granite Dam: 120,000 CFS Flow Duration: 2.5 Months					
Alternative (HYSSR) Run Number	**Average Flow at Lower Granite Dam, 1000 cfs (Number Years Target Met/Over Period)**				
	April 16-30	**May**	**June**	**July**	**August**
Dworshak Only (Base Condition) (SOS2AX3)	95.4 (10/50)	14.0 (22/50)	103.6 (19/50)	n/a n/a	n/a n/a
Dworshak With Galloway Added (SOS2AX4)	101.7 (14/50)	115.3 (22/50)	104.4 (21/50)	n/a n/a	n/a n/a
Dworshak With Galloway and Rosevear/Jacobsen Gulches Added (SOS2AX2)	106.6 (16/50)	119.6 (24/50)	109.2 (24/50)	n/a n/a	n/a n/a

Target Flow at Lower Granite Dam: 120,000 CFS Flow Duration: 4.5 Months					
Alternative (HYSSR) Run Number	**Average Flow at Lower Granite Dam, 1000 cfs (Number Years Target Met/Over Period)**				
	April 16-30	**May**	**June**	**July**	**August**
Dworshak Only (Base Condition) (SOS2AX3)	94.5 (10/50)	112.5 (22/50)	103.4 (19/50)	48.2 (0/50)	22.8 (0/50)
Dworshak With Galloway Added (SOS2AX4)	100.1 (14/50)	112.6 (22/50)	103.9 (21/50)	50.8 (0/50)	23.0 (0/50)
Dworshak With Galloway and Rosevear/Jacobsen Gulches Added (SOS2AX2)	102.6 (15/50)	115.0 (23/50)	106.6 (22/50)	54.3 (0/50)	26.2 (0/50)

f. System Power Cost Studies

The evaluation of impacts of the Galloway and Rosevear/Jacobsen Gulch projects on system power generation and costs were evaluated for flow targets of 85,000 cfs and 120,000 cfs, and flow duration periods of 2½ and 4½ months. The evaluation was completed using the HYSSR model results in conjunction with a spreadsheet model developed by the SOR Power Work Group. The HYSSR model, as explained in paragraph 2.05 of this report, simulates the operation of the Columbia/Snake River system over a 50-year hydrologic period of record. System power generation is one output report that is produced by the mode. This report shows how much power the system can generate, but does not calculate system generation costs.

The analysis of system generation costs for each alternative, including the use of existing storage in the Dworshak Reservoir to meet flow objectives, was done with the Power Work Group's spreadsheet model. The results for each alternative were then compared to the base condition to determine the change in system generation costs relative to the base condition. A more detailed description of the SOR spreadsheet model is presented in paragraph 2.11.a. of this report. The results of the analysis are summarized below:

Impacts on System Power Costs Target Flow at Lower Granite Dam: 85,000 CFS Flow Duration: 2.5 Months				
Alternative (HYSSR) Run Number	**System Generation (annual MW)**	**New Combustion Turbines (annual MW)**	**Total System Costs ($1,000)**	**Change From Base Condition ($1,000)**
Dworshak Only (Base Condition) (SOS2AX3)	15,504	4,100	1,657,000	Base Condition
Dworshak With Galloway Added (SOS2AX4)	15,509	3,650	1,594,000	(63,000)
Dworshak with Galloway and Rosevear/Jacobsen Gulches Added (SOS2AX2)	15,494	3,650	1,599,000	(58,000)

Impacts on System Power Costs Target Flow at Lower Granite Dam: 85,000 CFS Flow Duration: 4.5 Months				
Alternative (HYSSR) Run Number	**System Generation (annual MW)**	**New Combustion Turbines (annual MW)**	**Total System Costs ($1,000)**	**Change From Base Condition ($1,000)**
Dworshak Only (Base Condition) (SOS2AX3)	15,428	4,600	1,756,000	Base Condition
Dworshak With Galloway Added (SOS2AX4)	15,432	4,250	1,708,000	(49,000)
Dworshak with Galloway and Rosevear/Jacobsen Gulches Added (SOS2AX2)	15,422	4,100	1,691,000	(65,000)

Impacts on System Power Costs Target Flow at Lower Granite Dam: 120,000 CFS Flow Duration: 2.5 Months				
Alternative (HYSSR) Run Number	**System Generation (annual MW)**	**New Combustion Turbines (annual MW)**	**Total System Costs ($1,000)**	**Change From Base Condition ($1,000)**
Dworshak Only (Base Condition) (SOS2AX3)	15,453	4,700	1,746,000	Base Condition
Dworshak With Galloway Added (SOS2AX4)	15,456	4,350	1,698,000	(48,000)
Dworshak with Galloway and Rosevear/Jacobsen Gulches Added (SOS2AX2)	15,441	4,200	1,683,000	(63,000)
Impacts on System Power Costs Target Flow at Lower Granite Dam: 120,000 CFS Flow Duration: 4.5 Months				
Alternative (HYSSR) Run Number	**System Generation (annual MW)**	**New Combustion Turbines (annual MW)**	**Total System Costs ($1,000)**	**Change From Base Condition ($1,000)**
Dworshak Only (Base Condition) (SOS2AX3)	15,415	4,900	1,793,000	Base Condition
Dworshak With Galloway Added (SOS2AX4)	15,417	4,700	1,767,000	(26,000)
Dworshak with Galloway and Rosevear/Jacobsen Gulches Added (SOS2AX2)	15,407	4,550	1,751,000	(42,000)

g. Fish Survival Evaluation

Studies on fish survival were conducted by the Center for Quantitative Studies at the University of Washington, under contract with BPA, using CRiSP. The model used average monthly streamflow data output from the HYSSR system operation studies. A description of the HYSSR and CRiSP models is included in paragraphs 2.05 and 2.07, respectively. The following is a summary of the study results by species:

Median Smolt Survival[1]				
	Flow Target			
	85,000 cfs		120,000 cfs	
	Flow Duration Months		Flow Duration Months	
	2.5	4.5	2.5	4.5
Dworshak (Base) With Galloway Added				
Spring Chinook				
Base Condition	25	24	25	24
With Galloway	23	24	24	25
Summer Chinook				
Base Condition	28	27	28	29
With Galloway	28	28	27	28
Fall Chinook				
Base Condition	11	11	09	10
With Galloway	09	11	09	11
Dworshak Steelhead				
Base Condition	28	27	28	29
With Galloway	28	27	27	29
Dworshak (Base) With Galloway and Rosevear/Jacobsen Gulches Added				
Spring Chinook				
Base Condition	25	24	25	24
With Galloway	24	23	25	25
Summer Chinook				
Base Condition	28	27	28	29
With Galloway	28	28	29	29
Fall Chinook				
Base Condition	11	11	09	10
With Galloway	09	11	10	11
Dworshak Steelhead				
Base Condition	28	27	28	29
With Galloway	29	28	29	28

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

3.06. Conclusions

A list of conclusions for the BOR study is included in the Executive Summary of this report (see page S-16 of Appendix A).

Section 4 - Coordination

4.01. General

The Corps of Engineers has coordinated with various Federal and state agencies, individuals, and groups throughout the region on the SCS Phase I. The purpose of this coordination is to share ideas on the evaluation process of the various alternatives for additional Snake River Basin storage, as well as other SCS alternatives, and to inform the public on Corps programs related to fish activities. This coordination is discussed in more detail in the subsequent paragraphs.

4.02. The TAG

A group of technical experts representing regional fish agencies and tribes, river operating agencies and user groups, conservation groups, and other interested parties, was formed in the spring of 1991 to develop plans for the 1992 lower Snake reservoir drawdown test. This group has continued to meet since the completion of the March drawdown test, and has been designated the Columbia River Salmon Mitigation Analysis (CRSMA) TAG.

The TAG is responsible for: 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 proposed alternatives to be studied under the NPPC's Fish and Wildlife Program Amendments; 4) development of the scope of the Biological Plan for the lower Snake reservoir drawdown; and 5) providing guidance to the contractor responsible for the completion of this document. Input from the TAG is provided to NPPC's Drawdown Committee, as well as to the Corps of Engineers.
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.

4.03. Interagency Team on Additional Upstream Storage

The BOR facilitated an interagency committee effort to inventory and screen potential storage sites for further development. This committee was comprised of representatives from the BOR, the Corps, and BPA, as well as from the states of Washington, Oregon, and Idaho. The participation of the Corps in this process was initiated by a letter, dated October 11, 1991, from BOR.

4.04. Public Involvement

Information regarding public involvement is addressed in the SCS summary report.

Section 5 - Summary, Discussions, and Conclusions

5.01. Summary

Two separate but related studies regarding upstream storage are addressed in this report. The two studies include: 1) the Corps evaluation of the Galloway Project; and 2) the BOR-led interagency upstream storage study, which was broader in scope. The studies are addressed in sections 2 and 3 of this report, respectively. Although the studies were conducted separately, a common effort was made to evaluate system operation, system power costs, and fish survival for the Galloway Project. The Galloway project was a common denominator in both studies. In addition, a combination of the Rosevear/Jacobsen Gulches Projects was also evaluated as part of the BOR-led study. The following is a summary of each study.

a. The Corps Evaluation of the Galloway Project

The technical feasibility of the Galloway Project to provide upstream storage for increasing streamflows in the lower Snake and Columbia Rivers for anadromous fish survival was evaluated. The project evaluated was the same as that included in the Technical Report dated August 1990.

Environmental impacts related to the construction of the project were found to be minimal. Mercury ore and an old abandoned mercury mine are located in the reservoir area, and could cause concern in the early years of reservoir operation. The anadromous fishery would not be affected by the project because of a lack of fish passage facilities in projects downstream in the middle Snake River. This lack of facilities is already a block to anadromous fish passage.

Studies on fish survival were conducted by the Center for Quantitative Studies at the University of Washington using CRiSP. The project was evaluated based on two flow duration periods of 2½ months (16 April to 30 June) and 4½ months (16 April to 31 August), and two target flows of 85,000 cfs and 120,000 cfs at Lower Granite Dam.

The following is a summary of the median survival rates over the 50 years of record, by species, for the 85,000 cfs and 120,000 cfs flow targets for both the 2½- and 4½-month flow duration periods. The results are presented for both with and without the transportation program.

Dworshak (Base) With Galloway Added Median Smolt Survival (Standard Deviation)				
	Flow Target			
	85,000 cfs		**120,000 cfs**	
	Flow Duration Months		**Flow Duration Months**	
	2.5	**4.5**	**2.5**	**4.5**
Species, Without Transportation				
Spring Chinook				
Base Condition	25	24	25	24
With Galloway	23	24	24	25
Summer Chinook				
Base Condition	28	27	28	29
With Galloway	28	28	27	28
Fall Chinook				
Base Condition	11	11	09	10
With Galloway	09	11	09	11
Dworshak Steelhead				
Base Condition	28	27	28	29
With Galloway	28	27	27	29
Species, Without Transportation				
Spring Chinook				
Base Condition	38	37	38	37
With Galloway	37	37	37	37
Summer Chinook				
Base Condition	39	38	39	38
With Galloway	38	38	38	39
Fall Chinook				
Base Condition	42	41	42	40
With Galloway	38	42	37	40
Dworshak Steelhead				
Base Condition	45	44	45	44
With Galloway	44	44	43	44

The total estimated project cost for the project at the 1 October 1992 price level is $189 million. The current, fully-funded cost (cost escalated to midpoint of construction) of the project is estimated to be about $215 million. The following is a summary of the updated total annual costs of the project, as included in the August 1990 Technical Report:

Interest and Amortization	$18,340,000
OM&R	750,000
Increased Cost to Shippers	750,000
Increased Highway Maintenance	230,000
Total	**$20,050,000**

Below is a summary of the economic analysis of the Galloway Project. Costs for recreation, employment, and flood damage reduction were updated from the August 1990 Technical Report. New system operation and power cost studies were conducted by the SOR Power Work Group.

Economic Analysis of Galloway Project ($1,000, Except as Noted)				
	Flow Target			
	85,000 cfs		**120,000 cfs**	
	Flow Duration Months		**Flow Duration Months**	
	2.5	**4.5**	**2.5**	**4.5**
Average Annual Costs				
Implementation	20,050	20,050	20,050	20,050
Economic				
Power	(63,000)	(49,000)	(48,000)	(26,000)
Recreation	(196)	(196)	(196)	(196)
Employment	(78)	(78)	(78)	(78)
Flood Damage Reduction	(110)	(110)	(110)	(110)
Total	**(43,334)**	**(29,334)**	**(28,334)**	**(6,334)**

System power costs attributable to operating the Galloway Project for flow augmentation were found to be reduced, indicating a benefit. This occurs because of the ability to operate the Galloway Project on a first priority basis, prior to operating the Dworshak Project. In doing so, it relieves pressure from the Dworshak Project by allowing it to operate at a higher head for increased power generation.

b. The BOR-Led Interagency Upstream Storage Study

The final report, titled *Snake River Basin Storage Appraisal Study,* and dated January 1994, was submitted to NPPC by letter dated 11 February 1994 (see exhibit 3). The purpose of the study was to evaluate the potential for upstream storage develo9pment, as well as to examine the effectiveness of augmenting streamflows to increase salmon survival in the lower Snake and Columbia Rivers.

The study included a process of identifying and screening potential upstream storage sites based on established criteria, environmental impacts, water availability, and the cost of development and operation. Through a process of screening, the number of sites were reduced from an initial count of 414 (295 offstream sites and 119 onstream sites) down to 12 areas that would receive further evaluation. Based on water supply studies, the 12 areas were then narrowed down to 11 specific sites for further appraisal-level cost and environmental impact evaluations. Table S-1 in appendix A summarizes the study findings: including total reservoir capacity, average annual water released from the reservoir, and costs. This information is also presented in terms of unit costs per AF of water released from storage for each site. Based on this information, the 11 sites were then reduced down to three sites that were evaluated in more detail. The three sites included the Galloway, Rosevear Gulch, and Jacobsen Gulch sites. The following is a summary shoring reservoir storage capacity, average annual water that could be released from each reservoir, and the total cost per AF of water released:

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]	675,000	607,800	607,740	224
Jacobsen Gulch Project	209,600	188,600	188,680	269
Total	**1,784,900**	**1,511,400**	**1,152,070**	

[1]Upper Site.

To facilitate further analysis, the Rosevear and Jacobsen Gulch Projects were combined. consequently, further studies were limited to two scenarios that include the Galloway Project and a combination of the Rosevear/Jacobsen Gulch Projects.

System operation studies, system power cost studies, and fish survival studies were conducted on these sites to evaluate the impacts of adding the projects for flow augmentation. The projects were evaluated for two duration periods of 2½ months (16 April to 30 June) and 4½ months (16 April to 31 August), and two target flows of 85,000 cfs and 125,000 cfs at Lower Granite Dam. The following is a summary of the implementation and power cost studies for each project.

Cost Analysis
Average Annual Cost
Galloway and Rosevear/Jacobsen 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/Jacobsen Gulch				
Implementation Cost	207,407	207,407	207,407	207,147
System Power Cost	(58,000)	(65,000)	(63,000)	(42,000)
Total	149,407	142,407	144,407	165,147

[1]As updated and computed by BOR.

Studies on fish survival were conducted by the Center for Quantitative Studies at the University of Washington using CRiSP. The studies were based on output from the system operation studies. The following is a summary of the study results by species:

Median Smolt Survival[1]				
	Flow Target			
	85,000 cfs		120,000 cfs	
	Flow Duration Months		Flow Duration Months	
	2.5	4.5	2.5	4.5
Dworshak (Base) With Galloway Added				
Spring Chinook				
Base Condition	25	24	25	24
With Galloway	23	24	24	25
Summer Chinook				
Base Condition	28	27	28	29
With Galloway	28	28	27	28
Fall Chinook				
Base Condition	11	11	09	10
With Galloway	09	11	09	11
Dworshak Steelhead				
Base Condition	28	27	28	29
With Galloway	28	27	27	29
Dworshak (Base) With Galloway and Rosevear/Jacobsen Gulches Added				
Spring Chinook				
Base Condition	25	24	25	24
With Galloway	24	23	25	25
Summer Chinook				
Base Condition	28	27	28	29
With Galloway	28	28	29	29
Fall Chinook				
Base Condition	11	11	09	10
With Galloway	09	11	10	11
Dworshak Steelhead				
Base Condition	28	27	28	29
With Galloway	29	28	29	28

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

5.02. Discussions

Based on studies completed to date, it has been found that benefits attributable to upstream storage for increasing anadromous fish survival appears to have limited benefits. In some instances, the survival rates are increased slightly, while in others, the survival rates are actually decreased. These findings, however, can be explained 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 some of the more important parameters.

In spite of the marginal findings, the Galloway Project (and possibly other upstream storage sites) could still have high potential for being an economically feasible alternative for fish survival. Although the increased survival rates were estimated to be minimal and sometimes even negative, there are strong arguments that the system operation studies accomplished as part of the analysis do not allow for adequate fisher-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 did not evaluate the impacts of upstream storage during a series of low flow years. These discrepancies are further discussed in more detail below.

The HYSSR model is designed to analyze the impacts of various alternatives on the operation, and output of the Pacific Northwest hydropower generation system. Since the model was designed to analyze power, the controlling input to the program is power-related, with flood control criteria incorporated. The input assumptions, which are inherent to the program, control the output of the study. When using the HYSSR program for the flow augmentation portion of the anadromous fish analysis, the model input was manipulated in order to meet the flow objectives at Lower Granite Dam. Consequently, the model was controlled by hydropower interests, and only by manipulation of the input were the anadromous fishery requirements and interests reflected.

The HYSSR studies conducted as part of the analysis were made at an appraisal level of detail. At that level, there are normally numerous conditions under which each alternative must be evaluated. In order to simplify the study process, the conditions are commonly generalized or grouped together. In this particular case, two flow duration periods were analyzed including 2½ and 4½ months. This was a compromise in lieu of making evaluations for each month individually, or in durations of ½ month. With such a generalized case, target flows attempted to be met over the entire 2½- and 4½-month periods. In reality, smolt outmigration tends to concentrate on more specific timeframes, depending on the species in question. In some instances, flows could benefit one species at the expense of another, due to their different migration schedule. If target flows were concentrated on specific time periods, each species could be accommodated without wasting large amounts of stored water. If the analysis was made in this fashion, the survival rates could be increased substantially, and negative impacts on power production could possibly be reduced.

Fish survival rates evaluated for this study were the median over the 50-year period of record. Fish passage and survival is generally better during the average and high flow years, but is substantially reduced during low flow periods. During low flow periods, upstream storage could benefit fish survival the most by augmenting already low streamflows. Since the flow in the river would already be low, the percent-of-increase of flows would be much greater than during higher flow years. This would increase overall fish survival substantially through the low flow periods. Although the low flow periods are reflected in the overall median survival rates, as analyzed, the benefits get lost in the averages. The impacts of added flows during low flow periods should be separately analyzed and taken into consideration.

By allowing the upstream storage sites to operate on a first priority basis for flow augmentation, the Dworshak Project can operate on an as-needed basis to supplement flows. By doing so, the Dworshak reservoir can be maintained at a higher reservoir level and consequent higher head, and this allows more power to be produced for the system. In doing so, the total cost to the power generation system was actually reduced in every case with the Galloway Project. As an example, under the 85,000 cfs target flow and 2½-month flow duration period, the total average annual cost, including implementation costs and reduced cost of power generation, was estimated to be a negative $42,000,000 per year. Since the cost is negative, it is actually a benefit.

Offstream storage sites (*i.e.*, the Rosevear and Jacobsen Gulch Projects) could also be justified if the benefits could justify the costs. The Moores Hollow site could also be a consideration because of its high water supply potential.

The onstream Owyhee enlargement and Thief Valley sites have costs per AF of water released from storage that are about the same as those of the Galloway Project. The development of these sites may also be a consideration.

5.03. Conclusions

Based on the evaluation completed as part of the Phase I study, it has been determined that there are no quantifiable benefits of adding new upstream storage for the purpose of increasing fish survival in the lower Snake and Columbia Rivers. The estimated benefits to fish survival were found to be marginal, and fall within the margin of error in the analysis. Although additional storage showed no measurable quantifiable biological benefit, in terms of improved salmon survival (as determined using CRiSP), the Phase I analysis probably does 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 in all probability understate the benefits to fish migration.

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 reduction in system power generation costs. This benefit results in an economically cost-effective project.

Upstream storage is modeled with and without transport. Even with upstream storage, the system survival estimates could not meet those estimates attributable to transporting juvenile salmonids to below Bonneville Dam.

In spite of the marginal benefits of upstream storage to the anadromous fisher, there are numerous qualitative reasons that have been identified for keeping additional upstream storage as a viable alternative in the Phase II evaluation. The following is a list of those reasons:

- Upstream storage, including the Galloway Project, 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. 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.

- Water from upstream storage could be used for pulsation purposes to aid the migration process during peak migration periods.

- In the event that water from upstream storage could be effectively managed, and releases 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 2½- or 4½-month periods assumed in the Phase I study. In addition, optimization of flows would designate 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 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 increased efficiency.

- The feasibility of transferring the flood control storage space from the Brownlee Project to the Galloway Project could improve the effectiveness of upstream storage, and should be considered further.

- 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.

- Although preliminary studies by the BOR-led interagency team concluded that the lower Snake River reservoirs would normally refill within 1 month (one time-step in the HYSSR model), using just natural inflow, earlier refill using the stored water could result in benefits to power and navigation interests.

Exhibits

United States Department of the Interior

BUREAU OF RECLAMATION
PACIFIC NORTHWEST REGION
FEDERAL BUILDING & U.S. COURTHOUSE
BOX 043-550 WEST FORT STREET
BOISE, IDAHO 83724-0043

IN REPLY REFER TO:
PN-704

OCT 11 1991

Mr. John Velehradsky
Corps of Engineers
PO Box 3870
Portland OR 97209-2879

Subject: Snake River Basin Cooperative Storage Appraisal Study (Fish and Wildlife)

Dear Mr. ~~Velehradsky~~ John:

During the Salmon Summit the Bureau of Reclamation offered to initiate an appraisal study of new Snake River storage that could provide additional water for lower Snake River flow augmentation to aid migrating salmon and steelhead. This element was incorporated in the May 1, 1991, report of the Governors to Senator Hatfield (see enclosure). This measure is now being considered in the Northwest Power Planning Council's (NPPC) rule making process (see enclosure).

Since the date of the commitment in the Governors' report, we have done some preliminary work on study scoping, site identification, and site mapping.

We assume that this measure will be adopted by the NPPC for inclusion in the Columbia Basin Fish and Wildlife Program; on that basis we would like to meet with interested parties to discuss the appraisal study.

We have scheduled a meeting of potential study cooperators on November 20, 1991, to discuss the study. The meeting will be held at the Idaho Department of Water Resources office at 1301 North Orchard Street, Boise, Idaho, and will begin at 1:00 p.m. and conclude by no later than 4:00 p.m.

We expect the discussion to focus on study participation, study scope and timing, study conduct and cooperative responsibilities, need for oversight and work groups and membership, cost-sharing, damsite evaluation and screening criteria, reporting, etc. At the meeting we will distribute a preliminary draft study concept and tentative damsite list for use in discussions.

We envision this meeting as a "steering committee" meeting, therefore, we would appreciate the attendance of an appropriate representative from your office who could continue throughout the study in steering level capacity. We anticipate the establishment of a work group or groups at a later time. If you have any questions, please contact Ron Golus whose telephone number is (208) 334-1147 or FTS 554-1147.

Sincerely,

Regional Director

Enclosures

Identical letter sent to: See attached list.

Mr. John Velehradsky
Chief of Planning
Corps of Engineers
PO Box 3870
Portland OR 97209-2879

Mr. Jack Robertson
Acting Administrator
Bonneville Power Administration
PO Box 3621
Portland OR 97208

Mr. Keith Higginson
Director
Idaho Department of Water Resources
1301 North Orchard Street
Boise ID 83706

Mr. Bill Young
Director
Oregon Department of Water Resources
3850 Portland Road NE.
Salem OR 97310

Mr. Jerry Conley
Director
Idaho Department of Fish and Game
PO Box 25
Boise ID 83707

Mr. Randy Fisher
Director
Oregon Department of Fish and Wildlife
PO Box 59
Portland OR 97207

Mr. Ted Strong, Executive Director
Columbia River Basin Intertribal
Fish Commission
975 SE. Sandy Boulevard, Suite 202
Portland OR 97214

Mr. James Goller
Council Presiding Officer
Northwest Power Planning Council
851 SW. Sixth Avenue NE., Suite 1100
Portland OR 97204

Mr. Ed Chaney
Chinook Northwest, Inc.
PO Box 458
Eagle ID 83616

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Boise Field Station
4696 Overland Road, Room 576
Boise, Idaho 83705

October 14, 1992

Lieutenant Colonel Robert D. Volz
U. S. Army Corps of Engineers
Walla Walla District
(Attention: Sarah Wik)
Building 602, City-County Airport
Walla Walla, Washington 99362-9265

Subject: Weiser River - Galloway Project additional storage: System Configuration Study (351.6043)

Dear Lt. Colonel Volz:

In response to our scope of work, the Fish and Wildlife Service (Service) has reviewed its past Coordination Act Report (1985) and the Amendments of 1986 and 1989 on the subject project to determine what information needs updating and what further studies might be necessary. We view the System Configuration Study (SCS) to be a reconnaissance level analysis of possible alternatives for construction or structural alterations in the Columbia River System. Therefore, our approach at this time has been to focus on information gaps in the past studies, and to develop recommendations on where additional efforts will be needed before this alternative could be adequately evaluated. With regard to the Galloway Project, if construction or operation would vary from that previously evaluated, a substantial re-evaluation may be necessary. Below is an initial list of study needs; please be aware that with the short time given us for examining this question, and the limited information available on how this alternative fits into the overall SCS alterations, there may be other needs of which we are not yet aware.

1. A major benefit of the Galloway project was to provide augmentation flows for anadromous fish. It would be relevant to analyze whether the project would have had water available for this purpose during the current 6-year drought. In previous planning aid letters the Service analyzed benefits to smolt survival from the Galloway Project (Haberger and Nee). The Corps in 1984 updated and upgraded the Service's 1981 analysis (Fitzsimmons). Much has evolved since those analyses were completed. We believe the Fish Passage Center should be involved in any further update that would evaluate the benefits of augmentation flows from the Galloway project (1) with the existing system, (2) with drawdown, and (3) with a reconfigured system operating in a very different way from which it currently operates.

2. The effects of the operation of Galloway Reservoir on Brownlee water levels, water quality and fisheries should be evaluated. This evaluation

should be coordinated with Idaho Power Company (IPCO) and the Federal Energy Regulatory Commission (FERC).

3. The effects of altered flow regimes in the Hells Canyon Reach of the Snake River should be evaluated in relation to federally listed fall chinook salmon that spawn and rear in that reach of the river. Coordination with IPCO, FERC, the Service, the National Marine Fisheries Service, the States of Oregon and Idaho and tribes would be appropriate.

4. Galloway Reservoir water quality and limnological conditions should be evaluated. The Corps will need to model the projected water quality of Galloway reservoir for all alternatives, so that the Service can analyze conditions for fish.

5. The Corps should describe any change in proposed high evacuation flows on the channel of the Weiser River below the Galloway Reservoir site. Another analysis of effects to that reach of the river and its aquatic and riparian habitats may be appropriate.

6. The potential for mercury contamination of the Galloway Reservoir and resident fish should be evaluated. The Idaho Almaden mercury mine, located one mile up a tributary from the proposed reservoir shoreline, may restart operations, and past operations may be cause for concern.

7. The planned mitigation areas should be re-examined to determine whether the sites are capable of being rehabilitated and will replace lost values at an acceptable ratio. These evaluations should be conducted by a team of biologists, rehabilitation experts, and hydrologists (these last for the lower river sites which would be subject to scouring flows).

8. The reservoir fishery mitigation recommendations (structures in the reservoir) need re-evaluation to determine whether they really address the basic problems--the extensive drawdown of the reservoir and water quality concerns.

9. The mitigation recommendations for the Weiser River below Galloway dam (gabions in the river) need re-evaluation to determine whether these structures will withstand 11,000 cfs peak flows and how much they would contribute to the restoration of fish habitat. Our experience is that "fish condos" are not appropriate mitigation for lost habitat.

10. A realistic analysis of local interests and pressures to operate the reservoir for recreation or uses other than drawdown for anadromous fish flow augmentation should be conducted. This is likely a Corps responsibility under the National Environmental Policy Act and not a Service function under the Fish and Wildlife Coordination Act.

11. We suggest that surveys for the following species need to be conducted or updated:

ANIMALS

Bald Eagle	listed as endangered
Sharp-tailed Grouse	C2 species
Idaho Ground Squirrel	C2 species
Long-billed Curlew	3c species
Burrowing Owl	BLM sensitive, State Priority 2

Elk and Deer - Wintering use has increased in the project area since 1986, when the Squaw Butte fire destroyed large areas of prime winter range to the south.

PLANTS

Astragalus mulfordiae Mulford's milkvetch	C1, BLM Sensitive Sp.
Haplopappus radiatus Snake River goldenweed	C1, BLM Sensitive Sp. FS, R-4 Sensitive
Peraphyllum ramosissimum Squaw apple	BLM sensitive Sp.

12. Consultation pursuant to Section 7 of the Endangered Species Act should be re-initiated with the Fish and Wildlife Service and initiated with the National Marine Fisheries Service.

Thank you for the opportunity to provide this input to the SCS process. If you have any questions please contact Helen Ulmschneider or Susan Martin at (208) 334-1931.

Sincerely,

Charles H. Lobdell
Field Supervisor

cc: FWS-IFRO, Ahsahka
FWS-OCRC, Vancouver
FWS-FWE, Portland
FWS-FR, Portland
NMFS, Portland
IDFG, HQ, Boise
IDWR, HQ, Boise
Fish Passage Center, Portland
Oregon Dept. of Fish and Wildlife, Portland
Columbia River Intertribal Fish Commission, Portland
Nez Perce Tribe, Lapwai

United States Department of the Interior

TAKE PRIDE IN AMERICA

BUREAU OF RECLAMATION
Pacific Northwest Region
1150 North Curtis Road
Boise, Idaho 83706-1234

IN REPLY REFER TO:

PN-704

FEB 11 1994

Mr. Ted Bottiger
Chairman, Northwest Power Planning Council
851 SW Sixth Avenue Suite 1100
Portland OR 97204

Subject: Snake River Basin Storage Appraisal Study

Dear ~~Mr. Bottiger~~ Ted:

The Northwest Power Planning Council (Council) requested Reclamation in cooperation with the Corps of Engineers (Corps), States of Idaho and Oregon, Bonneville Power Administration, and others, to report on new storage potential that could increase the volume of regulated water supplies available to enhance lower Snake River flows for salmon migrations.

An advisory group which is composed of representatives from water user organizations, fish and wildlife groups, and State and Federal agencies was formed in late 1991 to work on identifying damsites. The group identified and mapped over 400 storage sites above Lower Granite Dam. The master list was evaluated by the advisory group in July 1992 and 12 "storage areas" (some areas have more than one damsite) were selected to receive further evaluations as to potential water supplies. In January 1993 the advisory group further narrowed the list to 11 damsites for the development of appraisal level information on costs, system operation, geologic, and environmental factors. A draft report covering study analyses with conclusions was prepared and reviewed by the advisory group and discussed at a January 11, 1994 meeting prior to report finalization.

The Snake River Basin Storage Appraisal Study report is enclosed as requested by the Council. The Corps and Reclamation staffs developed the technical information and have cooperated in preparing the report.

The preliminary information report on damsite potentials is an initial effort to address the need for making additional water supplies available for improving augmentation flows for salmon migrations. We look to the Council to determine if additional detailed studies should be pursued and in what scope. We are prepared to assist in detailed studies if desired. It would be desirable if the Council could reach a decision on this matter within 60 days.

Ron Golus of Reclamation will answer questions you may have. His telephone number is (208) 378-5085.

Sincerely,

John W. Keys, III
Regional Director

Enclosures

cc: See attached list.

Mr. Wayne Haas
Idaho Department of Water
Resources
1301 North Orchard Street
Boise ID 83706

Mr. Bert Bowler
Idaho Department of Fish
and Game
PO Box 25
Boise ID 83707

Mr. Tom Kline
Oregon Water Resources
Department
850 Portland Road NE
Salem OR 97310

Mr. Dave Castleberry
Oregon Water Resources Congress
Warm Springs Irrigation District
334 Main Street North
Vale OR 97918

Mr. Roger Fuhrman
Idaho Power Company
PO Box 70
Boise ID 83707

Mr. Dan Daley
Bonneville Power Administration
PO Box 3621
Portland OR 97208

Mr. John Ross
Manager, Owyhee Irrigation District
17 South First Street
Nyssa OR 97913-3894

Mr. Frank Sherman
Idaho Department of Water
Resources
1301 North Orchard Street
Boise ID 83706

Mr. V. Kent Searles
Eastern Region Manager
Oregon Water Resources
Department
1995 Third Street
Baker City OR 97814

Mr. Jim Normandeau
Bonneville Power Administration
304 North Eighth Street Room 450
Boise ID 83702-5836

Mr. Greg Robart
Oregon Department of Fish and
Wildlife
PO Box 59
Portland OR 97207

Mr. Tim Brewer
Idaho Power Company
PO Box 70
Boise ID 83707

Ms. Jan Boettcher
Oregon Water Resources Congress
727 Center Street NE #107
Salem OR 97301-3821

Mr. Jim Esch
U.S. Fish and Wildlife
Service
Boise Field Office
4696 Overland Road Room 576
Boise ID 83705

Mr. Tom White, CENPD-PE-PF
U.S. Army Corps of Engineers
North Pacific Division
PO Box 2870
Portland OR 97208
(w/4 encls)

Mr. Jerry Roediger, CENPD-PE-PR
U.S. Army Corps of Engineers
Walla Walla District Building 607
City-County Airport
Walla Walla WA 99362-9265
(w/2 encls)

(w/one encl to each unless noted)

Tables

Table 1 Pertinent Data for the Proposed Galloway Project	
Location (river mile)	13.5
Drainage Area (square miles)	1,460
Mean Annual Discharge (cfs)	1,024
Standard Project Flood (cfs)	130,200
Probable Maximum Pool (cfs)	190,000
Spillway Design Flow (cfs)	123,400
Regulating Outlet Capacity (cfs)	11,000
Water Quality Outlet Capacity (cfs)	500
Full Pool Elevation (feet)	2,480
Full Pool Capacity (acre-feet)	900,000
Maximum Reservoir Length (miles)	18.2
Maximum Reservoir Area (acres)	6,900
Conservation Pool Elevation (feet)	2,340
Conservation Pool Content (acre-feet)	185,000
Conservation Pool Area (acres)	3,400
Top of Dam Elevation (feet)	
Height (feet)	2,495
Length of Crest (feet)	300
Top Width (feet)	1,450
Side Slopes (H.V.)	40
Material earth and rockfill with impervious core	2:1
Powerhouse Capacity Range (cfs)	100 to 225
Generator Capacity (MW)	4.6
Average Annual Generation (MWh)	27,185
Annual Plant Factor (percent)	67
Penstock Diameter (feet)	5.5
Penstock Length (feet)	1,500
Camping Sites (Spaces)	18
Day-Use Sites (picnic tables)	24
Parking (Spaces)	72
Boat Ramps	1
Project Lands (acres)	8,751
Mitigation Lands (acres)	4,384

Table 2 Executive Cost Summary All Contracts								
Galloway Dam Project Weiser River, Idaho Budget Estimate			3:13:45 PM October 1, 1992 Price Level Prepared By: CENPW-WN-CB Reviewed and Approved By:					
Account Number	**Item Description**	**Estimated Cost 1 Oct 92**	**Contingency Amount ($)**	**Total Est. Cost 1 Oct 92**	**Budget Year (Qtr/Yr)**	**Inflated Estimated Amount**	**Inflated Contingency Amount**	**Current Fully-Funded Cost**
02---	Relocations	$699,581	$174,895	$874,476	1 Qtr 96	$802,000	$200,000	$1,002,000
03---	Reservoirs	$1,290,027	$322,507	$1,612,534	1 Qtr 96	$1,478,000	$370,000	$1,848,000
04---	Dams	$103,404,853	$25,851,213	$129,256,066	1 Qtr 96	$118,502,000	$29,625,000	$148,127,000
06---	Fish and Wildlife Facilities	$825,514	$206,379	$1,031,893	1 Qtr 96	$946,000	$237,000	$1,183,000
07---	Power Plants	$4,162,621	$1,040,655	$5,203,276	1 Qtr 96	$4,771,000	$1,192,000	$5,963,000
09---	Channel and Canals	$1,933,535	$483,384	$2,416,919	1 Qtr 96	$2,216,000	$554,000	$2,770,000
13---	Pumping Plant	$3,136,859	$784,215	$3,921,074	1 Qtr 96	$3,595,000	$899,000	$4,494,000
14---	Recreation Facilities	$1,310,827	$327,707	$1,638,534	1 Qtr 96	$1,502,000	$376,000	$1,878,000
18---	Cultural Resources Preservation	$575,000	$143,750	$718,750	1 Qtr 96	$659,000	$165,000	$824,000
20---	Permanent Operating Equipment	$185,021	$46,255	$231,276	1 Qtr 96	$212,000	$53,000	$265,000
	Total Construction Cost	$117,523,838	$29,380,960	$146,904,798		$134,683,000	$33,671,000	$168,354,000
01---	Lands and Damages	$6,370,856	$1,274,171	$7,645,028	1 Qtr 96	$7,078,000	$1,416,000	$8,494,000
30---	Planning, Engr, and Design	$14,102,861	$3,525,715	$17,628,576	1 Qtr 96	$15,668,000	$3,704,000	$18,519,000
31---	Construction Mgmt	$12,927,622	$3,231,906	$16,159,528	1 Qtr 96	$14,815,000	$3,704,000	$18,519,000
	Total Project Costs	$150,925,177	$37,412,751	$188,337,928		$172,244,000	$42,709,000	$214,953,000

Plates

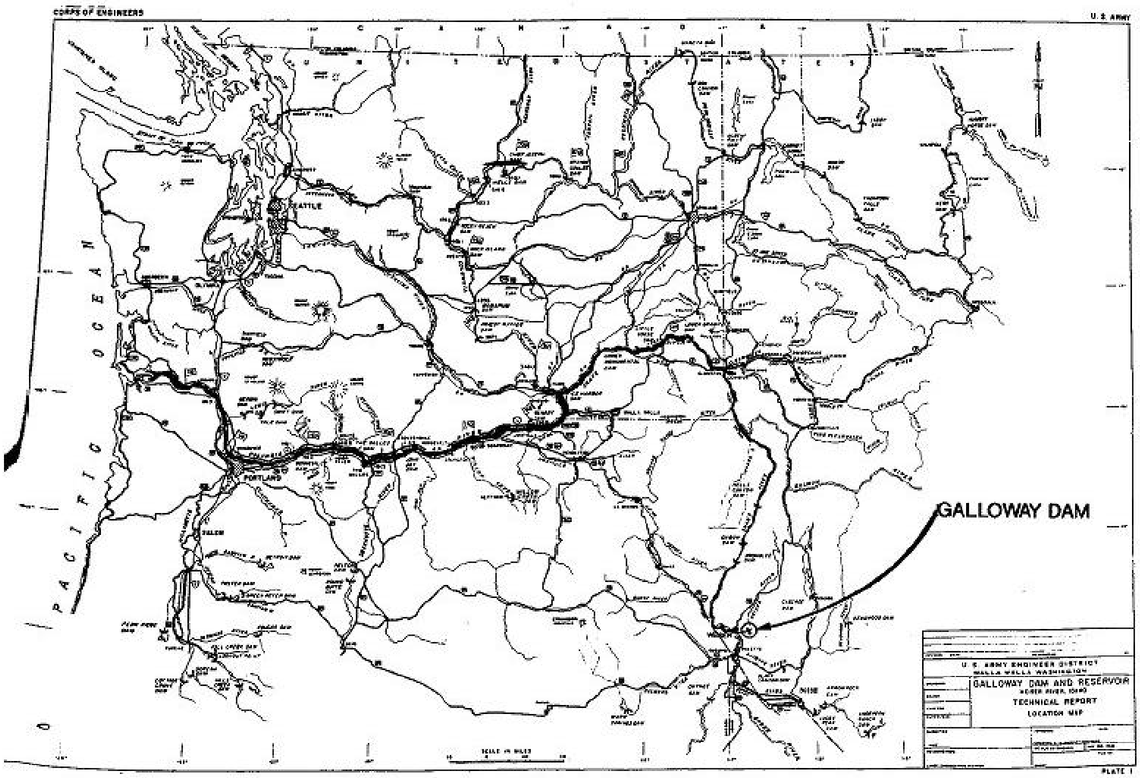


Plate 1. Galloway Dam Location Map

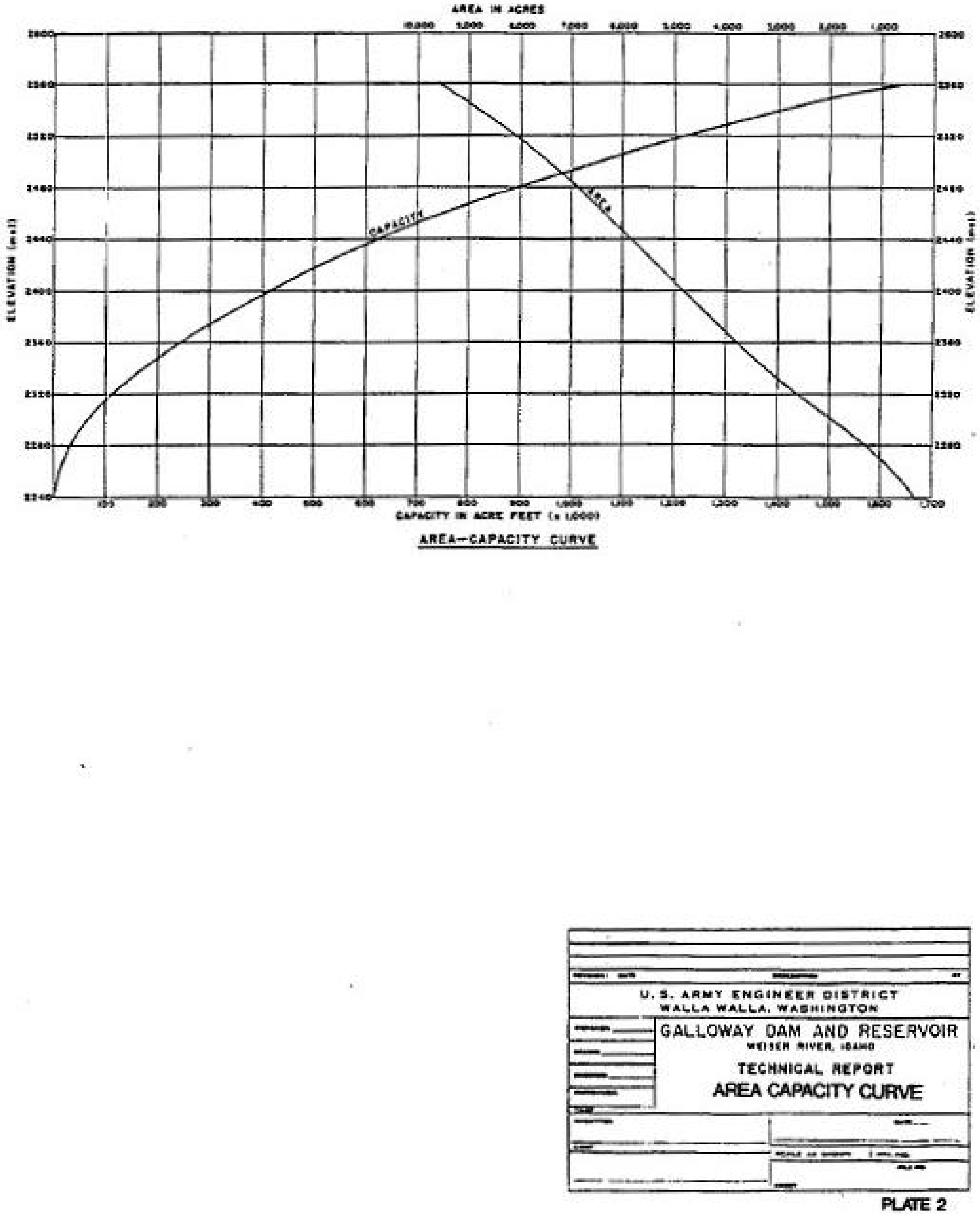


Plate 2. Galloway Dam Area Capacity Curve

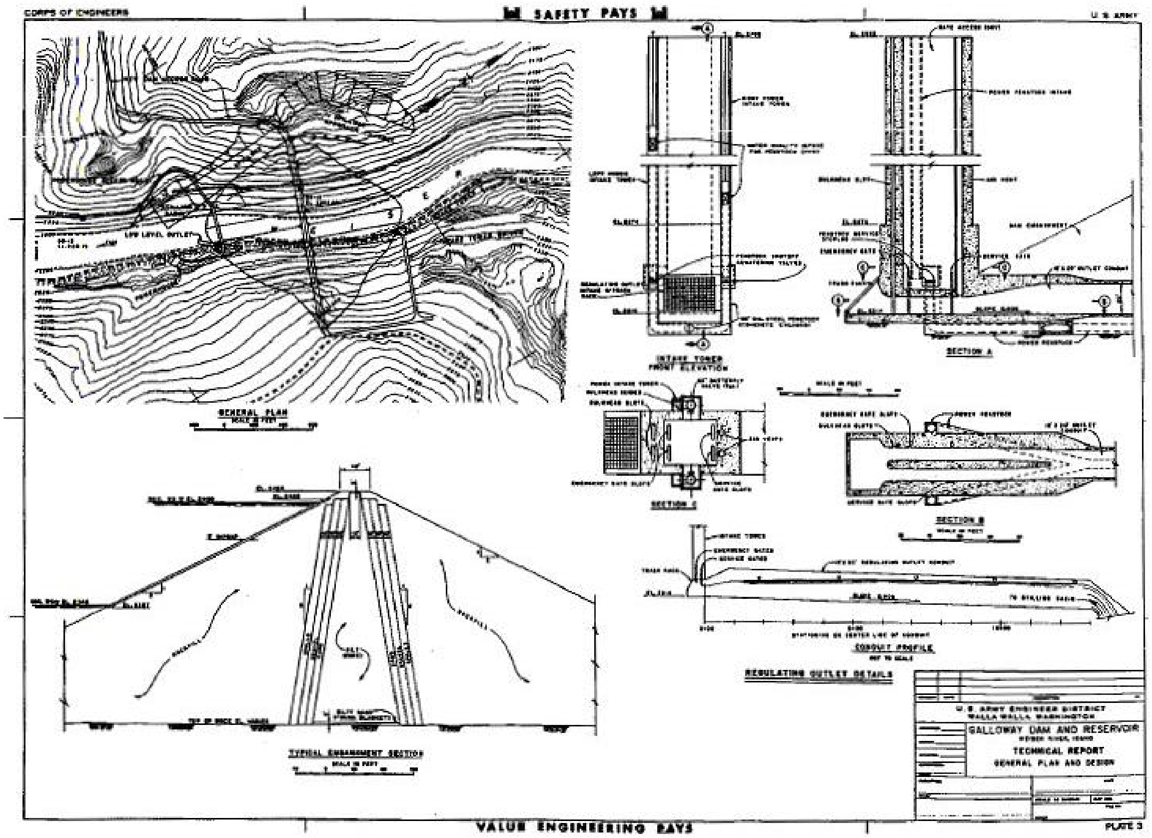
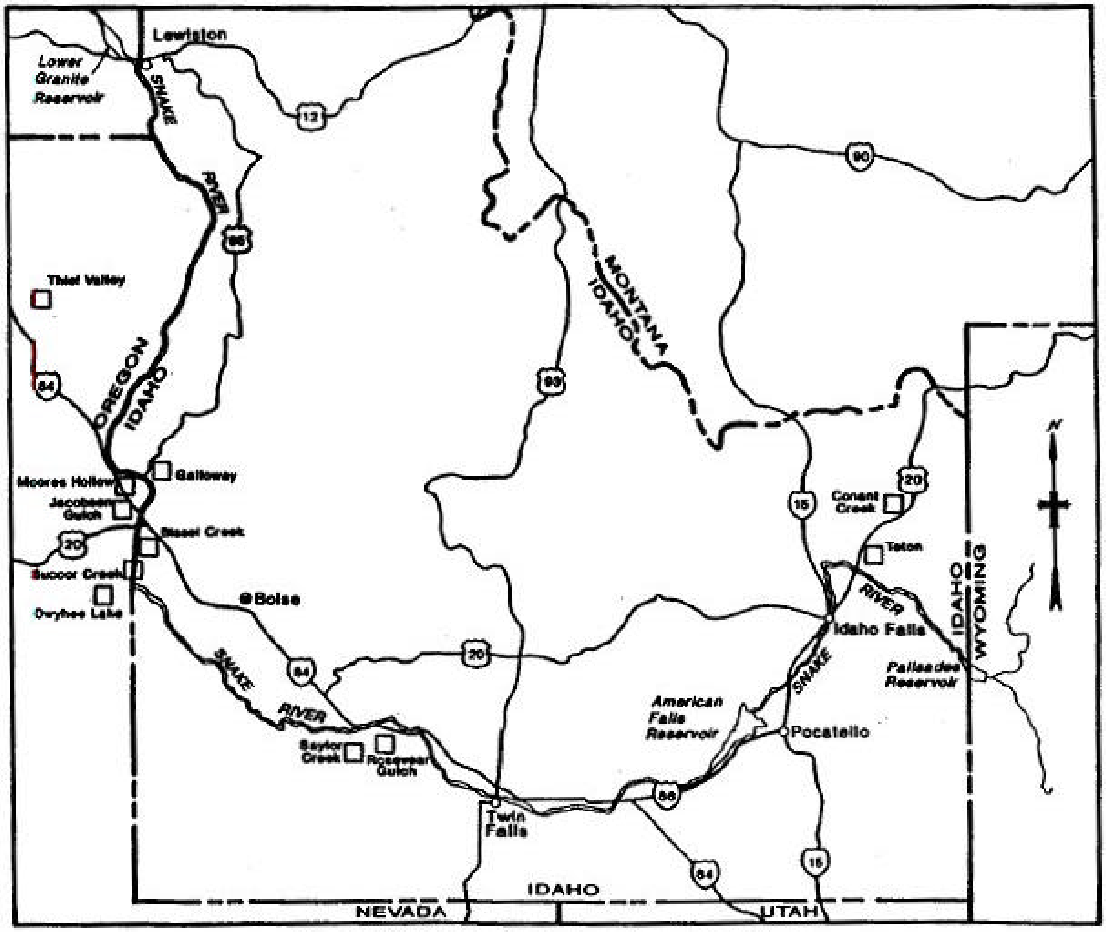


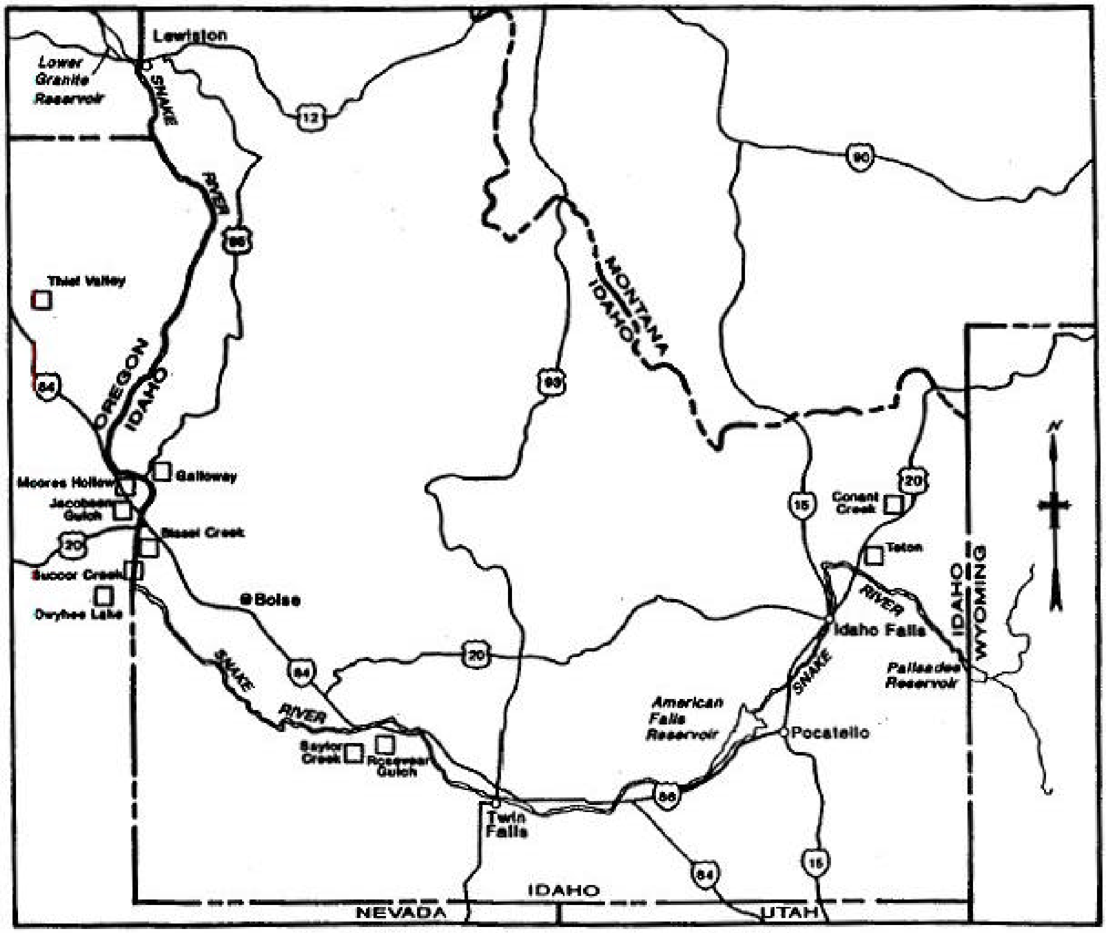
Plate 3. Galloway Dam General Plan and Design



Snake River Basin Storage Appraisal Study

Plate 4. Snake River Basin Storage Appraisal Study

Appendix A
Executive Summary of Interagency Snake River Basin Storage Appraisal Study Review



Snake River Basin Storage Appraisal Study

Executive Summary

A. Background

In the spring of 1990, several fishery interests responded to declining trends in returning adults of some salmon runs in the Pacific Northwest by petitioning the National Marine Fisheries Service (NMFS) to list the Snake River sockeye salmon; spring, summer, and fall runs of Snake River chinook salmon; and lower Columbia River coho salmon as threatened or endangered species under the Endangered Species Act. In December 1991, the NMFS responded by listing the Snake River sockeye as an endangered species and, in May 1992, the Snake River spring/summer and fall chinook were listed as threatened species. Coho salmon were determined not to be eligible for listing. A recovery team was established by NMFS to help develop a recovery plan for the listed stocks, but a final plan is not expected until late 1994.

State, Native American, fishery, hydropower, irrigation, and Federal interests cooperated in efforts to develop a management plan to benefit salmon in a process called the "Salmon Summit" during late 1990 and early 1991. A significant achievement of the summit was the extensive discussion of issues affecting salmon, including migration survival, harvest, habitat, and production. A number of measures that could improve conditions in 1991 for the stocks of concern were identified and implemented to the extent possible.

At the conclusion of the Salmon Summit process, the governors of the Northwest States asked the Northwest Power Planning Council (NPPC) to take the lead in developing a comprehensive salmon management plan by entering into a formal rulemaking to amend the NPPC's Columbia River Basin Fish and Wildlife Program in keeping with the Pacific Northwest Power Planning and Conservation Act of 1980.

The NPPC initiated a comprehensive four-phase process to amend its Fish and Wildlife Program. In August 1991, the NPPC adopted several urgent salmon habitat improvement measures into its program (Phase One) and asked entities having responsibility or capability to proceed expeditiously to implement these measures. Then, in December 1991, the NPPC adopted additional measures in Phase Two to address migration survival, harvest, hatchery production, and habitat needs. In September 1992, the NPPC consolidated its program measures into a Phase Three "Strategy for Salmon" document and reiterated the need for participating entities to expeditiously pursue implementation.

One of the measures included in the NPPC's Phase One "Regional Salmon Program for 1991" is the following:

Potential New Storage Appraisal

> 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 feasibility studies could follow.

Extensive water storage facilities have been constructed by Federal and non-Federal entities in the upper and central Snake River basin. However, the majority of the storage space provided by these facilities has been contracted to irrigation entities; committed for hydroelectric generation; used for flood control; recreation, and resident fish and wildlife purposes; or a combination of the above purposes. The potential for developing additional facilities to store and regulate unappropriated flows for lower Snake River flow augmentation needed to be investigated as a part of efforts to design a comprehensive salmon management strategy. An appraisal or preliminary evaluation of new storage potentials was chosen as the first step to help compare the costs and benefits of new storage to those of other alternatives for improving migration survival of salmon.

The Bureau of Reclamation (Reclamation) initiated work on the storage appraisal study in late 1991 with the formation of an appraisal study workgroup with representatives from water-user organizations, fish and wildlife agencies, and other State and Federal agencies. This report presents the findings of the appraisal study on the costs and environmental impacts of construction new storage for salmon flow augmentation.

B. Site Identification and Screening

As an initial step in the appraisal study, the workgroup inventoried and mapped 414 potential storage sites in the Snake River basin above Lower Granite Reservoir (see Addendum E). Most of these sites had been identified in previous studies by State and Federal agencies. To reduce the large number of sites to a more workable number, the workgroup evaluated the sites in July 1992 using agreed-upon screening criteria and information on the sites developed by Corps of Engineers (Corps) and Reclamation staff. Twelve areas (some with more than one damsite) were selected to receive further evaluation as to potential water supplies.

The areas selected for water supply evaluations were:

- Burnt River Basin, Oregon (Hardman and Dark Canyon sites--onstream)
- Weiser River Basin, Idaho (Galloway site and Lost Valley enlargement--onstream)
- Jump Creek Basin, Idaho (offstream sites)
- Succor Creek Basin, Idaho/Oregon (offstream sites)
- Teton River Basin, Idaho (Teton site--onstream)
- Malheur River Basin, Oregon (Warm Springs and other sites--onstream) and upper Malheur River Basin, Oregon (various sites--onstream)
- Owyhee River Basin, Oregon (Owyhee enlargement and other sites--onstream)
- Powder River Basin, Oregon (Thief Valley and other onstream sites, including the North Powder River Basin)
- Payette River Basin, Idaho (offstream sites on north side of river between Emmett and Payette)
- Bruneau area, Idaho (Saylor Creek, Rosevear Gulch, Grindstone Butte, Pilgrim Gulch, and other sites south of Snake River near Bliss and Glenns Ferry--offstream)
- Upper Snake River Basin, Fall River, Idaho (Conant Creek)

In January 1993, the appraisal study workgroup evaluated water supply information for the 12 storage areas, and selected the following 11 specific sites for appraisal-level cost and environmental impact evaluations by Corps and Reclamation staff.

- Onstream
  - Galloway site, Idaho
  - Teton River, Idaho
  - Owyhee Dam and Reservoir enlargement, Oregon
  - Thief Valley Dam, Oregon, replace existing dam with new dam

- Offstream
  - Moores Hollow, Oregon
  - Jacobsen Gulch, Oregon
  - Succor Creek Basin, Idaho/Oregon
  - Saylor Creek, Idaho
  - Rosevear Gulch, Idaho
  - Bissel Creek, Idaho
  - Conant Creek, Idaho

C. Summary of Analysis

The study developed information for 11 damsites that were identified for appraisal analysis. These damsites, both on and offstream, could provide water supplies for lower Snake River fish flow augmentation. Since the damsites are all located above Brownlee Reservoir, they could be used to refill Brownlee Reservoir if water Brownlee Reservoir were released for flow augmentation. The damsites located close to Brownlee Reservoir could also release water for direct flow augmentation (flow through Brownlee Reservoir).

Storage capacity, water supply, and cost information are summarized in Table S-1:

Table S-1
Summary of Storage Capacity, Water Supply, and Cost Information

Study Site	On- or Off-Stream	Stream	Total Reservoir Capacity	Average Annual Water Released For Fish	Total Cost	Invest Costs	OM&R Costs	Power Cost Per Year	Annual Cost of Damsites When Compared to Water Released From Reservoir ($/AF)
			(In Thousands of Acre-Feet)		(Millions of Dollars)				
Saylor Creek	Off	Saylor Creek, ID	347.4	312.67	425.1	522.0	0.4190	12.3390	178
Rosevear Gulch									
Lower	Off	Rosevear Gulch, ID	51.7	46.57	84.0	98.9	0.1141	1.5271	210
Upper			675.3	607.74	1,046.1	1,284.4	0.5017	29.6520	224
Thief Valley	On	Powder River, OR	75.0	47.77	39.0	45.9	0.0250	0	80
Succor Creek	Off	Succor Creek, OR	103.8	93.43	111.0	136.2	0.2295	7.4840	203
Jacobsen Gulch	Off	Jacobsen Gulch, OR	209.6	188.68	388.4	476.8	0.4888	10.8977	269
Bissel Creek	Off	Bissel Creek, ID	170.6	105.90	189.0	232.0	0.2908	5.2232	233
Moores Hollow	Off	Moores Hollow, OR							
Small			333.0	300.00	526.7	646.7	0.5801	18.4930	241
Large			863.2	776.87	1,710.0	2,098.6	0.9996	73.4660	319
Conant Creek	Off	Conant Creek, ID							
Lower			8.7	7.87	98.4	115.8	0.0609	0.0960	1,234
Upper			22.3	20.00	386.6	474.7	0.0855	0.2588	1,976
Owyhee Reservoir enlargement	On	Owyhee River, OR	65.6	23.96					
•Top of existing dam removal[1]									
5-foot					12.5	14.7	0	0	51
25-foot					29.0	34.1	0	0	117
50-foot					45.0	53.0	0	0	182
Teton	On	Teton River, ID	315.0	45.77					
•Rockfill					179.6	220.5	0.4820	0	408
•Concrete, Roller Compacted					284.3	349.1	0.4820	0	640
Galloway	On	Weiser River, ID	900.0	335.65	192.5	226.6	1.8400	0	61

[1] If dam construction for 5-foot enlargement were to occur, an upper portion of the existing dam would have to be removed due to deterioration. Cost estimates were made for removing 5-, 25-, and 50-feet of the existing dam.

Scenarios With Alternatives

A. Scenarios

Analyses of the potential storage sites considered use of the site's storage water supply to augment flow in the lower Snake River to meet salmon flow targets and to refill lower Snake River projects following drawdown. To evaluate how the new storage could meet salmon flow needs, potential damsites were grouped together into scenarios. Three scenarios were identified for analysis using the Corps' Hydrosystem Seasonal Regulation (HYSSR) computer program. Damsites included in each of the scenarios, along with data on the average amount of water released for fish and annual costs per acre-foot per-year of water released, are shown below:

Damsite	Water Released For Fish Average/Year (Acre-feet/Year)	Cost Per Acre-Foot/ Year of Water Released for Fish (Dollars Per Acre-Foot/Year)
Scenario 1 (Onstream Sites)		
Galloway, Weiser River, Idaho	335,650	61
Teton, Teton River, Idaho	45,700	408
Thief Valley, replacement, Powder River, Oregon	47,770	80
Owyhee enlargement, Owyhee River, Oregon (25 ft top of dam removal[1])	23,960	117
Total	**453,080**	
Scenario 2 (Onstream Sites)		
Galloway	335,650	61
Rosevear Gulch, Idaho (located south of Snake River near Glenns Ferry)	607,740	224
Upper Jacobsen Gulch, Oregon (located south of Brownlee Reservoir)	188,680	269
Total	**1,132,070**	
Scenario 3 Galloway		
	335,650	61

[1]If dam enlargement were to occur, an upper portion of the existing dam would have to be removed and reconstructed, due to deterioration.

Eventually, only Scenarios 2 and 3 were analyzed using the HYSSR program. The accumulative water supply for fish for Teton, Thief Valley, and Owyhee is relatively small; therefore, it was decided that Scenario 1 would be similar to Scenario 3 in terms of flow results.

B. Alternatives

Based on scenarios 2 and 3 described above, 12 system operation alternatives were developed to evaluate the contribution of the various sites in providing water for flow augmentation. The flow levels selected were 85,000 ft^3/s to conform with the high flow recommendation in the National Marine Fisheries Service's biological opinion, and 120,000 ft^3/s which represented a higher level of flow studied earlier by the Corps as part of their analysis of the Galloway Project. In addition, three alternatives were developed to evaluate the release of storage from lower Snake River project reservoirs and refilling them from upstream storage. These studies are summarized in Table S-2 below:

Table S-2
Summary of Alternatives

Alternative	HYSSR Name	Description
1	SOS2AX0	Existing system (base case) 85,000 ft^3/s Lower Granite Dam flow target, 2.5-month duration[1], use Dworshak only.
2	SOS2AX1	85,000 ft^3/s Lower Granite Dam flow target, 2.5-month duration, existing system plus Galloway used to meet flow target. Galloway would be used 1st, followed by Dworshak when needed.
3	SOS2AX2	85,000 ft^3/s Lower Granite Dam flow target, 2.5-month duration, existing system plus Galloway and Rosevear and Jacobsen Gulches used to meet flow target. (1) Water from Rosevear/Jacobsen Gulches; (2) followed by Galloway; (3) Dworshak if needed.
4	SOS2AX3	Existing system (base case). 85,000 ft^3/s Lower Granite Dam flow target, 4.5-month duration[2], use Dworshak only.
5	SOS2AX4	85,000 ft^3/s Lower Granite Dam flow target, 2.5-month duration, existing system plus Galloway used to meet flow target. Galloway would be used 1st, followed by Dworshak when needed.
6	SOS2AX5	85,000 ft^3/s Lower Granite Dam flow target, 2.5-month duration, existing system plus Galloway and Rosevear and Jacobsen Gulches used to meet flow target. (1) Water from Rosevear/Jacobsen Gulches; (2) followed by Galloway; (3) Dworshak if needed.
7	SOS2AY0	Existing system (base case). 120,000 ft^3/s Lower Granite Dam flow target, 2.5-month duration, use Dworshak only.
8	SOS2AY1	120,000 ft^3/s Lower Granite Dam flow target, 2.5-month duration, existing system plus Galloway used to meet flow target. Galloway would be used 1st, followed by Dworshak when needed.

9	SOS2AY2	120,000 ft^3/s Lower Granite Dam flow target, 2.5-month duration, existing system plus Galloway and Rosevear and Jacobsen Gulches used to meet flow target. (1) Water from Rosevear/Jacobsen Gulches, (2) followed by Galloway, (3) Dworshak if needed
10	SOS2AY3	Existing system (base case). 120,000 ft^3/s Lower Granite Dam flow target, 4.5-month duration, use Dworshak only.
11	SOS2AY4	120,000 ft^3/s Lower Granite Dam flow target, 4.5-month duration, existing system plus Galloway used to meet flow target. Galloway would be used 1st, followed by Dworshak when needed.
12	SOS2AY5	120,000 ft^3/s Lower Granite Dam flow target, 4.5-month duration, existing system plus Galloway and Rosevear and Jacobsen Gulches used to meet flow target. (1) Water from Rosevear/Jacobsen Gulches, (2) followed by Galloway, (3) Dworshak if needed
13	SOS6A0	Lower Snake River projects 33-foot drawdown, 2.5-month duration, refill from existing system.
14	SOS6A1	Lower Snake River projects 33-foot drawdown, 2.5-month duration, refill from existing system and Galloway.
15	SOS6A2	Lower Snake River projects 33-foot drawdown, 4.5-month duration, refill from existing system and Galloway.

[1]2.5-month period is from April 16 through June 30.
[2]4.5-month period is from April 16 through August 31.

System Operation Effects

System operation effects of flow at Lower Granite Dam - hydropower system generation, PNW hydro/thermal system costs, and survival of selected stocks of juvenile Snake River salmon to below Bonneville Dam were evaluated during the study. The results of the analyses are summarized in the following paragraphs.

Hydrology

Twelve alternative HYSSR analyses for augmenting flows were completed based upon the existing system operation, scenarios 2 and 3; target flows at Lower Granite Dam of 85,000 and 120,000 ft^3/s; and durations of the flow targets of 2.5 months (April 16 to June 30) and 4.5 months (April 16 to August 31).

Results based upon a 50-year historical period of analysis, 1928 to 1978 (years now shown below), indicate that a slight increase in "years met" (April through June) does occur with new storage as compared with attempting to meet the specified flow targets with existing storage (*i.e.*, Dworshak).

Table S-3
Meeting Lower Granite Target Flows
of 85,000 ft³/s and 120,000 ft³/s Through Augmentation

	April 16 to 30	May	June
85,000 ft³/s at Lower Granite for 2.5 Months			
Existing Operation (SOS2AX0)[1]			
Historical average, ft³/s Years met[2]	92,402 30/50	105,797 47/50	100,364 37/50
Scenario 3, Add Galloway (SOS2AX1)			
Historical average, ft³/s Years met	96,807 33/50	105,367 48/50	1101,273 38/50
Scenario 2, Add Galloway, Rosevear/Jacobsen Gulches (SOS2AX2)			
Historical average, ft³/s Years met	101,063 36/50	109,193 48/50	106,721 44/50

	April 16 to 30	May	June	July	August 1 to 15	August 16 to 31
85,000 ft³/s at Lower Granite for 4.5 Months						
Existing Operation (SOS2AX3)						
Historical average, ft³/s Years met	90,835 30/50	104,639 44/50	99,581 37/50	55,059 4/50	35,741 0/50	21,463 0/50
Scenario 3, Add Galloway (SOS2AX4)						
Historical average, ft³/s Years met	93,246 33/50	103,614 44/50	99,165 38,50	59,946 7/50	37,229 0/50	22,397 0/50
Scenario 2, Add Galloway, Rosevear/Jacobsen Gulches (SOS2AX5)						
Historical average, ft³/s Years met	95,621 35/50	105,744 46/50	102,067 40/50	63,079 7/50	41,130 0/50	25,898 0/50

120,000 ft³/s at Lower Granite for 2.5 Months			
Existing Operation (SOS2AY0)			
Historical average, ft³/s Years met	95,388 10/50	114,015 22/50	103,589 19/50
Scenario 3, Add Galloway (SOS2AY1)			
Historical average, ft³/s Years met	101,703 14/50	115,263 22/50	104,384 21/50
Scenario 2, Add Galloway, Rosevear/Jacobsen Gulches (SOS2AY2)			
Historical average, ft³/s Years met	106,585 16/50	119,581 24/50	109,174 24/50

	April 16 to 30	May	June	July	August 1 to 15	August 16 to 31
120,000 ft³/s at Lower Granite for 4.5 Months						
Existing Operation (SOS2AY3)						
Historical average, ft³/s Years met	94,474 10/50	112,516 22/50	103,431 19/50	48,165 0/50	25,495 0/50	20,172 0/50
Scenario 3, Add Galloway (SOS2AY4)						
Historical average, ft³/s Years met	100,075 14/50	112,621 22/50	103,915 21/50	50,776 0/50	25,769 0/50	20,173 0/50
Scenario 2, Add Galloway, Rosevear/Jacobsen Gulches (SOS2AY5)						
Historical average, ft³/s Years met	102,600 15/50	115,031 23/50	106,560 22/50	54,346 0/50	29,236 0/50	23,109 0/50

[1]HYSSR model-run description.
[2]"Years met" refers to the number of years out of the 50-year period of record (1928 to 11978) in which flow targets would be met.

Power

The system power generation analysis was obtained from the HYSSR studies and system generation costs were estimated by the SOR Workgroup using the spreadsheet model developed for the SOR. System costs include capital costs of acquiring new combustion turbines to replace generation lost due to operation of the hydrosystem to meet flow targets and variable costs of operating the existing system and new resources required to meet PNW loads for 1993. The analysis shows that adding new storage to the system would decrease total PNW hydro/thermal system costs by as much as $26 to $65 million annually. Results of the analysis, in terms of total system generation, new combustion turbine generation required, total system costs, and changes due to the addition of new storage for fish, are summarized in Table S-4.

Table S-4
Summary of Results of Effects on System Power Costs

	System Generation (aMW)[1]	New Combustion Turbines (aMW)	Total System Costs ($1,000/yr)	Change in Total System Costs[2]
Alternative 1 (SOS2AXO) (Existing System): 85,000 ft³/s for 2.5 months				
Power Effects	15,504	4,100	1,657,000	
Alternative 2 (SOS2AX1) Galloway added to Alternative 1				
Power Effects Compared to Alternative 1	15,509	3,650	1,594,000	(63,000)

Alternative 3 (SOS2AX2) Galloway and Rosevear/Jacobsen Gulches added to Alternative 1.				
Power Effects Compared to Alternative 1	15,494	3,650	1,599,000	(58,000)
Alternative 4 (SOS2AX3) (Existing System): 85,000 ft^3/s for 4.5 months				
Power Effects	15,448	4,600	1,756,000	
Alternative 5 (SOS2AX4) Galloway added to Alternative 4.				
Power Effects Compared to Alternative 4	15,432	4,250	1,708,000	(49,000)
Alternative 6 (SOS2AX5) Galloway and Rosevear/Jacobsen Gulches added to Alternative 4.				
Power Effects Compared to Alternative 4	15,422	4,100	1,691,000	(65,000)
Alternative 7 (SOS2AYO) (Existing System): 85,000 ft^3/s for 2.5 months				
Power Effects	15,453	4,700	1,746,000	
Alternative 8 (SOS2AY1) Galloway added to Alternative 7.				
Power Effects Compared to Alternative 7	15,456	4,350	1,698,000	(48,000)
Alternative 9 (SOS2AY2) Galloway and Rosevear/Jacobsen Gulches added to Alternative 4.				
Power Effects Compared to Alternative 7	15,441	4,200	1,683,000	(63,000)
Alternative 10 (SOS2AY3) (Existing System): 120,000 ft^3/s for 4.5 months				
Power Effects	15,415	4,900	1,793,000	
Alternative 11 (SOS2AY4) Galloway added to Alternative 10.				
Power Effects Compared to Alternative 10	15,417	4,700	1,767,000	(26,000)
Alternative 12 (SOS2AY5) Galloway and Rosevear/Jacobsen Gulches added to Alternative 10.				
Power Effects Compared to Alternative 10	15,407	4,550	1,751,000	(42,000)
Alternatives 13 through 15 (SOS6AY0, SOS6A1, SOS6A2). These are refill alternatives which existing system storage could meet without additional storage. No power effects were determined because no new storage was required.				
[1]aMW is defined as average megawatts. [2]Difference between scenarios with new sites added and existing system power operation. Adding new storage reduces system power costs.				

Fish Passage

The Columbia River Salmon Passage (CRiSP) model was used to obtain information on changes in salmon survival associated with the flow augmentation scenarios selected for analysis. Generally, the model results showed only small changes in survival, some positive and some negative, for Snake River spring/summer and fall chinook salmon smolts compared to existing operations.

Negative results were generally obtained when the available water was released to aid one stock (*e.g.*, spring/summer chinook), which resulted in lower flows for another stock (*e.g.*, fall chinook). Since the flow augmentation scenarios concentrated on providing specified 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 smolt survival. It is possible that if the additional supplies were used in conjunction with an in-season water management process to provide improved flows during time of greatest smolt movement, a more significant increase in smolt survival could be obtained.

D. Conclusions

The conclusions are presented under several sections: Water Supply, Costs, Environment, Scenarios, System Power, Fish Benefits, and Further Study of Storage Sites.

Water Supply

- The offstream sites, except for Galloway, have greater availability of water for release from storage.
- Onstream sites would have less water supplies available for storage every year than offstream storage sites.
- Offstream sites would have water supplies available for storage every year.
- New storage water supplies would increase the ability of the storage system to meet Lower Granite flow targets when compared over the 1928 to 1978 historical period to the existing system river operation. The flow increases would be 14 percent or less.
- System operation studies conducted for the SOR showed that a lower Snake River drawdown of 33-feet for Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and the John Day minimum operating pool to create increased fish passage flows through the reservoirs would not require new storage projects. The existing reservoir inflows for both the 2.5- and 4.5-month drawdown duration is adequate to refill reservoirs.

Costs

All sites analyzed had high capital costs. Onstream sites are less costly than offstream sites.

Environment

A summary of the most significant environmental impacts associated with the 11 potential sites is presented below.

Site		Environmental Comments
Onstream	**Offstream**	
	Saylor Creek	Environmental impacts probably could be mitigated. Minimum flows in the Snake River for sturgeon are a consideration.
	Rosevear Gulch	Environmental impacts are minimal and could be mitigated. Minimum flows in the Snake River for sturgeon are a consideration.
Thief Valley		Site has environmental concerns: Potential loss of wetlands Loss of wildlife habitat Possible impact to downstream fisheries Implications concerning Powder River Wild and Scenic designation
	Succor Creek	Probably not a viable site--significant environmental impacts
	Jacobsen Gulch	Environmental impacts are minimal and could be mitigated. Site drawback is distance from Snake River.
	Bissel Creek	Environmental impacts are minimal and could be mitigated.
	Moores Hollow	Environmental impacts are minimal and could be mitigated.
	Conant Creek	Significant fish and wildlife impacts. Habitat is unique and not readily mitigated. Two Threatened and Endangered species use the site.
Teton Dam		Significant fish and wildlife mitigation would be required.
Owyhee, enlargement		Significant environmental problems
Galloway Dam		Reservoir area contains inactive mercury mines which may threaten water quality in the reservoir.

Scenarios

Scenario 1 for streamflow augmentation compared to *Scenario 2* shows that:

1. Water released from storage is less than 50,000 acre-feet for each onstream site, except for Galloway, which is 336,000 acre-feet, with a majority of the offstream sites being considerably greater.
2. The facility costs are less.
3. The onstream sites' environmental concerns are greater.

Scenario 3 for streamflow augmentation, which is Galloway, compared to *Scenario 1* is better; but there is a question whether Galloway provides enough water for augmentation. If not, Owyhee enlargement and Thief Valley replacement may still be considerations.

Scenario 2 offstream storage sites are costly but, if water is needed, they could provide considerably more water supplies than the onstream sites, and most sites are environmentally acceptable.

Public acceptability of the selected sites analyzed was not a study task. The previous Corps study of Galloway did have public opposition. If sites are selected for further study, public input would be solicited.

System Power

- If releases for anadromous fish passage are first made from the new storage sites, followed by the existing storage facilities, a system power savings results.
- System power cost savings could be applied toward repayment of project costs.
- The reduction in system power costs would benefit onstream sites because these projects would have no pumping power needs that could reduce system power cost savings.
- The reduction in system power costs would not be as beneficial to offstream sites because project pumping power costs would reduce benefit obtained from reduction in existing system operation power costs. Although a savings in system power could be attained, its magnitude would be less than at onstream sites.
- The overall system power costs would be reduced, but an accounting of power costs for each facility, such as Brownlee Dam, would have to be accomplished to determine if costs would increase and if mitigation is necessary.

Fish Benefits

- CRiSP model results showed very little, if any, improvement in fish passage and survival. All results were interpreted based upon monthly averages. If daily modeling could have been accomplished, a more accurate interpretation of fish passage benefits could have been obtained.
- The additional flow augmentation from the potential upstream storage sites cannot achieve the survival estimated for transporting smolts.
- Benefits indicated by the CRiSP model are too small for all stocks and across all alternatives to be beyond the natural variability of uncertainty that is inherent in the model.

Further Study of Storage Sites

If flow augmentation continues to be a future component of strategies to improve downstream passage and survival of juvenile salmonids, based on potential reductions in system power generation costs, the following sites could be potentially cost-effective additions to the existing system. Conclusions about *cost-effectiveness* were based on estimated incremental system power cost savings being greater than or about equal to the cost of the additional storage. The projects are listed by flow and flow-duration objectives which were evaluated during the study.

Flow target of 85,000 ft^3/s for 2.5 months (April 16 to June 30):

Onstream Storage
—Galloway site
Offstream Storage
—Moores Hollow, small site

Flow target of 85,000 ft^3/s for 4.5 months (April 16 to August 31):

Onstream Storage
—Galloway site
Offstream Storage
—Rosevear Gulch, upper
—Moores Hollow, small site

Flow target of 120,000 ft^3/s for 2.5 months (April 16 to June 30):

Onstream Storage
—Galloway site
Offstream Storage
—Rosevear Gulch, upper
—Moores Hollow, small site

Flow target of 120,000 ft^3/s for 4.5 months (April 16 to August 31):

Onstream Storage

—Galloway site

Offstream Storage

—Rosevear Gulch, upper

—Moores Hollow, small site

In addition, because costs per acre-foot of water available for fish are comparable to costs from the Galloway project, the Thief Valley and Owyhee Reservoir sites also could be cost-effective additions to the system and may be cost-effective for fish.
If water supply is the major consideration, the offstream site's potential is high.