COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE I

EXISTING SYSTEM IMPROVEMENTS
TECHNICAL REPORT
LOWER SNAKE RIVER AND MCNARY DAM

EXECUTIVE SUMMARY

1. OVERVIEW.

The anadromous fish passage systems on the lower Snake River projects provide a safe and efficient route through, or around, the dams for both juvenile and adult fish. An important part of the juvenile fish passage system is the transportation program. Under this program, juvenile anadromous fish are collected at Lower Granite, Little Goose, Lower Monumental, and McNary Dams; transported downstream by barge or truck; and released below Bonneville Dam. The existing fish hatcheries principally produce salmon and steelhead to mitigate for the losses of natural fish habitat and turbine mortality due to the construction of the lower Snake River projects. In one form or another, the anadromous fish migrating on the lower Snake River are affected by the aforementioned systems.

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

The following paragraphs identify the alternatives and options evaluated, the biological effects on anadromous fisheries, and the associated construction costs and implementation schedules for each action. The information is broken down by category or area of improvement (*i.e.*, juvenile fish passage, adult passage, transportation improvements, hatchery modifications, and dam modifications). Under each category, there are a number of specific actions under investigation. Only a general description of the action and its associated benefits to anadromous fish are provided.

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

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

2. IMPROVEMENTS TO FISH HATCHERIES.

a. General.

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

b. Description of Evaluations.

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

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

It is believed in much of the region that perpetuating any improvement projects directed toward increasing the production of hatchery-origin juvenile salmonids, and especially steelhead trout, would be premature; and would act against the objective of focusing on wild salmon recover. This is true at least until the completion of the recently initiated U.S. Fish and Wildlife Service's (USFWS's) Programmatic Environmental Impact Statement on the Federally-funded and operated hatchery program. Currently, hatchery function has focused disproportionately on steelhead production in both the Snake River and Columbia River Basins, possibly at the expense or ecological bottlenecking of the more depressed wild Snake River Chinook salmon stocks.

Dependent upon the results derived through the USFWS evaluation, it is suggested that more study should be directed toward the improvement of subbasin supplemental facilities, with natural acclimation and disease eradication. Additional raceways at facilities such as these subbasin sites may be beneficial by reducing rearing densities for juvenile Chinook salmon. The primary point being perpetuated is that a more exerted effort from the subbasin level, concentrating on fry production from more localized wild broodstock, would be the more ecological and evolutionarily-adaptable choice for maintaining genetic fitness in wild salmon stocks.

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

3. IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS.

a. General.

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

b. Dispersed Release Sites.

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

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

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

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

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

c. <u>Extended Length Screens</u>.

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

Based upon the present knowledge that the Corps has regarding extended-length screen performance, it can be reasonably expected that Snake River spring and summer Chinook, fall Chinook, and sockeye salmon would benefit from the improved design and implementation of extended-length screens. At least an estimated 10-percent increase in FGE for all salmonid stocks passing each dam would cumulatively reduce turbine passage mortality for a greater portion of the total juvenile salmonid outmigrant population. Similar benefits would be expected to accrue for adult fallbacks of those same protected salmon stocks, in addition to Snake and Clearwater River steelhead. Based on the design of the existing extended-length screens that have been tested, screens could easily be designed for Lower Monumental and Ice Harbor Dams. Although relatively few wild Snake River juvenile salmon would be expected to remain in-river downstream to these two lower Snake River dams during maximum transport operations, improved FGE would benefit tributary and hatchery fall Chinook salmon stocks that enter the mainstem below Little Goose Dam. This train of thought is particularly consistent with the incremental benefit of the improved FGE for fall Chinook salmon afforded by extended-length screens. The maximum benefit of extended-length screens would be afforded to operational scenarios without transportation, especially from Lower Granite Dam. Any benefits attributable to extended-length screens at Lower Monumental and Ice Harbor Dams, during operational scenarios involving a high degree of transportation from each existing smolt collection dam, would be limited to Snake River subyearling (fall) Chinook salmon that are wild, as well as those releases from the Lyons Ferry Hatchery.

d. <u>Modifications to Lower Granite Dam Juvenile Fish Facilities</u>.

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

The biological community within the region generally agrees that pressurized passage systems increase stress to juvenile salmonids. It is generally accepted that the existing pressurized pipeline system at Lower Granite Dam should be replaced with an open flume system (based on the Little Goose design) to reduce this stress, and this would be a biologically-effective action. Wet separator construction at Lower Granite would be designed to separate smaller Chinook salmon from larger steelhead trout juveniles, much like the existing separators at Little Goose and Lower Monumental Dams. Current designs and regional discussion would classify these improvements as near-term actions that are implementable in a relatively short timeframe with lower economic cost. The NMFS and the regional technical committees have expressed interest in expediting these improvements, based upon the existing technology. Additional research is required to determine to what extent spring Chinook smolts benefit from segregation from steelhead smolts. The degree of potential benefit of wet separator implementation would be determined from this additional research as well.

e. <u>Auxiliary Water Intake Screens at McNary Dam</u>.

The water supply intake structure for the adult ladder located along the north shore (Washington side) of McNary Dam is not screened. The intake on the south shore (Oregon side) is equipped with a traveling system. However, this system has velocity conditions that allow fish to be impinged on the screens. Providing modern screening systems at these intakes, or modifying them to meet current fish criteria, could reduce juvenile mortality. A number of different options were investigated. Modifying the existing traveling screen system at the south shore intake structure with the new three-sided screen design, and retrofitting the trashracks of the north shore water intake structure with the new three-sided screens, were identified as the most desirable actions. North Wasco County Public Utility Department is installing a generating unit, under a Federal Energy Regulating Commission (FERC) license, within the north shore intake. This FERC license requires the public utility department to maintain a mitigation fund for affected anadromous salmonids.

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

f. Forebay Collection System.

Juvenile anadromous fish appear to be in the top 20 to 30 feet of the reservoir surface as they migrate downstream. The objective of a surface-oriented collector is to guide and collect these fish before they must dive to depths of 70 to 80 feet in order to be intercepted by the existing turbine screening bypass system. This type of surface collection system has been in operation at Wells Dam (on the Columbia River), and is reported to be very effective. Two design concepts of a forebay collection system were given cursory consideration: 1) vertical juvenile fish entrance slots based on the system at Wells Dam; and 2) a shallow skimmer weir or orifice similar in principal to the system at Ice Harbor Dam and The Dalles Dam (sluiceways). A single concept design, using a version of the Wells Dam fishway entrance in conjunction with a collection/sample and bypass system was identified as the preferred system. As such, it will be further developed in this study. For this evaluation, only the Lower Granite project was investigated. This project is considered to be representative of the powerhouse and spillway structures for the other lower Snake River dams, although flow dynamics in the forebay of each dam would vary. If this system proved to be effective at Lower Granite, this information could be transferred and hydrologically adapted to other dams, on both the Snake and the Columbia Rivers.

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

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

4. <u>IMPROVEMENTS TO JUVENILE FISH TRANSPORTATION SYSTEMS</u>.

a. <u>General</u>.

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

b. <u>Net Pens</u>.

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

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

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

c. <u>Barge Water Temperature Control</u>.

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

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

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

d. Fish Barge Exits.

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

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

e. New Fish Barges.

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

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

5. IMPROVEMENTS TO ADULT PASSAGE SYSTEMS.

a. General.

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

b. Fish Ladder Water Temperature Control.

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

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

c. Additional Fish Ladders.

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

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

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

d. **Fish Ladder Entrances and Attraction Water**.

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

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

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

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

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

This improvement would be considered a near-term action, in terms of the research available on providing attraction flow patterns for these dam operations and the available technology for formulating the design modifications. The implementation time required for this improvement at all of the lower Snake River dams, and any additional research and associated modeling, would indicate more of a long-term activity.

e. Fish Ladder Exits.

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

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

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

f. Adult Fish Collection Channel at McNary Dam.

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

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

g. <u>Extended Fishway Channels</u>.

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

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

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

6. DAM MODIFICATIONS--SPILLWAY/STILLING BASIN.

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

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

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

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

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

7. CONSTRUCTION COST ESTIMATES AND IMPLEMENTATION SCHEDULES.

Cost estimates and schedules presented in table ES-1 are preliminary, and are to be used in the planning process for comparative purposes only. They are not of sufficient detail for project authorization or appropriation. Construction cost estimates are based on a 1 October 1992 price level, escalated to midpoint of construction, using inflation factors established by the Office of Management and Budget for the fully-funded cost estimate. Average annual costs include interest and amortization at 8-percent interest; interest during construction; and increased operation, maintenance, and replacement (OM&R) costs. Duration periods represent the length of time, in months, to implement the alternative; and include design memorandums, plans and specifications, review, award of construction contracts, and actual construction. A summary of the estimated construction costs and implementation schedules is presented in table ES-1.

8. SUMMARY.

The preliminary evaluations conducted for these improvements has indicated that several of the improvements may warrant further evaluation, based on their potential benefit to anadromous fish. In addition, each improvement was examined for its value as a long-term or near-term type of action. Table ES-2 is a summary of the potential of each alternative to increase salmon fish survival, whether it is a near-term or long-term action, and the average annual cost.

Table ES-1 - Estimated Construction Costs and Implementation Schedules				
		Estimated Costs		
Improvement	Schedule (Months)	Project Cost Oct 1992 Price Level	Fully-Funded Cost	Average Annual Cost
JUVENILE FISH SYSTEMS				
Short-Haul Barging	39	9,428,000	12,144,000	2,266,000
Extended-Length Screens	41	45,753,000	59,666,000	4,622,000
Modifications to Lower Granite Juvenile Facility	59	19,684,000	25,652,000	1,862,000
Auxiliary Water Intake at McNary	61	24,340,000	31,682,000	2,298,000
Surface-Oriented Collection (Lower Granite)	70	101,530,000	133,840,000	10,053,000
JUVENILE FISH TRANSPORTATION				
Net Pens	41	21,051,000	26,606,000	6,758,000
Barge Water Temperature Control	53	48,617,000	63,507,000	7,130,000
Fish Barge Exits	23	1,476,000	1,809,000	146,000
Additional Fish Barges	27	45,452,000	58,546,000	4,748,000
ADULT PASSAGE SYSTEMS				
Fish Ladder Water Temperature Control	26	12,445,000	15,396,000	1,243,000
Additional Fish Ladders	61	150,879,000	200,972,000	13,733,000
Fish Ladder Entrance and Attraction Water	33	19,781,000	24,844,000	1,676,000
Fish Ladder Exits	37	856,000	1,101,000	75,000
Adult Collection Channel Modifications	21	353,000	434,000	31,000
Fish Channel Extensions	51	52,007,000	67,299,000	4,586,000
DAM MODIFICATIONS				
Spillway/Stilling Basin Modifications	79	137,468,000	187,788,000	12,420,000
HATCHERY MODIFICATIONS				
Truck Loading	6	360,000	473,000	55,000
Added Containment Facilities				
Dworshak Hatchery	65	14,109,000	18,563,000	1,400,000
Magic Valley Hatchery	49	3,569,000	4,695,000	358,000

Table ES-2 - Summary of Existing System Improvements Evaluations

Alternative	Salmon Survival Benefits: Effective	Salmon Survival Benefits: Maybe Effective	Salmon Survival Benefits: Not Effective	Average Annual Cost ($1,000)[1]	Near-Term Measure[2]	Long-Term Meas[3]
IMPROVED JUVENILE FISH SYSTEMS						
Dispersed Release Sites						
Short-Haul Barging		✖		303	✖	
With Flume System			✖	4,622	✖	
Extended-Length Screens (Fall Chinook)	✖			1,862	✖	
Modifications to Lower Granite Juvenile Facility	✖			2,298	✖	
Auxiliary Water Intake At McNary				2,266		
North shore		✖				✖
South shore		✖			✖	
Surface-Oriented Collection and Bypass	✖			10,053		✖
IMPROVED JUVENILE FISH TRANSPORTATION SYSTEMS						
Net Pens			✖	6,758		✖
Barge Water Temperature Control				7,130		
Spring Chinook			✖			✖
Fall & Summer Chinook		✖				✖
Fish Barge Exits	✖			146	✖	
Additional Fish Barges	✖			4,748	✖	
IMPROVED ADULT PASSAGE SYSTEMS						
Adult Ladder Temperature Water Control	✖			1,243		✖
Additional Adult Fish Ladders	✖			13,733		✖
Ladder Entrance and Attraction Water		✖		1,676		✖
Adult Ladder Exits		✖		75	✖	
Adult Collection Channel Modifications			✖	31	✖	
Adult Channel Extensions		✖		4,586		✖
IMPROVED FISH HATCHERIES						
Truck Loading Pump		✖		55	✖	
Additional Containment Facilities		X		1,758		✖
DAM MODIFICATIONS						
Spillway/Stilling Basin Modifications		✖		12,420		✖

[1]Construction costs at October 1992 price level and fully-funded cost estimates are presented above.

[2]Near-term measures are considered to be relatively minor improvements which could be implemented without extensive additional research or testing, provided they have regional support and funding is available.

[3]/Long-term measures are considered to be major improvements requiring significant research and testing prior to implementation. These actions require further study.

COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE I

EXISTING SYSTEM IMPROVEMENTS
TECHNICAL REPORT

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

SECTION 3 - PROPOSED IMPROVEMENTS TO EXISTING SYSTEMS

TABLE OF CONTENTS (continued)

SECTION 4 - ENGINEERING EVALUATION OF PROPOSED IMPROVEMENTS

TABLE OF CONTENTS (Continued)

SECTION 5 - ENVIRONMENTAL EFFECTS

SECTION 6 - COST ESTIMATES AND IMPLEMENTATION SCHEDULES

TABLE OF CONTENTS (continued)

SECTION 7 - SUMMARY/CONCLUSIONS

SECTION 8 - AGENCY COORDINATION

TABLES

PLATES

IMPROVEMENTS TO FISH HATCHERIES

Number

IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS

TABLE OF CONTENTS (continued)

PLATES (continued)

COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE 1

LOWER SNAKE RIVER AND MCNARY DAM
SYSTEM IMPROVEMENTS

SECTION 1 -- INTRODUCTION

1.01. <u>BACKGROUND</u>.

The passage systems on the lower Snake River projects provide the means for allowing juvenile fish to safely and efficiently bypass the dams during downstream migration, as well as the means for allowing adult fish to pass over the dams during upstream migration. An important part of the juvenile fish passage system is the transportation program. Under this program, juvenile anadromous fish are collected at Lower Granite, Little Goose, Lower Monumental, and McNary Dams; transported downstream by barge or truck; and released below Bonneville Dam. The existing fish hatcheries produce salmon, steelhead, and other fish to mitigate for losses of natural fish habitat and turbine mortality due to the construction of the lower Snake River projects. In one form or another, a large majority of the anadromous fish migrating on the lower Snake River are affected by the aforementioned systems. Therefore, even minor improvements to these systems may have a dramatic effect upon the survival of anadromous fish.

Potential improvements to the juvenile fish facilities, adult fish facilities, and the juvenile fish transportation program were identified in the Northwest Power Planning Council's (NPPC's) *Amendments to the Columbia River Basin Fish and Wildlife Program (Phase Two)*, dated December 11, 1991. Potential juvenile fish facility improvements were identified in section III.1, paragraphs B (1 through 7), pages 25 through 26; potential adult fish facility improvements were identified in section III.5, paragraph A(2), pages 55 through 56; and potential juvenile fish transportation program improvements were identified in section III.3, paragraphs A(5) and A(9), pages 29 through 30. These improvements, as well as others identified by U.S. Army Corps of Engineers (Corps) personnel, comprise the improvements considered in this study.

1.02. <u>AUTHORITY</u>.

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

1.03. PURPOSE.

Improvements to the existing fish passage systems on the lower Snake River projects, the juvenile fish transportation program, the existing Corps-constructed fish hatcheries serving the lower Snake River drainage, and other modifications to McNary Dam and the lower Snake River dams are under consideration to enhance the survival of anadromous fish. The objective is to improve the existing systems by eliminating or reducing fish stress, predation, physical injury, and other factors that have a detrimental effect upon the survival of fish. The purpose of this study is: 1) to identify potential improvements to the existing systems and to evaluate the technical feasibility of implementing these improvements; 2) to estimate the biological benefits to salmon that may result from implementing the improvements; 3) to identify operational requirements and potential problems associated with the improvements; and 4) to develop cost estimates and implementation times for the improvement work.

1.04. SCOPE.

The Corps, Walla Walla District, was tasked with studying potential improvements to Corps-constructed dams and fish facilities on the lower Snake River, answers at McNary Dam. The Corps, Portland District, was tasked with studying similar improvements to Corps-constructed systems on the lower Columbia River.

This reconnaissance-level study focuses on improvements to fish hatcheries, juvenile fish collection and bypass systems, juvenile fish transportation systems, adult passage systems, and modifications to the dams. The improvements comprise new construction, modifications to existing structures and systems, and changes in current operational practice. Descriptions of the existing systems and preliminary designs, environmental effects (including biological benefits), operational requirements, potential problems, implementation times, and costs of the proposed improvements are presented in this study. The results of these evaluations are meant only for use in comparing alternatives being investigated under the System Configuration Study (SCS). The specific improvements and modifications considered in this study are categorized and listed in section 3, Proposed Existing System Improvements.

COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE 1

LOWER SNAKE RIVER AND MCNARY DAM
SYSTEM IMPROVEMENTS

SECTION 2 -- EXISTING SYSTEM DESCRIPTION AND OPERATION

2.01. GENERAL.

Early efforts to help anadromous fish were focused on providing fish ladders to allow adult fish passage over the dams. These efforts progressed to compensating for declining fish runs by constructing fish hatcheries, and then towards improving conditions for outmigrating juvenile fish. To better describe the systems currently being used to help anadromous fish, the systems are arranged and discussed under the following categories: 1) hatcheries and satellite facilities; 2) juvenile fish bypass facilities; 3) juvenile fish transportation facilities; and 4) adult passage facilities.

2.02. HATCHERIES AND SATELLITE FACILITIES.

The Corps, Walla Walla District, has constructed numerous fish hatcheries and satellite facilities throughout the Snake River drainage. These facilities were constructed to compensate for anadromous fish losses caused by the construction of the lower Snake River dams. The majority of these facilities were constructed under the Lower Snake River Fish and Wildlife Compensation Plan (LSRFWCP), which was passed into law in October 1976. The LSRFWCP includes 9 hatchery complexes and 15 satellite facilities located in the states of Idaho, Oregon, and Washington. The LSRFWCP is the largest, most comprehensive fish and wildlife program ever undertaken by the Corps. Other hatchery complexes have been constructed by the Corps under different programs. All of these hatcheries and satellite facilities, excluding Dworshak National Fish Hatchery (Dworshak) and Hagerman National Fish Hatchery (Hagerman), have been turned over to, and are being operated by, state agencies. Dworshak remains part of the Dworshak Dam project, and both Dworshak and Hagerman are operated by the U.S. Fish and Wildlife Service (USFWS). Operation and maintenance funding of all LSRFWCP hatcheries is provided by the USFWS, even for the hatcheries operated by state agencies.

Each hatchery and corresponding satellite facility system has the facilities needed to maintain fish through the entire fish rearing process. The extent and type of the facilities provided at a hatchery or satellite depends on the design and operation of the system. Some hatcheries are capable of acting independently of the satellites, while others rely on the satellites for adult trapping, spawning, and acclimation/release of juvenile fish. Facilities that are typically provided at the hatcheries include: 1) water supply systems; 2) spawning, incubation, and early rearing facilities; 3) rearing raceways and/or rearing ponds; 4) residences for hatchery personnel; 5) administration facilities; 6) settling and treatment facilities for hatchery effluent; and 7) mechanical buildings. Facilities typically provided at satellite facilities include: 1) adult trapping, holding, and handling facilities; 2) acclimation ponds; 3) operator residences; and 4) settling ponds for acclimation pond effluent.

The yearly fish rearing capacity at hatcheries constructed by the Corps in the Snake River drainage exceeds 2 million pounds. The fish produced include: 1) spring, summer, and fall Chinook salmon; and 2) steelhead (genus *Oncorhynchus*) and rainbow trout. The production at these hatcheries is summarized in table 2-1.

TABLE 2-1

Annual Fish Hatchery Production in Thousands of Pounds of Fish*

HATCHERY	TYPE OF FISH				
	SUMMER CHINOOK	FALL CHINOOK	SPRING CHINOOK	STEELHEAD	RAINBOW TROUT
McCALL	61.3	0	0	0	0
HAGERMAN	0	0	0	340	0
MAGIC VALLEY	0	0	0	291.5	0
DWORSHAK	0	0	70	383.3	100
SAWTOOTH	0	0	149	0	0
CLEARWATER	0	0	91.3	350	0
LYONS FERRY	0	101.8	8.8	116.4	45
TUCANNON	0	0	0	0	41
LOOKINGLASS	0	0	69.6	0	0
	0	0	0	279.6	0

* Quantities listed are approximate, actual production varies.

2.03. JUVENILE FISH COLLECTION AND BYPASS FACILITIES.

a. General.

Lower Granite, Little Goose, Lower Monumental, and McNary Dams each have juvenile bypass systems designed to collect and bypass anadromous fish around the turbines. The bypass systems are designed to allow the fish to be released directly to the river, or diverted to holding and loading facilities for subsequent barge or truck transport. A juvenile bypass system, similar to the existing facilities upriver, is currently being designed for Ice Harbor Dam. Holding and loading facilities at Lower Monumental Dam are currently being constructed. State-of-the-art juvenile fish bypass, holding, and loading facilities are currently being constructed at McNary Dam.

b. Little Goose and Lower Monumental Dams.

The juvenile bypass systems at Little Goose and Lower Monumental Dams are each comprised of submerged traveling screens (STS's), vertical barrier screens (VBS's), fish orifices, attraction lighting, a collection channel, a transportation channel, primary and secondary dewatering systems, and a corrugated metal flume (CMF).

Each turbine has three intake bays, and each intake bay has a slot for an intake gate and a bulkhead gate. In each bulkhead gate slot, an STS is installed and lowered down into the flow upstream of the turbines. Each STS consists of a loop of mesh screen revolved about a framework. In this manner, debris caught on the upstream side of the mesh is washed away on the downstream side during each evolution. Three STS's are required to screen one turbine. The VBS's are installed as a barrier between gate slots. Water and fish are diverted by the STS's into the bulkhead gate slots. The water passes through the VBS's, down the intake gate slot, and through the turbine. The VBS's prevent fish that have been guided by the STS from passing down through the other slot and entering the turbines. The VBS's were designed to maintain less than 0.5 feet-per-second (fps) flow velocity across the surface of the VBS. This is necessary to prevent injury to the collected fish as they rise toward the water surface in the intake gate slot. The fish follow this current along the screen and into the intake gate slots.

Two 12-inch-diameter orifices are installed in each intake gate slot below the water surface, for the purpose of passing fish from the intake gate slot into the fish collection channel. At normal minimum operating pool (MOP), the orifices are submerged 4 feet. Depending upon forebay elevation, each orifice passes a flow ranging between 11 and 15 cubic feet per second (cfs). The orifice flow discharges freely (non-submerged discharge) into the fish collection channel. The fish are attracted to the orifices by the flow through them, as well as by attraction lighting placed on the collection channel side of the orifices. The attraction lighting is directed through each orifice toward the intake gate slot. From a gallery located above the collection channel, access is provided to each orifice in order to allow inspection and maintenance of the orifices and the fish attraction lighting.

The fish collection channel is a 7-foot-wide by 8-foot-high rectangular channel mined (and shotcrete finished) through the dam parallel to the longitudinal axis of the dam. It extends across the full length of the powerhouse. The orifices discharge a total flow of approximately 270 cfs into the collection channel.

The transportation channel is a 7-foot-wide by 8-foot-high rectangular channel that carries the water from the collection channel, out through the downstream face of the dam, to the primary dewatering structure. A portion of the transportation channel is mined through the dam and shotcrete finished. The remainder of the transportation channel is a fully-enclosed rectangular conduit, 7 feet wide by 8 feet high, and is external to the dam.

The primary dewatering structure is a 100-foot-long structure designed to remove all but 30 cfs of the incoming transportation channel flow. Dewatering occurs as the flow passes across a screened surface located in the floor of the structure. The water level in the primary dewatering structure is maintained by spilling the surplus water over automatically-controlled weirs. The surplus water from the primary dewatering chamber is piped for discharge into the river. The screened floor of the dewatering chamber is kept clean using automatic screen-cleaning equipment.

The fish, now concentrated in the 30-cfs flow, exit the primary dewatering chamber and enter secondary dewatering. The facility operator uses the secondary dewatering to fine tune the flow entering the CMF and optimize the hydraulic performance of the flume.

The CMF design was developed and extensively tested to ensure the safe passage of juvenile fish. It begins at the outlet of the secondary dewatering structure, and extends to the fish facilities located downstream. The CMF is placed at a 3.4-percent slope to pass approximately 30 cfs at a mean velocity of 9 fps and a mean depth of 18 inches. At Little Goose Dam, flow through the CMF may be diverted around the fish facilities through the use of a switch gate, and continued to the river release point through a CMF. At Lower Monumental Dam, the flow from the CMF may also be diverted around the fish facilities through the use of a switch gate, but the flow is continued to the river release point using a polyethylene pipe.

The river release points are located at least 800 feet downstream of the powerhouse, in an area where the river velocity is sufficient to minimize losses due to predation as the fish enter the river.

c. Lower Granite Dam.

The portions of the bypass system that are within Lower Granite Dam are similar to those at Lower Monumental and Little Goose Dams, except that the fish orifices at Lower Granite Dam are 10 inches in diameter. The major differences are that the Lower Granite Dam system uses a pipe rather than a CMF, and dewatering occurs at the fish facility rather than up close to the dam. Also, the release to the river at Lower Granite Dam occurs through the fish facility, and no direct bypass is present.

d. McNary Dam.

The new juvenile fish collection, bypass, holding, and loading facilities at McNary Dam will be similar in principle to the facilities at Little Goose and Lower Monumental Dams. Due to the greater volume of fish and water that will be passing through the McNary facilities, the facilities will be considerably larger.

2.04. JUVENILE FISH TRANSPORTATION.

a. General.

The Corps, Walla Walla District, has been transporting juvenile salmon and steelhead around Snake and Columbia River dams since 1969. From 1969 through 1980, transport was conducted by the National Marine Fisheries Service (NMFS), as research under contract to the Corps. Fish trucks were the primary transport vehicles used through the mid-1970's. Five 3,500-gallon fish trailers were acquired. In response to a strong regional plea to save the fish runs from devastating losses that would have been caused by the extremely low water year of 1977, the Corps contracted with a local towboat and barging company to convert two barges for fish transportation use. These barges were used to transport approximately 400,000 fish from Lower Granite Dam to the Columbia River below Bonneville Dam.

Because of the success in 1977, regional fishery agencies requested that barging continue in 1978. The Corps had two U.S. Army surplus barges converted for fish transportation. Each of these barges was capable of hauling approximately 23,000 pounds of fish in 86,000 gallons of water. Two towboats were contracted to push these barges from Lower Granite Dam to the release areas below Bonneville Dam. By 1980, fish collection and loading facilities had been installed at Little Goose and McNary Dams, and nearly 5 million fish were being barged annually. In 1981 and 1982, two barges of 50,000-pound capacity (100,000 gallons of water) were added, and the number of towboats used increased to four. Numbers of fish collected and transported continued to increase. In 1989, two additional barges were constructed, each capable of hauling 75,000 pounds of fish (150,000 gallons of water). Four towboats continued to be used. The smallest barges, when used, were transported in tandem with medium-sized barges. In recent years, approximately 73 percent of the fish arriving at Lower Granite Dam have been collected there, while approximately 70 percent of those arriving at Little

Goose and Lower Monumental Dams have been collected. Of the juvenile fish arriving at each project, a relatively high percentage are collected. Of the total Snake River juvenile fish population, the overall percentage of fish collected and transported is estimated to be 52 percent for steelhead and 32 percent for salmon. This low percentage is due to: 1) mortality upstream of the Lower Granite reservoir; 2) mortality within the lower Snake River reservoirs; and 3) turbine passage and mortality for fish that are not guided into the collection systems (estimated at 15 percent of those that are passed, although evidence suggests that it could be less).

Currently, fish are collected at four dams: Lower Granite, Little Goose, Lower Monumental, and McNary. Trucks are used early and late in the migration season when fish numbers are low, and barges are used during the peak of the fish migration when fish numbers are high. Two trucks are used at Lower Granite and McNary Dams, while only one is needed at Little Goose Dam. Barges start at Lower Granite Dam; and take on additional fish at Little Goose, Lower Monumental, and McNary Dams before proceeding downstream to the area between Skamania Light and Warrendale (below Bonneville Dam). The largest, most modern barges are used for most of the season. Small barges, when used, are used in tandem with medium-sized barges. Barges are scheduled to arrive below Bonneville Dam during the night so that releases can be made in darkness to minimize predation by birds and fish. Trucking resumes when numbers decline; usually by late June on the Snake River, and by late July at McNary Dam. Transportation is conducted from late March through October at the Snake River dams, and from late March through December at McNary Dam.

The number of fish migrating down the Snake and Columbia Rivers has increased over the past 15 years. On the Snake River, production has increased from a low of 3.4 million salmon and steelhead in the mid-1970s to over 28 million during recent years. Most of the increase is due to production by LSRFWCP hatcheries. When these hatcheries reach full production, as many as 47 million fish may be produced above Lower Granite Dam. On the Columbia River, natural production in the Hanford Reach has contributed up to 40 million fish in recent years, with hatchery production adding several million more fish. Recent efforts to increase production (irrigation screening, hatchery construction, and the improvement of natural construction) in the Yakima River and other mid-Columbia tributaries will increase fish numbers there, as well. In the Snake River, studies indicate that as many as 30 to 60 percent of the hatchery fish may die before reaching the Lower Granite reservoir. Similar studies have shown that as many as 80 to 95 percent of the wild fish tagged in tributaries may not survive to the Lower Granite reservoir.

The numbers of fish collected and transported from the three collection facilities peaked in 1990, with 22.4 million collected and 21.5 million transported. These numbers include Columbia and Snake River fish. In

1991, approximately 17.4 million fish were collected, and 15.4 million were transported. Due to higher than normal flows in the Columbia River, extended spill at McNary Dam resulted in perhaps half of the fish passing over the spillway. Also, because of higher flows, nearly 2 million juvenile fish that had been collected were bypassed back to the river according to the "spread the risk" policy of regional fishery agencies and Indian tribes. With a record daily collection of 676,476 fish at Lower Granite Dam on May 21, 1991, barging capacity was exceeded. Over a 2-day period, approximately 183,000 fish had to be bypassed back to the river at Lower Granite Dam because there was not enough room in raceways or barges to hold them. On May 6, 1992, following 4 consecutive days of collecting over 400,000 fish per day, 118,000 fish had to be bypassed at Lower Granite Dam because of inadequate barge capacity. Over approximately the same time periods, because barges were nearly filled at the Snake River dams, fish had to be trucked from McNary Dam and released below Bonneville Dam.

Over 20 years of research on various aspects of truck and barge transportation have indicated that no significant impact to homing or survival can be attributed to transportation, and the majority of tests have shown that transportation returns more adult fish than in-river passage. Research in recent years, since improvements have been made at the collection facilities, has consistently indicated that transporting all species of anadromous fish would be beneficial. While there is no consensus among conservation groups and fishery agencies of the Pacific Northwest that transportation is a permanent solution to fish passage problems at Corps dams, the program has strong regional support as an interim program, and is absolutely necessary in low runoff years.

Transportation has been credited with playing a major role in the doubling and quadrupling of the steelhead runs in the Snake River, and fall Chinook runs in the mid-Columbia River. While less successful for spring/summer Chinook, the blame for the decline of these runs cannot be determined. The decline is probably caused by one of two possible occurrences: 1) increased production of hatchery fish that do not survive well; or 2) virtually all of the hatchery spring/summer Chinook, and the majority of wild spring/summer Chinook, are plagued with bacterial kidney disease (BKD). What can be determined with a high degree of certainty is that collection and transportation of Snake River salmon allows many more (up to 98 percent of those collected) fish to arrive below Bonneville Dam than would otherwise get there through in-river passage (20 to 50 percent). Transportation also gets fish downstream while they are physiologically adapted to entering the ocean. Historically, it took 20 to 30 days for fish to get from the headwaters of the Salmon River to the estuary. Since the creation of the reservoirs, this time has increased to an estimated 30 to 90 days. While transportation gets them there faster than the natural rate (3 to

4 days, counting holding and trucking or barging time), research has shown this does not diminish their ability to return.

In permitting the Transportation Program for 1992 under the Endangered Species Act (ESA), NMFS has recognized the important role the program plays in protecting juvenile Snake River salmon in bypassing Snake and Columbia River dams and reservoirs. The NMFS has requested that the program be maximized in normal and low flow years, that the facilities and procedures be refined to maximize the survival of Snake River salmon, and that the program be extended to maximize protection of Snake River fall Chinook.

b. Fish Barge Design and Operation.

The current barges are double-hulled vessels that contain fish holding chambers. River water is pumped through the chambers while fish are being loaded or transported. The small and medium (23,000 and 50,000 pounds) barges each have three diesel-engine-powered pumps, two that are run during transport and one that is used only as a spare. The large barges (75,000 pounds) have four diesel-engine-powered pumps, one of which is a spare. The small barges can hold 86,000 gallons of water; the medium barges hold 100,000 gallons; and the large barges hold 150,000 gallons. At 5 pounds of fish per gallon-per-minute (gpm) inflow; fish loading is determined by the 5,200-, 10,000-, and 15,000-gpm inflow, respectively, rather than the gallon capacities of the barges.

On the small barges, the water is pumped through pipes and sprayed against a baffle to aerate or dissipate supersaturated gas in the water. In the medium and large barges, water is pumped through packed columns and trickles down into the fish holding compartments. Both systems have proven effective in controlling dissolved-gas levels.

On the small barges, fish are released through openings in the central bottom area of the fish compartments. When water is circulated within the barge, it flows out through a screened box and through a piping system to the sides of the barge, where it is discharged into the river. Beneath the screened box is the release port. To release fish, the screened box is raised and, after it has been lifted a preset distance, the plug in the release port is pulled. Fish and water exit through the port because the water level within the barge is higher than the water level of the river. On the medium- and large-sized barges, the water circulation system is separate from the fish release port. During release, a plug is mechanically pulled in each compartment, and the fish and water drain out.

With the current equipment, operation through the season has followed a fairly well-established pattern for the past several years. At the beginning of the juvenile fish outmigration (late March), fish are collected and trucked from Lower Granite, Little Goose, and McNary Dams. When fish numbers approach 20,000 per day at Lower Granite Dam (mid-April), barges (usually the 75,000-pound barges) leave Lower Granite Dam every other day (the round trip to the release site at Bonneville Dam takes about 4 days), stopping at Little Goose and McNary dams to pick up additional fish. As numbers increase, a barge leaves Lower Granite Dam every day (alternating 50,000- and 75,000-pound barges). During peak days (mid-May), the 23,000-pound barges are added to the 50,000-pound barges. As the numbers of fish decline, the small barges are no longer used (late-May), barging reverts to an every-other-day schedule and, finally (mid-June), transport reverts to trucking from Lower Granite and Little Goose Dams. However, since fish numbers are still high at McNary Dam, barging continues there until mid-August. One towboat takes a barge downstream every other day, unless numbers increase to the point that a second towboat and every day barging is required. When barging is concluded at McNary Dam, all equipment is returned to Lower Granite Dam, where it is stored and maintained.

c. Fish Truck Design and Operation.

Five fish-hauling tanker trucks are used to transport juvenile fish from the fish facilities prior to, and after, the peak outmigration period. The rated capacity of the tankers is 3,500 gallons. At the current Fish Transportation Oversight Team loading criterion of 0.5 pounds of fish per gallon of water, a fully loaded tanker can transport 1,750 pounds of fish. Driving times from collection point to release vary; taking about 8 hours from Lower Granite, 6.5 hours from Little Goose, and 3.5 hours from McNary.

Each fish tanker is a specially-fabricated unit permanently mounted to a semi-trailer. The tanks are of double wall construction, with insulation between the walls. On two of the tankers, the inner tank is painted steel. The inner tank on the other three tankers is stainless steel. The outer tank on each tanker is aluminum. Each tanker is divided into four compartments, each compartment having a vented access hatch.

From the fish facilities, fish are loaded into the tankers through the access hatches in the top of the tankers. Each tanker is equipped with one 12-inch-diameter, hydraulically-operated valve for releasing fish. Bolt-on transitions downstream of the release valve provide flexibility in release pipe sizing. During a typical release operation, a 5-inch-diameter flexible hose is used to direct fish into the river.

Water temperature in the tankers is kept within 3 degrees Fahrenheit (^{o}F) of the river temperature at the release site by using chillers mounted on the tanker. The tanker is also equipped with a means of aeration and degassification. The tanker water is degassified by pumping the water to the top of the tanker and spraying it down to the water surface. Aeration is achieved through a liquid oxygen/carbon block system. Liquid oxygen is directed from onboard tanks to each tanker compartment. Within each compartment, two carbon blocks are mounted to the tanker walls near the bottom of the tanker. In order to maintain oxygen levels in the water, the liquid oxygen passes through the carbon blocks and into the water. An onboard compressed-air system serves as a backup in the event of a failure in the liquid oxygen/carbon block system.

2.05. ADULT FISH PASSAGE.

McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams each have an adult fish passage system to allow the passage of upstream migrating adult salmon and steelhead. Each adult fish passage system is comprised of the following: 1) fish entrances; 2) a collection channel; 3) attraction pumps; and 4) a fish ladder (ladder). The arrangement, magnitude, and operation of the adult passage systems varies at each dam. McNary, Ice Harbor, and Lower Monumental have a fish passage system and ladder on each shore. At these dual ladder projects, one of the passage systems is arranged as described above, while the other is a simpler system that lacks a collection channel.

Upstream migrating adult fish pass over the dams by entering the passage system through the fish entrances (approximately 10) located at the downstream side of the dam, swimming along the collection channel (as applicable) to the ladder, swimming up the ladder, and exiting the ladder into the forebay. Water flowing out of the fish entrances attracts the adult fish into the fish passage system.

The fish entrances along the powerhouse are a combination of floating orifices and weir gates. These entrances are located in the wall of the fish collection channel. The floating orifices have a 2-foot-tall by 6-foot-wide opening that is operated with 1 to 2 feet of head across the orifice. The orifices are typically operated with the orifice centerline 4 feet below tailwater. The width of the weir gates varies from project to project. Typically, the weir gates are operated with a minimum of 8-foot submergence below tailwater.

In general, the fish entrances located at the shoreline are weir gates. Ideally, the weir gates should be operated with at least 8 feet of submergence below the tailwater. In some instances, the 8-foot submergence cannot be achieved. The width of the weir gates varies from project to project. One of the entrances on the south shore of Lower Monumental Dam is a sluice gate with an 8-foot width. The sluice gate is typically operated with a 6-foot opening height.

The majority of the water supply for the fish entrances, collection channel, and lower portion of the fish ladder is provided by fish attraction water pumps. The remaining portion of the adult attraction water supply comes from water passing down the fish ladder from the forebay. The fish attraction water pumps take water from the tailrace and discharge the water, through a supply channel, into diffusers located in the floor of the collection channel and the floor of the fish ladder. These pumps are high-volume, low-head pumps where the pumped output varies greatly, with relatively minor variations in pumping head.

Each fish collection channel is a large concrete channel running parallel to the longitudinal axis of the dam beneath the tailrace deck. The collection channels are open-flow channels, having widths and depths that vary from project to project. The collection channel connects with the shoreline fish entrances prior to reaching the ladder.

Each dam has at least one ladder. McNary, Ice Harbor, and Lower Monumental Dams have two ladders, one on each shore. Little Goose and Lower Granite Dams have one ladder on the south shore, with a transportation tunnel through the spillway structure connecting the collection channel to entrances on the north shore. Ladder flow, slope, width, and arrangement varies from project to project. The upper portion of the ladders is supplied by flow coming in the ladder exits and, with the exception of the McNary ladders, auxiliary supply from the forebay. The auxiliary supply enters the upper portion of the ladder from diffusers located in the ladder floor. An automatic control system regulates the water flow into the ladder entrance and auxiliary supply in order to maintain a constant ladder flow over the normal range of forebay fluctuations.

COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE 1

LOWER SNAKE RIVER AND MCNARY DAM
SYSTEM IMPROVEMENTS

SECTION 3 -- PROPOSED IMPROVEMENTS TO EXISTING SYSTEMS

3.01. GENERAL.

Potential improvements to juvenile fish facilities, adult fish facilities, and the juvenile fish transportation program were identified in NPPC's *Amendments to the Columbia River Basin Fish and Wildlife Program (Phase Two)*, dated December 11, 1991. Potential juvenile fish facility improvements were identified in section III.1, paragraphs B (1 through 7), pages 25 and 26; potential adult fish facility improvements were identified in section III.5, paragraph A(2), pages 55 and 56; and potential juvenile fish transportation program improvements were identified in section III.3, paragraphs A(5) and A(9), pages 29-30. These improvements, as well as others identified by Corps personnel, comprise the improvements considered in this study. The specific improvements and modifications considered in this study are categorized and listed below. Other potential improvements and areas of study that were not examined in this study are listed and described at the end of this section.

3.02. IMPROVEMENTS TO FISH HATCHERIES.

a. Truck Loading.

Improve truck loading at existing fish hatcheries to eliminate the current practice of using fish pumps for planting or transportation operations.

b. Additional Containment Facilities.

Provide additional containment facilities at existing fish hatcheries to reduce fish rearing densities and produce fewer, but healthier fish.

3.03. IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS.

a. Dispersed Release Sites.

To reduce predation losses, provide dispersed release at the outfalls of the existing juvenile bypass systems at Little Goose, Lower Monumental, and McNary Dams.

b. Extended-Length Screens.

Provide extended STS's for the existing juvenile fish collection systems at Lower Monumental and Ice Harbor Dams to improve fish guiding efficiency (FGE).

c. Modifications to Lower Granite Dam Juvenile Fish Facilities.

Replace the pressurized bypass pipe that runs from the dam to the separator with a flume system similar to that being used at Little Goose and Lower Monumental Dams. Replace the fish separator, raceways, and raceway flume system, and provide shading of project features. These changes are required to improve the bypass, holding, and loading facilities at Lower Granite Dam.

d. Auxiliary Water Intake Screens at McNary Dam.

Screen the north and south shore fish ladder auxiliary water intakes at McNary Dam to reduce juvenile fish losses.

e. Short-Haul Barging.

Provide short-haul barges for the Lower Granite, Little Goose, Lower Monumental, and McNary Juvenile Fish Facilities to reduce predation losses at the river release points.

f. Forebay Collection System.

Provide a surface-oriented collection system to attract, collect, and bypass juvenile fish from higher forebay depths in front of the dams. This alternative is intended to improve juvenile fish survival by reducing migration delay, predation, and fish stress.

3.04. IMPROVEMENTS TO JUVENILE FISH TRANSPORTATION SYSTEMS.

a. Net Pens.

Provide net pens to supplement or replace the fish barges.

b. Barge Water Temperature Control.

Provide a means of reducing and controlling water temperatures in the fish barges in order to improve conditions in the barges.

c. Fish Barge Exits.

Increase the size of the fish release exits on the barges to reduce fish stress during release.

d. New Fish Barges.

Provide new fish barges to supplement the existing fleet in order to increase direct loading capability and improve transport capability.

3.05. IMPROVEMENTS TO ADULT PASSAGE SYSTEMS.

a. Fish Ladder Water Temperature.

Control the fish ladder water temperatures to reduce the impact to adult fish passage caused by water temperature differences between the forebay, fish ladder, and tailrace.

b. Additional Fish Ladders.

Provide north shore fish ladders at Lower Granite and Little Goose Dams to enhance adult fish passage, and provide a backup fish ladder at each dam in the event of problems with the existing fish ladder.

c. Fish Ladder Entrances and Attraction Water.

Improve the adult fish collection systems to operate more effectively by enhancing entrance performance and attraction flows.

d. Fish Ladder Exits.

Improve hydraulic control of the exit gates at the McNary Dam fish ladders.

e. Adult Fish Collection Channel at McNary Dam.

Eliminate the low velocity area in the adult fish collection channel at McNary Dam to enhance adult passage.

f. Extended Fishway Channels.

Extend the collection channels and entrances serving the north shorelines at Lower Granite and Little Goose Dams to improve adult fish passage during spill.

3.06. DAM MODIFICATIONS.

Modify the spillways/stilling basins to reduce levels of dissolved gasses in the downstream flow when spilling operations are required.

3.07. OTHER POTENTIAL IMPROVEMENTS AND AREAS OF STUDY.

a. Turbine Replacement.

Replace old turbines with new and more efficient units that will improve juvenile survival during downstream migration. Testing at the Bonneville Second Powerhouse suggests that new and efficient turbines may allow up to 97-percent survival of fish passing through the turbines, whereas survival through older and less efficient turbines has been estimated at approximately 85 percent.

b. Bird Wire at Release Sites.

Install bird wire at the release sites at the juvenile fish facilities to reduce bird predation. When juvenile fish are released in the river, they enter it at speeds up to 30 fps. Upon impact, the fish may be disoriented, and tend to be near the surface of the river. This makes them easy prey for many birds (*e.g.*, seagulls). In order to reduce bird predation, the release sites could be covered with bird wire. Since birds would be unable to get through the wire, the juvenile fish could recover from the release and dive into deeper water before the birds could reach them.

COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE 1

LOWER SNAKE RIVER AND MCNARY DAM
SYSTEM IMPROVEMENTS

SECTION 4 -- ENGINEERING EVALUATION OF PROPOSED IMPROVEMENTS

4.01. GENERAL.

This section presents detailed discussions of the proposed existing system improvements. Descriptions of existing systems and conditions, alternative means of making improvements, evaluation of improvement alternatives, design criteria, proposed designs, costs, and implementation schedules are provided for each proposed improvement, as applicable. Potential problems, variations, operational changes, and operational requirements associated with the proposed improvements are presented, whenever applicable. Benefits to fish are estimated, where possible.

In conducting the technical evaluation of the proposed improvements, the effects of these improvements upon related existing systems were considered. Because it was not known which of the proposed improvements would be considered in detail following this Phase I study, the effect the proposed improvements would have upon one another was not evaluated. Therefore, the interaction between the alternatives selected for further study must be considered. For example, if both the additional fish ladders improvement and the fish ladder water temperature improvement were to be further evaluated, temperature control on the additional fish ladders may need to be added.

The evaluation of the existing system improvements and the development of preliminary designs were performed assuming normal project operation. The effects of drawdown on existing system improvements were not considered.

The implementation schedules for the proposed designs consist of time to prepare design memorandums (DM's), time to prepare plans and specifications, and time for contract award and construction. The DM is an extensive design document that includes the scope of work, an evaluation of design alternatives, and much of the preliminary design for the project. In addition, the DM is also used to coordinate the proposed design with other agencies (such as fish agencies), to develop a more accurate cost estimate, and to develop a clear direction for the plans and specifications phase that follows the completion of the DM. The plans and specifications are the working documents required to complete construction. After the completion of plans and specifications, the design package is reviewed, advance notice is given, and the contract is awarded. The contract award process typically takes about 4 months.

4.02. IMPROVEMENTS TO FISH HATCHERIES.

a. Truck Loading.

(1) General.

At Corps-constructed fish hatcheries on the lower Snake River drainage system, it is common practice to pump fish from raceways or ponds into fish trucks for subsequent planting. Some evidence suggests that the pumps used in this operation may cause descaling and/or injury to the fish. The pumps may also stress the fish. Therefore, it may be beneficial to replace the current fish pumps with an alternate system (*e.g.*, gravity-fed truck loading).

(2) Existing System.

The fish pumps typically used at the hatcheries are specially designed pumps known as heliaxial pumps. These pumps were originally developed to pump soft produce (such as tomatoes) without causing damage. A heliaxial pump has a single-port impeller that creates a pressure difference across the suction and discharge of the pump. Flow through the pump is caused by this pressure difference. From suction flange to discharge flange, a clear opening (3-, 5-, or 6-inch diameter, depending upon the pump model) is always maintained through the pump. The fish never contact an impeller blade. The pumps are usually equipped with a variable-speed drive system so that pumping rates can be varied. Depending upon the pump model, pumping capacity ranges from 85 gpm at 7 feet of head, to 750 gpm at 20 feet of head. The pumps come as a complete package, with a suction and discharge system designed for fish handling.

The fish pumps were tested extensively by the manufacturer, and were found to cause extremely low levels of injury to trout. These pumps have been used for years at Corps-constructed hatcheries with success on steelhead trout. However, it has been observed at the hatcheries that the pumps cause descaling when used to pump Chinook salmon. Although other physical damage to the fish is not apparent, it is suspected that unseen injuries from pumping and pressurization through the pump may have a delayed effect upon fish health and survivability.

(3) Alternatives to Conventional Fish Pumping.

Two alternatives to conventional fish pumping have been identified: 1) install gravity-fed truck loading; and 2) provide an improved pumping system.

(a) Gravity Fed Truck Loading.

Each of the hatcheries holds fish in containment facilities (*i.e.*, raceways and ponds) that are somewhat spread out across the hatchery grounds. Typically, the containment facilities are separated into several facilities that are operated independently for different fish species, as well as for different stages of fish development. An extensive piping system is required to serve these separated containment facilities. These piping systems are comprised of water supply, drainage, auxiliary water supply, and cleaning effluent piping.

To provide gravity-fed truck loading, a trench system must be excavated to allow a truck-loading flume system to be installed and sloped from each separate containment facility to a truck loading station. The truck loading station(s) would consist of a pit (excavated deep enough to provide the 12-foot clearance needed for a fish truck), and flume dewatering facilities. The flume dewatering facilities would be required to dewater excess flow so that fish trucks are not overfilled.

Installation of gravity-fed truck loading systems would be complicated by the following problems:

- Many of the hatcheries were designed to use fish pumping as the primary means of truck loading. Therefore, a common release system was not installed for the separated containment facilities. At those hatcheries without a common release system, the containment facilities would have to be modified to provide a means of connecting the containment facilities to a flume leading to the truck loading pit. Some hatcheries have a common release system for containment facilities used to raise a specific species of fish. The release systems are not connected to, or not provided for, all containment facilities and fish species.

- Much of the existing hatchery piping would have to be excavated and replumbed to allow installation of the truck-loading flume system. This would require the containment facilities to be shut down during certain periods of construction, and could detrimentally impact fish production.

- In some instances, the truck-loading pit would have to be excavated to depths below groundwater level (all of the hatcheries are located adjacent to a river). As a result, relief valves would be required to prevent buoyancy, and the pit would accumulate water.

- Many of the hatcheries have little or no room for such a truck loading system. The truck-loading pit would have to be located in an area large enough to allow truck access, and to meet turning radius requirements.

- Many of the containment facilities at the hatcheries are so spread out and oriented so differently that a single truck-loading facility would not be feasible. Several truck-loading facilities would be required at some hatcheries.

(b) Improved Pumping System.

A means of improving the existing heliaxial pumping systems should be considered. It may be possible to eliminate descaling problems and reduce possible injuries to fish by redesigning or modifying the existing pumps, or simply by changing the way the pumps are used.

An Archimedes-type fish pump could be used to pump the fish from containment facilities into fish trucks (see plate 1). This type of pump has been used successfully for years at commercial hatcheries to pump salmon and trout, and will be evaluated at Irrigon Fish Hatchery in the near future. The Archimedes-type fish pump consists of an auger permanently attached to an outer cylindrical shell. Pumping is accomplished by inserting one end of the pump into the water, sloping the cylinder up to the discharge elevation, and rotating the cylinder/auger assembly. Fish are lifted from the containment facility to the truck in what could be described as a bucketful at a time. The fish never contact an impeller, and the pumping cylinder is never pressurized.

The pump cylinder is mounted to an external frame through bearings at each end of the cylinder. The assembly is equipped with wheels to allow easy movement. The pump is equipped with a specially-designed inlet and outlet nozzle. The special features of the outlet nozzle include dewatering capabilities and a pivoting release pipe to allow the discharge to be redirected.

An electric, variable-speed drive system is provided to allow for variations in the pumping rate. The density of the fish in the pump may be changed by varying the crowding rate in the containment facility and varying the pump speed.

(4) Recommendations.

The difficulties and costs associated with installing gravity-fed truck loading are considerable. The hatcheries on the lower Snake River system are so different in design and operation that each hatchery would have to be analyzed separately. Unlike other items being considered in the SCS, where similarities enable one preliminary design to be extrapolated to cover multiple projects, separate and unique truck-loading designs would have to be developed for each system at each hatchery. With considerable effort, preliminary design, costs, and implementation schedules could be developed for gravity-fed truck loading at each hatchery. Considering the magnitude of the efforts required to achieve this, gravity-fed truck loading has not been fully analyzed in this report. If considered desirable, gravity-fed truck loading should be further analyzed in the SCS Phase II.

If an alternate means of truck loading is considered desirable, it is recommended that an Archimedes-type fish pump be purchased and tested at one of the hatcheries. Testing should be performed using both steelhead trout and Chinook salmon. If this new pump is determined to be unsuccessful, gravity-fed truck loading should be considered further.

(5) Implementation.

The Archimedes-type fish pump is a standard product that can be purchased and delivered within 6 months. Testing should take from 1 to 2 years. It would take approximately 1 year to provide one pump at each of the ten hatcheries. It is assumed that, at each hatchery, one compartment in one truck would be loaded at a time. Therefore, only one pump would be required. Different truck-loading practices may require more than one pump to be provided at some of the hatcheries.

b. Additional Containment Facilities.

(1) General.

Fish quality at the existing fish hatcheries might be improved by providing additional containment facilities (*e.g.*, raceways). Additional containment facilities would improve fish production by allowing the hatcheries to reduce fish densities and, thereby, reduce the impact of disease and other stress-related fish rearing problems. Improving the quality of hatchery fish may relieve hatchery pressure on wild stocks by reducing disease transmission and stress. Ten Corps-constructed fish hatcheries could benefit by providing additional containment facilities. These 10 hatcheries are: 1) Sawtooth; 2) Magic Valley; 3) Hagerman; 4) Dworshak; 5) Clearwater; 6) Tucannon; 7) Lyons Ferry; 8) McCall; 9) Irrigon; and 10) Lookinglass. To reduce fish densities, either the existing production levels must be decreased, or additional containment facilities must be provided. Provision of additional containment facilities would require more land and an increase in the hatchery water supply, and would also require changes to related systems.

Generally speaking, the aforementioned hatcheries were not designed to accommodate any substantial expansions. In most cases, there is insufficient room and/or insufficient water supply to allow expansion. The exceptions to this are the hatcheries at Dworshak, Magic Valley and, possibly, Lyons Ferry. The Dworshak Hatchery would require significant modifications, while Magic Valley Hatchery was designed with expansion in mind. Lyons Ferry Hatchery has an adequate water supply to accommodate a substantial expansion, but it has not been determined exactly how an expansion could be accomplished, because of real estate and operational concerns. Because expansion at most of the hatcheries does not appear to be feasible, it may be advantageous to reduce fish production (and thereby reduce fish densities) at the hatcheries to either make up the difference in lost production by constructing additional hatcheries; or produce fewer, healthier fish that would better survive the journey to Lower Granite Dam.

The primary containment facilities at Dworshak Hatchery consist of 30 raceways and 84 Burrows ponds. The 30 raceways are used to rear spring Chinook salmon, while the 84 Burrows ponds are used to rear steelhead trout. There is sufficient room at the hatchery to construct additional raceways to reduce the rearing densities of spring Chinook salmon. The additional raceways would require an additional water supply of 10,000 gpm. Steelhead trout densities could be reduced by converting the 84 Burrows ponds (each require approximately 600 gpm) into 168 raceways that would use 500 gpm each (see plate 2). The net increase in water demand for the Burrows pond conversion would be approximately 34,000 gpm. The provision of 20 new raceways and conversion of the Burrows ponds to raceways would increase the total hatchery demand from approximately 82,000 gpm to approximately 126,000 gpm. Water for Dworshak Hatchery is pumped from the North Fork Clearwater River by six pumps located in the main pumping plant. A large increase in water demand would require substantial modifications to the existing main pumping plant and its associated components. All six pumps would have to be replaced with larger units, the electrical system would have to be replaced and upgraded accordingly, additional emergency generators would have to be provided to drive the pumps in the event of a power outage, the existing substation that feeds the main pumping station would be inadequate and would have to be upgraded, and additional packed columns and piping would be required to degassify/aerate the additional flow.

The primary containment facilities at Magic Valley Hatchery consist of 32 raceways used for rearing steelhead trout. The raceways are arranged in back-to-back banks of 16, separated by a water supply channel. The raceway water supply enters the raceways from the supply channel, and exits into drain channels located on the extreme downstream end of each bank. Each raceway is approximately 216 feet long, and may be divided into four sections through the use of screens and weirs. Space was provided at the drain channel end of each bank of raceways for future expansion. The hatchery may be expanded by extending each bank of raceways approximately 110 feet. The existing hatchery water supply is sufficient to accommodate such an expansion, as are the wastewater settling ponds. The expansion of each bank of raceways would include the following steps: 1) partially filling the existing drain channels with concrete, and demolishing the outermost drain channel wall; 2) constructing a new 110-foot-long by 170-foot-wide section of raceways with weirs, screens, and a new drain channel; 3) plugging the existing drain channel outlet piping, and extending the drain piping to the new drain channels; 4) extending piping for raceway cleaning water, auxiliary supply water, and high pressure water; 5) relocating the fish food supply system to the new drain channel wall; 6) extending the drive rack, rail system, and electrification system for the existing movable bridge; and 7) extending the bird netting and support structure to cover the new length of raceways.

Expansion of Magic Valley Hatchery for the purpose of rearing salmon does not appear to be feasible. There is insufficient space to provide separate salmon and steelhead rearing facilities. Furthermore, the existing hatchery water supply is too warm for rearing salmon, and would have to be chilled to achieve the appropriate rearing temperature.

(2) Implementation.

It is important to note that the total project time estimates listed below were prepared under the assumption that sufficient manpower and resources would be available during all phases of the projects. Lengthy review processes, manpower shortages, and limited resources would have a definite impact upon the total estimated project times.

(a) Dworshak Hatchery.

The total project implementation time is estimated to be approximately 65 months. This time includes 10 months for DM preparation, 12 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 36-month construction period. The 36-month construction time is required to allow conversion of the Burrows ponds to be completed in three 1-year phases. This is necessary to allow the hatchery to continue production during construction by shifting fish between the three Burrows pond systems.

(b) Magic Valley Hatchery.

The total project implementation time is estimated to be approximately 49 months. This time includes 8 months for DM preparation, 10 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 24-month construction period. The 24-month construction time is required to allow the hatchery to continue production during construction.

4.03. IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS.

a. Dispersed Release Sites.

(1) General.

The purpose of dispersed release is to provide more than one release site to the river for the juvenile fish bypass facilities at the dams. Predator fish tend to gather near juvenile release sites, and prey upon smolts. Changing release sites periodically may reduce the number of juvenile fish lost to predation. Alternative means of providing dispersed release include: 1) short-haul barging to alternate release points; 2) extending release flumes downstream of the current release points; and 3) providing multiple release points near the juvenile fish facilities. Multiple release points near the juvenile fish facilities was chosen as the method for analysis in this preliminary study. The aforementioned alternatives, as well as others that may arise, should be evaluated following this Phase I study, if additional study is required.

Flume modification layouts and short write-ups are included for providing multiple release points at the McNary, Little Goose, and Lower Monumental Juvenile Fish Facilities. Dispersed release will be provided for the main bypass pipe, as well as downstream of the separator. Dispersed release on the main bypass may improve conditions during 100-percent bypass, while dispersed release downstream of the separator may improve conditions during bypass by species. The following items are included in the preliminary designs:

- A transition from the existing main bypass pipe/flume to a 30-inch-wide by 36-inch-high rectangular flume.

- A 12- to 18-inch-wide by 18-inch-high flume for dispersed release downstream of the separator.

- Extending the rectangular flume more than 200 feet to allow for two drop gate release points per flume.

- Covering the rectangular flumes.

- A walkway along the length of the pipe/flume for inspection and maintenance of the flume and drop gates.

- Two drop gates within each flume to provide a total of three release points per flume (two drop gates and release out the end of the flume).

- Work platforms under the drop gate cylinders to provide maintenance access.

- Flush lines to flush fish through the flumes downstream of the drop gates.

The preliminary designs are based on the following assumptions:

- The design was based on conditions at McNary for the new Permanent Juvenile Fish Facilities.

- The design is based on current operating conditions and criteria (average tailwater elevations, 30-cfs flow rate down the flume, 30-fps maximum impact velocities with the river, *etc.*). If the operating conditions and/or criteria change, it could affect the slope, length, and layout of the river release flume. If the flume were extended to provide more release points, potential tailwater interference would need to be considered.

- Drop sites are 100 feet apart. If different spacing is required, the design would need to be changed to reflect this.

- Flush-line water supply is taken from the main facility supply pipe. If the holding and loading facility is not operating during the bypass mode, the facility will not be impacted by flush-line operations. If the facility is operating, the fish will be released to the river through the smaller flume, and flush water will be required. If it is not possible to tie into the existing flush line, or if the additional flushing water requirements affect the operation of the holding and loading facility, another flushing water supply line may need to be provided.

The following design considerations must be taken into account:

- Drop gates should be spaced to drop juvenile fish between in-water pipe supports. Predator fish rest in slack water created by pilings, *etc.* Since the juveniles may be stunned upon impacting the water, their chances of survival will increase if they land in free-flowing current. This will not only begin moving them downstream, but will also discourage predator fish from staying near the release sites.

- All joints in the bypass pipe must be smooth. Pipe joints, transitions, and new connections need to be carefully constructed to avoid injury to fish.

- Much of the construction for extending the flume will occur in the tailrace of the dams. This will increase costs, because in-water construction costs more than land-based construction; and higher velocities downstream of the turbines during their operation make in-water construction more difficult.

- Potential navigation problems need to be considered when extending the flumes at each facility. The added flume length could impact normal river traffic, as well as fish barge operation at barge-loading facilities.

(2) <u>McNary Dam</u>.

(a) <u>Existing System</u>.

The current design for the bypass river release pipe/flume at McNary Dam includes approximately 440 feet of 30-inch-diameter polyethylene pipe just upstream of the river release point. The first 175 feet slopes at 0.20, with the last 265 feet sloping at 0.0091. The following information applies to this release point:

- Flow rate (Q) = 30 cfs (approximately).

- Velocity (V) = 16 fps (approximately).

- Impact velocity (Vi) = 30 fps [Vi at the river with water surface elevation (WSE) 263].

For the facilities currently being constructed at McNary Dam, river release after the separator is only available for juvenile Chinook salmon. After leaving the separator, a drop gate in the flume drops the juveniles into a 10-inch-diameter pipe. Two other pipes merge into the Chinook river release pipe: the passive integrated transponder (PIT)-tag river release pipe and the lab/raceway river release pipe. Slopes on the pipe vary from 0.04 to 0.13, with the last 260 feet sloping at 0.02. Shortly after the slope change to 0.02, the pipe transitions from 10 inches to 14 inches in diameter. Flow down the pipe is between 3 and 6 cfs, with velocities up to 13 fps at the outfall. The outfall elevation is at inert elevation (IE) 272. Impact velocity with the river is less than 30 fps at WSE 263.

(b) New System.

1. Main Bypass Pipe/Flume.

After the 0.20 slope, there is approximately 230 feet of river release pipe at 0.0091 before the 12.5-feet-long transition to a 30-inch-wide rectangular flume. Velocities should be about 17 fps at this point. After this transition, the rectangular flume will slope 0.007. The first drop gate is approximately 32.5 feet past the transition, with the second drop gate 100 feet downstream. The outfall of the flume is another 100 feet downstream, increasing the entire flume length by approximately 210 feet over the original design. Adding the extra flume length will drop the outfall elevation to IE 271.6. This should be above tailwater elevations at least 96 percent of the time. See plate 3 for the general site plan, and plate 4 for flume details.

With 30 cfs design flow going down the flume, depths should range from about 0.8 to 1.1 feet, with velocities between 11.0 and 15.5 fps at the release points. At tailwater WSE 263, impact velocities will be less than 30 fps at all release points.

The rectangular flume will be covered along its length, and a walkway will be added from the retaining wall to the end of the new flume. The walkway will provide access for inspection and maintenance of both the flume and the drop gates. Drop gates will have a 5-foot-long opening, and will be operated remotely or by computer.

2. River Release Downstream of the Separator.

In the proposed design, the lab tank/raceway river release pipe and the Chinook river release pipe will be separate. The lab tank release pipe will still merge into the 14-inch-diameter pipe, with the outfall at the same location and elevation as the current design. Slopes for the Chinook release pipe will be changed to merge with the new steelhead release pipe.

a. Lab Tank/Raceway River Release Pipe.

The lab tank/raceway river release pipe will remain basically the same. Since the Chinook release pipe routing will be changed, the existing intersection of the two pipes will need to be modified. This can be done in one of two ways. First, the existing 14-inch-diameter pipe from the Chinook release pipe could be capped off after removing the length of pipe upstream from this merge. Secondly, a new connection could be manufactured to make the transitions required from the lab/raceway pipe to the 14-inch-diameter pipe.

b. Steelhead River Release Pipe.

In order to provide river release capabilities for steelhead, the steelhead system needs to be modified. Due to the congestion of pipes and structures at the facility, the most convenient place to provide a river release pipe would be between the raceways (see plate 3).

Currently, a drop gate takes the steelhead from the 12-inch-wide flume into a 10-inch-diameter pipe near the laboratory building. After the pipe curves 90 degrees around the corner of the raceway, two transitions and a drop gate would be added. The first transition (from a 10-inch-diameter pipe to a 12-inch-wide flume) would be connected to a standard 14-foot-long drop gate section. Steelhead would fall through the drop gate into a 10-inch-diameter pipe, taking them to the river release. After the drop gate, there would be another transition back to a 10-inch-diameter pipe.

The 10-inch-diameter pipe below the drop gate would slope at 0.035 for about 690 feet. It would be parallel to the Chinook river release pipe for about 150 feet before merging into a 12-inch-diameter pipe. After 10 feet, the pipe will transition into a 12-inch-wide flume. The first drop gate will be about 40 feet downstream (near the original outfall location). Here the slope will be changed to 0.01. Another drop gate will be located 100 feet downstream, with the final outfall 100 feet past the drop gate.

Flows down the 12-inch-wide flume will generally be between 3 and 6 cfs, with velocities ranging from 5 to 12 fps. At times, during PIT-tagged fish releases, flows could reach 9 cfs with velocities up to 13 fps. The Vi will be less than 30 fps with the river at WSE 263. With the new outfall at elevation 271, the release should be above the river surface about 96 percent of the time.

c. Chinook River Release Pipe.

The Chinook river release pipe will remain unchanged until about 24 feet past the merge with the PIT-tag release pipe. At this point, the pipe slope will be changed to 0.064 for 297 feet, and then to 0.035 for 150 feet. Here, the Chinook release pipe and the steelhead release pipe will merge into a 12-inch-diameter pipe. This routing eliminates the 0.13 slope. See paragraph 4.0.3.a.(2)(a)b., above, for flows and conditions in the flume.

3. Flush Lines.

Flush water will be provided at all drop gates to flush fish through the flume downstream of the current release point. The flush-water supply line will tie into the 48-inch-diameter main facility supply pipe in the ice and trash sluiceway just before the main supply pipe exits the sluiceway. These flush lines will be remotely or computer operated, and will provide a flow of about 5 cfs to the main bypass flume and 1 cfs to the 12-inch-wide flume. Flow conditions in the flumes are indicated below, using a smooth flume (Manning's n=0.009):

- Main Bypass Flume
  Width = 30 inches
  Slope = 0.07
  Flow = 30 cfs
  Normal Depth = 0.35 feet
  Normal Velocity = 5.71 fps
- Steelhead/Chinook Flume
  Width = 12 inches
  Slope = 0.01
  Flow = 1 cfs
  Normal Depth = 0.22 feet
  Normal Velocity = 4.55 fps

(3) Little Goose Dam.

(a) Existing System.

1. Main Bypass Flume.

The bypass river release flume at the Little Goose Permanent Juvenile Fish Facilities includes over 500 feet of 36-inch-diameter CMF, sloping at 0.0473 before the outfall. The following information applies to this release point:

- Q = 30 cfs (approximately).
- V = 10.2 fps (approximately).
- Vi = 27.4 fps (Vi at the river with WSE 540).

2. Steelhead and Chinook River Release Pipes.

The Chinook river release pipe is accessed by a switch gate off the main Chinook flume, on the east side of the raceways. After the switch gate, the 18-inch-wide flume transitions into a 10-inch-diameter pipe. This pipe slopes at 0.027 for about the last 300 feet to the outfall at IE 547. About 3 cfs flows through the pipe. For a smooth pipe (Manning's n = 0.009), normal depth and velocity are 4.6 feet and 9.8 fps, respectively. The Vi with the river will be less than 30 fps with WSE 540.

In order to release steelhead to the river, the truck and barge loading areas must be bypassed. If barge or truck loading is taking place, it would not be possible to river release steelhead.

(b) New System.

1. Main Bypass Flume.

At the end of the existing CMF, there will be a 12.5-foot-long transition from 36-inch-diameter CMF to 30-inch-wide by 36-inch-high rectangular aluminum flume. Beginning with the transition, the flume slope will be changed to 0.007. The first drop gate will be located 18 feet past this transition, with the second drop gate another 100 feet downstream. The new outfall will be another 100 feet past this, extending the flume by approximately 230 feet over the existing length. Adding the extra flume provides a new outfall elevation of IE 548 (see plate 5). Since WSE 548 is the maximum tailwater elevation for design, actual flume layout could change from that shown. The outfall should be at, or above, the tailwater during all operating design considerations, and the location of the outfall may need to be adjusted based on other design considerations (*i.e.*, river velocities and depths at the release points).

With a design flow of 30 cfs in the flume, water depth should be about 1.2 feet at the release points, and the velocity should be near 10.5 fps. The flume will be covered along its length, and the walkway will be extended about 230 feet to the outfall, similar to the existing flume design. Drop gates will have a 5-foot-long opening, and will be operated remotely or by computer.

2. River Release Downstream of the Separator.

a. Steelhead River Release Pipe.

In order to provide river release for juvenile steelhead independent of the truck and barge loading functions, a new pipe needs to be added to the system. At the southwest corner of the raceways, a new switch gate will be added to the steelhead flume. When switched, fish will be diverted north into the existing flume system. Otherwise, the fish will enter a new pipe/flume west of the raceways.

After the switch gate on the new pipe/flume, the 18-inch-wide flume will transition to a 12-inch-diameter pipe over 5 feet. The 12-inch-diameter pipe will run for 130 feet at a slope of 0.01. Normal depth and velocity in this reach will be 0.54 feet and 6.8 fps, respectively, with a flow of 3 cfs. This pipe will pass over the existing Chinook river release pipe and increase in slope to 0.05. Soon after, the pipe will transition from a 12-inch-diameter pipe to a 10-inch-diameter pipe over 3 feet. The steelhead pipe will slope at 0.05 for about 43 feet and then change slope to 0.027, running parallel with the Chinook river release pipe, at the same elevation.

About 35-feet upstream from the existing outfall, the two 10-inch-diameter pipes will merge into one 12-inch-diameter pipe over 5 feet. After 10 feet, the 12-inch-diameter pipe will transition to a 12-inch-wide by 18-inch-high flume. The first drop gate will be located 15-feet downstream of this transition. After the drop gate, the slope will change to 0.01. Another drop gate will be located 100 feet downstream, with the outfall 100 feet past this last drop gate (IE 545).

b. Chinook River Release Pipe.

The Chinook river release pipe will remain unchanged until about 35 feet upstream of the existing outfall. Here, the Chinook release pipe will merge with the steelhead release pipe. See the above paragraph (on the steelhead river release pipe) for details.

3. Flush Lines.

Flush lines will be provided downstream of all drop gates, similar to the proposed McNary design. The flush-line supply will tie into the 30-inch-diameter facility supply line upstream of the junction for the head box supply.

(4) Lower Monumental Dam.

(a) Existing System.

1. Main Bypass Flume.

The bypass river release pipe at Lower Monumental Dam includes about 485 feet of 30-inch-diameter polyethylene pipe upstream of the outfall. The first 255 feet slopes at 0.20, with the last 230 feet sloping at 0.013. The following information applies to this release point:

- Q = 30 cfs (approximately).
- V = 15.5 fps (approximately).
- Vi = 29.7 fps (Vi at the river with WSE 437).

2. Steelhead and Chinook River Release Pipes.

Currently, there are separate 12-inch-diameter river release pipes for steelhead and chinook. These pipes slope at about 0.085 for 285 feet, then change to 0.03 for the last 135 feet before the outfall. With flows of 6 cfs, velocities could reach 18 fps, with a depth of 0.4 feet on the 0.085 slope. Outfall depths and velocities for a smooth pipe (Manning's n = 0.009), at a slope of 0.03, are 0.6 feet and 12.5 fps, respectively. The outfall elevation is 447.0. The Vi with the river should be less than 30 fps at WSE 437.

(b) New System.

1. Flume Design.

At the end of the existing polyethylene pipe, there will be a 12.5-foot-long transition from the 30-inch-diameter pipe to the 30-inch-wide by 36-inch-high rectangular aluminum flume. Beginning with the transition, the flume slope will be changed to 0.007. The first drop gate will be located 18 feet past the transition, with the second drop gate another 100 feet downstream. The new outfall will be another 100 feet past this, at IE 445 (see plate 6). Maximum normal tailwater is WSE 440, with the 10-year-flood at WSE 449. During normal operating conditions, the flume should be above the tailwater. Adding the rectangular flume extends the total flume length by approximately 230 feet.

Since the river release flume is downstream of the barge-loading facilities at the Lower Monumental Permanent Juvenile Fish Facilities, special consideration will need to be given to the layout of the extended flume. Final placement will depend on river velocity studies and barge traffic requirements.

With a design flow of 30 cfs in the rectangular flume, depths should be between 0.8 and 1.1 feet at the release points, and velocities should be between 11 and 15 fps. The flume will be covered along its length. Approximately 430 lineal feet of walkway will extend along the flume out to the end of the new flume. Drop gates will have a 5-foot-long opening, and will be operated remotely or by computer.

At the existing outfall for the Chinook and steelhead river release pipes, there will be a 5-foot-long transition from the two 12-inch-diameter pipes to one 18-inch-diameter pipe. After 10 feet, there will be a transition to an 18-inch-square flume. The first drop gate will be located 10-feet downstream, with the second drop gate another 100-feet downstream. The outfall will be 100 feet past the last drop gate, at IE 444.7. The slope along the new pipe/flume will be 0.01.

With flows of 6 to 12 cfs down the 18-inch-square flume, normal depths should be between 0.5 and 1.1 feet, with normal velocities between 6 and 9 fps. The Vi with the river will be less than 30 fps at WSE 437.

2. Flush Lines.

Flush lines will be provided downstream of all drop gates, similar to the proposed McNary design. The flush-line supply will tie into the 36-inch-diameter facility supply pipe just upstream of the junction for the holding tank supply line. In order to prevent water from going to the facility during bypass operations, a 36-inch-diameter valve will be installed in the supply line, between the flush-line supply and holding tank supply junctions.

(5) Ice Harbor and Lower Granite Dams.

(a) Ice Harbor Dam.

At present, Ice Harbor Dam does not have a river release flume for bypassing juvenile fish. Therefore, no design or costs were developed for a dispersed release structure at this facility.

(b) Lower Granite Dam.

Lower Granite Dam does not currently have direct bypass capabilities at the juvenile fish facility. Therefore, no design or cost analyses were developed for a dispersed release structure at this facility. However, it would be possible to modify the existing release system (the existing release system releases fish through piping after separating adults from juveniles) for dispersed release. Also, dispersed release could be included under the "Modifications to Lower Granite Dam Juvenile Fish Facilities" alternative.

(6) Implementation.

The minimum times needed to implement dispersed release at the dams are listed below. The minimum implementation times assume prompt review and advertisement/award, and the availability of sufficient manpower during all stages of the project. Lengthy review processes, manpower shortages, and limited resources would have a definite impact on the total estimated project time. The total project implementation time is estimated to be approximately 33 months for each project. This implementation time includes the following allowances:

- The DM--6 months.
- Plans and Specifications--8 months.
- Review--3 months.
- Contract Award--4 months.
- Construction--12 months.

b. Extended-Length Screens.

(1) General.

When research began on methods of screening juvenile salmon and steelhead out of turbine intakes in the late 1960's, the vertical distribution of fish was measured within the intakes, and screens were designed to screen the areas where over 90 percent of the fish migrated. The screen design was based on research that showed that 90 percent of the fish traveled in the upper one-fourth of the turbine intake. To fish the upper one-fourth of the turbine intakes, screens 20 feet long by 20 feet wide were developed. These screens, known as standard STS's, were designed to tilt at an angle of 55 degrees into the incoming turbine flow.

Over the years, research has shown that the STS's obstruct the flow, causing disruption of the vertical distribution of fish. Research has also shown that early in the outmigration, juvenile fish tend to be distributed deeper in the turbine intake, and some species or races of fish tend to be distributed deeper than others.

As the STS's were developed and their limitations became apparent, the fishery agencies and tribes revised their criteria to require higher guiding efficiencies than could be achieved with STS's. Therefore, extended-length submerged traveling screens (ESTS's) and extended-length submerged bar screens (ESBS's) were developed. The extended screens were made 40 feet long, because that is the greatest length that can be installed and pivoted at McNary Dam. The extended screens will screen a greater percentage of the distribution of the various species and races of fish (see plate 7) than the standard screens.

The ESTS's and ESBS's were tested at McNary Dam in 1991, 1992, and 1993. Further tests may be conducted at McNary Dam in 1994. Tests were also conducted at Little Goose Dam in 1993, and may possibly be conducted in 1994. While results at McNary Dam have been promising, modifications to fine tune the design of the ESBS's and ESTS's have been required. Results have also shown that the extended-length screens increase flows and velocities up the bulkhead slots causing fish strikes and descaling of fish on the VBS's that separate the bulkhead slots from the operating gate slots. Therefore, extended-length screen research has prompted additional research that led to the development of new VBS designs for McNary Dam. Prototype VBS designs will be installed and tested during the spring of 1994.

Research results to date are not conclusive enough to decide that extended length screens can be used at every dam. Extended screens have provided increased FGE (from 50 to 60 percent to nearly 80 percent for spring/summer Chinook, and from about 80 percent to over 90 percent for steelhead), but also increased descaling. For fall chinook, which have the poorest fish guidance, the ESBS's have nearly doubled FGE (from around 35 percent to over 60 percent).

Although extended-length screens appear to provide significant benefits, other issues must be addressed (such as the effect of extended screens upon survival on non-guided fish and descaling problems) before full commitment can be made. If shown to provide a net benefit, extended-length screens and related devices may need to be installed at Lower Monumental and Ice Harbor Dams, which are currently being equipped with STS's (extended screens are either existing, or are already programmed for construction, at McNary, Lower Granite, and Little Goose Dams).

(2) Implementation.

The minimum time to implement extended screens is 41 months. This allows 11 months for DM preparation, 11 months for design, 3 months for review, 4 months for contract award, and a 12-month construction period. This minimum implementation time assumes prompt review and advertisement/award, and the availability of sufficient manpower during all stages of the project. The aforementioned implementation time does not include time for modeling and testing. It may be possible to adapt the Lower Granite powerhouse three-bay sectional model for use in modeling Lower Monumental Dam. A new three-bay sectional model of the Ice Harbor powerhouse will need to be built. Construction of this model will take approximately 8 months, and subsequent testing will take 10 to 15 months.

c. Modifications to Lower Granite Dam Juvenile Fish Facilities.

(1) General.

The fish facilities at Lower Granite Dam are the oldest of the fish facilities on the lower Snake River. Since construction of the Lower

Granite juvenile fish facilities, fish facility design has evolved considerably. As Lower Granite Dam is the first obstacle to fish migration downstream of the confluence of the Snake and Clearwater Rivers, improvements made to the Lower Granite fish facilities could greatly benefit fish. These improvements (see plate 8) would include the following:

- An improved collection channel;
- dewatering structure;
- bypass flume that extends to the river;
- new wet separator with species separation capabilities;
- new PIT-tag sample and holding tanks;
- new sample and holding tanks;
- new raceways; and
- improved barge loading and river release conditions.

(2) Existing System.

The existing juvenile fish bypass system consists of STS's to guide the fish up the bulkhead slots, through orifices, and into the collection channel. Approximately 100 to 200 cfs flow through the orifices into the collection channel, which spans the length of the generator bays (see plate 8). Adding additional water brings flows to approximately 225 cfs. Shortly after the collection channel enters the erection bay, the fish enter a 20-foot-deep downwell connected to a 42-inch-diameter pipe. They travel through approximately 1,675 feet of pressurized pipe to the holding and loading facility.

At the facility, the fish upwell into a large head tank and pass through a fish separator. From the separator, the fish are directed to raceways for holding, or to a sample tank for counting and marking. From the raceways, the fish can be loaded into trucks or barges, or released to the river.

The existing system diverts fish into the collection channel through two sets of slots in the turbine intake area (see plate 8.1). These slots are the bulkhead slots and the Wagner horns and fish screen slots.

• The bulkhead slots are the main diversion slots. Orifices, 10 inches in diameter, connect the bulkhead slots to the collection channel. Eighteen of the thirty-six orifices are used at a time.

• The Wagner horns and fish screen slots are connected by 8-inch-diameter orifices to the collection channel, and are only used to release fish that may be trapped in the slots. The Wagner horns and fish screen slots were installed during the initial construction of the dam, with the idea that placing the fish screens further forward in the intake might improve screen guidance. The Wagner horns were provided to allow water that flowed into the fish screen slot to go back down through the turbines. This concept did not work, and is not being used as part of the guidance system.

(3) Proposed System.

(a) Collection Channel.

The proposed system would use the bulkhead slots for fish diversion. Orifices would be drilled out to 14-inch diameters and lined with 12-inch-diameter stainless steel liners similar to the collection channel orifices at McNary. The Wagner horns and fish screen slots would be permanently sealed or screened. Screening some slots would allow the existing 8-inch-diameter orifice valves to be used as water-up valves. The collection channel would be widened from 6 to 7 feet in the vicinity of the orifices, to ensure that fish do not impact the opposite wall of the collection channel. Existing grating may need replacement after widening the collection channel to provide access to all valves.

Once past the last generator bay, approximately 140 feet of new 6-foot-wide rectangular channel would be mined out of the erection bay, exiting the dam near the south end of the bay. Mining would begin at the current downwell. The downwell would need to be filled in or spanned, and should be able to support any mining equipment required to drill out the new channel section. A 6-foot-wide channel section would continue outside of the dam for about 170 feet, where it would terminate at the primary dewatering structure (see plate 10).

The existing channel slopes 0.0009. All new channel would slope 0.002. All curves would have a minimum centerline radius of 18 feet to minimize unbalanced flow conditions in the channel. Flows would range from 120 to 280 cfs over a forebay fluctuation of 733 to 738 feet. Channel velocities should be between 5 and 8 fps. While this amount of water is required for attraction flows, it is not required for transportation. Therefore, a dewatering structure would be added downstream. Just before entering the dewatering structure, the channel transitions from 6 feet wide to 7 feet wide to slow the velocity.

(b) Primary Dewatering.

Approximately 30 cfs is required to transport the juvenile fish to the holding and loading facility or bypass them to the river. A dewatering structure (similar to the one at Lower Monumental) would remove excess flows. The structure is approximately 90 feet long, and uses a combination of overflow weirs and floor dewatering screens to remove excess flows. Water drains through the floor screen at a velocity less than, or equal to, 0.5 fps. It then exits the structure by flowing through orifices and over a series of weirs that automatically adjust to maintain a constant WSE in the transportation flume. The excess water for the dewatering chamber would be routed into the adult fish collection system to augment fish attraction water flow.

In case of a malfunction in the primary dewatering system, the dewatering structure also includes an overflow weir capable of handling the maximum flow of 280 cfs. This system only keeps the transportation channel flume from overtopping, and is not meant to be used for dewatering on a regular basis. In addition, secondary dewatering and an emergency fish bypass system are located here.

(c) Transportation Flume.

Upon leaving the dewatering structure, the collection channel transitions from 7 feet wide down to a 3-foot-diameter CMF. This slopes at about 0.032 for approximately 1,200 feet down, to a switch gate. Along any CMF, the following is required:

- Partial shading;
- walkways; and
- access to the flume for trash removal.

From the switch gate, fish are either diverted to the holding and loading facility or a river release point approximately 780-feet downstream. Based on a flow of 30 cfs, the water depth and velocity is about 1.5 feet and 9.0 fps, respectively.

Assuming the 36-inch-diameter CMF continues from the switch gate to the river release point at a constant slope of 0.041, the depth and velocity would be about 1.3 feet and 9.8 fps, respectively. With a release elevation of 643.0 and a maximum 10-foot drop to a minimum tailwater of 633.0, the Vi at the river would be less than 30 fps.

(d) Porosity Control and Wet Separator.

If the fish are diverted to the holding and loading facility, they enter the porosity control first. Most of the 30 cfs of transportation water is removed here, and the fish flush through to the wet separator.

The objective of the separator is to sort the fish by species. The separator has three compartments: the first separates Chinook; the second separates steelhead; and the third separates adults and large non-salmonids. Separation is accomplished by taking advantage of the fact that most juvenile Chinook are smaller in size than juvenile steelhead. Separation bars, oriented parallel to the incoming flow, are placed near the surface of the separator in the Chinook and steelhead compartments. Enough water is supplied through the floor of the separator to cover the bars with approximately 2 inches of water. Sensing the current from below, the fish dive through the bars towards the water source. The separator bars are 1 inch in diameter, with centerline spacing in the Chinook portion of the separator set at 1.625 inches. Steelhead bars have a centerline spacing of 2.25 inches. The larger fish will not fit through the smaller spacings and, therefore, must continue downstream to the steelhead compartment. Adult fish will not fit through either set, and are released into a trough at the end of the separator. They then enter a 14-inch-diameter pipe and return to the river.

(e) Juvenile Fish Pipe/Flume Routings.

Juvenile fish travel to the raceways down a flume that is 1 foot wide by 1.5 feet high, on a slope of 0.03. Most other routings will be in 10-inch-diameter pipes, with the exception of the pipes to and from the laboratory, which can be as small as 6 inches in diameter. Flows range from 3 to 6 cfs, with the exception of PIT-tag operations, which require flows down to 1.5 cfs at the drop gates. Depths range from 2 to 8 inches, and velocities range from 6.5 to 14.5 fps. Pipe/flume slopes are between 0.02 and 0.075 (see plate 9) for the proposed juvenile facility layout. The provided routings are as follows:

- From the separator to PIT-tag sample tanks, sample tanks, raceways, adult river release, direct river release for Chinook, and direct barge loading for steelhead and Chinook.

- From the PIT-tag sample tanks to holding tanks that release to the river.

- From the sample tanks to holding tanks that release to the lab or a raceway.

- From the lab to an outside holding tank and a raceway.

- From the holding tank to barge loading, truck loading, and river release.

- From the raceways to truck loading, barge loading, and river release.

All pipes and flumes will be gravity flow with the possible exception of pipes from the lab to the lab tanks and a raceway. These pipes may be a combination of manual and gravity flow.

(f) <u>Assumptions</u>.

This preliminary design is based on the following assumptions:

- The existing lab building, truck and barge loading will remain and will work with a new holding and loading system. Only minor modifications will be necessary. If these items do not work with the new system, new facilities will need to be provided.

- Supply the same raceway capacity as the current system at Lower Granite. Use 8-foot-wide raceways (in a more detailed analysis, various raceway widths should be considered).

- Use the same size sample tanks, holding tanks, PIT-tag tanks, porosity control, and separator as used at McNary.

- Use the same lab tank used in the McNary DM. It may be necessary to add an extra tank section to the lab tank if there is not enough elevation to route a pipe from the lab to a raceway.

- Truck and barge loading, and river release locations and elevations, are based on current site layout and elevations. These require further study, by either prototype or model testing, to determine their final locations and elevations. The site plan may change from this proposed design.

- The existing grating in the collection channel will need to be replaced to cover the new wider collection channel.

(4) Advantages Over Current System.

The proposed system offers the following advantages over the current system:

(a) Larger orifices from the bulkhead slots to the collection channel offer higher attraction flow and improved fish passage conditions.

(b) Open channel flow from the collection channel to the holding and loading facility or river release.

(c) Low-velocity dewatering (average of 0.5 fps or less) before the transportation flume to the holding and loading facility, or bypass to river release.

(d) Direct, open channel bypass from the collection channel to the river.

(e) Separation of juvenile fish by size (Chinook and steelhead) at the wet separator.

(f) Direct barge loading or river release from the separator.

(g) PIT-tag diversion/holding/river release system.

(5) Options.

The following will be included as options in the cost estimate:

(a) Mining out the collection channel in the generator bays from 6 to 9 feet wide. While the existing collection channel at McNary Dam was wide enough to easily accommodate a 9-foot-wide channel, it may not be practical at Lower Granite Dam.

(b) Increasing the raceway capacity. At times, the current holding and loading facilities cannot handle the number of smolts collected. Doubling the raceway capacity could eliminate or reduce the number of smolts bypassed to the river.

(c) Dispersed release may be added to the river release system to reduce fish losses associated with predator fish that tend to gather and feed near a single release point.

(6) Implementation Schedule.

The estimated implementation contains four parts:

(a) The DM.

Much of the hydraulic design will be conducted during the DM phase. The DM is expected to take approximately 11 months to complete.

(b) Plans and Specifications.

Preparation of plans and specifications is expected to take approximately 11 months.

(c) Review, Advance Notice, and Contract Award.

The review, advance notice, and contract award is expected to take approximately 4 months.

(d) Construction of the Facility.

Construction should take approximately 30 months. There are several reasons for the long construction schedule. These reasons include the following:

- Drilling and splitting the concrete in the dam (to widen the collection channel and drill new channel) is a time-consuming process. At Lower Monumental Dam, required mining was on the critical path for completion of the bypass contract.

- Fish migration windows can restrict the construction schedule. Assuming that fish passage must be maintained during construction periods, work that may affect the adult salmonid upstream migrations must be performed between 1 January and 1 March. This window could affect the mining in the dam (mining operations would affect the existing collection channel and transportation system), placement of the transportation channel, construction of the dewatering unit, and any in-water work. Restrictions during the downstream migration of the salmonid smolts could reduce the construction window even further.

Existing raceways must be demolished and removed, and the site must be prepared for construction.

d. Auxiliary Water Intake Screens at McNary Dam.

(1) General.

Water supply intake structures are located in the forebay on the north and south shores at McNary Dam. These intakes are not screened properly to prevent juvenile fish from entering the intake or from being damaged by the existing intake screens. Providing modern screening systems at these intakes or modifying them to meet current fish criteria, could reduce juvenile fish losses at McNary Dam.

(2) Existing System.

(a) South Shore.

The south shore intake structure is located just upstream of the south shore fish ladder exit (see plate 11.1). Approximately 1,230 cfs of water flows into this structure and supplies water to the following three locations:

- The downstream end of the fish ladder. About 1,000 cfs is used to supply diffusers in the fish ladder.

- The wildlife area. A maximum flow of 90 cfs is supplied to this area.

- Up to 140 cfs is diverted to the West Extension Irrigation District (WEID) exchange facilities, operated by the U.S. Bureau of Reclamation.

Velocities through the traveling screen at the intake approach 1 fps. This exceeds the recommended withdraw velocity of 0.4 fps. Other features of the intake structure include trashracks upstream of the traveling screens, bulkhead slots upstream and downstream of the screens, and a juvenile fish bypass around the intake. The floor of the intake structure is at elevation 275.

(b) North Shore.

The north shore intake structure is located on the non-overflow dam near the north shore fish ladder (see plate 11.1). The intake structure supplies four conduits that deliver about 1,750 cfs to the diffusion chambers in the fish ladder and fish ladder entrances.

The top of the intake opening is at elevation 305.5, with the invert at elevation 262. Trashracks keep large debris out of the water supply, but no screening is currently used in front of the intakes. The average velocity through the open areas of the intake structure is about 0.9 fps, and this exceeds the recommended withdraw velocity of 0.4 fps.

(3) Design Requirements.

(a) South Shore.

At least 3,075 square feet of open screen area is required to bring screen velocities down to 0.4 fps or less.

(b) North Shore.

The existing intake structure has approximately 1,900 square feet of open area at the structure face. In order to achieve velocities of 0.4 fps or less at the face, about 4,375 square feet of open screen area is required.

(4) Design Alternatives.

There are several alternative ways to improve the intake screen systems. They include:

(a) Traveling Screens and Trashracks.

It would be possible to cover the intakes with traveling screens and trashracks. The traveling screens would be self-cleaning, and would require fairly low maintenance. If the tops of these screens come above the water surface, they would be exposed to floating debris. Therefore, trashracks may be required for these screens even though velocities will be low.

(b) Modifying the Existing North Shore Structure.

It would be possible to modify the existing structure by adding enough screen area to meet current criteria. If the existing structure were to be modified, it would need to be fitted with wedge wire bar screen, perforated plate, and screen cleaners. Approximately 2,475 square feet of screen area would need to be added.

(c) Reducing the Amount of Inflow.

Modifications to the intake structures could be reduced or eliminated by reducing the amount of flow through the existing structures. Flows would be augmented by a pumped water supply. On the south shore, this would require reducing the inflow to approximately 500 cfs (down from 1,230 cfs). Reducing the inflow to this amount would eliminate the need to modify the structure. Water would then need to be pumped to the fish ladder, wildlife area, and WEID water exchange facilities, as needed.

The north shore intake would need to be reduced to 765 cfs. Again, the excess water required to supply the diffusers in the fish ladder would need to be supplied by pumps.

(d) Power Plant at North Shore Intake.

North Wasco County Public Utilities Division (PUD) has filed for a permit to build a power plant at the north shore intake. Water supplying the north shore fish ladder would be used to generate the power. If the PUD does build this plant, they would be responsible for designing an intake that meets velocity and screen requirements for juvenile fish.

(e) Modifying the South Shore Structure.

It would be possible to extend the screens on the intake to provide the desired screen area. New screen cleaning systems would be required.

(f) Replacing the North Shore Structure.

The north shore intake structure could be replaced with a new steel structure.

(5) Proposed Designs.

(a) South Shore Intake Structure.

For this preliminary design, modifying the existing intake structure was the chosen alternative. In order to provide the desired screen area, the intake structure needs to be extended about 13 feet upstream. The proposed design includes a three-sided screen, 13 feet wide by 30 feet long, on the upstream face of the intake structure. Screening the three sides of the extended structure with 55-foot-high screens will provide the required screen area. Instead of traveling screens and trashracks, the proposed design uses a combination of wedge wire bar screen, perforated plate, and moving-brush screen cleaners at the intake (see plate 11.1).

The wedge-wire bar screen will be used on the outside of the structure, and will be cleaned by the screen cleaners. Since velocities are low at the intake, large pieces of trash should not be impinged on the structure. The screen itself will be submerged at least 5 feet, so floating debris should not be a problem. Perforated plate placed on the inside of the structure, just behind the wedge-wire bar screen, should aid in an even flow distribution across the intake screens.

The screens will be supported by a stainless steel frame attached to the upstream face of the intake structure. Divers are required to attach the prefabricated screen structure to the intake structure. Mechanical screen-cleaning equipment will be mounted to a platform on top of the new framework.

(b) North Shore Intake Structure.

For this preliminary design, replacing the intake structure with a new steel structure was the chosen alternative. The new structure would be about 40 feet high and 105 feet long (see plate 11.1). Wedge wire bar screen would be placed on the face of the structure, and would be cleaned by eight moving-brush screen cleaners that are each 13 feet wide. Perforated plate behind the bar screen would help distribute the flow across the intake screen. The entire structure, as well as the screen cleaners, would be submerged. Crane access would be available for maintenance of the structure. Due to the low intake velocity and submergence of the intake structure of more than 30 feet, no trashracks would be required.

(6) Construction Option.

The south shore intake structure is immediately upstream of the fish ladder. Another option in this study is to modify the fish ladder exits at McNary so they operate with a fixed vertical slot weir instead of adjustable weirs. If both of these options are selected for improvement, it may be beneficial to combine these two contracts for the following reasons:

(a) The two structures are adjacent on the south shore. Combining the designs would allow for an improved design to both structures.

(b) Both designs could require the use of cofferdams during construction. If the two designs are combined, only one set of cofferdams would be required. This potentially reduces the overall cost of construction.

Since the intake structures both supply water to the fish ladders, modifying the fish ladder exits and the intakes at the same time would minimize the affects on fishway operations. During modification of the fish ladder exits, the fish ladder would be inoperable. While modifying the intake structure would not necessarily shut down the fish ladders, there would be substantially less attraction flow through the fishway and entrances during construction. Constructing both the fish ladders and the intake structures simultaneously would reduce the amount of time the fishways were affected.

(7) Implementation.

The implementation schedule for modifying the intake structures assumes they are designed and constructed separately from the fish ladder exits. This schedule contains five parts:

(a) The Design Memorandum.

The DM would probably take about 8 months to complete.

(b) Review and Approval.

The review and approval process would take approximately 3 months.

(c) Plans and Specifications.

The plans and specifications phase would probably take about 10 months to complete.

(d) Review, Advanced Notice, and Award Contract.

The review, advanced notice, and award contract generally takes about 4 months.

(e) Construction.

Construction would probably take about 18 months for each intake structure. Work on each structure should be performed independently. Therefore, the total construction time would be 36 months. This would include placing the cofferdams, excavating for the new intake structures, removing any existing structures required, building the new structure, and removing the cofferdams. Restrictions on in-water work only allow placement and removal of cofferdams during two time periods each year. While the actual construction may not take 18 months, the intake structure may be in-operable for this length of time.

e. Short-Haul Barging.

(1) General.

Substantial numbers of juvenile fish may be lost to predation as they are discharged into the river from the juvenile fish facilities. Upon re-entering the river, confused or stunned juvenile fish may be eaten by predator fish and birds that have gathered near the outfall pipes. The discharge of juvenile fish at the release points may actually result in higher levels of predators in the vicinity.

It is believed that the predation losses at the outfall pipes may be reduced by varying the discharge locations. By varying the discharge locations, the numbers of predators gathering at the release points may be reduced and, therefore, the predation losses may be reduced.

Two methods of varying the discharge locations have been identified; the first being an extended outfall system that has multiple release points [see paragraph 4.03.(a)], and the second being short-haul barging.

(2) Description.

The short-haul barges could be used in conjunction with the existing barge loading facilities at Lower Granite, Little Goose, Lower Monumental, and McNary Dams. The barges could be loaded, and then moved to the desired release points. The frequency of loading and releasing could be varied by using the raceways at the juvenile fish facilities to hold the fish while the short-haul barges are releasing fish downstream. For the purposes of this study, it was assumed that one 20,000-pound-capacity short-haul barge (see plate 11.3) would be required at each of the four projects. Each barge would require a dedicated tug and crew. Under normal conditions, the 20,000 pound capacity is sufficient for one release trip per day.

The short-haul barges would provide considerable flexibility in selecting release points. Different release points could be used each day. Release points could be selected virtually anywhere along the river, provided the barges can access the locations.

(3) Implementation.

The minimum time to implement the short-haul barge option is 39 months. This allows 8 months for DM preparation, 12 months for design, 3 months for review, 4 months for contract award, and a 12-month construction period. This minimum implementation time assumes prompt review and advertisement/award, and the availability of sufficient manpower during all stages of the project.

f. Forebay Collection.

(1) General.

An alternate fish collection system located near the water surface in the forebay has long been considered as a possible means of improving juvenile fish passage around the lower Snake River dams. The existing juvenile fish collection systems were developed around the existing intake structures of the dams (see plate 8.1). These systems, although effective in diverting and collecting large numbers of fish, subject fish to turbulent flows as wells as velocity and pressure changes. Conditions in the existing collection systems may stress and injure the fish. Developing a new fish collection system in the forebay may increase the numbers of fish diverted and collected, plus reduce fish stress and injury. Forebay collection systems, being less restricted by the existing structures of the dams, could provide a more subtle and direct means of collecting and bypassing juvenile fish around the dams.

A forebay collection system would attempt to take advantage of the behavioral tendency of juvenile fish to swim in the upper levels of the reservoir pool. Water flowing into a forebay collection system, located above and in front of existing turbine intakes, would provide migrating juvenile fish with another passage route around operating turbines. The forebay collection system could be operated independently or in conjunction with the existing collection system. It is possible that simultaneous operation of the forebay collection system and the existing collection system could result in significantly higher levels of overall FGE. The existing collection system may collect fish that pass below the forebay collection system. Also, flow into the forebay collection system may cause fish to stay higher in the water column, enabling the existing collection system to gather fish that might otherwise pass below the existing diversion screens. A forebay collection system may also reduce the time that juvenile fish spend in the forebay area close to the dam structure.

This section discusses the concept of a forebay collection system for Lower Granite Dam. Design assumptions, concept descriptions, cost estimates, and preliminary implementation schedules are presented. A version of this same concept could be used at other lower Snake River projects.

(2) Design Concepts.

Two design concepts that were considered in this report include:

(a) Vertical Juvenile Fish Entrance Slots.

This concept is based in part on a system presently used at Wells Dam (PUD Number 1 of Douglas County, Washington), on the mid-Columbia River. Wells Dam, being a hydrocombine design (spillways located directly above the powerhouse intakes) is significantly different than the lower Snake River dams. Due to its design, conventional intake screening and diversion systems would be ineffective at Wells Dam. To allow guidance of juvenile fish, vertical-slot fish entrances were placed in the intake gate slots in front of the spillways. The vertical-slot fish entrances divert fish away from turbines, and discharge them through spillways. The vertical slots extend from the forebay surface to a depth of 70 feet, and are 16 feet wide. Five vertical-slot fish entrances are used, strategically placed across the powerhouse. For an application of this concept at Lower Granite Dam, vertical-slot fish entrances (the bottom of the slot being roughly 60 feet below the forebay surface at normal pool elevations) could be used to lead juvenile fish into a collection channel and related features. One entrance per generating unit (for a total of six) could be located across the face of the powerhouse. Vertical slots would provide large entrances and create a flow in the upper portion of the forebay to attract downstream migrating fish into the fish collection and bypass system.

(b) Shallow Skimmer Weirs or Orifices.

This concept is based on a portion of a system that has been used at Ice Harbor Dam on the lower Snake River. Ice Harbor Dam was constructed with an ice-and-trash sluiceway, located above the turbine intakes on the upstream face of the dam. The ice-and-trash sluiceway is used as a surface weir system to attract and collect fish swimming in the upper water column. Fish enter the ice-and-trash sluiceway, and pass into another sluiceway that discharges directly to the tailrace. For Lower Granite Dam, a surface weir system similar to that at Ice Harbor Dam could be used to skim juvenile fish into a collection channel that would lead to collection or bypass facilities.

(3) Description of Selected Concept.

A single concept design, using a version of the Wells Dam fishway entrance in conjunction with a collection/sample and bypass system, has been developed in this study to demonstrate the feasibility of a forebay collection system. Many of the same features would be common for both a Wells Dam and Ice Harbor Dam type of design.

(a) Assumptions.

The following assumptions were used in developing the design:

1. The forebay collection system will be used as a supplement to the existing turbine fish collection and bypass system.

2. Full dewatering of fish collection and transport flows will be required to allow sampling of fish.

3. The system will function over the following operating ranges:

a. Regular juvenile fish collection/sampling/transport, or bypass operations during normal forebay elevations (733 to 738).

b. Special juvenile fish bypass operations using the southern-most spillway bay during emergency operations. Emergency operations would be implemented when the main collection system is not functional.

4. The amount of flow required to attract juvenile fish into the vertical slots will be approximately 5 percent of the powerhouse flow (about 1,100 cfs per unit, or 6,600 cfs total, for normal operations).

5. Water velocities approaching dewatering screens will be limited to 5 fps or less. Water velocities perpendicular to screens will be held between 0.4 and 0.5 fps.

6. Fish and transportation water from the surface collection facility will connect to a new juvenile fish facility using an open flume design instead of using the existing pressurized fish transport pipe system. The costs and implementation schedule at the end of this evaluation, do not include provisions for an open flume transport channel and related downstream features. Improvements to the transportation flume and downstream features are considered in paragraph 4.03.c., Modifications to Lower Granite Dam Juvenile Fish Facilities.

7. Current state-of-the-art juvenile fish facility design criteria, as it relates to pressure changes, fish transfer water velocities, *etc.* will be used for normal operations. (Note: Emergency operations will not necessarily be designed to meet all optimal fishery criteria because of anticipated low usage.)

(b) General Operations.

1. Juvenile fish approaching the dam will have the option of:

- Entering the new forebay collection system;
- entering into the existing collection system;
- going through the turbines; and/or
- swimming away from the turbine intakes back into the reservoir.

2. Fish and attraction water entering into the forebay collection system will pass through vertical slots located across the front of the powerhouse and into a collection channel. The collection channel will lead fish and water to: 1) collection/sampling/bypass facilities during normal operations; and 2) bypass/spill facilities during emergency operations. The main collection channel will have dewatering capabilities to reduce the amount of water that will need to be handled downstream of where fish enter into the system. See plate 11.4 for a general plan of the system layout.

(c) Fish Collection/Sampling/Bypass Operation.

1. Fish Transportation Channels.

Fish swimming into the forebay collection system will pass through one of six 16-foot-wide by 61-foot-deep slots (see plate 11.8, detail 2), and into a 10-foot-wide fish collection channel that extends across the length of the powerhouse. Average velocities through the slot openings will range between 1 and 2 fps, assuming 1,100-cfs entrance flow per slot. Slot openings and depths can be reduced to optimize fish passage and hydraulic conditions by adding solid panels to the framework of the slot openings. Dewatering of entrance flows (see paragraphs below) will be completed within the collection channel, which will keep collection channel flows at about 1,100 cfs across the powerhouse. Average collection channel velocities across the powerhouse will range between 1 and 2 fps.

Fish and collection channel transportation flows (about 1,100 cfs) reaching the south end of the powerhouse will then enter into a floor transition and additional side dewatering sections. The floor invert will rise at about a 17-percent slope [about a 10-degree adverse angle (see plate 11.8)] until it reaches a floor dewatering section. The water depths and flow amounts in this transition channel will be reduced from about 61 feet of depth and 1,100 cfs, to about 8 feet of depth and about 250 cfs at the upstream end of the floor dewatering section. Water velocities throughout the transition and side dewatering will range between 1 and 2 fps. Velocities will increase to approximately 5 fps at the upstream end of the floor dewatering.

Fish and transportation flows (reduced from about 250 to 30 cfs in the floor dewatering section) will pass into a 36-inch-diameter conduit, flowing 18 inches deep. This conduit, with fish and water, will continue until it is eventually combined with another flume system that is part of an important existing collection system. The combined flows will pass down a flume to collection, sampling, and bypass facilities located downstream of the dam (see paragraph 4.03.c.) on the south shore.

2. Extension of the Existing Fish Collection Gallery within the Dam.

The existing fish collection gallery located within the powerhouse (that is used as part of the existing turbine intake screen system) will be extended or mined (see plate 11.5) through the south end of the powerhouse. The existing downwell, pressure fish transportation pipeline, and related features that are currently used to carry fish and water to the existing holding and loading facilities will be abandoned or demolished, as necessary. The new extended collection gallery, in addition to new dewatering and related features, will eventually combine (see previous paragraph) with the new normal operation fish transportation flume coming from the forebay collection system.

3. Side Dewatering System.

The majority of the excess water from the forebay collection channel will be removed by a side manifold dewatering system spread out along the collection channel. This dewatering system, comparable in concept to a system currently under construction for the new McNary Juvenile Fish Facilities (see plates 11.6 and 11.7), will remove excess water through bar screen panels placed between the collection channel and the dewatering system. Velocities perpendicular to the screen are equal to or less than 0.4 fps.

The manifold dewatering system will consist of a total of five stations across the powerhouse, and one station located in the collection channel floor transition area near the south shore. Each station will have ten conduits and control gates directing discharges to a common water withdrawal channel located between the manifold dewatering system and the upstream face of the dam. A brush screen cleaning system will be used to periodically clean the bar screens of debris.

The water withdrawal channel carrying excess flows to the north end of the powerhouse will discharge into a large chamber separating, during normal operations, a single spillway bay from the forebay (see plates 11.4 and 11.9). The spillway gate in the isolated bay will be opened enough to discharge excess collection channel flows over the spillway.

During high river flow conditions, when all of the spillway bays are needed and fish collection and bypass operations are halted, a bulkhead will be installed at the north end of the water withdrawal channel. Bulkheads will be removed from the large chamber around the spillway gate to allow discharge from the forebay through the spillway.

4. Floor Dewatering System.

The floor dewatering system, comparable in design to existing primary dewatering systems used at the Lower Monumental and Little Goose Juvenile Fish Facilities, will further reduce the channel flow remaining after the side dewatering. Water is removed from the system through bar screen panels located in the floor. Water velocities perpendicular to the bar screen will be equal to or less than 0.4 fps. A brush screen-cleaning system will be used to periodically clean the bar screens of debris.

(d) Emergency Fish Bypass Operations.

It will be possible to use the forebay collection system to divert fish to the nearest spillway bay if downstream portions of the main bypass system become non-functional. Although this part of the system will be capable of passing fish directly to the tailrace from the surface collection system, it will not necessarily be designed to meet all optimal fishery criteria because of anticipated low usage of this system.

To implement emergency bypass, a bulkhead will be installed in the fish channel at the south end of the powerhouse, and a bulkhead will be removed from the fish channel at the north end of the powerhouse. The manifold side dewatering system will be shut down, and a bulkhead will be installed at the north end of the water withdrawal channel.

In the emergency bypass mode, fish and transportation water from the fish collection channel will move northward toward the nearest spillway bay rather than southward towards the regular facilities. Fish and water will proceed into the large chamber at the north end of the powerhouse and, finally, through the spillway to the tailrace.

Flow passing into the vertical entrance slots and in the collection channel will be controlled by the amount of water passing through the spillway gate. Slot openings and depths could be reduced to somewhat optimize fish passage and hydraulic conditions. As previously discussed, flow conditions during these operations will not necessarily meet optimum fishery criteria. The harshest conditions (*i.e.*, high velocities, *etc.*) will occur as fish pass through the spillway gate and over the spillway to reach the tailrace.

Fish and transportation flows (reduced from about 30 cfs in the floor dewatering section) will pass into a 36-inch-diameter conduit flowing 18 inches deep. This conduit, with fish and water, will continue until it is eventually combined with another flume system that is part of the existing collection system (see the next paragraph). The combined flows will pass down a flume to collection, sampling, and bypass facilities located downstream of the dam on the south shore.

(e) Construction Methods.

1. General.

The channel and dewatering system will be constructed of structural steel. This will result in a channel that is much lighter than if it were constructed of concrete. Consequently, erection of the channels will be easier. All work can be performed without upstream cofferdams. Concrete corbels will be installed on the upstream face of the dam to support the dewatering and fish channels. Steel piling embedded into rock with steel framing will be used to create a dewatering chamber that allows water from the dewatering channel to pass over the southernmost spillway bay.

2. Concrete Corbels.

Precast concrete corbels (see plates 11.6 and 11.7) will be attached to the pier noses on the upstream face of the powerhouse intake and erection bay structures. Prior to installing the corbels, reinforcing steel anchorage bars must be grouted into the existing structures. The drilling and grouting will be performed underwater. The bars will extend upstream of the powerhouse to receive the corbels. The corbels will be fabricated on the shore, and will have blockouts to receive the anchorage bars. After the grout holding the anchorage bars in the dam has obtained an adequate strength, the corbels will be loaded onto a barge by use of a barge-mounted crane, and erected. The crane will lower the corbels into position with the anchorage bars extending into the blockouts in the corbels. The blockouts will then be grouted underwater. The corbels will have to be held in place by crane until the grout in the corbels has obtained enough strength to support the corbels.

3. Channel Sections.

Individual 30-foot-long structural steel channel sections, which include the fishway channels, dewatering manifolds, and the water withdrawal channel, can be fabricated on shore just upstream of the dam. As much of the fabrication as possible can be performed on the shore to minimize underwater assembly. The structural steel channel sections would be loaded onto barges with barge-mounted cranes, and set on the corbels. Each channel section would be capable of spanning between adjacent corbels, with adjacent channel sections attached together and to the corbels. The steel may be protected from corrosion by use of an impressed current cathodic protection system.

The forebay fish collection channel would extend downstream of the dam until it merged with the fish collection channel from the existing fish collection system. The downstream fish transportation channel could be a CMF supported by steel towers, similar to that used for the Little Goose Juvenile Fish Facility.

4. Channels Extending Through the Dam.

The fish channel passing through the dam would be mined out of the existing concrete by drilling, splitting, and then removing the concrete. A bulkhead and frame placed on the upstream side of the mined channel can be used to hold back reservoir water during construction. A potential route for the fish channel runs diagonally through the erection bay and north non-overflow monoliths. The channel, approximately 3 feet in diameter, would extend between the existing access gallery and the proposed extension of the existing powerhouse collection gallery (see section D, plate 11.6).

5. Dewatering Chamber Adjacent to Spillway.

A chamber just upstream of the southernmost spillway bay is required to allow water from the dewatering channel to pass over the spillway. The water level in this chamber will be lower than the reservoir water level. The structural steel frame of the chamber will be equipped with passages for normal and emergency operation. Stop logs will be installed in, or removed from, the passages for the various operating modes, as needed.

Large holes will be drilled into the rock at the bottom of the reservoir. Piling consisting of large wide flange sections would be welded together at a work area near the upstream shoreline. The piling may be loaded onto a barge with a barge-mounted crane, and moved by barge for placement in bedrock.

Following erection of the piling, a structural steel framework may then be installed to connect the piling together, as well as to the upstream face of the spillway monolith. Some of the steel erection must be performed underwater with divers.

Steel stoplogs would be fabricated and installed in the stoplog slots located on each end of each piling group. To allow access to the stoplog guides, a heavy platform should be constructed over the structural steel framework at the same elevation as the top of the dam. A tire-mounted crane could then remove or install the stoplogs, as necessary.

(4) Implementation.

The total time to implement the forebay collection system at Lower Granite Dam is estimated to be approximately 70 months. This time includes 12 months for DM preparation, 18 months for design and specification preparation, 3 months for review, 4 months for advertisement and award, and a 33-month construction period. It is important to note that the total project implementation time was estimated assuming that sufficient manpower and resources will be available during all phases of the project. Lengthy review processes, manpower shortages, and limited resources would have a definite impact on the total estimated project time. This implementation time does not include implementation of the transportation flume and related improvements. The transportation flume improvements are considered separately in paragraph 4.03.c.

4.04. IMPROVEMENTS TO JUVENILE FISH TRANSPORTATION SYSTEMS.

a. Net Pens.

(1) General.

Net pens for juvenile downstream passage have been proposed as an alternative to the existing truck and barge transport system. Several reasons have been given by the designer and originator of the net pen proposal, Mr. Don Weitkamp of Parametrix Inc., as to why this should be considered an improvement. The main reason is that fish will be transported in "natural water and light conditions that will prevent stress and allow the smolts to undergo normal physiological processes." Mr. Weitkamp notes the following additional reasons: fish will have current to swim against; net pens would have less design and construction costs than barges; net pens have no mechanical systems to fail or maintain; and net pen transport from Lower Granite Dam to Bonneville Dam can be adjusted to take 3 to 5 days.

(2) Description.

As described in Mr. Weitkamp's proposal, the net pens will be comprised of an external framework upon which knotless nylon netting will be secured (see plate 13). Buoyancy of the pens will be maintained by using 4-foot-diameter pontoons, one located on each bottom side of the external frame. Air will be added or released from the pontoons to change buoyancy, as needed. Each buoyancy pontoon will be subdivided into three compartments, with one relatively small compartment being centered between two compartments of equal volume. The smaller compartment will be used to store compressed air, while the larger compartments will be used to adjust the buoyancy volume. Secondary flotation members filled with flotation material will be provided along the top sides of the frame to prevent sinking of the pens. A large opening will be provided for the release of fish without causing release stress. It is assumed that a fleet of 24 net pens will be required to provide transportation equivalent to that of the existing fish barges and trucks. Each net pen will be approximately 100 feet long by 40 feet wide by 13 feet deep, and will carry approximately 45,000 pounds of fish at a loading density of 0.1 pounds per gallon. Each net pen will require a dedicated tug for navigation along the transport route.

(3) Evaluation.

To accommodate the net pens, the fish-loading piping at each existing fish facility will require modification. The loading piping must be rerouted to provide pipe velocities ranging between 7 and 15 fps, with a minimum of 3-inches water depth in the pipe, and less than 30-fps terminal velocity at the loading point. To accomplish the additional 10-foot drop to the net pens, each existing fish facility will require approximately 250 feet of rerouted/new piping and supports.

Floating net pens were considered by the Corps and other fish agencies prior to selecting barges as equipment for transporting juvenile fish. Net pens were not selected for a number of reasons. The primary reason for this nonselection was the consideration of gas supersaturation levels encountered in the reservoirs through which the fish are transported. The transportation barges are equipped with aeration equipment capable of reducing gas supersaturation levels of over 140 percent to less than 105 percent. Levels in excess of 120 percent are common each year, due to involuntary spill or spill for juvenile fish passage. The NMFS observed a 68-percent mortality rate for juvenile fish held in 4.5-meter-deep pens (those proposed are approximately 4.0 meters deep), when dissolved-gas levels ranged from 127 to 132 percent. Furthermore, the barges normally pump river water through the holding compartments from the beginning of the trip to the end. The barges are also equipped with a recirculation mode in the event that some form of pollution is encountered enroute to their destination. This mode of operation allows the inflow from the river to be shut off so the water may be recirculated within the barge until the pollution is no longer of concern.

Although trucks are enclosed, essentially eliminating natural light, the majority of the surface on the barge holds are open, so natural light to the holds is ample. Turbidity of the water generally reduces light penetration, so enclosed sides on the barges do not have a significant effect. Other researchers (Dr. Carl Schreck) have suggested that juvenile fish be transported in a reduced-light environment. Also, recommendations from the Salmon Summit for the "special care" transportation operation called for shading raceways. The purpose was to minimize heating effects from direct sunlight, as well as to provide darkened sanctuary areas.

Like net pens, the current transportation system eliminates turbine mortality for those fish collected at each of the facilities (Lower Granite, Little Goose, and McNary). Because the net pens would depend upon the existing collection and bypass systems (with appropriate dewatering facilities also required) to load the fish, the net pens would be no more effective at eliminating turbine mortality than the trucks or barges. Also, the barges are just as effective as net pens would be at eliminating mortality due to predation and migration delay.

Current transportation procedures include loading the fish directly into the barge whenever possible, thus reducing the extra handling and stress potentially caused by raceway loading and crowding. However, there are time periods when raceway loading is unavoidable, and these periods are expected to be just as frequent with a net pen as they are with the barge system. As proposed with the net pens, barges also leave daily during the majority of the season.

Although the trucks do not offer the natural light and flow through river water that the barges and net pens do, research efforts have not indicated any significant problems with stress or homing ability. Existing data suggest homing is imprinted prior to the transport process, so it does not appear to be affected by trucking. Trucks are generally only used during the beginning and end of the transportation season, when fish numbers are low. The cost difference between barging and trucking is a big consideration in the decision to truck when numbers are low enough to allow trucking. It costs approximately $350 per truck trip versus approximately $16,000 per barge trip.

Since the net pens and barges have the same method of propulsion, timing through the reservoirs could be adjusted for either one.

The proposal indicates that net pens would be transported at 3 to 4 knots (this speed would have to be evaluated to ensure velocities would not cause fish impingement). The barges are transported at about 10 knots. Where barge delivery of fish is 2 days, the proposer recommends 4 days or longer. This could be achieved with barges, but additional equipment would be required. However, there is no supporting data to suggest that 4 days is better than 2 days. In fact, fish agencies and tribes recommend limiting confinement time whenever possible.

Another consideration would be the structural integrity of the transport equipment under adverse weather and river flow conditions. At times, conditions become so severe (particularly on the John Day reservoir, the McNary reservoir, and in some reaches of the Snake River) that the tugs and barges must find safe mooring until the weather improves. Unless net pens were of substantial structural strength, it is unlikely they would survive some of the environmental conditions encountered.

Varying the location of release is recommended by the proposer. This is currently standard practice with the barge releases. Fish are released in a different spot each trip, over a range of 4 miles. As far as release method is concerned, fish are released from the barges through one 18-inch opening per compartment, and through the bottom of the barge. All interior surfaces are smooth and painted, so little abrasion should occur. A larger exit from the barge has been evaluated under a separate part of this study. Lack of access to the net pens during releases could result in mortalities from stranding. Many fish tend to remain in a vessel as long as possible, so their fins and opercula could get hung up on the netting. Acclimation prior to release is not supported by existing data, and extended holding could pose questions of food requirements, *etc*.

The proposal indicates loading at 0.05 to 0.1 pounds per gallon. Barges (and trucks) are loaded to a maximum of 0.5 pounds per gallon, but loading density is sometimes significantly less than this (as low as 0.002 pounds per gallon). Loading rates of 1.5, 1.0, 0.75, 0.5, and 0.25 pounds per gallon have been researched, and no evidence was found that loading densities less than 0.5 pounds per gallon significantly reduced stress to fish. The 0.5-pounds-per-gallon rate is only reached when the barges are fully loaded (during the peak of the season). Additional research on loading densities and stress was recently performed, but the results of this research are not yet available.

Another proposed advantage to the net pens is that they would provide a current against which the fish could swim. If the net pens travel at a rate greater than the river flow, this current would be flowing from downstream to upstream, and would have to be minimized to prevent fish impingement. The current barging system provides flow through the holds, which could be considered a current of sorts.

There are several concerns specific to the net pens, in addition to those listed above (inability to reduce dissolved-gas concentrations and structural integrity questions). Although it is possible that mechanical equipment used to move water through the fish barges may fail, a biologist (as well as mechanic) is on board, and is able to easily observe fish behavior within the holds and measure dissolved-gas concentrations, *etc.* Without a substantial change in the net pen layout and operation concept, the net pens would not offer the monitoring/testing capability of the fish barges. Changing the net pen design to provide monitoring capability that approaches that of the fish barges would result in, essentially, a fish barge similar to those currently in use. Wave action in some of the reservoirs, which at times becomes severe, may impinge fish upon the netting and support framing. A final concern is that debris in the river could damage or plug the netting, resulting in fish loss.

The existing moorage facilities at Lower Granite Dam are insufficient to handle a fleet of net pens. Therefore, additional moorage facilities will be required.

The mobile net pen concept may be applicable to the concept of variable release sites as an alternative to fixed location bypass release pipes. Some of the advantages to variable release sites include unlimited release locations and timing, the possibility of holding fish for nighttime release, and greater operational flexibility than a fixed site.

Generally speaking, there seems to be no apparent significant advantages to this alternative method of transportation over the existing truck and barge system, with the possible exception of its potential application to the concept of short-haul, variable release sites, as discussed above. There is no evidence to indicate net pens would cause less mortality than the barges. [Transport mortality in barges averages less than 1 percent annually, the majority resulting from other factors (*i.e.*, disease and pre-dam and pre-transport injuries.)]

If this proposal were adopted, it would result in increased cost to replace the existing fleet of 6 barges with 24 net pens (at half the speed; twice as many downward-bound, and twice as many upward-bound at one time). It would also take up to four times as many towboats. This would quadruple the current towboat cost of $1 million per year. If net pens were used to replace trucks, the use of tugs would be required throughout the transportation season, escalating the costs of transport even more.

(4) Implementation.

The total minimum time required for design and construction of the net pen fleet and moorage facilities, assuming all (if any) prototype testing has been completed, is 41 months. This time includes 8 months for DM preparation, 8 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and an 18-month construction period. It is important to note that the total project time estimate was prepared with the assumption that sufficient manpower and resources will be available during all phases of the projects. Lengthy review processes, manpower shortages, and limited resources would have a definite impact upon the total estimated project time.

It has been recommended by the proposer that, before a net pen program is implemented, a prototype net pen be designed, constructed, and tested so the performance of the net pens may be evaluated and any shortcomings discovered. If it is determined that a prototype test is necessary, the design and construction schedule must be adjusted accordingly. The total minimum time needed to design, construct, and test a prototype net pen is 2 years. The testing time may need to be increased considerably to provide sufficient information for analysis. Assuming that major redesign would not be necessary after the prototype testing, the subsequent total minimum time to construct the net pen fleet and moorage facilities could be reduced.

b. Barge Water Temperature Control.

(1) General.

The objective of this action is to meet a target water temperature in the barges of 68^{o}F. The 68^{o}F-temperature is the maximum temperature recommended by fish biologists (based on their fish-rearing experiences) at which fish should be transported. Fish health is improved, in general, and fish have less chance of experiencing disease-related mortality at lower water temperatures. During the 1990 transport season, water temperatures remained below 60^{o}F through mid-June at Lower Granite, Little Goose, and McNary Dams. The temperatures rose to 68^{o}F at these projects during the third week in July. During August, the temperatures rose to 76^{o}F at Granite/Goose, 71^{o}F at McNary, and 75^{o}F at Bonneville. In general, barging is completed by 15 June on the Snake River, and by late July on the Columbia River. Under current operating practices, there is very little time when temperature control of barge water would be beneficial.

(2) Evaluation.

Assuming a design maximum river water temperature of 73^{o}F, the resulting 5^{o}F temperature drop to (68^{o}F) would require chilling the

15,000-gpm barge water flow. This temperature drop requires a cooling capacity of approximately 11 megawatts (MW).

There are many methods and combinations of methods that may be used to provide the needed cooling. They include pumping cooler water into the barges from greater depths in the river by using a lowered pump suction, and a host of other more conventional cooling/refrigeration methods.

Pumping cooler water from the river is considered impractical for several reasons. First, temperature stratification in the river is not always significant, especially in the lower Columbia River, due to the mixing caused by the dams. Second, some type of automatically-adjustable pump suction must be developed to raise and lower, as necessary, to avoid obstructions in the sometimes shallow navigation channel. A sonar-type system would be needed to make this concept work. Finally, as the barge passes down river, water at varying temperatures would be pumped into the barge. This would be accentuated by a pump suction nozzle that raises and lowers to avoid obstructions. The uncontrollably-varying water temperature would, most likely, adversely affect the fish in the barge.

Based upon the need for a dependable, high-capacity system that is capable of delivering a large amount of relatively constant temperature water, cooling through the use of chillers powered by diesel generators will be considered the preferred method of conventional cooling in this analysis. Assuming a two-chiller system, each 5.5-MW chiller would weigh as much as 64,000 pounds, and would require the installation of new pumping, control, and electrical power systems. The existing fish barges would be overwhelmed by the weight and space requirements of such a chiller system. Therefore, temperature control of barge water is not feasible if equipment is to be directly mounted on the existing fish barges.

An alternative to placing the equipment on the fish barges is to provide an additional "chiller barge" that will carry the new cooling, pumping, and generator equipment (see plate 14). An additional benefit to this system is that pumping could occur entirely on the chiller barge, thus eliminating sources of vibration on the fish barge. The pumps on the fish barge would serve as a backup water supply system to the chilled water supply, and would be used to provide water when chilling is not required.

The chiller barges would consist of two large chiller units, four diesel generators, and three separate pumping systems. Each barge would need to be approximately 40 feet wide by 180 feet long, and would need to be covered to protect the equipment mounted on deck. Water would pass from the chiller barge to the fish barge through quick-disconnect piping, and discharge directly from the fish barge into the river. The chiller barges would be coupled alongside the fish barges using barge winches provided on the chiller barges.

Except when the fish barges travel through contaminated water, single-pass flow through the fish barges is desirable in order to "imprint" the fish for their return upstream. The use of heat exchangers to recover some of the waste energy from the discharge flow is impractical due to the low temperature difference between the river water and the discharge flow.

Each fish barge would require a chiller barge and, therefore, six chiller barges would be necessary for the existing fleet of six fish barges. As additional fish barges are provided, additional chiller barges would be required, or the new fish barges would have to be made larger to accommodate room for chiller equipment.

The use of chilled water in the fish barges would require a change in the current mode of operating the fish barges. Under the current mode of operation, fish are loaded into the barges at each successive dam as the barges travel downstream. This practice would have to change to prevent thermal shock of the fish as they pass from the fish facility water into the chilled barge water. The most likely means of overcoming this problem is to leave barges at each collection facility, and fill them prior to shipment downstream. As the barges begin their journey downstream, the water temperature could be slowly lowered to the desired temperature. Shortly before the release of the fish from the barge, the water temperature could be slowly increased to the river water temperature.

The operation and maintenance costs for the chiller barges would be high. Each chiller barge would consume approximately 7,000 gallons of diesel fuel per day, and the fleet of chiller barges would require the equivalent of two full-time mechanics to maintain, adjust, and repair the equipment on board. Operation and maintenance cost savings would be realized if the chiller barges are used only during the periods when the water temperature rises above 68°F.

The existing barge moorage facilities at Lower Granite Dam are insufficient to handle a fleet of chiller barges. A new moorage facility, similar in design and magnitude to the existing moorage facilities, would be required for the chiller barge fleet. This facility would be comprised of docks and access platforms anchored to pilings.

(3) Implementation.

The total project implementation time, assuming all prototype testing has been completed, is estimated to be 53 months. This time includes 10 months for DM preparation, 18 months for design and specifications preparation, 3 for review, 4 for advertisement and award, and an 18-month construction period. The 18-month construction period is the estimated time needed to construct the entire fleet. It is possible that at least one of the barges could be operational in less than 9 months. It is important to note that the total project time estimate was prepared with the assumption that sufficient manpower and resources will be available during all phases of the projects. Lengthy review processes, manpower shortages, and limited resources would have a definite impact on the total estimated project time.

Availability and lead-time of equipment (*i.e.*, chillers, pumps, and generators) may significantly impact the construction schedule. If a prototype test is deemed necessary, the project implementation times must be adjusted accordingly. Design, construction, and testing of a prototype chiller barge could take up to 4 years.

c. Fish Barge Exits.

(1) General.

The fish release exits on the existing fish barges vary in size from a 10-inch inside diameter (ID) to a 17.25-inch ID. These small exits may stress the fish during release and increase their chances of subsequent mortality. To reduce the possibility of causing this stress, it is desirable to increase the size of the fish release exits as much as possible. On four of the six existing barges, the exits may be replaced with 35-inch-ID exits. The water velocity through a 35-inch-ID exit would be approximately one-fourth of the velocity through a 17.25-inch-ID exit. On the remaining two existing fish barges (that have 10-inch-ID exits), the size of the fish exits cannot be made larger than a 17.25-inch D, due to interference with structural supports. The water velocity through a 17.25-inch-ID exit would be approximately one-third of the velocity through a 10-inch-ID exit.

Replacement of the fish exits involves dry-docking the barges to allow the hulls to be cut and new larger-sized exits to be welded in place. In addition, new plugs for the exits must be fabricated and installed, and the mechanisms and supports for opening and closing the exits must be modified accordingly.

(2) Implementation.

The minimum total time to implement the fish exit change for the existing fleet of six barges is 23 months. This allows for a 4-month DM preparation period, 4 months for design, 3 months for review, 4 months for contract award, and an 8-month construction period. This minimum implementation time assumes prompt review and advertisement/award, and the availability of sufficient manpower during all stages of the project.

d. New Fish Barges.

(1) General.

Over the past several years, barging schedules have returned barges to Lower Granite Dam up to 20 hours before the next scheduled departure. Up to 75 percent of the barged fish in a given year have been loaded into the barges without first being loaded into the raceways. Regional fisheries experts agree that eliminating the stress of having to crowd the fish out of the raceways into the barges should be beneficial. In their ESA Biological Opinion, dated April 1992, NMFS recommended that direct loading (loading fish into barges without holding them in raceways) of fish into barges be expanded to include projects in addition to Lower Granite. By 1993, they asked that direct loading capability, including separation of fish by size, be developed at Little Goose Juvenile Fish Facilities. In 1993, collection facilities will be completed at Lower Monumental Dam that will have direct loading capability with size separation. Direct loading with size separation will also be possible at the new McNary collection facility scheduled for completion in April 1994. As early as April 1996, new collection facilities, and the ability to separate juvenile fish by size, could be available at Lower Granite Dam. Direct loading would require that a barge be moored at the facility for an extended period of time and that, when it was transported downstream, a replacement barge would have to be available to continue direct loading.

Extended-length fish screens are being considered for McNary, Little Goose, and Lower Granite Dams. If the extended-length screens are perfected, they may increase fish collection significantly at the dams. This would result in an increase in the number of fish being transported from each of these dams.

(2) Technical Evaluation.

(a) General.

The quantity of fish barges required depends on the size of the barges, the numbers of fish expected to be transported, and the number of projects where each barge will receive fish. For the purpose of this study, a barge size of 75,000 pounds (150,000 gallons) was used (see plate 12), and it was assumed that direct barge loading would occur at Lower Granite, Little Goose, Lower Monumental, and McNary Dams.

New 75,000-pound barges will allow some of the barge fleet to be parked at fish facilities for direct loading while other barges are in transport. Also, minor revisions to the proven 75,000-pound barge design would be required, rather than of a complete redesign. This would save time and money in procurement.

(b) Fleet Options.

Three options for fleet size and operation have been considered:

1. Option 1 would be to originate transport from Lower Granite Dam, picking up loaded barges at Little Goose, Lower Monumental, and McNary Dams. Empty barges would be parked at each dam for direct loading. A towboat departing from Lower Granite Dam would pick up an additional barge at each collector dam, so it would be pushing four barges after it left McNary Dam. On the return trip, barges would be dropped off at the collector dams as the towboat traveled upstream. During the towboat rotation (leaving Lower Granite each day), a total of 13 barges would be required (existing ones, plus 9 new ones). The small barges are not considered because NMFS has recommended that they be replaced. Two barge riders per trip would be required to take mortalities out of barges and to monitor water quality. Additional maintenance personnel and moorage facilities would be required.

2. A second option would be to run four towboats out of Lower Granite Dam transporting barges from Lower Granite, Little Goose, and Lower Monumental Dams, and one towboat from McNary Dam transporting barges only from McNary. This option would require only 11 barges (7 new ones). However, this option would also require an additional towboat, substantially increasing that cost, and an additional barge rider. Additional maintenance personnel and moorage would also be required.

3. The third option would be to operate in the current way, starting at Lower Granite Dam and taking on additional fish from the collection facilities at the downstream dams. Under existing fish numbers, all collected fish could be barged in a total of eight fish barges (a total of four new ones). By parking barges at the other collector dams when collection numbers were low to moderate at Lower Granite Dam, the percentage of fish direct loaded could be substantially increased, though not maximized as under option 1.

(c) Costs.

For rough cost-estimating purposes, $2 million is used for each new barge, $50,000 for each full-time employee, and a base cost of $150 to $200 per hour for towboats (sized to push one barge, or up to four barges). Minimum engineering and design costs are shown for upgrading existing barge designs. These costs are for comparative purposes only between the three barging options.

Capital, annual, and maintenance costs:

COSTS ($1,000 or FTE'S)	OPTIONS 1	2	3
Capital cost	$18,000	$14,000	$8,000
Engineering & Design costs	100	100	100
Supervision & Admin. costs	1,980	1,540	880
Moorage facilities	900	700	400
Total capital cost	$20,980	$16,340	$9,380
Added towboat cost	$433	$583	0
Added maintenance	1.8 FTE	1.4 FTE	0.8 FTE
Added barge riders	1.0 FTE	0.8 FTE	0.4 FTE
Added labor cost	140	110	60
Total annual cost			
FTE	2.8 FTE	2.2 FTE	1.2 FTE
Dollars	$573	$693	$60

(3) Recommendation.

Based on the expressed desire of NMFS to maximize direct loading, and thereby minimize stress in transport, option 1 would be preferred. However, this option has the highest capital cost ($20,980), and substantially higher annual costs than option 3. Option 3 could achieve a good portion of the benefit of option 1 at less than half the capital cost, and minimal added annual cost. Therefore, option 3, acquisition of four new 75,000-pound barges, is recommended.

(4) Implementation.

It is important to note that the total project time estimates listed below were prepared with the assumption that sufficient manpower and resources will be available during all phases of the project. Lengthy review processes, manpower shortages, and limited resources would have a definite impact upon the total estimated project times.

The total project implementation time is estimated to be approximately 27 months. This time includes 4 months for DM preparation, 4 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 12-month construction period.

4.05. IMPROVEMENTS TO ADULT PASSAGE SYSTEMS.

a. Fish Ladder Water Temperature.

(1) General.

One of the adult facility improvements identified in section III.5, paragraph A(2), pages 55 and 56, of NPPC's *Amendments to the Columbia River Basin Fish and Wildlife Program (Phase Two)*, dated December 11, 1991, was to evaluate the potential for reducing water temperatures in adult fish ladders on each of the Snake River dams. Shading, sprinkler systems, and pumping cooler water are alternative measures for achieving this goal.

Five of the six fish ladders on the Snake River dams are similar in design, having nominal design flows of 75 cfs, a 1-vertical to 10-horizontal slope, and widths of 16 or 20 feet. The sixth ladder, located on the south shore of Ice Harbor Dam, has a design flow of 96 cfs, a slope of 1 vertical to 16 horizontal, and a width of 24 feet.

(2) Evaluation.

A heat transfer analysis was performed to estimate the maximum water temperature rise that could occur in the fish ladder flow due to heat gains from solar and kinetic energy conversion. In this heat transfer analysis, the fish ladder was modeled with a steady flow of 75 cfs, 20-foot ladder width, a 7-feet 6-inch mean water depth in the ladder, 1,120 feet of ladder length, and a 96-foot difference in elevation from the ladder exit to a point just upstream of the adult attraction supply at the ladder entrance. It was assumed that the entire 96-foot head difference was converted into heat energy in the water. Solar gains were estimated using peak values from American Society of Heating, Refrigerating, and Air Conditioning Engineers Fundamentals (1985), at a latitude of 46^{o}N. Assuming steady flow and steady state heat transfer, and neglecting heat losses due to evaporative cooling, the maximum temperature rise in the fish ladder was calculated to be 0.5^{o}F.

In 1991, the Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU) collected data and performed a comparison of water temperatures in the forebays, fish ladders, and tailraces of the four Snake River dams. In a letter addressed to Sarah Wik, dated January 2, 1992, the ICFWRU presented graphs of their findings and noted that, "Tailrace temperatures were usually 0.5-2.0^{o}C lower than temperatures in the ladders during the summer and early fall." It is important to note that this temperature difference should not be attributed solely to a temperature rise in the fish ladders. The temperature difference is largely due to warm ladder flow, coming from warmer water near the top of the forebay water surface, and cool tailrace water, being a mixture of cooler water taken from much greater forebay depths. Temperature data collected by the Corps over the last decade indicates that forebay water temperatures at the Snake River dams may vary significantly from river surface to near river-bottom depth. At Lower Granite Dam, temperature differences as great as 5.9°F have been recorded (the 5.9°F difference being between the water surface temperature and the temperature at a depth of 112 feet).

Attempting to lower fish ladder water temperatures by shading or by sprinkler/latent heat cooling would be ineffective. As previously mentioned, the maximum possible temperature rise in the ladder water is 0.5°F. Providing shading or sprinkler cooling would, at best, keep temperatures in the lower end of the ladder only 0.5°F lower. The most effective means of lowering ladder temperatures would be to supply cooler water at each fish ladder exit. This may be achieved by directing water from greater forebay depths into the fish ladder exit and auxiliary supply. Two alternative methods of accomplishing this are considered in this study.

(a) Alternative 1--Exit and Auxiliary Supply Caissons.

Large-diameter piping may be extended from near the river bottom, up the face of the dam to caissons that cover the ladder exit and auxiliary supply intakes (see plate 20.1). An automatically-controlled weir would maintain a 1-foot differential between the forebay water surface and the water surface in the caisson covering the fish ladder exit. This head difference would provide the driving force needed to pass the cooler water from the river bottom through the new supply pipe and into the fish ladder exit. Similarly, the head difference between the forebay water surface and the water surface in the ladder would drive cooler water from the depths of the forebay through the new piping and into the fish ladder auxiliary supply.

The existing means of maintaining near-constant ladder flows is to throttle the flow through the auxiliary supply as the forebay elevation fluctuates. In this manner, as flow into the ladder exit increases, the auxiliary flow decreases. As flow into the ladder exit decreases, auxiliary flow increases. Using the aforementioned pipe/caisson supply, ladder flows could be maintained by automatically throttling the auxiliary supply in a manner similar to current practice.

Introducing cold water into the fish ladders may present a problem with thermal shocking the fish as they enter and leave the ladders. If ladder water temperature is significantly below the tailrace temperature, fish may be shocked as they enter the ladder. Similarly, fish may be shocked if the water temperature at the forebay surface is significantly greater than the ladder water temperature. For example, water temperature differences between the forebay surface and forebay bottom may be as great as 5.9°F at Lower Granite Dam. If the flow from the forebay surface into the ladder exit is minimal, and the majority of the 75-cfs ladder flow is cold water entering the auxiliary supply from the forebay bottom, the temperature difference between the upper portion of the ladder and the forebay water surface could approach 5.9°F. Under similar ladder flow conditions, the water leaving the ladder could be significantly colder than the tailrace water temperature (the extreme case, although not realistic, would be 5.9°F colder).

To prevent the possible thermal shock problem at fish ladder entrances and exits, a means of monitoring and controlling ladder water temperature should be provided. To achieve this, temperature measuring devices could be placed near the forebay surface, in the ladder, and in the tailrace. Readings from these devices could be gathered by an acquisition device and used to control a warm water supply valve located in the caisson of the auxiliary supply (see plates 20.1 and 20.2). This warm water valve could be automatically throttled to control the input of warm water, as needed, to maintain the desired ladder temperatures with respect to forebay and tailrace temperatures. This system could be used to control both warm and cold water being supplied to the ladder. With this type of control, the effects of forebay fish ladder tailrace temperature differences could be minimized. For example, a 5.9°F difference could be spread out over the system, so that the forebay to ladder difference is 3°F and the ladder to tailrace difference is less than 3°F. If the temperature measuring device in the ladder is placed in the lower section of the ladder (above the supply diffusers), it would be possible to account for temperature gains in the ladder.

(b) Alternative 2--Floating Pump Platform and Auxiliary Supply Caisson.

To control the temperature of the water entering the auxiliary fish ladder supply, a caisson system similar to that described in alternative 1 would be used. Piping from the bottom of the forebay would be directed to the auxiliary supply inlet without branching to the fish ladder exit. Control valves would regulate the amount of cold and warm water entering the auxiliary supply to regulate temperatures in the ladder, as needed.

To reduce the water temperature in the vicinity of the fish ladder exit, large pumps would discharge cool water just beneath the water surface in front of the exit (see plate 20.3). The primary components of this system would be the floating platform, pumps, intake piping, and intake screen. Cold water would enter this system through the intake screen at the river bottom, pass up to the floating platform through polyethylene intake piping, and enter a pumping chamber beneath the floating platform. The pumps would direct the water from this chamber toward the fish ladder exit.

To effectively reduce the water temperature in the vicinity of the fish ladder exit, the pumps must discharge at least 100 cfs.

This discharge is based upon a 75-cfs peak flow into the ladder exit, and an assumed 25-cfs surplus to accommodate losses due to flow currents in the forebay. The actual quantity of water required will be site specific, and will vary with water temperatures and the characteristics of flow in the forebay. Four pumps, rated at 11,500 gpm (5-foot total dynamic head, 40 horsepower), are proposed to supply this flow. To reduce turbulence and discharge velocities, the pumps discharge into expansion plenums in the floating platform.

To handle 100 cfs with an approach velocity of 0.5 fps, a large intake screen is required. The intake screen would need to be at least 8 feet in diameter and 24 feet long. To prevent fish entry and screen clogging, a profile wire-type screen should be used. To clean the screen, an air-blast backflush system should be used, where the air is piped to the screen from a compressor/receiver on the floating platform. The screen must be sufficiently elevated above the river bottom and held in place using, for example, a large concrete anchor block.

The intake piping must be of sufficient size to carry the 100-cfs flow with minimal friction loss, and flexible enough to accommodate pool fluctuations. To accomplish this, 54-inch-diameter polyethylene pipe could be used. The pipe length versus wall thickness must be carefully evaluated to ensure that bending caused by pool fluctuations does not damage the pipe.

To prevent vortexing and other pump performance problems, flow approaching the pumps in the pump chamber should be uniform, with a velocity of less than 1 fps. Baffles between the inlet chamber and the pump chamber (see plate 20.3) could be used to evenly distribute the flow approaching the pumps. The depth of the pump chamber and the pump column length must be sufficiently large to keep the water depth in the chamber greater than the minimum depth required for pump submergence.

To determine the proper installed location of the floating platform, the characteristics of flow in the forebay must be determined. For the purposes of this study, it was assumed that the platform would be located 100 feet from the face of the dam. In actuality, this distance may have to be adjusted, and flow curtains may need to be installed to establish adequate flow patterns. The floating platform could be kept in place by the combined reactions of pump thrust, intake pipe stiffness and weight, and cables secured between the platform and the dam.

To prevent adult fish from getting too close to the pump discharge, large bar screens could be placed at the end of the pump discharge plenums.

Power to the floating platform (for the pumps, compressor, lighting, *etc.*) could be provided from the dam through a submerged or suspended cable.

(3) Discussion.

(a) Alternative 1.

The system proposed in alternative 1 would help regulate temperature differences between the forebay, ladder, and tailrace; and could help reduce thermal shock. However, the temperature differences may still cause adult passage delays in the forebay and tailrace. Adult fish may prefer the cooler fish ladder water over the warmer forebay water and, therefore, hold in the upper end of the fish ladder. Similarly, the adult fish may prefer the cooler tailrace water over the warmer fish ladder water, and hold in the tailrace. Finally, the success of this temperature control system will depend on both the accuracy of the temperature measurements and system reliability. Poor performance of the control system could result in no measurable benefits to adult passage.

(b) Alternative 2.

The system proposed in alternative 2 would help maintain cooler fish ladder temperatures and cool water temperatures near the fish ladder exits. The cooler water in the vicinity of the exit may improve the overall passage of adults. However, the adults may tend to gather in the cool water near the fish ladder exit due to warmer surface water beyond the floating platform. This system may also affect juvenile fish passage. The juveniles may be attracted to the cooler water near the ladder exit, and hold there.

(4) Implementation.

(a) Alternative 1.

The minimum time to implement fish ladder water temperature control at each project is 24 months. This time includes 5 months for DM preparation, 6 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 6-month construction period per ladder. The DM time may be reduced if all four projects are covered in one DM. Similarly, if construction at all four projects is accomplished under one contract, implementation times could be reduced significantly. The minimum implementation time assumes the prompt review and advertisement/award, and the availability of sufficient manpower during all stages of the project.

(b) Alternative 2.

The minimum time to implement the fish ladder water temperature control at each project is 26 months. This time includes 5 months for DM preparation, 6 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and an 8-month construction period per ladder. The DM time may be reduced if all four projects are covered in one DM. Similarly, if construction at all four projects is accomplished under one contract, implementation times could be reduced significantly. The minimum implementation time assumes prompt review and advertisement/award, and the availability of sufficient manpower during all stages of the project.

b. Additional Fish Ladders.

(1) General.

Lower Granite and Little Goose Dams each have one ladder on the south shoreline (see plates 15 and 16). At either dam, adult fish entrances in the north spillway retaining wall are connected to the ladder by a tunnel through the spillway structure to the powerhouse collection system. Placing an additional fish ladder on the north shore would provide a back-up to the single ladder at each dam, potentially reduce the number of adult fish dropping out of the powerhouse entrances, and provide more direct passage for adults entering the north shore entrances. The analysis below focuses on the aforementioned problems. Another problem is that adults cannot enter the north spillway entrances during spill. The adult entrance during spill problem is addressed in paragraph 4.05, Extended Fishway Channels. It is important to note that the additional ladders and extended fishway entrances may be combined to address both problems simultaneously.

(2) Lower Granite Dam.

(a) Existing System.

Operating between minimum tailwater elevation and maximum forebay elevation, the ladder system accommodates a total elevation difference of 105 feet. The ladder is a weir-and-pool-type ladder, approximately 940 feet long and 20 feet wide. Water control through the ladder is accomplished by a 160-foot-long vertical-slot control section at the top of the ladder. A forebay-fed, gravity-flow diffuser located at the bottom of the water control section automatically adjusts for forebay and tailwater fluctuations, and maintains a constant flow of 75 cfs in the ladder.

The design operational range for the ladder is 733 to 738 feet (forebay) and 633 to 642 feet (tailwater). Corresponding river discharges vary from zero to 225,000 cfs.

An auxiliary ladder exit and water supply system is available for those extreme high water years when the pool level must be reduced at the dam to prevent overtopping the flood control levees protecting the city of Lewiston. The existing auxiliary exit system consists of an arrangement of three pumps, a false weir, and release piping. One of the three pumps supplies water to the false weir, while the remaining two pumps supply the upper portions of the ladder. At forebay elevation 710, each pump delivers 11,000 gpm for a total supply of 33,000 gpm (73.5 cfs). The false weir is located at the end of an exit channel adjacent to the normal fish exit channel. When the auxiliary exit is used, the auxiliary pumps are started, the gravity-fed auxiliary supply is closed, and the normal fish exit channel is closed. The auxiliary pumped supply maintains ladder water flows, and provides attraction flow for the false weir. Fish pass over the false weir, into a chute, and out to the forebay through an 18-inch-diameter fish release pipe.

Water for fish entrance attraction flows and the transportation channel is supplied by three electric pumps that pump water from the tailrace to the diffusers. The pumps each have a capacity of 1,050 cfs.

The existing ladder system also has facilities for trapping adult fish, and a vertical-slot fish counting station.

At Lower Granite Dam, the delay in adult passage during spill is magnified by the location of the navigation lock. The navigation lock is located between the spillway and the north shore. As a result, a pool of water exists between the navigation lock and the north shore. Due to the high velocities in the spillway during spill, adult fish are unable to enter the "north shore" entrances located on the south side of the navigation lock. Adult fish on the north side of the navigation lock must go back downstream, around the spilled flow, and up the south shoreline to reach the ladder entrances.

(b) Proposed Additional Fish Ladder.

Placing a ladder on the north side of the navigation lock is complicated by the fact that the ladder would have to pass through the earthen north embankment. The extent to which the earthen embankment would have to be excavated could be reduced by extending the ladder to the top of the embankment, providing a pumping system to deliver the required ladder flow, and providing an exit flume system to pass the fish from the top of the ladder into the forebay. Placing the ladder on the north side of the navigation lock would also take care of the problem of fish entering the north entrances during spill.

Placing the ladder on the south side of the navigation lock may affect the stability of the navigation lock. The stability of the navigation lock must be examined in further studies of this alternative.

Several alternatives exist on where the new fish ladder should be placed, and how it should be oriented. In this analysis, the preliminary design places the new ladder on the south side of the navigation lock, primarily to avoid disturbing the earthen embankment on the north side of the navigation lock.

The new permanent north shore ladder would be constructed between the spillway right training wall and the navigation lock. The new north ladder would include a fish counting station, and would operate under the normal pool levels described above. Attraction water to the entrances would be supplied from the forebay through new floor diffusers and a new supply channel.

The existing entrances in the spillway right training wall would be used to access the north shore ladder. On the downstream side of the training wall are two weir gate entrances, with one sluice gate entrance facing into the stilling basin. The sluice gate entrance invert will be lowered 3 feet (to IE 625) in order to meet the desired entrance criteria. At this lower elevation, the entrance invert will always be at least 8 feet below minimum tailwater. A new gate will be provided for the sluice gate entrance, with an electric hoist to raise and lower the gate.

Modifying the existing fishway channel in the right training wall to access the new ladder will essentially cut off access between the existing entrances and the south shore fishway. In order to prevent adult fish from entering the fishway channel under the spillway, the channel will be screened off near the north powerhouse entrances. The screen will not only prevent access, but will keep hydrostatic pressure differences in the closed fishway near design values.

Cofferdams will be required during construction of the lower end of the new ladder and the water intake structure on the upstream side of the dam.

One method for supplying water to the new ladder diffusers would be to access the forebay and provide a gravity flow system. A 10-foot-square intake could be mined from the channel beneath the spillway into the forebay. A series of energy dissipating valves would be installed to control the amount of inflow from the forebay.

- Intake screens would be required at the new intake. The intake screens would be wedge-wire panels designed for 300-pounds-per-square-foot loading (approximately 2-pounds-per-square-inch pressure drop), with .125-inch-wide slots between screen bars. A differential pressure-sensing device to warn of high pressure drop across the screens would be necessary.

- A large sluice gate would be installed on the face of the dam behind the intake screen to shut off the intake channel. This gate would be operated from the deck of the dam by using an extended gate operator shaft. A smaller filling port would be installed to allow the channel to be filled without using the sluice gate.

- A screen-cleaning system would be installed to clean debris off of the intake screen. The cleaning system would be controlled by the differential pressure-sensing device. The screen-cleaning system would be similar to those used at the juvenile fish facilities, but would be more elaborate because of the greater operating depths and the absence of cross flow to help sweep debris away. It may be possible to use the existing trashrack cleaners at the dam to clean the new screens.

- A valve chamber large enough to house the upper portions of all the energy dissipation valves would be mined adjacent to the new supply channel. Passageways large enough for installing 54-inch-diameter supply pipes would be mined between the supply channel and the valve chamber. Flanged pipe sleeves would be required in these passageways. A modulating-type valve operator would be required on one of the energy dissipation valves, with the other valves having standard electric operators.

(3) Little Goose Lock and Dam.

(a) Existing System.

The existing ladder is similar to the existing ladder at Lower Granite Dam. Operating between minimum tailwater elevation and maximum forebay elevation, the fishway accommodates a total elevation difference of 101 feet. The weir-and-pool ladder is approximately 900 feet long and 20 feet wide. The design operational range for the ladder is 633 to 638 feet at the forebay, and 537 to 544 feet at the tailwater. Each of the turbine-driven attraction water pumps delivers approximately 850 cfs to the ladder entrances. Unlike Lower Granite Dam, Little Goose Dam does not have an auxiliary ladder exit.

(b) Proposed Additional Fish Ladder.

Because the design of the fishways at Little Goose and Lower Granite Dams is similar, the modifications proposed for providing the north shore ladders and diffusion chamber water supplies are almost identical.

Several alternatives exist for the placement and orientation of the new fish ladder. In this analysis, the preliminary design places the new ladder on the south side of the earthen embankment, primarily to avoid problems associated with disturbing the earthen embankment.

(4) Implementation.

It is important to note that the total project time estimates listed below were prepared with the assumption that sufficient manpower and resources will be available during all phases of the projects. Lengthy review processes, manpower shortages, and limited resources would have a definite impact on the total estimated project times.

(a) Lower Granite Dam.

The total project implementation time is estimated to be approximately 61 months. This time includes 18 months for DM preparation, 18 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and an 18-month construction period.

(b) Little Goose Dam.

The total project implementation time is estimated to be approximately 67 months. This time includes 12 months for DM preparation, 18 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 30-month construction period.

c. Fish Ladder Entrances and Attraction Water.

(1) General.

Upstream migrating adult fish pass over the dams by entering the passage system through the fish entrances located at the downstream side of the dam, swimming along the collection channel (as applicable) to the fish ladder, swimming up the ladder, and exiting the ladder into the forebay. Auxiliary attraction water is pumped into the lower portions of the ladder and collection channel. The combined auxiliary attraction water and ladder flows pass out of the collection channel and into the tailrace through the fish entrances. The flow through the adult fish entrances attracts the upstream migrating fish into the passage system and around the dam. The fish entrances are located along the tailrace and on the shorelines adjacent to the dams.

After the construction of Ice Harbor and Lower Monumental Dams, the criteria that had been established for operating the adult passage system was changed. These changes increased the minimum submergence of the fish entrance weirs to 8 feet. Due to this increase, the fish entrances and attraction water supply systems at Ice Harbor and Lower Monumental Dams are not able to meet the new criteria during low tailwater conditions. The adult passage systems at each of the lower Snake River projects may be improved by improving entrance performance and enhancing attraction flows.

(2) Fish Ladder Entrances.

(a) General.

The Fish Passage Plan for 1992 (FPP) lists criteria for operating the adult fish entrances at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams. The FPP was developed in coordination with regional fisheries agencies, Indian tribes, and Bonneville Power Administration, through the Fish Facility Operation and Maintenance Subcommittee of the Fish Passage Development and Evaluation Program (FPDEP) Technical Coordinating Committee. For each of the four dams, the FPP indicates which entrances are to be operated, under what hydraulic conditions they should be operated, and when they should be operated and maintained. In the FPP, it is noted that many of the entrances may not be operated within the established criteria during low tailwater conditions.

The fish entrances along the powerhouse are a combination of floating orifices and weir gates. These entrances are located in the wall of the fish collection channel. The floating orifices have a 2-foot-tall by 6-foot-wide opening. The width of the weir gates varies from project to project. The FPP indicates that the floating orifices are to be operated with 1 to 2 feet of head above the orifice, and the weir gates are be to operated with a minimum 8-foot submergence below tailwater.

The fish entrances located at the shoreline are a combination of weir gates and sluice gates. The width of the weir gates and sluices varies from project to project. The FPP indicates that the weir gates are to be operated with a minimum 8-foot submergence below tailwater, and the sluice gates are to operated with a 6-foot opening height.

The FPP indicates that the adult passage facilities at the dams are operated from March 1 through December 31 each year, and normal maintenance and repairs take place from January 1 through February 28.

(b) Lower Granite Dam.

1. Existing System.

Entrances located in the north (right) spillway training wall, a transportation channel (constructed beneath the spillway deck), a powerhouse collection system, and south shore entrances provide for adult fish access to the ladder on the south shore.

In the north spillway training wall, there are two downstream entrance gates (6-foot-wide and 17.5-foot-high weir gates) and a single side entrance gate into the spillway stilling basin (a 6-foot-wide and 12.5-foot-high weir gate). Both downstream entrances are normally used with the side entrance closed. The transportation channel IE connecting the north entrances is 622.0. The channel from the north entrances to the powerhouse is 900 feet long and 17.5 feet wide.

The powerhouse collection system is composed of ten floating orifices, two downstream entrance weir gates (6 feet wide by 15.5 feet high), one side entrance weir gate into the spillway stilling basin (6 feet wide by 12.5 feet high), and a common transportation channel. Four of the floating orifices, and the two downstream entrances at the north end of the powerhouse collection system, are normally used.

The two south shore entrances are 4-foot-wide by 17.5-foot-high weir gates, with IE's of 628.0. Both entrances are normally used.

2. Evaluation of the Existing System.

The floating orifices, south shore entrances, and the north shore entrances may be operated within established criteria over the entire range of tailwater fluctuations.

The recommended minimum water depth in the transportation channel is 6 feet. During minimum tailwater conditions (elevation 633.0), with 1 to 2 feet of head in the transportation channel (1 to 2 feet of head above tailwater), the depth in the channel would be 8 to 9 feet.

When fully lowered, the weirs of the north powerhouse entrances are only submerged 5 feet below minimum tailwater.

3. Modifications to the Existing System.

To enable the north powerhouse entrances to operate within criteria during low tailwater conditions, the gates must be lowered 3 feet, and the transportation channel behind the gates must be lowered 1 foot. The resulting gate sill and channel elevation would be 625.0, 8 feet below the minimum tailwater elevation of 633.0. To accommodate the 3-foot lower gate sill, the gates must be lengthened by 3 feet, and the gate guides/blockouts must be lengthened to extend 6 feet lower.

(c) Little Goose Dam.

1. Existing System.

Entrances located in the north (right) spillway training wall, a transportation channel (constructed beneath the spillway), a powerhouse collection system, and south shore entrances provide for adult fish access to the ladder on the south shore.

In the north training wall, there are two downstream entrance gates (6-foot-wide by 13.5-foot-high weir gates), and a single side entrance gate into the spillway stilling basin (a 6-foot-wide by 10.5-foot-high weir gate). Both downstream gates are normally used with the side entrance closed. The transportation channel IE connecting the north entrances is 532.0. The channel from the north shore entrances to the powerhouse is 900 feet long and 17.5 feet wide.

The powerhouse collection system is composed of ten floating orifices, two downstream entrance weir gates (6 feet wide by 15.5 feet high), one side entrance weir gate into the spillway stilling basin (6 feet wide by 12.5 feet high), and a common transportation channel. Four of the floating orifices, and the two downstream entrances at the north end of the collection system, are normally used.

The two south shore entrances are 4-foot-wide by 18-foot-high weir gates, with IE's of 628.0. Both entrances are normally used.

2. Evaluation of the Existing System.

The floating orifices, south shore entrances, and the north shore entrances may be operated within established criteria over the entire range of tailwater fluctuations.

The recommended minimum water depth in the transportation channel is 6 feet. During minimum tailwater conditions (elevation 537.0), with 1 to 2 feet of head in the transportation channel (1 to 2 feet of head above tailwater), the depth in the channel would be 8 to 9 feet.

When fully lowered, the weirs of the north powerhouse entrances are only submerged 5 feet below minimum tailwater.

3. Modification of the Existing System.

To enable the north powerhouse entrances to operate within criteria during low tailwater conditions, the gates must be lowered 3 feet and the transportation channel behind the gates must be lowered 1 foot. The resulting gate sill and channel elevation would be 529.0, 8 feet below the minimum tailwater elevation of 537.0. To accommodate the 3-foot lower gate sill, the gates must be lengthened by 3 feet and the gate guides/blockouts must be lengthened to extend 6 feet lower.

(d) Lower Monumental Dam.

1. Existing System.

The 16-foot-wide north shore ladder connects to two north shore entrances (4-foot-wide by 18-foot-tall weir gates) and the powerhouse collection system. The powerhouse collection system has two downstream entrances (6-foot-wide by 13.5-foot-high weir gates), one side entrance into the spillway stilling basin (a 6-foot-wide by 13.5-foot-high weir gate), ten floating orifices, and a common transportation channel. The two north entrances, two downstream south powerhouse entrances, and five of the floating orifices are used during normal operation. The sills on the north shore entrances are at elevation 429.0, and the south powerhouse entrance sills are at elevation 432.0.

The south shore ladder has a small collection system with two downstream entrances (one 6-foot-wide by 14.5-foot-high weir gate and one 6-foot-wide by 11-foot-high sluice gate) and a side entrance into the spillway stilling basin (a 6-foot-wide by 11-foot-high sluice gate). The two downstream entrances are used during normal operation. The sills on the south shore fishway entrances are at elevation 431.0.

2. Evaluation of the Existing System.

The floating orifices and the north shore entrances may be operated within established criteria over the entire range of tailwater fluctuations.

The recommended minimum water depth in the transportation channels is 6 feet. During minimum tailwater conditions (elevation 437.0), with 1 to 2 feet of head in the transportation channel (1 to 2 feet of head above tailwater), the depth in the north shore collection system channel would be 6 to 7 feet above the channel floor. The depth in the south shore collection channel would be 7 to 8 feet above the channel floor.

When fully lowered, the weirs of the south powerhouse entrances are only submerged 5 feet below minimum tailwater. Similarly, the weirs of the south shore entrances are only 6.5 feet below minimum tailwater.

3. Modifications to the Existing System.

To enable the south powerhouse entrances to operate within criteria during low tailwater conditions, the gates and the transportation channel behind the gates must be lowered 3 feet. The resulting gate sill and channel elevation would be 429.0, 8 feet below minimum tailwater. To accommodate the 3-foot lower gate sill, the gates must be lengthened by 3 feet and the gate guides/blockouts must be lengthened to extend 6 feet lower.

To enable the south shore entrances to operate within criteria during low tailwater conditions, the gates and the transportation channel behind the gates must be lowered 2 feet. The resulting gate sill and channel elevation would be 429.0, 8 feet below minimum tailwater. To accommodate the 3-foot lower gate sill, the gates must be lengthened by 2 feet and the gate guides/blockouts must be lengthened to extend 4 feet lower.

(e) Ice Harbor Dam.

1. Existing System.

The south shore adult fish entrance system includes two south shore entrances (12-foot-wide by 13-foot-high weir gates) and a powerhouse collection system. The powerhouse collection system consists of a 17.5-foot-wide channel across the length of the powerhouse, with 12 floating orifices, 2 downstream entrances (12-foot-wide by 13-foot-high weir gates), and 1 side entrance into the spillway basin (a 12-foot-wide by 13-foot-high weir gate) at the north end of the powerhouse. The downstream entrances and side entrance are located at the north end of the powerhouse. One of the downstream entrances, one of the south shore entrances, and seven of the floating orifices are used during normal operation.

The north shore adult entrance system consists of two downstream entrances (12-foot-wide by 13-foot-high weir gates) and one side entrance into the north side of the spillway basin (a 12-foot-wide by 13-foot-high weir gate). During normal operation, one downstream entrance is used and the other two entrances are closed.

2. Evaluation of the Existing System.

The floating orifices may be operated within established criteria over the entire range of tailwater fluctuations.

The recommended minimum water depth in the transportation channels is 6 feet. The floors of the transportation channels serving the south and north shore collection system are at elevation 332.0. During minimum tailwater conditions (elevation 335.0), with 1 to 2 feet of head in the transportation channel (1 to 2 feet of head above tailwater), the depth in each channel would be 4 to 5 feet above the channel floor.

When fully lowered, the weirs of the north powerhouse entrances and north shore entrances are only submerged 2.5 feet below minimum tailwater. Similarly, the weirs of the south shore entrances are only 6.5 feet below minimum tailwater.

3. Modifications to the Existing System.

The entire transportation channel serving the south shore collection system must be lowered by 2 feet. This is a substantial modification that will require the construction of cofferdams and an interim means for adult passage, similar to that described for the adult collection system modifications at Lower Monumental Dam in the Drawdown Design Plan.

The north powerhouse entrances, north shore entrances, and the portions of collection channel behind them, must be lowered 5.5 feet to allow 8 feet of submergence. The resulting gate sill and channel elevations would be 328.0. To accommodate the 5.5-foot lower gate sill, the gates must be lengthened by 5.5 feet and the gate guides/blockouts must be lengthened to extend 11 feet lower.

The south shore entrances must be lowered by 1.5 feet, for a sill elevation of 328.0. To accommodate the 1.5-foot lower gate sill, the gates must be lengthened by 1.5 feet and the gate guides/blockouts must be lengthened to extend 3 feet lower.

(3) Attraction Water.

(a) General.

The attraction water systems are required to maintain proper flows at adult fish entrance points in order to effectively attract the migrating fish into the passage system. Gravity flow provided by the ladder or ladders contributes between 70 and 145 cfs per ladder (depending on the project) into the system. The system must be supplemented by pumped water to operate properly.

Attraction water is distributed into the collection channel through a system of conduits, junction pools, gated and ungated openings and, finally, through diffusers that deliver the water at reduced velocities into the channel. (See plate 18 for typical diffuser construction and gated opening details, and plate 17 for typical diffuser locations.)

The attraction water systems require evaluation in order to determine whether they can accommodate the increased flows and system head associated with low tailwater conditions, and the proposed modifications to the fish entrances and collection channels.

(b) Little Goose Dam.

1. Existing System.

Attraction water is provided by three hydraulic Francis turbine-driven pumps that supply the entire adult fish collection system. The pumps are located in the erection bay at the south end of the powerhouse (see plate 19). The three units consist of hydraulic turbines rated at approximately 550 horsepower (output is a function of forebay water surface elevation); gear reducers; and axial-flow, fixed-blade, propeller pumps. Each unit (including turbine discharge) is rated to deliver 850 cfs at a pump head of 4 feet and turbine gross head of 93 feet. According to *Hydraulic Evaluation of Adult Fish Passage Facilities at Little Goose, Lower Monumental, and McNary (South Shore) Dams*, a study dated November 1988, all three pumps are operated to deliver an average total flow ranging from 1,700 to 1,900 cfs at a total pump head of 4 feet. At this flow, 1 to 1.5 feet (depending on tailwater conditions) of differential head exists between the adult collection channel and the tailwater.

The collection channel and, ultimately the entrances, receive the pumped attraction water through a system of conduits, gated openings, and supply diffusers that are all fed by a common chamber from the attraction water pump discharge.

The north shore entrances are supplied through a pressurized conduit that runs directly below the collection channel along the powerhouse. It is then diffused into the collection channel at the north end of the powerhouse. The supply to this north shore diffuser is controlled by two 3-foot by 4-foot gated openings.

The powerhouse entrances are supplied by a pressurized conduit that passes water through diffusion chambers into the collection channel. Each generator bay has a diffusion chamber that is connected to the supply conduit by a gated opening. Diffusers in bays 1 through 4 are supplied by one 3-foot by 3.5-foot gated opening, while bays 5 and 6 are supplied by three 3-foot by 4-foot gated openings.

The south shore entrances are supplied by a pressurized conduit that feeds two large diffusion chambers that have a total of five gated supply openings: two 3-foot by 3-foot openings, and three 4-foot by 4-foot openings. The bottom end of the ladder, also on the south shore, is supplied attraction water through ungated openings that feed diffusers similar to those found in the collection channel. Control for the ladder diffusers is maintained by fixed overflow weirs.

2. <u>Evaluation of the Existing System</u>.

A hydraulic analysis of the flows between the collection channel and tailwater was performed in order to determine the flow rates required to maintain the channel and fish entrances within operating criteria at minimum tailwater. The analysis indicated that the fish attraction water pumps must deliver a minimum of 2,690 cfs into the collection channel (this flow, along with the 75 cfs supplied by the ladder, make a total flow through the channel and fish entrances of 2,765 cfs) to maintain 2 feet of head between the collection channel and minimum tailwater.

The attraction water distribution system between the pump intakes and the collection channel required hydraulic analysis in order to determine the pumping head required to pass 2,765 cfs through the system. Data collected on this system in 1988 by the Corps, Walla Walla District, Hydraulic Design Section, as found in *Hydraulic Evaluation of Adult Fish Passage Facilities at Little Goose, Lower Monumental, and McNary (South Shore) Dams*, was used in this analysis.

The distribution system analysis showed that the pumps would require a total head of 10 feet for a 2,690-cfs flow. This operating point is way off of the existing pump curves. An entirely new pumping system would have to be installed, including new pump impellers, since the existing system was designed to operate at a total head of about 4 feet. Installing pumps of this capacity is not practical from an operating standpoint because of the great cost increase associated with operating a pump system at this capacity.

The distribution system analysis showed that roughly 95 percent of the system head losses occur across the gated openings, which feed the diffusers. It was found that by adding gated openings between the pressurized supply conduits and the north shore and powerhouse supply diffusers, the system losses could be reduced and the pumps could operate at the required flow rate and against a total effective head of 4.8 feet. This operating point should allow the existing pump impellers to be retained (this would have to be verified with the impeller manufacturer, or determined by analysis).

3. Modifications to the Existing System.

The distribution system would be modified by adding one 3-foot by 3.5-foot gated opening, one 4-foot by 4-foot gated opening to the powerhouse diffusers in bays 1 through 4, one 4-foot by 4-foot gated opening to the diffusers in bays 5 and 6, and increasing the size of the two gated openings for the north shore supply diffuser (see plate 18). New sluice gates and gate operating systems would be similar to the existing ones.

Due to the increase in required flow, the existing pumping systems would have to be replaced with higher output systems. Existing turbine drives require replacing because they do not put out sufficient power to pump water at the new criteria. Each pump in the new installation needs to deliver approximately 897 cfs, at 4.8 feet of head, in order to maintain 2 feet of head in the collection channel. Each of the three new pump installations will consist of a 750-horsepower (approximately, assuming 65-percent efficiency) electric-drive motor connected to a new right-angle gear box that drives the existing pump impeller through new shafting, and all new associated mounting hardware and electrical supply and control. Turbine supply and exit piping would need to be capped after turbine removal.

(c) Lower Monumental Dam.

1. Existing System.

Attraction water is provided to the entire adult collection system by three hydraulic Francis turbine-driven pumps identical to those at the Little Goose project. The pumps are located in the erection bay at the north end of the powerhouse (see plate 19). All three pumps are operated to deliver an average total flow of approximately 1,800 to 2,000 cfs at a total pump head of 4.1 feet, according to *Hydraulic Evaluation of Adult Fish Passage Facilities at Little Goose, Lower Monumental, and McNary (South Shore) Dams*, a study dated November 1988. This flow provides between 1 and 1.5 feet (depending on tailwater conditions) of differential head between the adult collection channel and tailwater.

The collection channel and ultimately the entrances, receive the pumped attraction water through a system of conduits, gated openings, and supply diffusers very similar to the Little Goose project, with the exception that Lower Monumental Dam has two ladders.

The north shore entrances are supplied by a pressurized conduit that feeds three large diffusion chambers having a total of eight gated supply openings: two 3-foot by 4-foot openings, three 2-foot by 3-foot openings, and three 4-foot by 4-foot openings. The bottom end of the north shore ladder is supplied attraction water through ungated openings that feed diffusers similar to those found in the collection channel. Control on the ladder diffusers is maintained by fixed overflow weirs.

The powerhouse entrances are supplied by a pressurized conduit that passes water through a diffusion chamber into the collection channel. Each generator bay has a diffusion chamber that is connected to the supply conduit by a gated opening. Diffusers in bays 1 through 5 are supplied by one 3-foot by 3.5-foot gated opening, while bay 6 is supplied by two 3-foot by 3.5-foot gated openings.

The south shore entrances are supplied by a pressurized conduit that runs directly below the collection channel, and through the spillway to the south shore system. The south shore ladder system is totally separated from the north shore and powerhouse systems. The supply to the south shore diffusers is through four 4-foot by 4-foot openings, three gated and one ungated. The south shore ladder is also supplied attraction water through ungated openings, fixed weirs, and diffusion chambers.

2. Evaluation of the Existing System.

The attraction water flows through the fish entrances of the two separate systems were analyzed in the same manner as for Little Goose Dam. It was found that the fish attraction water pumps must deliver a minimum of 2,490 cfs into the collection channel [this flow, along with the 75 cfs supplied by each ladder, make a total flow through both the separate systems (south shore and north shore/powerhouse), of 2,640 cfs] to maintain 2 feet of head between the collection channel and minimum tailwater. The new juvenile fish bypass system provides an additional 200 to 240 cfs of water to the adult attraction system. However, this additional flow may not be available throughout the operating period of the adult passage system, and should not be considered a constant source of supply.

The attraction water distribution system between the pump intakes and the collection channel was again analyzed in the same manner used for Little Goose Dam. System head losses were reduced by including additional openings to supply the diffusers. Analysis of the modified distribution system showed that the pumps would have to be able to deliver 2,490 cfs against a total effective pump head of 4.4 feet. This operating point is slightly lower than that for Little Goose Dam due to lower flows, and because Lower Monumental has a less restrictive two ladder system.

Similar to the Little Goose project, the existing pump impellers may be able to be retained (this would have to be verified with the impeller manufacturer, or determined by analysis).

3. Modifications to the Existing System.

The proposed modification to the distribution system would add one more 3-foot by 3.5-foot gated opening and one 4-foot by 4-foot gated opening to the powerhouse diffusers in bays 1 through 5, and would also add one 4-foot by 4-foot gated opening to the diffuser in bay 6 (see plate 18). New sluice gates and gate operating systems would be similar to the existing ones.

Due to the increase in required flow, the existing turbine-driven pumping systems would have to be replaced. The existing turbine drives require replacing because they do not put out sufficient power to pump the required volume of water. Each pump in the new installation needs to deliver approximately 830 cfs at 4.4 feet of head in order to maintain 2 feet of head in the collection channel, at a total flow of 2,640 cfs. Of the total, 150 cfs is supplied by the two ladders. Each of the three new pump installations will consist of a 650-horsepower (approximately, assuming 65-percent efficiency) electric-drive motor connected to a new right-angle gear box that drives the existing pump impeller through new shafting, and all new associated mounting hardware and electrical supply and control. Turbine supply and exit piping would have to be capped after turbine removal.

(d) Lower Granite Dam.

1. Existing System.

Attraction water is provided by three electric-driven pumps that supply the entire adult fish collection system. The pumps are located in the erection bay at the south end of the powerhouse (see plate 19). The three units consist of 800-horsepower electric motors; gear reducers; and axial flow, fixed blade, propeller pumps. Presently, two of the pumps are adequate to handle normal flows of approximately 2,100 cfs. At the present time there is no data available on actual or modeled flows for this system. Each pump is rated at 1,050 cfs at 4 feet of head. The existing flows maintain between 1 and 1.5 feet (depending on tailwater conditions) of differential head between the adult collection channel and the tailwater.

The collection channel and, ultimately, the entrances receive the pumped attraction water through a system identical to that found at Little Goose (with the exception of some gated opening sizes).

The north shore entrances are supplied in the same manner, and with the same gated opening sizes, as at Little Goose Dam.

The powerhouse entrances are supplied by a similar conduit as Little Goose Dam, but have a slight variation in the arrangement and sizes of gated openings. Diffusers in bays 1 through 4 are supplied by one 3-foot by 4-foot gated opening, two 4-foot by 4-foot gated openings in bay 5, and two 4-foot by 5-foot gated openings in bay 6.

The south shore entrances are supplied by a pressurized conduit that feeds two large diffusion chambers that have a total of six gated supply openings (two, 3 feet by 4 feet; and four, 4 feet by 4 feet). The lower reaches of the ladder, also on the south shore, are supplied attraction water through ungated openings that feed similar style diffusion chambers as those found in the collection channel. Fixed weirs control the flow through the ladder diffusers.

2. <u>Evaluation of the Existing System</u>.

The attraction water flows through the fish entrances were analyzed in the same manner as for Little Goose Dam. It was found that the fish attraction water pumps must be able to deliver a minimum of 2,790 cfs into the collection channel (this flow, along with the 75 cfs supplied by the ladder, make a total flow through the system of 2,865 cfs) to maintain 2 feet of head between the collection channel and minimum tailwater.

At this time, there are no available computer models of the Lower Granite attraction water distribution system, or actual field data on the present flow rates. Given the similarities between the projects, it is assumed that similar analysis results would be obtained.

3. <u>Modifications to the Existing System</u>.

The proposed modifications to the distribution system and the pumping systems would be similar to those modifications proposed for Little Goose Dam, given the close similarities between the two project's adult attraction water systems. One variation between the two is the existing size of the pump drive motors. Little Goose has three turbine-driven pumps, each rated at 550 horsepower, that are operated continuously during the adult season. Lower Granite has three electric-driven pumps, each rated at 800 horsepower, but only two are operated during the adult season. Therefore, the existing pumping system at Lower Granite Dam may be adequate to meet the new criteria. However, the pump normally used as a backup would have to be used during normal operation. Distribution system modifications, similar to those mentioned in the Little Goose Dam discussion, would be required.

(e) Ice Harbor Dam.

1. Existing System.

The attraction water and collection and transportation systems for adult passage are separated into two different facilities. One facility serves the north shore ladder, and the other serves the south shore ladder.

The adult attraction water for the north shore system is provided by three electric-driven pumps. The pumps are located in a pump house near the downstream side of the navigation lock. The three units consist of 200-horsepower electric motors; gear reducers; and axial-flow, fixed-blade, propeller pumps similar to, but smaller than, those on the other three lower Snake River dams. Presently, all three pumps are required to maintain 1 to 1.5 feet of differential head between the collection channel and tailwater. The existing pumps are rated at 250 cfs each at 4 feet of head. At the present time there is no data available on actual or modeled flows for this system.

The north shore entrance is supplied by a pressurized conduit from the pump house. The supply conduit supplies one large diffuser near the ladder entrance, and eight diffusers in the lower reaches of the ladder. All diffusers in this system are controlled by fixed weirs.

The south shore fish entrances are on a common attraction water system with the powerhouse fish entrances. The attraction water for this system is supplied by eight electric-driven pumps. The pumps are located in a pump house on the south shore just downstream of the south shore fish entrances. These units are similar to those on the north shore, with the exception of operating speeds and capacities. The south shore pumps are driven by 250-horsepower electric motors, and are rated to deliver 300 cfs at 4 feet of head. At the present time, all eight pumps are required to maintain 1 to 1.5 feet of differential head between the collection channel and tailwater. Data is not available on actual or modeled flows for this system.

The south shore entrances are supplied through a pressurized conduit that runs from the pump house to the south shore entrances, where the conduit branches off to supply the powerhouse collection system as well. The south shore fish entrance diffuser is fed from the supply conduit through three 3-foot by 4-foot gated openings.

The powerhouse entrances are supplied in a manner similar to that described for the other projects. Each generator bay has a diffusion chamber that is connected to the supply conduit by one 3-foot by 4-foot gated opening.

2. Evaluation of the Existing System.

The attraction water flows through the fish entrances were analyzed in the same manner used for Little Goose Dam. It was found that the 3 fish attraction water pumps for the north shore must be able to deliver a minimum of 755 cfs into the collection system. This flow, along with the 75 cfs supplied by the ladder, make a total flow through the north shore system of 830 cfs. The 8 attraction water pumps that serve the south shore and powerhouse systems must be able to deliver 2,125 cfs. This flow is supplemented by the south shore ladder that provides approximately 140 cfs, for a total flow of 2,265 cfs, in the south shore system. These flows are required for both systems to maintain 2 feet of head between the collection channel and minimum tailwater.

Due to the absence of model study and field data for the Ice Harbor systems, a detailed analysis was not performed. It is assumed that analysis of the Ice Harbor systems would provide results similar to the analyses results for the other dams.

3. Modifications to the Existing System.

The proposed modifications to the distribution system are similar to the modifications proposed for Little Goose Dam. The existing pumping systems for both of the Ice Harbor attraction water systems are rated very close to the desired flow rates, at 4 feet of head. Therefore, by modifying the distribution systems to reduce system head loss, the existing pumping systems may require only a moderate upgrade.

(f) Observations, Comments, and Further Study.

1. Observations.

By replacing the turbine-drive units at Little Goose and Lower Monumental with electric motors, the flow rates would be much more predictable because the pump input power is no longer a function of forebay water surface elevation.

The existing attraction water pump impellers may be able to be retained in the new systems. The condition of the impellers should be closely evaluated before making this determination.

2. Comments.

Supplementing the flow in the adult attraction system with the use of gravity flow from the forebay is an option. The cost of this option, including the cost of foregone power generation, should be compared to the cost of installing and operating a system that pumps water from the tailrace.

The existing turbine-drive units at Little Goose and Lower Monumental are in need of repair due to their age. If repair of these units is required prior to implementing the proposed improvements, consideration should be given to using the reworked turbine-drive units in the new system.

The proposed modifications in this report assumed that all pumps at each project would be required to meet the operating criteria. It may be desirable, if possible, to provide a spare attraction pump for each system as a backup against unforeseen problems.

The distribution system analyses of the Little Goose and Lower Monumental projects were performed to show that the required system flow rates could be achieved. The systems would be adjusted by throttling flow through the gate openings to properly distribute the flow, as needed.

Flows in the adult attraction system at Little Goose and Lower Monumental, as determined by computer model and field measurements, were found to be only about 75 percent of the pump-rated flow. Actual flows at the other two projects have not yet been analyzed, and this should be done before further analysis is completed.

3. Future Study.

Alternative means of modifying the distribution systems should be investigated. The cost of more extensive distribution system modifications could be offset by savings in pump operating costs.

Diversion of presently wasted high-head flows (ice and trash sluiceway flows, juvenile fish bypass primary dewatering flows, *etc.*) into the adult attraction water systems to supplement flows would help reduce pumping costs, and should be investigated.

The installation of variable-pitched propeller pumps or pumps with multi-speed motors may be cost effective due to the increased efficiencies gained during changes in tailwater elevations that affect pumping requirements.

Collection channel velocities need to be considered during system configuration changes to ensure that velocity criteria is not violated.

The use of highly efficient turbine-drive units may be a viable alternative to using motor-driven pumps at Little Goose and Lower Monumental Dams.

(4) Implementation.

It was assumed that the projects would be completed in sequence, and progressing in a down-river direction; and that models and methods developed during the design of the first project would be applicable to the remaining projects. Construction times include a 6-month lead time for speed reducers. The construction time may be reduced by purchasing the speed reducers and other major lead-time items, and furnishing them to the installation contractor.

It is important to note that the total project time estimates listed below were prepared with the assumption that sufficient manpower and resources will be available during all phases of the projects. Lengthy review processes, manpower shortages, and limited resources would have a definite impact on the total estimated project times.

(a) Lower Granite Dam.

The total project implementation time is estimated to be approximately 33 months. This time includes 6 months for DM preparation, 8 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 12-month construction period.

(b) Little Goose Dam.

The total project implementation time is estimated to be approximately 28 months. This time includes 5 months for DM preparation, 6 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 10-month construction period.

(c) Lower Monumental Dam.

The total project implementation time is estimated to be approximately 28 months. This time includes 5 months for DM preparation, 6 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 10-month construction period.

(d) Ice Harbor Dam.

The total project implementation time is estimated to be approximately 28 months. This time includes 5 months for DM preparation, 6 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 10-month construction period.

d. Fish Ladder Exits.

(1) General.

Flow through the fish ladders at McNary Dam are controlled by telescoping and tilting weirs near the fish ladder exits. These weirs must be adjusted as the forebay water level fluctuates. Adult passage may be improved by replacing these weirs with weirs similar to those used on the lower Snake River dams.

(2) Existing System.

McNary Lock and Dam has two adult fish passage systems: one on the north shore and one on the south shore. These systems differ from adult fish passage systems on the Snake River in several ways. These differences include the following:

- Greater flows down the ladders. Flows down the north shore ladder reach 180 cfs, with flows down the south shore ladder of 210 cfs.

- Wider ladder widths. McNary adult fish ladders are 30 feet wide instead of 16 or 20 feet wide, as on the other lower Snake River projects.

- Ladder flows are controlled by a regulating telescoping weir and tilting weirs at the upstream end of the McNary fish ladders. Other projects have fixed vertical slots or orifice control weirs at the upstream end of the ladders. Both systems are used to regulate the flows into the ladders over the range of forebay fluctuations. Downstream of the fixed weirs, make-up water is added through floor diffusers to bring the ladder flows up to design flows. McNary weirs, however, are adjusted as the forebay fluctuates to control the amount of flow down the ladder and the head on the tilting weirs. The entire fish ladder flow enters the system at the upstream end. No make-up water is added until the bottom of the ladders near the North and south shore entrances.

- Constant elevation at the upstream end of the ladders. McNary fish ladders have a constant IE of 328 for the first 250 to 280 feet of the ladders (in the area of the adjustable weirs). After the last tilting weir, the invert slopes at 1:20. Snake River projects with fixed weirs have sloping inverts along their lengths.

(3) Proposed Fish Ladder System.

(a) Vertical Slot Weirs.

In order to simplify the operation of the McNary fish ladder system, the regulating and tilting weirs would be replaced by fixed weirs, such as vertical-slot weirs (see plate 20). Vertical-slot weirs control the flow into the ladder system without adjustment as the forebay water surface elevations change. Flows will change as the water surface elevations change, and make-up water will need to be supplied downstream of the vertical-slot weirs to ensure flows of 180 to 210 cfs down the ladder systems.

This design was based on the fish ladder design for the McNary second powerhouse. Pool sizes were taken from the McNary second powerhouse DM. The number of pools was based on a 1-foot drop in WSE between pools at a maximum forebay elevation of 340. Assuming a water surface elevation of 334 just above the first existing fixed weir, five pools were required. Flows through the vertical slots for fluctuating forebay elevations from the DM were used for calculating the required make-up water needed for the ladder.

(b) Make-up Water.

In order to bring ladder flows up to 180 to 210 cfs, make-up water would be added downstream of the vertical-slot weirs. Based on DM flows through the vertical slots, between 145 and 190 cfs would be added to the south shore ladder, and between 115 and 160 cfs would be added to the north shore ladder. This is 60 to 90 percent of the design flow in the ladders. While this is a high percentage of flow added to the system, the final design would optimize the amount of flow through the vertical-slot weirs, as well as flow added as make-up water.

In the current design, the entire fish ladder flow is brought in through the fishway exit. Excess flows (water not going down the vertical-slot weirs) will pass through a screen into a collection channel. The screen area will be large enough to remove make-up water at 0.5 fps or less. At the end of the channel, downstream of the last vertical-slot weir, the make-up water will be reintroduced through another screened area at a velocity of 1.0 fps or less. The amount of make-up water added will be controlled by a gate in the collection channel. This will be the only adjustment necessary as the forebay elevations fluctuate. An automatic control could be used to raise or lower the gate to provide a constant WSE in the pool downstream of the last vertical-slot weir.

Water will be removed and reintroduced through the side of the fishway channel. While floor diffusers are a common method of adding flows to fishways, it would involve major construction in this case. The improvements to the fish ladder will be on the upstream side of the dam, where the invert of the fishway is below the minimum forebay WSE. Adding a floor diffuser to the current system would involve construction below the water level in the reservoir. Removing and adding water through the side of the channel should still meet velocity requirements, even though the flow will not be as evenly distributed throughout the pool.

(c) Design Considerations.

While the proposed design may not be the final design, the costs and time involved in the design and construction should be similar to what is required for a fixed weir system at the upstream end of the McNary fish ladders. Since the fish ladder exit at McNary is unique (when compared to other Corps projects), it was not possible to use an existing fish ladder design in this system. A model study may be required to finalize the design of the system and ensure that fishway requirements are met.

In addition, since the ladder is 30 feet wide and flows are relatively high, it may be possible to design the ladder to pass more flow than existing vertical-slot weir designs. If this could be done, it would reduce the amount of make-up water needed.

(d) Temporary Adult Fish Passage.

The modifications of the fish ladders could take place during the winter maintenance period. One ladder would remain operational at all times.

(4) Implementation.

The total project implementation time is estimated to be approximately 37 months. This time includes 18 months for DM preparation (includes model studies), 6 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 6-month construction period. It is important to note that the total project time estimate was prepared with the assumption that sufficient manpower and resources will be available during all phases of the projects. Lengthy review processes, manpower shortages, and limited resources would have a definite impact on the total estimated project time.

e. Adult Collection Channel Modifications at McNary Dam.

(1) Existing System Description.

The Oregon shore fishway system at McNary Lock and Dam (see plate 23) is comprised of two north powerhouse fishway entrances, a collection channel running along the face of the powerhouse, two south shore fishway entrances, and a fish ladder leading to exits at the upstream side of the dam. Water is supplied to the Oregon shore system by three sources:

(a) The Fish Ladder.

Approximately 210 cfs enters the ladder through the fish ladder exit. This water continues down the fish ladder and eventually leaves the fishway system through the entrances.

(b) The Gravity Supply System.

About 900 to 1,000 cfs of water is supplied to the fishway from the Oregon shore intake structure. This structure is located upstream of the fish ladder exit, and supplies water through diffusers near the downstream end of the fish ladder (diffusion chambers numbers 8 through 14).

(c) The Pumped Supply System.

This water is added to the fishway system through floor diffusers. Diffusers are located along the collection channel, in junction pools at the north and south end of the powerhouse, and in the last few chambers of the fish ladder (diffusion chambers numbers 1 through 7).

A hydraulic evaluation of the Oregon shore fishway system was completed by the Corps in 1988. Flows from the fishway entrances were measured, and a computer model was developed to calculate the amount of pumped flow supplied through the floor diffusers. Based on this information, an area of the collection channel appears to have low velocities ranging from 0.8 to 1.8 fps, depending on the tailwater elevation. This area is located between the junction pool at the south end of the powerhouse and the first floating orifice (see plate 23). Since no diffusers exist in this area, water may not be added to increase velocities.

The low velocity area of the transportation channel is 17.5 feet wide, approximately 180 feet long, and has an IE that varies along its length. For about 33 feet downstream of the south junction pool the invert is at elevation 245, but then drops to elevation 242 for the next 119 feet. Just before the first floating orifice, the channel bottom slopes at 1:5 for 30 feet, to IE 236.

(2) Evaluation of Proposed System Modifications.

(a) General.

The goal of the proposed modifications is to increase the velocities through the low velocity area of the collection channel. This may be accomplished by narrowing the collection channel or by increasing the water flow through the channel. For several reasons, narrowing the collection channel is the alternative considered in this study. First, narrowing the channel is a simple solution that will not require the control and monitoring that water addition would require. Second, narrowing the channel will change the velocities almost immediately, while the velocity change associated with water addition would occur gradually over the entire length of the addition area.

(b) Narrowing the Collection Channel.

The collection channel velocity may be increased by narrowing the channel to a width of 10 feet between the south junction pool and the first floating orifice (see plate 24). While it is proposed to narrow the channel to a 10-foot width, the actual design could be adjusted depending on the flow conditions. Implementing the proposed system would involve performing a hydraulic evaluation of the existing and proposed systems to determine the actual amount the collection channel must be narrowed, and then adjusting the system to provide the flows desired down the collection channel and out the fishway entrances.

In a 10-foot wide channel, with existing flows of approximately 500 cfs, velocities should be between 1.5 and 3.0 fps (depending on the tailwater elevation). This assumes an IE of 242.0 and 1.5 feet of head on the fishway entrances.

An 18-inch-thick wall would be placed in the fishway channel between the south junction pool and the first floating orifice (see plate 23). Most of the wall would run parallel with the fish channel walls, reducing the collection channel width to 10 feet. Both ends of the wall would taper back to the original collection channel wall at a 12.5-degree angle over about 34 feet. A fish grating placed in the wall below minimum tailwater elevation (257.0) would ensure fairly equal water pressure on both sides of the wall, with minimal effect on the channel flows.

Approximately 33 feet downstream of the south junction pool, the channel invert changes suddenly from IE 245.0 to 242.0. To reduce the amount of head required to get the desired flows through the collection channel, a gradual transition would be added to connect the channel inverts. This transition would be concrete, and would slope at 1:5 for 15 feet.

Narrowing the channel in the low velocity area has several advantages:

- Higher velocities occur along the entire length of the narrowed section.

- With a 10-foot wide channel, the velocities are similar to those obtained by adding 300 cfs of water to the 17.5-foot-wide channel.

- This system is simple and predictable.

Potential disadvantages of narrowing the collection channel include:

- A 10-foot-wide channel may be narrower than the desired fishway channel width. This could be changed in the final design.

- An increase in head, of about 0.09 feet, is required to get the same amount of flow through the narrower collection channel. While this amount of head is small, it may be enough to require readjustment of the weirs and diffusers in order to get the desired flows through the system.

(3) Assumptions.

Assumptions used in this evaluation include the following:

- Low velocities exist in the adult collection channel. This is based on information from a previous hydraulic evaluation, but has not actually been measured. Channel velocities should be confirmed before designing this system.

- It will be possible to adjust the existing system to optimize the flows out the fishway entrances and down the collection channel. Diffuser gates may be stuck and/or difficult to adjust. If this is the case, extra work may need to be done to the water supply system in order to make the desired adjustments.

- The previous hydraulic evaluation and math models can be applied to this design. This assumes the computer model of the existing auxiliary water supply system can be easily adapted to represent any new design conditions. If this does not work, a new computer model may need to be developed.

(4) Further Evaluation.

While there is an area of suspected low velocities in the collection channel, the velocities in this area have not been measured. A hydraulic evaluation of the current auxiliary water supply system would provide the following:

- Information on the actual velocities in the collection channel.

- Information on the effects of adjusting diffusers and entrance weirs on collection channel flows.

The current design for the McNary Permanent Juvenile Fish Facility uses the dewatering water from the juvenile collection channel to supply water to the fishway entrances north of the powerhouse. While this is operating, the diffusers to the north junction pool would be shut off. Pumped flows would be redistributed throughout the system. Flows through the fishway need to be analyzed both with and without the dewatering water. These evaluations should show the extent of the low velocity problem in the collection channel. Based on this information, final channel improvements and auxiliary water supply operations can be determined.

(5) Implementation.

The total project implementation time is estimated to be approximately 21 months. This time includes 5 months for DM preparation, 3 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 6-month construction period. It is important to note that the total project time estimate was prepared with the assumption that sufficient manpower and resources will be available during all phases of the projects. Lengthy review processes, manpower shortages, and limited resources would have a definite impact upon the total estimated project time.

f. Extended Fishway Channels.

(1) General.

Lower Granite and Little Goose Dams each have fishway entrances on the north side of, and immediately adjacent to, the spillway. The entrance configurations at both dams are similar, and consist of two 6-foot-wide entrances facing downstream and one 6-foot-wide entrance facing into the stilling basin. At Lower Granite Dam, the north entrances are located on the south side of the navigation lock. Similarly, the north entrances at Little Goose Dam are located on the south side of the fishway dike. The navigation lock and fishway dike create a pool of water on the north shore below the earthen embankment at each dam. Fish traveling up the north shoreline tend to enter this pool, and must swim around the navigation lock/fishway dike to reach the fish ladder entrances. During spill, fish traveling along the north shore are unable to reach the north shore entrances due to the turbulent, high velocity flows in the spillway. Extending the fishway channel and providing new entrances to the north shore pool may reduce the delay of fish trying to enter the fish ladder system.

(2) Proposed Modifications.

(a) Lower Granite Dam.

In order to provide access to the fishway from the north side of the spillway, the proposed design includes adding on to the existing channel near the existing fishway entrances. The new channel would connect to the north side of the existing fishway channel, and then continue downstream parallel to the navigation lock side wall for most of its length (see plates 21 and 22). The channel would extend to the end of the navigation lock guide wall, and have two entrances facing downstream. A side entrance to the north shore pool could be provided by extending the fishway channel out past the end of the guide wall. This will be considered during the final design of the extended fishway.

The entrances to the extended fishway channel will be 6 feet wide, and similar to the existing entrances in the right training wall. Weirs at these entrances will be adjusted to provide the desired clearance below tailwater. When these entrances are not in use, the weirs will be raised to block off access to the fishway channel at these points.

A bulkhead will be installed near the beginning of the extended channel in order to block off this fishway when the new entrances are not being used. A small screened opening below the water line in the bulkhead will ensure equalized pressures throughout the fishway channel.

During the first phase of construction, concrete in the existing north fishway channel wall would be removed to connect the existing channel to the new channel extension. A bulkhead would be used to dewater the area where each new channel support is to be constructed. The bulkhead would be attached to the navigation lock wall, and would be reusable for each support. The supports would consist of reinforced concrete attached to the navigation lock monoliths. Precast concrete channel sections would then be floated into place above the supports. The channel sections would then be flooded, and would rest on the supports. Cofferdams would be used to dewater an area just south of the downstream navigation lock guide wall. Cast-in-place concrete channel sections would then be placed. The cast-in-place sections would rest on rock. The cofferdams would then be removed. This would complete the first phase of construction. During the second phase of construction, the final precast concrete channel section would be placed. It would span between the ends of the cast-in-place channel and the precast channel that was installed during the first phase of construction.

(b) Little Goose Dam.

In order to provide access to the fishway from the north side of the spillway, the proposed design includes adding on to the fishway channel near the existing entrances. The new channel section will connect to the north side of the existing channel, and then continue north through the fishway dike. On the north side of the dike, the channel will bend 90 degrees, and continue downstream just past the end of the dike (see plate 22.1). There will be two entrances facing downstream, and one side entrance on the north side of the extended channel.

The entrances on the extended channel will be 6 feet wide, and similar to the existing downstream entrances on the right training wall. Weirs at these entrances will be adjusted to provide the desired clearance below tailwater. When these entrances are not in use, the weirs will be raised to block off access to the fishway channel at these points.

A bulkhead will be installed near the beginning of the extended channel in order to block off this fishway when the new entrances are not being used. A small screened opening below the water line in the bulkhead will ensure equalized pressures throughout the fishway channel.

Concrete in the existing north fishway channel wall would be removed to connect the existing channel to the new channel extension. A portion of the existing fishway dike would then be excavated. The channel extension would consist of precast concrete channel sections floated into position. The channel sections would then be flooded, and would bear directly on the excavated portion of the fishway dike. A portion of the excavated material would then be used as backfill around the new channel extension.

(3) Implementation.

It is important to note that the total project time estimates were prepared with the assumption that sufficient manpower and resources will be available during all phases of the projects. Lengthy review processes, manpower shortages, and limited resources would have a definite impact on the total estimated project times.

(a) Lower Granite Dam.

The total project implementation time is estimated to be approximately 51 months. This time includes 8 months for DM preparation, 12 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 24-month construction period.

(b) Little Goose Dam.

The total project implementation time is estimated to be approximately 33 months. This time includes 6 months for DM preparation, 8 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 12-month construction period.

4.06 DAM MODIFICATIONS--SPILLWAY/STILLING BASIN MODIFICATIONS.

a. General.

This section discusses potential modifications that might be used to improve the performance of the existing spillways and stilling basins, as it pertains to high dissolved-gas levels generated during spill periods. For the lower Snake River projects, dissolved-gas levels during spill periods are typically higher than what many biologists consider good for fish migration conditions. No matter what modifications might be made to reduce dissolved-gas levels, the spillways and stilling basins would still have to provide adequate energy dissipation for all design spills. In addition, spillway operation and function, as it relates to effective adult fish passage, would have to be studied and optimized.

b. Description of Existing Spillways and Stilling Basins.

The stilling basins were designed to provide optimum energy dissipation for the regulated standard project flood of 420,000 cfs (for some projects, original studies used 340,000 cfs). In addition, the stilling basins were to provide adequate energy dissipation to ensure the safety of the projects during the spillway design flow of 850,000 cfs. For flows of less than the standard project flood, the spillways were designed to operate optimally, assuming full powerhouse flows in addition to spillway flows.

Lower Granite, Lower Monumental, and Ice Harbor utilize a hydraulic jump-type stilling basin. The design of these basins require that the hydraulic jump used for energy dissipation be confined partly, or entirely, within the stilling basin.

Little Goose utilizes a toothed, roller bucket-type energy dissipator. The design of these basins require that, for adequate energy dissipation to occur, the tailwater depth must be within defined limits.

Flow deflectors designed to control nitrogen levels were installed in the spillways at Lower Granite, Little Goose, and Lower Monumental Dams. Nitrogen-related flow deflectors were not installed at Ice Harbor Dam.

c. Project Modifications.

(1) General.

Different levels of project modifications might be attempted in order to reduce dissolved-gas levels associated with current spillway operations. It will be assumed for this study that a target for system improvements in spillway operations will be to reduce, with as much confidence as possible, the current levels of dissolved gas.

Judgments related to the effectiveness of various spillway-related modifications in reducing dissolved-gas levels are based on an examination of existing technical information for the projects, as well as on observations made during 1992 spill and drawdown-related tests at Lower Granite and Little Goose Dams.

(2) Discussion of Alternatives Considered.

Three different alternatives to improve spillway and stilling basin-related dissolved-gas performances were initially considered. These alternatives were: 1) tailwater control devices; 2) adjustable/relocated spillway flow deflectors; and 3) elevated (shallower) stilling basins. Each of these alternatives would require extensive analysis, including hydraulic (and possibly numerical) model studies, as well as prototype testing of existing and newly constructed projects, in order to evaluate and optimize the various designs. It is recommended that all of these alternatives (plus any new ones that may be developed) be pursued in later stages of the study if this investigation is carried forward.

(3) Selected Alternative.

In this study, an elevated (shallower) stilling basin will be used for all four of the lower Snake River projects to develop concept designs and cost estimates for attempting to reduce the dissolved-gas levels associated with spill. The elevated stilling basin option was selected because it was determined that a shallower basin would more predictably reduce dissolved-gas levels.

Constructing entirely new elevated stilling basins at the projects may lower dissolved-gas levels associated with spill by eliminating the deep plunging flow conditions that lead to dissolved-gas problems. Shallower stilling basins would require that the basins be longer and/or contain baffles to ensure that the energy from the spillway is fully dissipated over a wide range of discharges and tailwater elevations. Although baffles may help with dissolved-gas levels, the effect that these baffles would have on fish passing over the spillway is uncertain.

An example of how a shallower stilling basin might be a factor in reducing dissolved-gas levels from the forebay to the tailwater can be found at The Dalles project on the Columbia River. Although it is not fully understood, it appears that passing flows over the spillway at The Dalles may reduce river dissolved-gas levels as the flow passes the project.

Major similarities and differences between The Dalles and the lower Snake River projects include the following:

- The Dalles spillway and stilling basin is somewhat comparable in design to the hydraulic jump and baffle-type basin at Ice Harbor. The stilling basin floor, however, is substantially shallower. Depending on flow conditions, it appears that The Dalles tailwater depth could be anywhere from 10 to 30 feet shallower, depending on the lower Snake River project and flow conditions that are being compared.

- The Dalles and the lower Snake River projects have different orientations of the powerhouses with respect to the spillways. This may be a factor in how effective powerhouse flows dilute dissolved-gas levels generated by spill.

- Determining the effectiveness of elevated stilling basins on reducing dissolved-gas levels would require extensive research of existing projects (such as prototype testing at The Dalles), in addition to conducting hydraulic and numerical model studies of the different projects. It would probably require prototype installation and testing of an elevated stilling basin to fully evaluate and optimize new designs.

d. Description and Construction Methods.

(1) General.

The elevated stilling basin designs were roughly evaluated to check the feasibility and constructability.

(2) Descriptions and Construction Methods.

It is assumed, for this concept design, that basins similar in appearance to Ice Harbor, but raised to different elevations, would be installed at all four of the lower Snake River projects. No detailed analysis has been completed, at this time, to determine if the basins would need to be longer, or the way the arrangement of the stilling basin baffle blocks would have to be designed.

Rock fill would be placed (for the project being modified) above the existing stilling basin and rockline downstream of the basin. Included in this rockfill would be a drainage system that would act to reduce hydrostatic uplift forces acting on the new stilling basin. The new stilling basin would be placed over the rockfill.

The worksites for each modified project must be dewatered to allow for construction. To accomplish this, the spillway gates or stoplogs upstream of the stilling basins would be used to contain upstream water. Downstream of the stilling basins, cofferdams would be used to contain water. The cofferdams would be installed in two phases. At each project, phase one would include installing the cofferdams to allow dewatering of half of the stilling basin. Following modification of the first half of the stilling basin, the cofferdams would be relocated to allow dewatering of the remaining portion of the stilling basin. This would allow half of the spillway and stilling basin to remain operational at any given time.

e. Implementation.

It is important to note that the total project time estimates listed below were prepared with the assumption that sufficient manpower and resources will be available during all phases of the projects. Lengthy review processes, manpower shortages, and limited resources would have a definite impact on the total estimated project times. The implementation times listed below are based on the assumption that the projects will be addressed individually. The overall time for implementing spillway modifications at the four dams could be reduced by performing some of the DM, plans and specifications, and construction work either concurrently or in a staggered sequence.

The total project implementation time is estimated to be approximately 79 months per project. This time includes 18 months for DM preparation, 18 months for design and specifications preparation, 3 months for review, 4 months for advertisement and award, and a 36-month construction period.

COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE 1

SYSTEM IMPROVEMENTS
LOWER SNAKE RIVER AND MCNARY DAM

SECTION 5 -- ENVIRONMENTAL EFFECTS

5.01. GENERAL.

The evaluation of environmental effects for each improvement was limited to the effects on the anadromous fishery. The following paragraphs address the effects that the identified improvements would have on the anadromous fishery. For convenience, a brief description of each improvement is included at the beginning of each evaluation. A more detailed description of the options evaluated, and the reasons for selecting a particular option for further evaluation, is included in section 4 of this report.

5.02. IMPROVEMENTS TO FISH HATCHERIES.

a. General.

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

b. Description of Evaluations.

Improved truck loading at existing fish hatcheries was considered to eliminate the current practice of using fish pumps that can cause physical injury and acute stress for planting or transportation operations. Two alternatives to conventional fish pumping were identified: incorporating gravity-fed truck loading, and providing an improved pumping system (*e.g.*, an Archimedes-type fish pump). Although the gravity-fed system would be the preferred alternative for producing the greatest biological benefit (in terms of reducing stress and physical injury), the Archimedes-type fish pump was chosen because it is simple to operate, inexpensive, and very sensitive to reducing physical injury to soft tissue.

Additional containment facilities at existing fish hatcheries were considered to reduce fish rearing densities and produce healthier fish at similar abundances to those currently produced. Of the ten LSRFWCP Hatcheries evaluated, only the Dworshak and Magic Valley Hatcheries were found to have an adequate water supply and room for expansion.

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

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

5.03. IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS.

a. General.

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

b. Dispersed Release Sites/Short-Haul Barging.

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

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

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

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

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

c. Extended Length Screens.

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

Replacing the existing 20-foot long (standard length) STS's submersible traveling screens (SSTS's) at all of the Snake River dam turbine intakes with 40-foot-long screens will increase the FGE, as measured in percent. Either the proposed ESBS's or the ESTS's will divert a greater percentage of juvenile fish into the existing turbine bypass systems of each dam, thereby increasing the total estimated survival of juvenile fish passing each dam by exposing that greater number of diverted fish to a bypass/collection mortality estimate (generally 0 to 8 percent) that is much less than estimated turbine survival (10 to 15 percent). A benefit would also be expected for diverting an additional percentage of adult salmonids that "fallback" through the juvenile turbine bypass systems.

A large amount of coordinated research has been devoted to designing, installing, and testing more efficient turbine bypass systems. The concept of the extended-length screens was tested at Lower Granite in 1987. These tests demonstrated that FGE would be increased with extended-length screens, but impingement and descaling appeared to increase. More recent scaled physical modeling from the Corps' Waterways·Experimental Station (WES), and an underwater video, suggests that some flow/velocity vortexing can actually occur at the tip of longer screens, causing fish within that localized boundary layer to be caught within a reversed current condition where physical abrasion to fish may occur for a period of time.

It is likely that the hydraulic conditions within the turbine intake may be altered by extended-length diversion screens and modified balanced flow VBS's (MBFVBS's). The change in the hydraulic conditions could effect turbine efficiency, which has been correlated to turbine passage survival of salmonids. Research is being conducted at WES to study the hydraulic conditions created by screening equipment. This research may clarify how extended-length screens and MBFVBS's may increase or decrease turbine passage survival compared to existing SSTS systems. Any hydraulic model study results elucidated by WES would need comparable biological testing with current fish tagging technology to verify the true effect on smolt survival.

Both ESTS's and ESBS's were constructed for tests at McNary Dam in 1991 and 1992. Brege *et al*. (1992) concluded that both 40-foot-long ESTS's and ESBS's provided a higher FGE than 20-foot-long SSTS's, but there was no significant difference in FGE between the two extended-length screen types. Descaling rates were higher for ESTS's than for ESBS's and SSTS's. Because ESBS's appeared to cause less descaling that ESTS's, require less maintenance, and because the ESTS's were to be redesigned to significantly decrease the framework, tests in 1992 concentrated on the bar screens.

Brege *et al*. conducted FGE and descaling tests in 1992, varying screen type, turbine flow volume, operating gate position, perforated plate porosity, and screen gap width. They found that ESBS's guided both yearling and subyearling Chinook salmon significantly better than SSTS's. They also found that an ESBS at the standard elevation and a partially raised operating gate produced descaling rates that were not significantly different than those produced by an SSTS.

Because FGE and descaling are controlled by the flow of water through both the diversion and barrier screens, VBS configuration is a crucial component to bypass design. Existing VBS's were designed for 20-foot diversion screens, and Brege *et al*. suggest that flow distribution with 40-foot diversion screens could be improved with a VBS redesign or reconfiguration. Fish condition should also be enhanced if flow distribution can be improved through VBS operating modifications, if such modification could reduce or eliminate the screen tip vortexing concerns addressed previously.

Along with the diversion screen tests, the Corps has also tested several types of VBS's. Tests to be conducted in 1994 will focus on prototype MBFVBS design and associated orifice passage efficiency. The WES has performed, and is currently conducting, model studies to determine the best design for both MBFVBS's and extended-length diversion screens that would efficiently function as a system.

Based on the research described above, the operation of MBFVBS's and extended-length screens at each of the lower Snake River dams would increase FGE for juvenile spring/summer and fall Chinook salmon by at least 10 percent over those FGE estimates for the existing SSTS systems. Some level of descaling and mortality is likely to occur with the use of any screen diversion system, but the Corps believes that the MBFVBS/extended-length screen system can be modified to decrease descaling to levels equal to or less than that occurring with the existing SSTS's. It is also possible that those fish not guided by the extended-length screens would exhibit a different, possibly higher, mortality rate than those not guided by an SSTS. Research is being conducted on this possibility, but current evaluations assume that turbine passage mortality rates are the same for extended-length and standard-length screens.

Assuming that the only effect of the MBFVBS/extended-length screen system is an increase in FGE, as input value estimates for Columbia River Salmon Passage (CRiSP) 1.4 model runs derived from 3 years of research at McNary and 1 year of research at both Lower Granite and Little Goose Dams. These studies suggest average increases in FGE of greater than 10 percent for each dam. Therefore, 10 percent less for the total population would pass through the turbines. Turbine passage mortality is assumed to be within the 10 to 15 percent range and bypass mortality is within the 0 to 8 percent range (predominately an average of 2 percent).

The following shows the estimated FGE with extended-length screens based upon known NMFS screen research.

	Yearling Chinook	Subyearling Chinook	Steelhead
LGR w/62' raised gate	70 (66-73.7)	47 (44-53)	84.7 (82.2-89.1)
LGO w/62' raised gate	85 (84-86)	47 (44-53)	89.5 (87-92)
LMO	80 (72-86)	43 (41-47)	86 (65-93)
IHR	86 (82-94)	43 (41-47)	100 (98-100)
MCN	85.5 (78.5-90.5)	59 (52-81)	85 (81-90)

Through comparison of adult ladder counts at McNary, Ice Harbor, and Priest Rapids Dams the majority of spring Chinook salmon ascend the Snake River, while the majority of the summer and fall Chinook and sockeye salmon ascend the Columbia River. It is likely that a substantial number of the March through August total of adult fallback Chinook salmon are of Snake River origin, and that some of these fish are of the threatened wild stocks. In 1992, about half the total of 1454 fallback Chinook salmon were collected in the bypass facilities at McNary Dam from March through August, and were officially counted as spring/summer Chinook salmon. The remaining half of that total adult fallback for 1992 were collected in the McNary Dam bypass facilities from September through December, and were officially counted as fall Chinook salmon. Wild Snake River fall Chinook salmon adults did likely exist migrating upriver through McNary Dam and reservoir earlier than the official cutoff dates standardized for counting. In 1992, 430 adult fallback sockeye (*Oncorynchus nerka*) salmon were collected in the juvenile bypass system at McNary Dam. Wagner stated that most of the sockeye collected as fallbacks in 1990 were actually kokanee from Lake Roosevelt. Many of these fallbacks would have passed through the turbines if the SSTS's were not in place. Wagner and Hillson cited several studies estimating that adult steelhead mortality through hydroelectric turbines ranged from 22 to 57 percent. They concluded that mortality of adult salmonids through the bypass system at McNary Dam was low. Because of the increased volume of water that the ESBS's will intercept, it is likely that guidance of adult fallbacks away from the turbines will increase with the full suite of ESBS operation in the lower Snake River.

No data is available on the magnitude of the increased FGE of adult salmon with ESBS's, or the improvement in survival through the bypass system at McNary, compared with turbine passage survival. Because turbine passage mortality of adult salmon is believed to be substantially high, it seems likely that bypassed adult salmon would benefit highly from improved diversion efficiency afforded by extended-length screen implementation. Therefore, any increase in FGE attributable to ESBS's should result in benefits to reducing adult salmon interdam mortality.

In conclusion, no completely safe and totally efficient method of dam bypass has yet been devised, so operation of the juvenile bypass systems at the lower Snake River dams and McNary with ESBS's/ESTS's and MBFVBS's, would entail some mortality to individuals of the listed Snake River salmon stocks. The previous testing for improved FGE has prompted the Corps to schedule the installation and operation of extended-length screens into Lower Granite, Little Goose, and McNary Dams by 1996. Subsequent testing for FGE is scheduled for Little Goose in 1994, and for Lower Granite in 1995. Based on present knowledge about extended-length screen performance it can be reasonably expected that Snake River spring/summer and fall Chinook and Snake River sockeye salmon would benefit from the improved design and implementation of extended-length screens, because such screening systems would reduce turbine passage mortality for a greater portion of the juvenile salmonid outmigrants. Similar benefits would be expected to accrue for adult fallbacks of those same listed stocks, as well as Snake and Clearwater rivers steelhead. Based on the design of the existing extended-length screens that have been tested, screens could easily be designed for Lower Monumental and Ice Harbor during the SCS Phase II. Although relatively few Snake River fish would be expected to reach these two lower Snake River dams if the full transportation operation is continued, optimal screening for improved FGE would remain to be required for tributary and hatchery fall Chinook salmon stocks that enter the mainstem below Little Goose Dam. This train of thought is particularly consistent with the incremental benefit of the improved FGE for fall Chinook salmon afforded by extended-length screens.

d. Modification to Lower Granite Dam Juvenile Fish Facilities.

The Lower Granite juvenile fish bypass facilities were analyzed for improved passage and separator efficiency, because they are the oldest and most outdated facilities in the entire lower Snake River hydrosystem. The

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

Technical parties within the region are fairly agreeable about the increased stress related to pressurized passage systems for fish. It can be generally accepted that the existing pressurized pipeline system at Lower Granite Dam should be replaced with an open flume system based upon the Little Goose design. Wet separator construction at Lower Granite would be designed to separate smaller Chinook salmon from larger steelhead trout juveniles, much like the existing separators at Little Goose and Lower Monumental Dams. Independent barge transporting of Chinook salmon and steelhead trout would be desirable based upon biological reasons, including potential stress to Chinook salmon that overlap spatially with and could be prey for steelhead trout. The results of sea water challenge tests performed at Lower Granite Dam in 1982 indicated that the osmoregulatory performance of spring Chinook salmon smolts was impaired after confinement with steelhead smolts for 24 hours (Mathews *et al.*, 1986). In contrast, assays of blood cortisol concentrations in migrating spring Chinook salmon smolts confined with an equal number of steelhead smolts at the same density per gallon of water, did not indicate that the Chinook salmon were stressed (Congleton *et al.*, 1984). Additional research is required to determine to what extent spring Chinook smolts benefit from segregation from steelhead smolts. The degree of potential benefit of wet separator implementation would be determined from this additional research. Chinook smolts exiting the separators at Little Goose and Lower Monumental Dams appeared to be stressed during 1993 tests (Schreck *et al.*, 1993), likely because Chinook and steelhead actively resisted exiting from the separators, and remained there for extended periods. Chinook exiting the upstream section of the Lower Monumental fish separator appeared to have experienced more vigorous or prolonged swimming than fish exiting the downstream section (Schreck *et al.*, 1993). The objective of maintaining fish condition under uncertain circumstances would suggest that the wet separator and, especially, the open flume should be constructed.

e. Auxiliary Water Intake Screens at McNary Dam.

The water supply intake structure for the adult ladder located along the north shore (Washington side) of McNary Dam is not screened. The intake on the south shore (Oregon side) is equipped with a traveling system. However, this system has velocity conditions that allow fish to be impinged on the screens. Providing modern screening systems at these intakes, or modifying them to meet current fish criteria, could reduce juvenile mortality. A number of different options were investigated. Modifying the existing traveling screen system at the south shore intake structure with the new three-sided screen design, and retrofitting the trashracks of the north shore water intake structure with the new three-sided screens, were identified as the most desirable actions. North Wasco County Public Utility Department is installing a generating unit, under a FERC license, within the north shore intake. This FERC license requires the public utility department to maintain a mitigation fund for affected anadromous salmonids.

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

f. Forebay Collection.

Juvenile anadromous fish, appear to be in the top 20 to 30 feet of the reservoir surface as they migrate downstream. The objective of a surface-oriented collector is to guide and collect these fish before they have to dive to depths of 70 to 80 feet in order to be intercepted by the existing turbine screening bypass system. This type of surface-oriented collection system has been in operation at Wells Dam (on the Columbia River), and is reported to be very effective. A single concept design using a version of the Wells Dam fishway entrance, in conjunction with a collection/sample and bypass system, was identified as the preferred system and was further developed in this study. For this evaluation, only the Lower Granite Project was investigated. This project is considered to be representative in powerhouse and spillway structure for the other lower Snake River dams, although flow dynamics in the forebay of each dam would vary. If this system proved to be effective at Lower Granite, this information could be transferred and hydrologically adapted to other dams, not only on the Snake River, but on the Columbia River as well.

Surface-oriented collection and bypass designs vary, but are generally based upon the Wells Dam hydrocombine system or various systems developed for traditional turbine/spillway configurations within and outside the mid-Columbia River. A surface-oriented system could be designed specifically for fish passage, in unison with improved submerged screening systems, to equal or exceed the estimated FGE expected for an upstream collector screening structure (95 percent). A surface-oriented collector would be expected to reduce forebay delay of those juvenile salmonids not intercepted by the pull of the turbine intake flow funnel that become disoriented immediately adjacent to the dam. One of the more promising aspects of the surface-oriented concept is its potential flexibility in operation: juvenile salmonids would be intercepted throughout their vertical distribution, and could be collected via the existing bypass system or directly bypassed without handling or delay back to the river via the spillway, while using much reduced spill water volume. Reduced spill volume, down to 5 percent of the total volume, would be instrumental in controlling the generation of high dissolved-gas supersaturation to within acceptable Federal and State water quality standards, while efficiently passing a significant proportion of the juvenile salmonids (greater than 90 percent at Wells Dam for a target level).

The spillway passage is the most critical concern of the most currently proposed design. First, the L-shaped bend toward a single spillway may be sufficient to expel the dewatered volume of water needed to meet velocity criteria, but is not conducive for fish health. Physical damage would be expected. In addition, single exiting of the dewatered volume would assist in adult ladder attraction flow but, if used to pass juvenile fish, it would act to concentrate those fish toward awaiting predators conditioned to that locale. That proportion of juvenile salmonids passed should be spread across the spillway in some fashion to minimize predation, if possible. Second, the exit structure is dependent on the existing spillway configuration and operation. If the collector is operated at full pool or MOP elevation, fish must still be drawn down to near 50 feet of depth to be passed through the venturi effect of the submerged gate openings. A more optimal design for fish condition would be either the exiting of juvenile salmonids down a newly designed cascading juvenile "ladder," or operating the current surface-oriented collector/bypass design in unison with a reservoir drawdown to spillway crest. Free-flow of spilled water at spillway crest would allow a more laminar and efficient flow patterning for fish. This type of operation and the degree of laminar flow expected would be dependent on the dynamic runoff volume, and management through powerhouse operation would need to ensure a near maximum of 25,000 cfs spill volume to control dissolved-gas supersaturation. The default operation would be collection through the existing juvenile collection/bypass system for MOP operation or a new collection/bypass channel designed to operate at spillway crest flows.

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

5.04. IMPROVEMENTS TO JUVENILE FISH TRANSPORTATION SYSTEMS.

a. General.

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

b. Net Pens.

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

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

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

c. Barge Water Temperature Control.

The concept of controlling barge water temperature below a maximum of 68 ^{o}F was considered to provide a more optimal temperature for juvenile salmonids. Two options were considered to cool the water including: 1) drawing water from the bottom of the reservoir; and 2) using "chillers" located on the barges. The chiller concept was chosen as the option to further evaluate, but the operation and maintenance was found to be extremely costly.

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

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

d. Fish Barge Exits.

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

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

e. New Fish Barges.

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

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

5.05. IMPROVEMENTS TO ADULT PASSAGE SYSTEMS.

a. General.

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

b. Fish Ladder Water Temperature Control.

Fish ladders are used to pass adult fish around the dams. These ladders consist of a series of weirs or steps within an open, shallow flume. Water temperatures in these ladders can be significantly higher than in the ladder entrance at the tailrace below the dam during the summer months, which discourages adult fish from entering the ladders.

The University of Idaho has measured more than a 10 ^{o}F increase in adult ladder water temperatures when compared to tailrace water temperature at Lower Granite Dam. Bjornn *et al.* (1993) postulated that this difference in temperature could have a "blocking" effect that contributes to adult passage delay. Reducing water temperatures in these ladders could reduce this delay effect. The decrease in water temperature would be more beneficial to adult summer and fall Chinook salmon, due to their average run timing during the summer.

Three methods of reducing the water temperature in the adult ladders at all of the Snake River included shading, sprinklers, and pumping cooler water from the bottom of the forebay behind each dam. It was determined that cooling the ladder temperature water locally at the entrance would only result in physically relocating the temperature differential effect up the ladder to its exit, thus providing no solution to reducing the delay effect. A reasonable temperature gradient needs to be established in the area of the forebay that supplies water to the ladder in order to functionally eliminate any thermal shock zone that would be detected by adult salmonids climbing the ladder. The most effective means of lowering the water temperature around the ladder exit is to recirculate cooler water from the depths of each forebay (*e.g.*, NMFS has proposed using existing air-bubbler system technology), and introduce that water to the vicinity of each fish ladder exit.

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

c. <u>Additional Fish Ladders</u>.

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

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

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

d. Fish Ladder Entrances and Attraction Water.

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

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

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

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

5.5 feet, and lowering the transport channel 2 feet in elevation. This would require cofferdam construction and an interim means of adult passage during the time duration needed to perform the work on the powerhouse face in the tailrace.

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

This improvement would be considered a near-term action in terms of the research available on providing attraction flow patterns for these dam operations, and the available technology for formulating the design modifications. The implementation time required for this improvement at all of the lower Snake River dams, and any additional research and associated modeling, would indicate more of a long-term activity.

e. Fish Ladder Exits.

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

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

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

f. Adult Fish Collection Channel at McNary Dam.

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

Although the greater velocity of water traveling through the channel may incrementally enhance the adult attraction flow across the face of the powerhouse, there is no empirical evidence that suggests that this has any negative effect on attracting or delaying adult salmonids. In fact, there is uncertainty as to whether the low velocity condition actually exists at the estimated location within the channel. It has never actually been measured, and only appears in a modeled situation Also, reduced velocity areas may provide short-term resting areas, where maintaining a sustained high level of swimming performance may be beneficial to reducing energy depletion. A greater concern for adult passage would be the possible construction of the channel to the point of creating a bottleneck area that could act to crowd and possibly delay adult salmonids. The estimated channel width at the low velocity area, if modified, would be less than 10 feet, and could be outside of established criteria.

This improvement would be a near-term action, and is easily implementable with little cost to improving perceived adult attraction efficiency in the ladder system. However, some video monitoring of the area of the collection channel in question should be performed to give insight into whether this is an area contributing to adult delay and possibly crowding.

This project is better suited as an operation and maintenance improvement and, as such, can be implemented more readily than through the SCS process.

g. <u>Extended Fishway Channels</u>.

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

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

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

5.06. DAM MODIFICATIONS--SPILLWAY/STILLING BASIN MODIFICATIONS.

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

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

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

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

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

COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE 1

LOWER SNAKE RIVER AND MCNARY DAM
SYSTEM IMPROVEMENTS

SECTION 6 -- COST ESTIMATES AND IMPLEMENTATION SCHEDULES

6.01. GENERAL.

This section presents the estimated costs and implementation schedules for the various alternatives identified to improve the existing anadromous fishery passage systems on the Lower Snake River and at McNary Dam. The cost estimates and schedules are of a planning level of detail, and should be used for cost comparative purposes only. The following paragraphs discuss the cost estimates and schedules in more detail.

6.02. CONSTRUCTION COST ESTIMATES.

The total project cost estimates for each alternative were estimated at an October 1992 price level. Contingencies factors for each alternative range from 10 percent to 50 percent, depending on the construction risk, unknowns, and the level of design detail available for this study. The project cost estimate includes 28 percent of the construction cost for biological research, feasibility studies, model studies, DM's, and engineering and design. An additional 11 percent of the construction cost was included for construction management.

To allow for inflation during the research, design, and construction phase of an alternative, a fully funded cost estimate was developed. The fully-funded cost estimate was prepared, based on estimated implementation periods and projected rates of inflation in the out-years. The estimated implementation periods varied, depending on the scope and complexity of the alternative. Table 6-1 includes a summary of cost estimates at October 1992 price level, as well as the fully-funded cost estimates for each alternative. A table showing the derivation of the October 1992 and fully-funded cost estimates is included in appendix A.

6.03. AVERAGE ANNUAL COSTS.

Average annual costs were developed for each alternative for comparative purposes. Average annual costs include interest and amortization, and increased costs for operation, maintenance, and replacement. Annual costs for interest and amortization was based on the total investment cost which includes the total project cost plus interest during construction. Both interest during construction, and interest and amortization were computed based on 8 1/2-percent interest. Table 6-1 shows the total average annual cost for each alternative. Table 6-2 shows a more detailed breakdown of the derivation of the average annual cost.

6.04. IMPLEMENTATION SCHEDULES.

Implementation time periods for each alternative include the preparation of the DM, plans and specifications, review, contract award, and construction. Table 6-3 shows the generalized implementation periods for each alternative. Implementation time requirements for each alternative are also addressed in section 4 which, in some cases, includes more specific information about the implementation of each alternative.

Table 6-1 -- Estimated Construction Costs and Implementation Schedules				
		Estimated Costs		
Improvement	Schedule (Months)	Project Cost Oct 1992 Price Level	Fully-Funded Cost	Average Annual Cost
JUVENILE FISH SYSTEMS				
Short-Haul Barging	39	9,428,000	12,144,000	2,266,000
Extended-Length Screens	41	45,753,000	59,666,000	4,622,000
Modifications to Lower Granite Juvenile Facility	59	19,684,000	25,652,000	1,862,000
Auxiliary Water Intake at McNary	61	24,340,000	31,682,000	2,298,000
Surface-Oriented Collection (Lower Granite)	70	101,530,000	133,840,000	10,053,000
JUVENILE FISH TRANSPORTATION				
Net Pens	41	21,051,000	26,606,000	6,758,000
Barge Water Temperature Control	53	48,617,000	63,507,000	7,130,000
Fish Barge Exits	23	1,476,000	1,809,000	146,000
Additional Fish Barges	27	45,452,000	58,546,000	4,748,000
ADULT PASSAGE SYSTEMS				
Fish Ladder Water Temperature Control	26	12,445,000	15,396,000	1,243,000
Additional Fish Ladders	61	150,879,000	200,972,000	13,733,000
Fish Ladder Entrance and Attraction Water	33	19,781,000	24,844,000	1,676,000
Fish Ladder Exits	37	856,000	1,101,000	75,000
Adult Collection Channel Modifications	21	353,000	434,000	31,000
Fish Channel Extensions	51	52,007,000	67,299,000	4,586,000
DAM MODIFICATIONS				
Spillway/Stilling Basin Modifications	79	137,468,000	187,788,000	12,420,000
HATCHERY MODIFICATIONS				
Truck Loading	6	360,000	473,000	55,000
Added Containment Facilities				
Dworshak Hatchery	65	14,109,000	18,563,000	1,400,000
Magic Valley Hatchery	49	3,569,000	4,695,000	358,000

Table 6-2 -- Average Annual Costs 1/

TITLE	1 OCT 92 PROJECT COST($)	INTEREST DURING CONSTRUCTION ($,8 1/2%)	INCREASED ANNUAL OPERATING COSTS ($)	INCREASED ANNUAL MAINTENANCE COSTS($)	INCREASED ANNUAL REPLACEMENT COSTS($)	AVERAGE ANNUAL COST($)
HATCHERIES						
1. Truck Loading	360,000	0	0	0	0	54,900
2. Additional Containment						
a. Dworshak Hatchery	14,109,000	882,400	85,000	15,000	3,370	1,400,000
b. Magic Valley Hatchery	3,569,000	223,200	20,000	10,000	0	358,000
1. Dispersed Release						
a. McNary	1,277,000	22,800	2,000	1,500	340	116,000
b. Little Goose	894,000	16,000	1,500	1,500	270	82,000
c. Lower Monumental	1,155,000	20,600	1,500	1,500	270	105,000
2. Extended Length Screens						
a. Lower Monumental	22,876,000	409,000	18,000	5,000	12,660	2,311,000
b. Ice Harbor	22,876,000	409,000	18,000	5,000	12,660	2,311,000
3. Lower Granite Fish Facilities	19,684,000	1,006,600	40,000	30,000	3,380	1,862,000
4. McNary Intake Screens	24,340,000	1,522,300	25,000	30,000	6,740	2,298,000
5. Short-haul Barging	9,428,000	168,500	1,220,000	75,000	500,000	2,266,000
6. Forebay Collection System (Lower Granite)	101,530,000	13,234,900	60,000	60,000	10,110	10,053,000
FISH TRANSPORTATION						
1. Net Pens	21,051,000	606,400	4,000,000	600,000	42,200	6,758,000
2. Temp. Control Barges	48,617,000	1,400,000	2,000,000	200,000	42,200	7,130,000
3. Barge Exits	1,476,000	15,800	0	0	0	146,000
4. New Barges	45,452,000	812,500	60,000	100,000	1,000,000	4,748,000

Table 6-2 -- Average Annual Costs 1/ (Continued)

TITLE	1 OCT 92 PROJECT	INTEREST DURING CONSTRUCTION ($,8 1/2%)	INCREASED ANNUAL OPERATING COSTS ($)	INCREASED ANNUAL MAINTENANCE COSTS($)	INCREASED ANNUAL REPLACEMENT COSTS($)	AVERAGE ANNUAL COST ($)
ADULT PASSAGE						
1a. Ladder Temp. Control (Alt 1)						
a. Lower Granite	843,000	6,000	11,000	700	300	85,000
b. Little Goose	843,000	6,000	15,000	700	300	89,000
c. Lower Monumental	1,687,000	12,000	25,000	1,400	600	174,000
d. Ice Harbor	2,108,000	15,000	25,000	1,400	600	211,000
1b. Ladder Temp. Control (Alt 2)						
a. Lower Granite	1,914,000	20,400	15,000	3,000	5,700	191,000
b. Little Goose	1,914,000	20,400	20,000	3,000	5,700	196,000
c. Lower Monumental	3,825,000	40,800	35,000	5,000	11,400	386,000
d. Ice Harbor	4,791,000	51,100	35,000	5,000	11,400	470,000
2. Additional Ladders						
a. Lower Granite	75,440,000	2,173,000	60,000	90,000	0	6,861,000
b. Little Goose	75,440,000	2,173,000	60,000	90,000	0	6,861,000
3. Ladder Entrances and Attraction Water						
a. Lower Granite	4,764,000	85,200	0	0	0	419,000
b. Little Goose	5,218,000	93,200	0	0	0	459,000
c. Lower Monumental	5,035,000	90,000	0	0	0	443,000
d. Ice Harbor	4,764,000	85,200	0	0	0	419,000
4. McNary Ladder Exits	856,000	6,100	0	0	0	75,000
5. McNary Collection Channel	353,000	2,500	0	700	0	31,000
6. Extended Entrances						
a. Lower Granite	45,675,000	1,822,100	0	0	0	4,038,000
b. Little Goose	6,332,000	113,200	0	0	0	548,000
DAM MODIFICATIONS						
1. Spillways/Stilling Basins						
a. Lower Granite	34,367,000	2,149,500	0	0	0	3,105,000
b. Little Goose	34,367,000	2,149,500	0	0	0	3,105,000
c. Lower Monumental	34,367,000	2,149,500	0	0	0	3,105,000
d. Ice Harbor	34,367,000	2,149,500	0	0	0	3,105,000

1/ Includes Interest and amortization based on the total investment cost, and increased operating , maintenance, and replacement costs.

Table 6-3 -- Implementation Time Periods - Summary

Times in Months

Title	DM	Plans	Review	Award	Const.	Total
Fish Hatcheries						
* Truck Loading	NA	NA	NA	NA	NA	6
* Additional Containment Facilities	10	12	3	4	36	65
Juvenile Fish System						
* Dispersed Release Sites	6	8	3	4	12	33
* Extended Length Screens	11	11	3	4	12	41
* Modifications to Lower Granite Dam Juvenile Facility	11	11	3	4	30	59
* McNary Auxiliary Intake	8	10	3	4	36	61
* Short-haul Barging	8	12	3	4	12	39
* Forebay Collection	12	18	3	4	33	70
Juvenile Fish Transportation Systems						
* Net Pens	8	8	3	4	18	41
* Barge Water Temperature Control	10	18	3	4	18	53
* Fish Barge Exits	4	4	3	4	8	23
* New Fish Barges	4	4	3	4	12	27
Adult Passage Systems						
* Fish Ladder Water Temperature (Alt 1)	5	6	3	4	6	24
* Fish Ladder Water Temperature (Alt 2)	5	6	3	4	8	26
* Additional Fish Ladders	18	18	3	4	18	61
* Fish Ladder Entrances and Attraction Water	6	8	3	4	12	33
* Fish Ladder Exits	18	6	3	4	6	37
* Adult Collection Channel Modifications--McNary Dam	5	3	3	4	6	21
* Fish Enterance Extensions --						
Lower Granite Dam	8	12	3	4	24	51
Little Goose Dam	6	8	3	4	12	33
Dam Modifications						
* Spillway/Stilling Bains Modifications	18	18	3	4	36	79

NOTE: For Multi-project improvements, the time shown is the time to complete the improvement for one of the projects.

COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE 1

LOWER SNAKE RIVER AND MCNARY DAM
SYSTEM IMPROVEMENTS

SECTION 7 -- SUMMARY/CONCLUSIONS

The preliminary evaluations conducted for these improvements have indicated that several of the improvements may warrant further evaluation, based on their potential benefit to anadromous fish. Each improvement was examined for its value as a near-term or long-term measure. Near-term measures are considered to be relatively minor improvements that could be implemented without extensive additional research or testing, provided they have regional support and funding is available. Long-term measures are considered to be major improvements requiring significant research and testing prior to implementation. Table 7-1 summarizes the potential of each alternative to increase salmon fish survival, whether it is a near-term or long-term action, and the average annual cost.

Table 7-1-- Summary of Existing System Improvements Evaluations						
	Salmon Survival Benefits					
Alternative	Effective	Maybe Effective	Not Effective	Average Annual Cost ($1,000)[1]	Near-Term Meas[2]	Long-Term Meas[3]
IMPROVED JUVENILE FISH SYSTEMS						
Dispersed Release Sites						
Short-Haul Barging		✖		303	✖	
With Flume System			✖	4,622	✖	
Extended-Length Screens (Fall Chinook)	✖			1,862	✖	
Modifications to Lower Granite Juvenile Facility	✖			2,298	✖	
Auxiliary Water Intake At McNary				2,266		
North shore		✖				✖
South shore		✖			✖	
Surface-Oriented Collection and Bypass	✖			10,053		✖
IMPROVED JUVENILE FISH TRANSPORTATION SYSTEMS						
Net Pens			✖	6,758		✖
Barge Water Temperature Control				7,130		
Spring Chinook			✖			✖
Fall & Summer Chinook		✖				✖
Fish Barge Exits	✖			146	✖	
Additional Fish Barges	✖			4,748	✖	
IMPROVED ADULT PASSAGE SYSTEMS						
Adult Ladder Temperature Water Control	✖			1,243		✖
Additional Adult Fish Ladders	✖			13,733		✖
Ladder Entrance and Attraction Water		✖		1,676		✖
Adult Ladder Exits		✖		75	✖	
Adult Collection Channel Modifications			✖	31	✖	
Adult Channel Extensions		✖		4,586		✖
IMPROVED FISH HATCHERIES						
Truck Loading Pump		✖		55	✖	
Additional Containment Facilities		✖		1,758		✖
DAM MODIFICATIONS						
Spillway/Stilling Basin Modifications		✖		12,420		✖

[1]Construction costs at October 1992 price level and fully funded cost estimates are presented on table 6-1.
[2]Near-term measures are considered to be relatively minor improvements which could be implemented without extensive additional research or testing, provided they have regional support and funding is available.
[3]Long-term measures are considered to be major improvements requiring significant research and testing prior to implementation. These actions require further study.

COLUMBIA RIVER SALMON MITIGATION ANALYSIS
SYSTEM CONFIGURATION STUDY
PHASE 1

LOWER SNAKE RIVER AND MCNARY DAM
SYSTEM IMPROVEMENTS

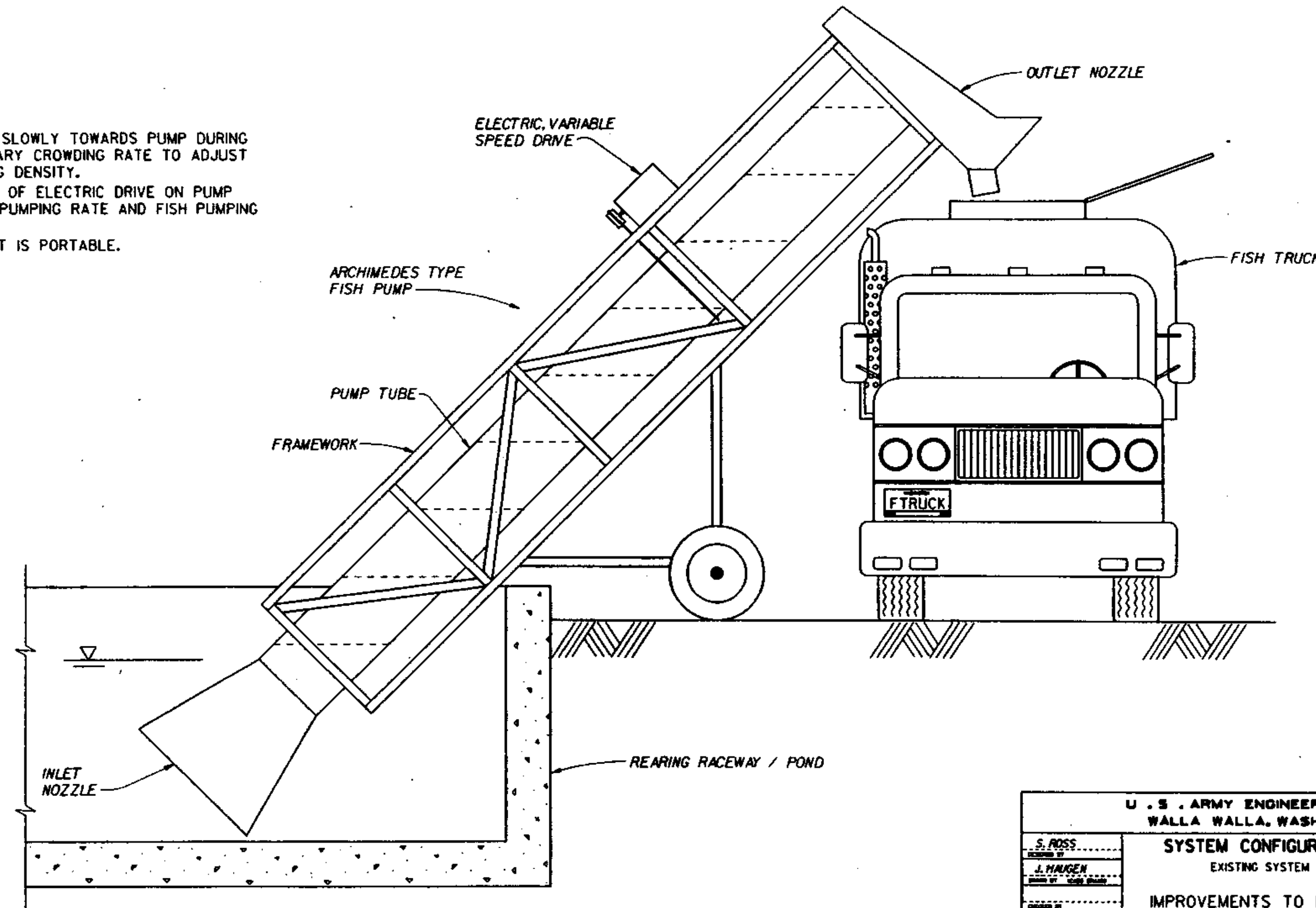
SECTION 8 -- AGENCY COORDINATION

Alternatives identified and evalutated in this report were coordinated with the USFWS and the NMFS. Copies of letters from the USFWS, and the USFWS comments on previous draft reports, are included in appendix A.

PLATES

CORPS OF ENGINEERS SAFETY PAYS U. S. ARMY

NOTES:
1) CROWD FISH SLOWLY TOWARDS PUMP DURING PUMPING. VARY CROWDING RATE TO ADJUST FISH PUMPING DENSITY.
2) VARY SPEED OF ELECTRIC DRIVE ON PUMP TO ADJUST PUMPING RATE AND FISH PUMPING DENSITY.
3) PUMPING UNIT IS PORTABLE.



SECTIONAL ELEVATION

NOT TO SCALE

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS

IMPROVEMENTS TO FISH HATCHERIES
ARCHIMEDES TYPE FISH PUMP

S. ROSS
J. HAUGEN

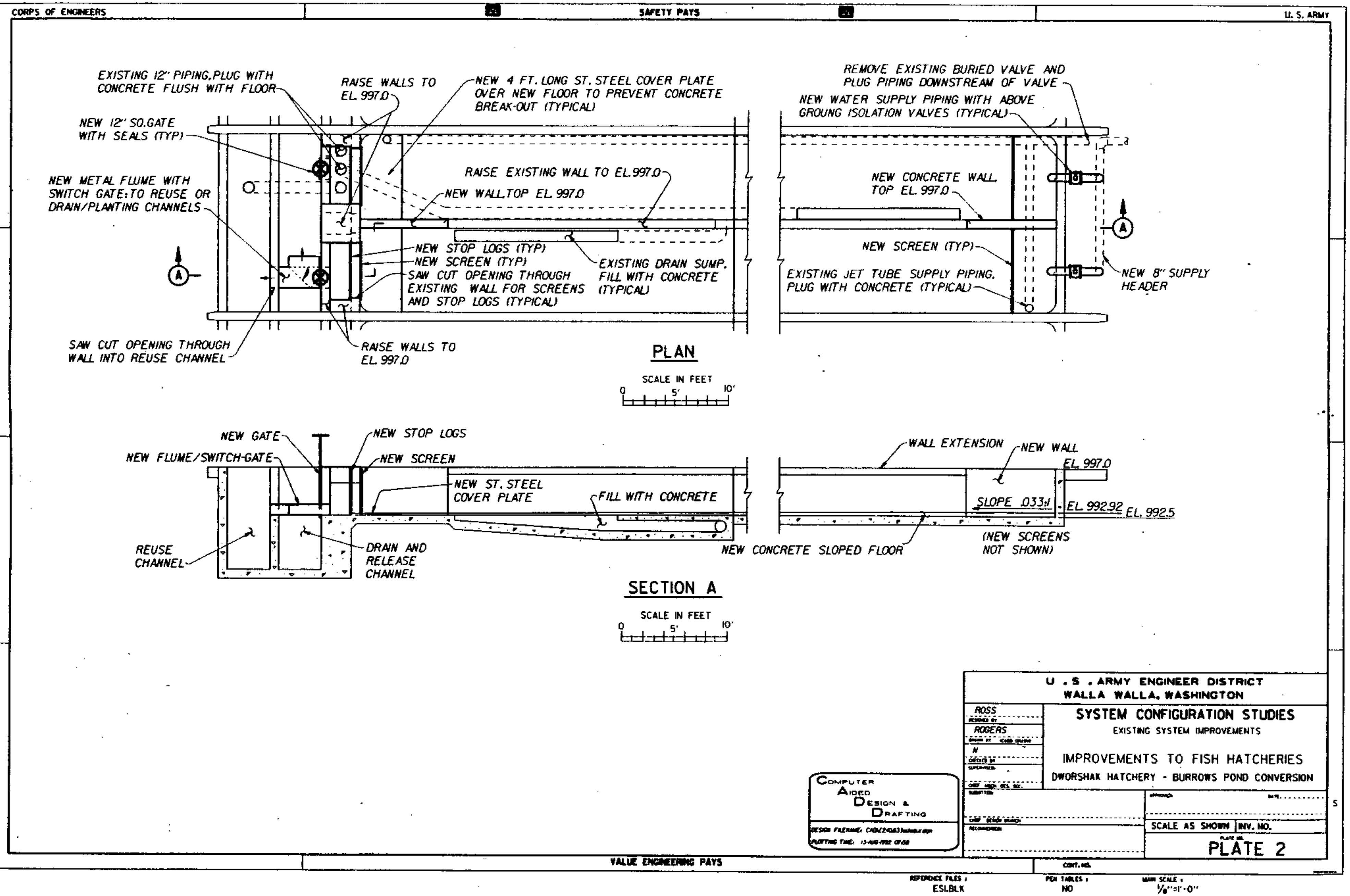
COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

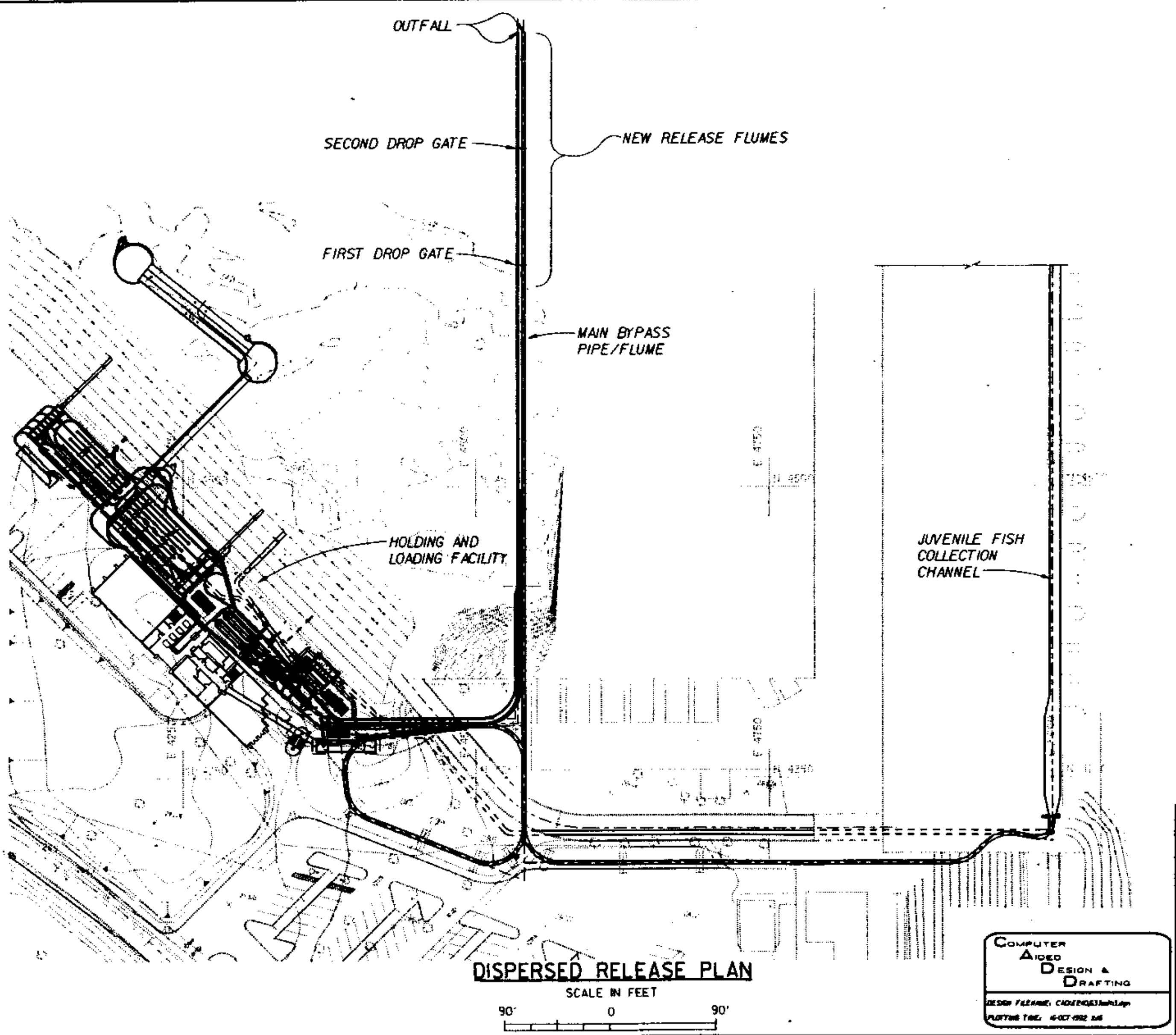
PLATE I

VALUE ENGINEERING PAYS

REFERENCE FILES: SCS:ESLBLK.TB
PEN TABLES: NO
MAIN SCALE: 1/4"=1'-0"



CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
EXISTING 12" PIPING, PLUG WITH CONCRETE FLUSH WITH FLOOR
RAISE WALLS TO EL 997.0
NEW 4 FT. LONG ST. STEEL COVER PLATE OVER NEW FLOOR TO PREVENT CONCRETE BREAK-OUT (TYPICAL)
REMOVE EXISTING BURIED VALVE AND PLUG PIPING DOWNSTREAM OF VALVE
NEW WATER SUPPLY PIPING WITH ABOVE GROUNG ISOLATION VALVES (TYPICAL)
NEW 12" SQ.GATE WITH SEALS (TYP)
RAISE EXISTING WALL TO EL.997.0
NEW WALL TOP EL 997.0
NEW CONCRETE WALL TOP EL 997.0
NEW METAL FLUME WITH SWITCH GATE: TO REUSE OR DRAIN/PLANTING CHANNELS
NEW STOP LOGS (TYP)
NEW SCREEN (TYP)
SAW CUT OPENING THROUGH EXISTING WALL FOR SCREENS AND STOP LOGS (TYPICAL)
EXISTING DRAIN SUMP, FILL WITH CONCRETE (TYPICAL)
EXISTING JET TUBE SUPPLY PIPING, PLUG WITH CONCRETE (TYPICAL)
NEW 8" SUPPLY HEADER
SAW CUT OPENING THROUGH WALL INTO REUSE CHANNEL
RAISE WALLS TO EL 997.0
A
PLAN
SCALE IN FEET
0 5' 10'
NEW GATE
NEW STOP LOGS
NEW FLUME/SWITCH-GATE
NEW SCREEN
NEW ST. STEEL COVER PLATE
FILL WITH CONCRETE
WALL EXTENSION
NEW WALL
EL 997.0
SLOPE .033:1
EL 992.92
EL 992.5
REUSE CHANNEL
DRAIN AND RELEASE CHANNEL
NEW CONCRETE SLOPED FLOOR
(NEW SCREENS NOT SHOWN)
SECTION A
SCALE IN FEET
0 5' 10'
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
ROSS
ROGERS
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO FISH HATCHERIES
DWORSHAK HATCHERY - BURROWS POND CONVERSION
COMPUTER AIDED DESIGN & DRAFTING
SCALE AS SHOWN
INV. NO.
PLATE 2
VALUE ENGINEERING PAYS
REFERENCE FILES: ESI.BLK
PDI TABLES: NO
MAIN SCALE: 1/8"=1'-0"



DISPERSED RELEASE PLAN

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

SYSTEM CONFIGURATION STUDIES

EXISTING SYSTEM IMPROVEMENTS

IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS

McNARY DISPERSED RELEASE - PLAN

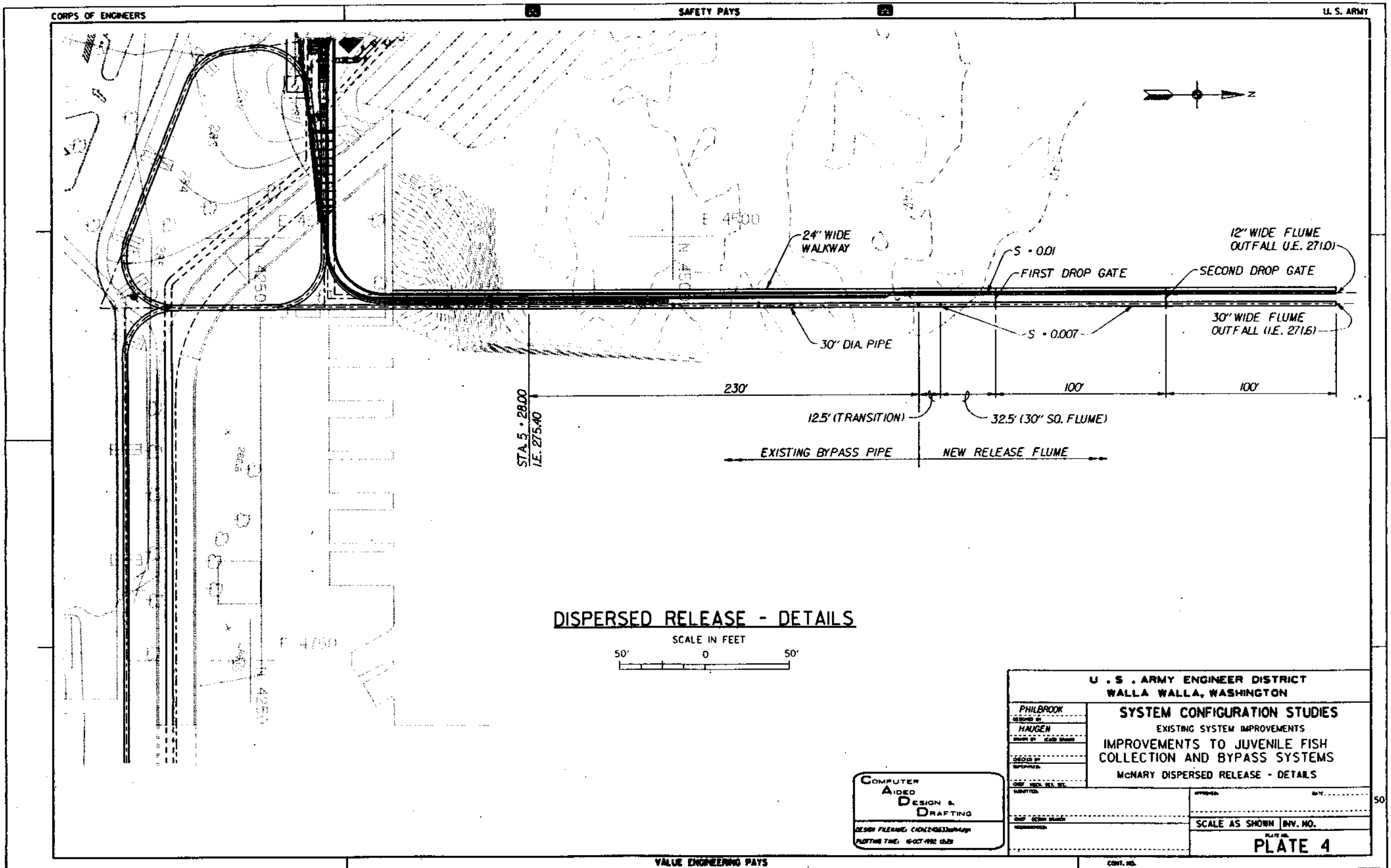
PHILBROOK
HAUGEN

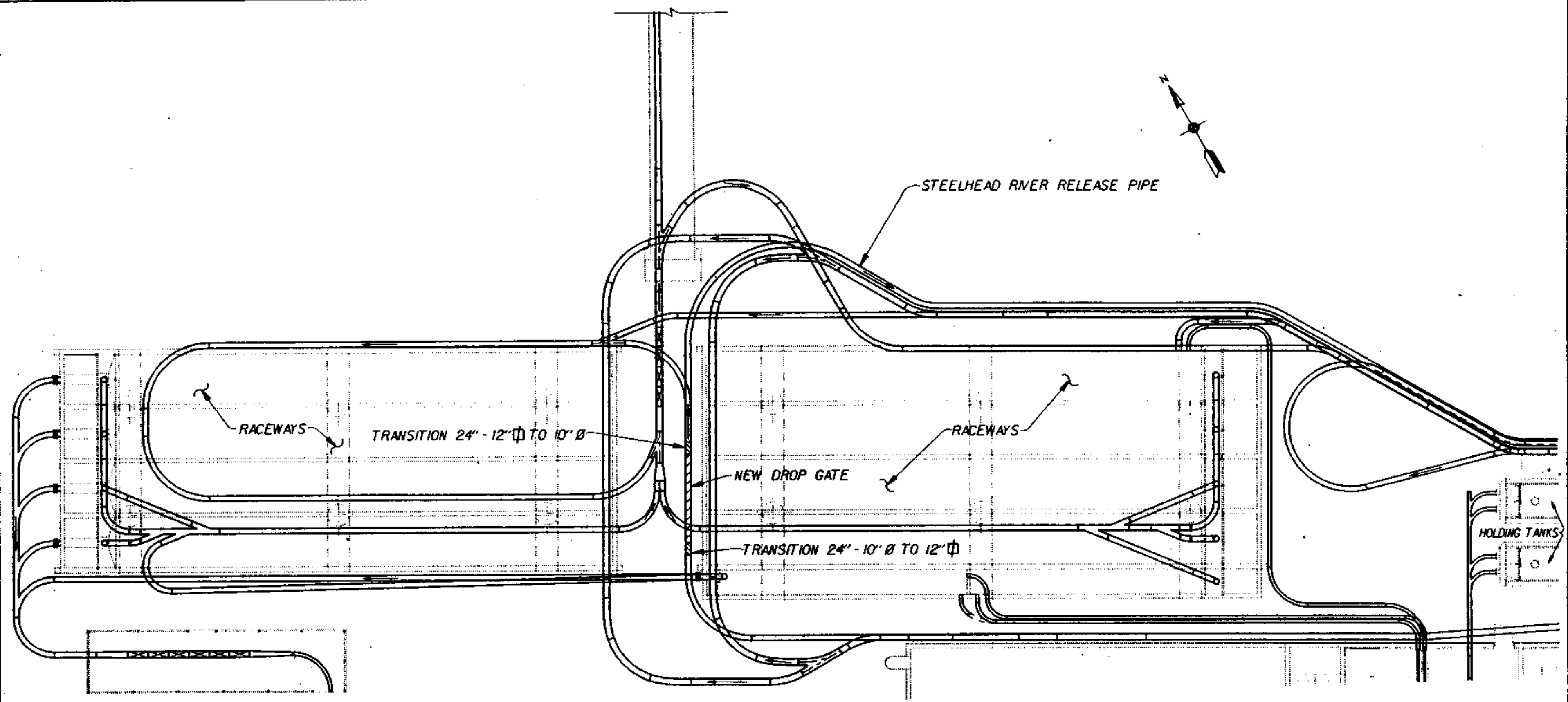
COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

PLATE 3

REFERENCE FILES: SCSiESI.BLK,TB
PEN TABLES: ESIH3.IPL
MAIN SCALE: 1"=90'-0"


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
N
24" WIDE WALKWAY
12" WIDE FLUME OUTFALL (I.E. 271.0)
S = 0.01
FIRST DROP GATE
SECOND DROP GATE
30" DIA. PIPE
S = 0.007
30" WIDE FLUME OUTFALL (I.E. 271.6)
230'
100'
100'
STA. 5 + 28.00
I.E. 275.40
12.5' (TRANSITION)
32.5' (30" SQ. FLUME)
EXISTING BYPASS PIPE
NEW RELEASE FLUME
DISPERSED RELEASE - DETAILS
SCALE IN FEET
50' 0 50'
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
PHILBROOK
HAUGEN
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS
McNARY DISPERSED RELEASE - DETAILS
COMPUTER AIDED DESIGN & DRAFTING
SCALE AS SHOWN
INV. NO.
PLATE 4
VALUE ENGINEERING PAYS



HOLDING FACILITIES FISH DISTRIBUTION FLUME PLAN

SCALE IN FEET
0 10' 20'

COMPUTER AIDED DESIGN & DRAFTING

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS

IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS
McNARY DISPERSED RELEASE - DETAILS II

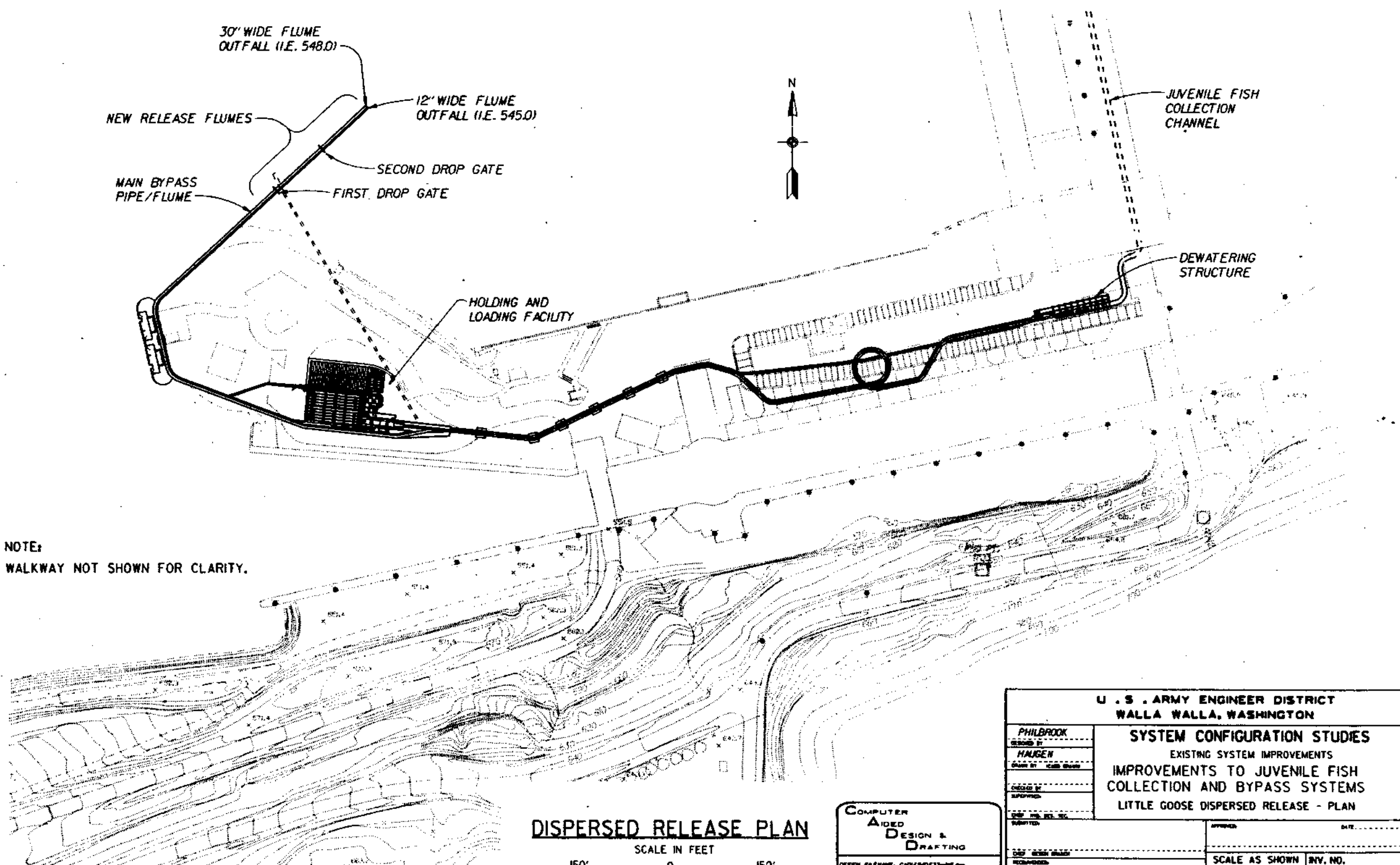
PHILBROOK
ROGERS
N

SCALE AS SHOWN | INV. NO.

PLATE 4.1

REFERENCE FILES: ESI.BLK MJFLUME2.2D MJFSITE.DGN
PEN TABLES: HMJFMI7I.IPL
MAIN SCALE: 1/8"=1'-0
LEVELS OFF: 62, 63

CORPS OF ENGINEERS SAFETY PAYS U. S. ARMY



NOTE:
WALKWAY NOT SHOWN FOR CLARITY.

DISPERSED RELEASE PLAN

SCALE IN FEET
150' 0 150'

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

PHILBROOK
HAUGEN

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH
COLLECTION AND BYPASS SYSTEMS
LITTLE GOOSE DISPERSED RELEASE - PLAN

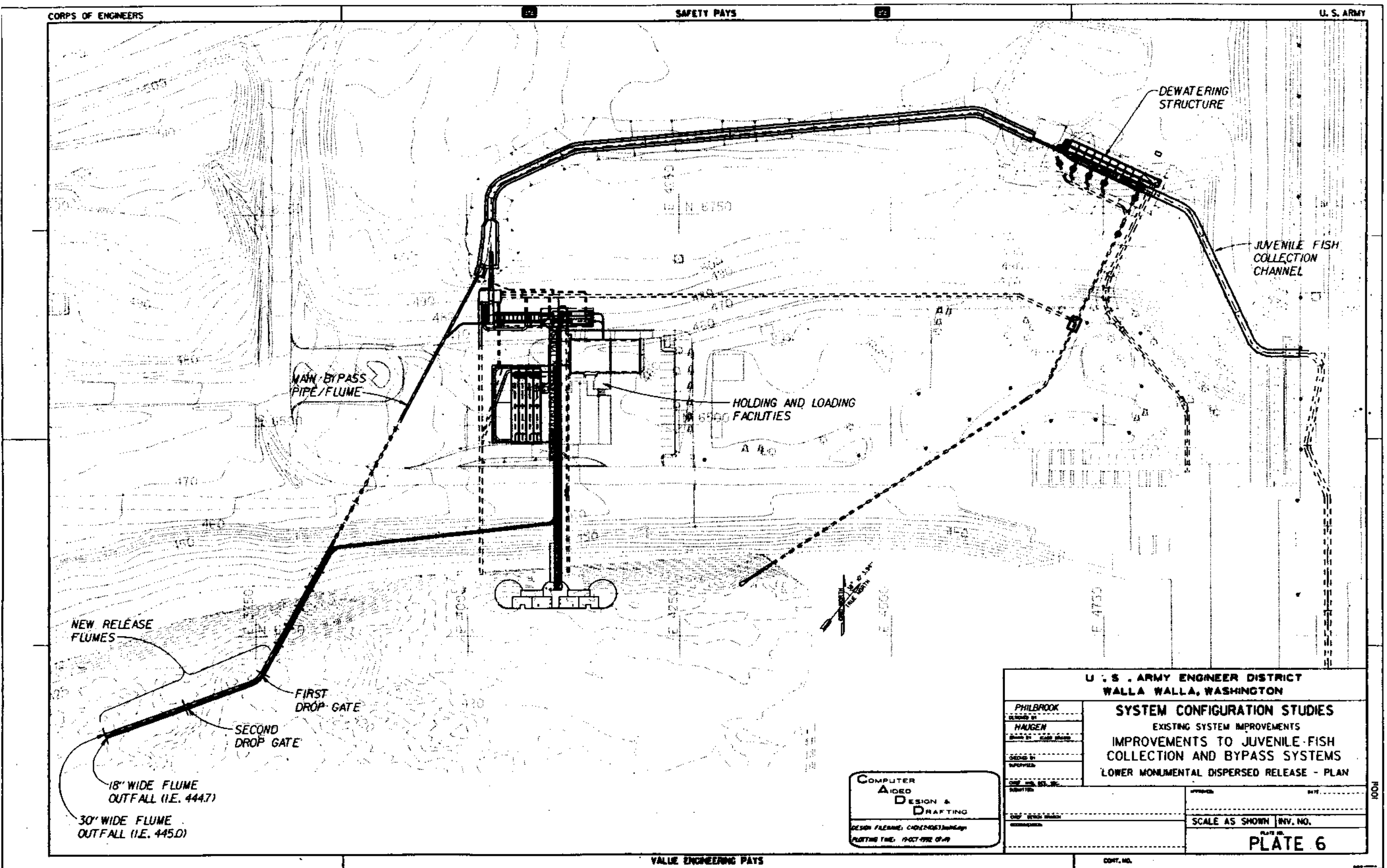
COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

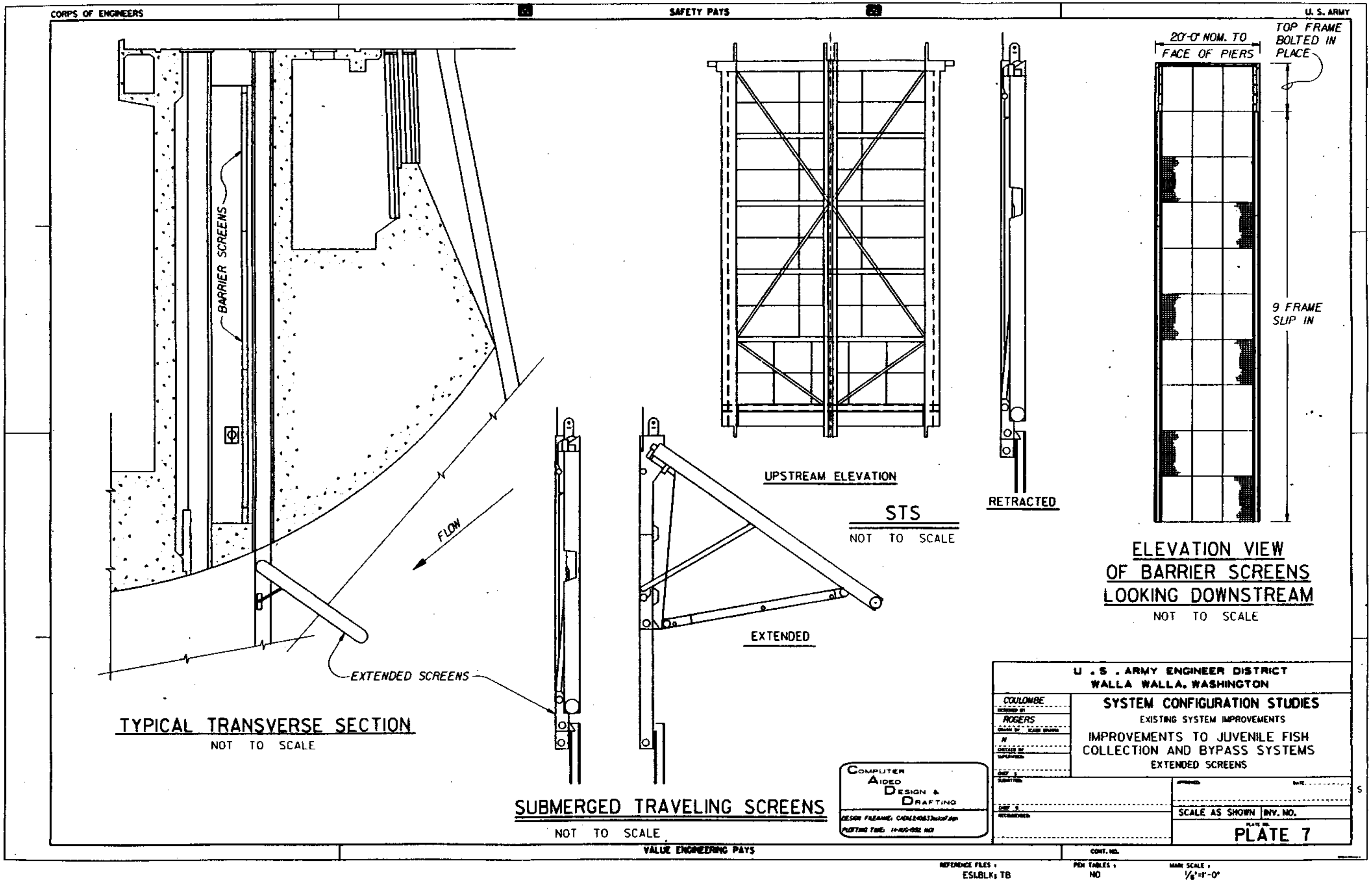
PLATE 5

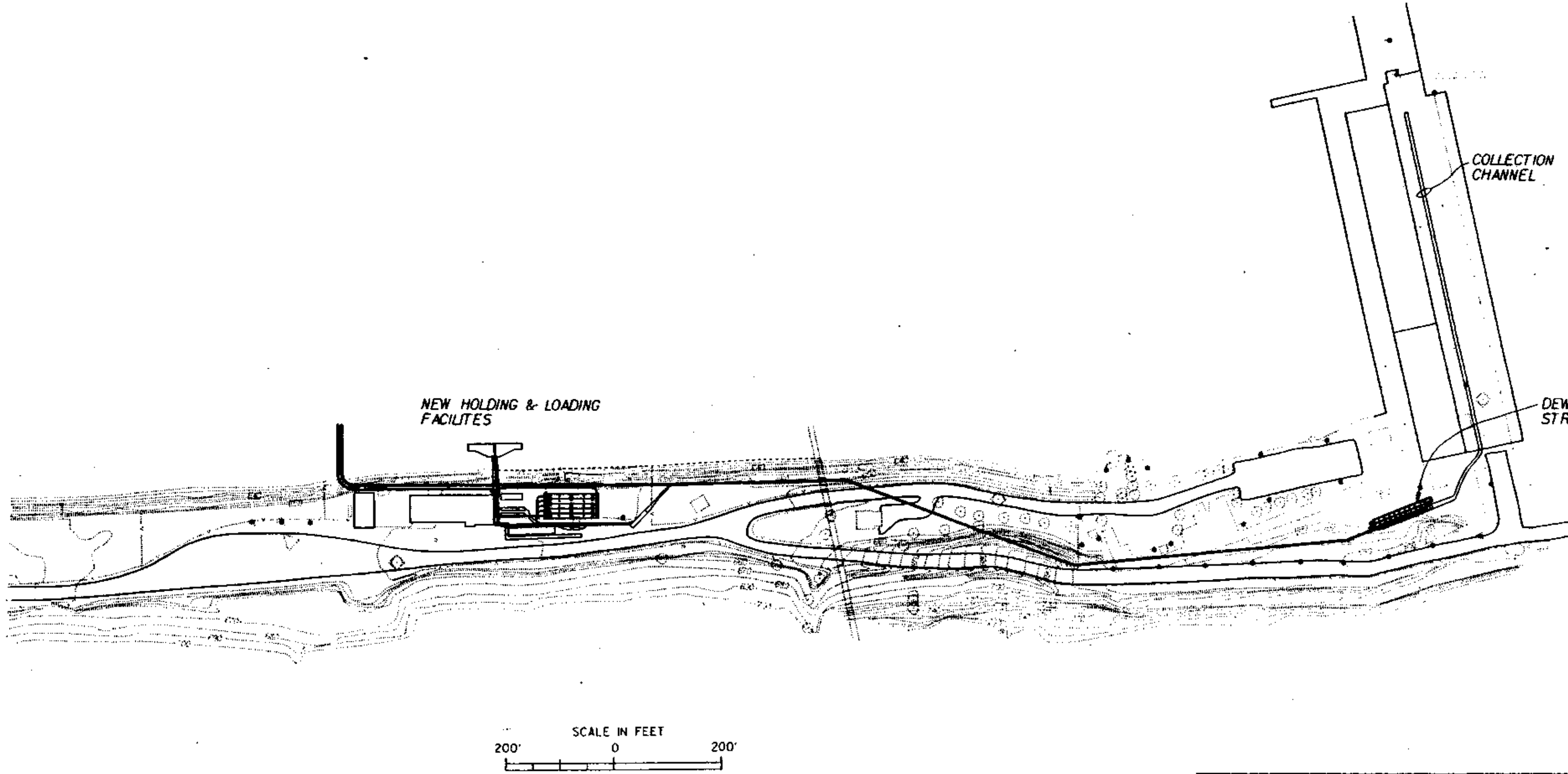
VALUE ENGINEERING PAYS

REFERENCE FILES: SCS:ESI.BLK,TB
PEN TABLES: SCS:ESHS.IPL
MAIN SCALE: 1"=150'-0"



CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
DEWATERING STRUCTURE
JUVENILE FISH COLLECTION CHANNEL
MAIN BYPASS PIPE/FLUME
HOLDING AND LOADING FACILITIES
NEW RELEASE FLUMES
FIRST DROP GATE
SECOND DROP GATE
18" WIDE FLUME OUTFALL (I.E. 444.7)
30" WIDE FLUME OUTFALL (I.E. 445.0)
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
PHILBROOK
HAUGEN
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS
LOWER MONUMENTAL DISPERSED RELEASE - PLAN
COMPUTER AIDED DESIGN & DRAFTING
SCALE AS SHOWN
INV. NO.
PLATE 6
VALUE ENGINEERING PAYS
REFERENCE FILES: SCS:ESI.BLK,TB
PEN TABLES: SCS:ESNG.IPL
MAIN SCALE: 1"=100'-0"


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
BARRIER SCREENS
EXTENDED SCREENS
FLOW
TYPICAL TRANSVERSE SECTION
NOT TO SCALE
SUBMERGED TRAVELING SCREENS
NOT TO SCALE
UPSTREAM ELEVATION
EXTENDED
RETRACTED
STS
NOT TO SCALE
20'-0" NOM. TO FACE OF PIERS
TOP FRAME BOLTED IN PLACE
9 FRAME SLIP IN
ELEVATION VIEW OF BARRIER SCREENS LOOKING DOWNSTREAM
NOT TO SCALE
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
COULOMBE
ROGERS
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS
EXTENDED SCREENS
COMPUTER AIDED DESIGN & DRAFTING
SCALE AS SHOWN
INV. NO.
PLATE 7
VALUE ENGINEERING PAYS
REFERENCE FILES : ESLBLK; TB
PEN TABLES : NO
MAIN SCALE : 1/8"=1'-0"



U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

SYSTEM CONFIGURATION STUDIES

EXISTING SYSTEM IMPROVEMENTS

IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS

LOWER GRANITE FISH FACILITY - PLAN

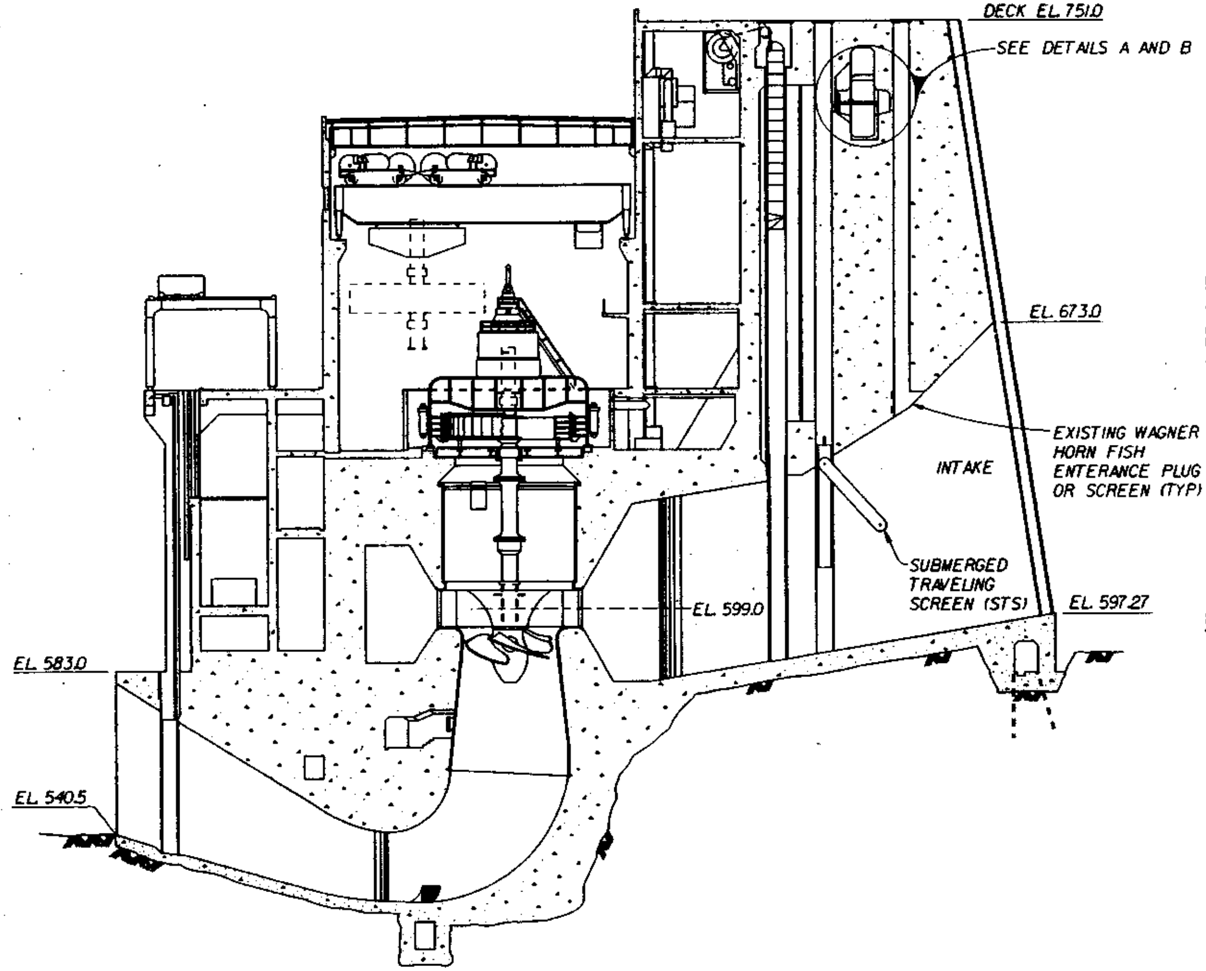
PHILBROOK
GLASSLEY

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

PLATE 8

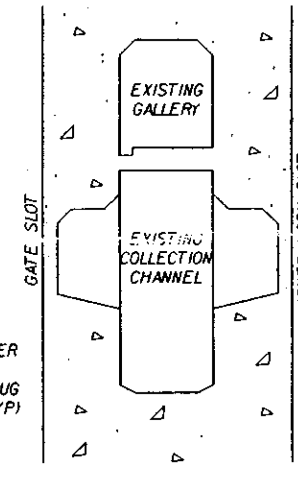
REFERENCE FILES: ESI.BLK
PEN TABLES: LWGRSITE.IPL



TRANSVERSE SECTION

LOWER GRANITE DAM

SCALE IN FEET 0 20' 40'

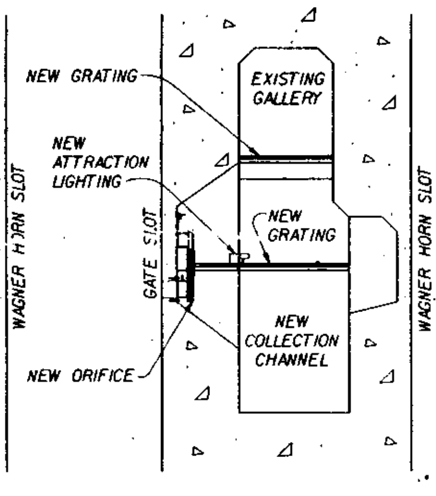


DETAIL A

EXISTING COLLECTION CHANNEL

SCALE IN FEET 0 5' 10'

NOTE:
EXISTING ORIFICES NOT SHOWN



DETAIL B

PROPOSED COLLECTION CHANNEL

SCALE IN FEET 0 5' 10'

NOTE:

1) EXISTING COLLECTION CHANNEL SHALL BE MODIFIED INTO NEW COLLECTION CHANNEL SHAPE.

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

S. ROSS
J. HAUGEN

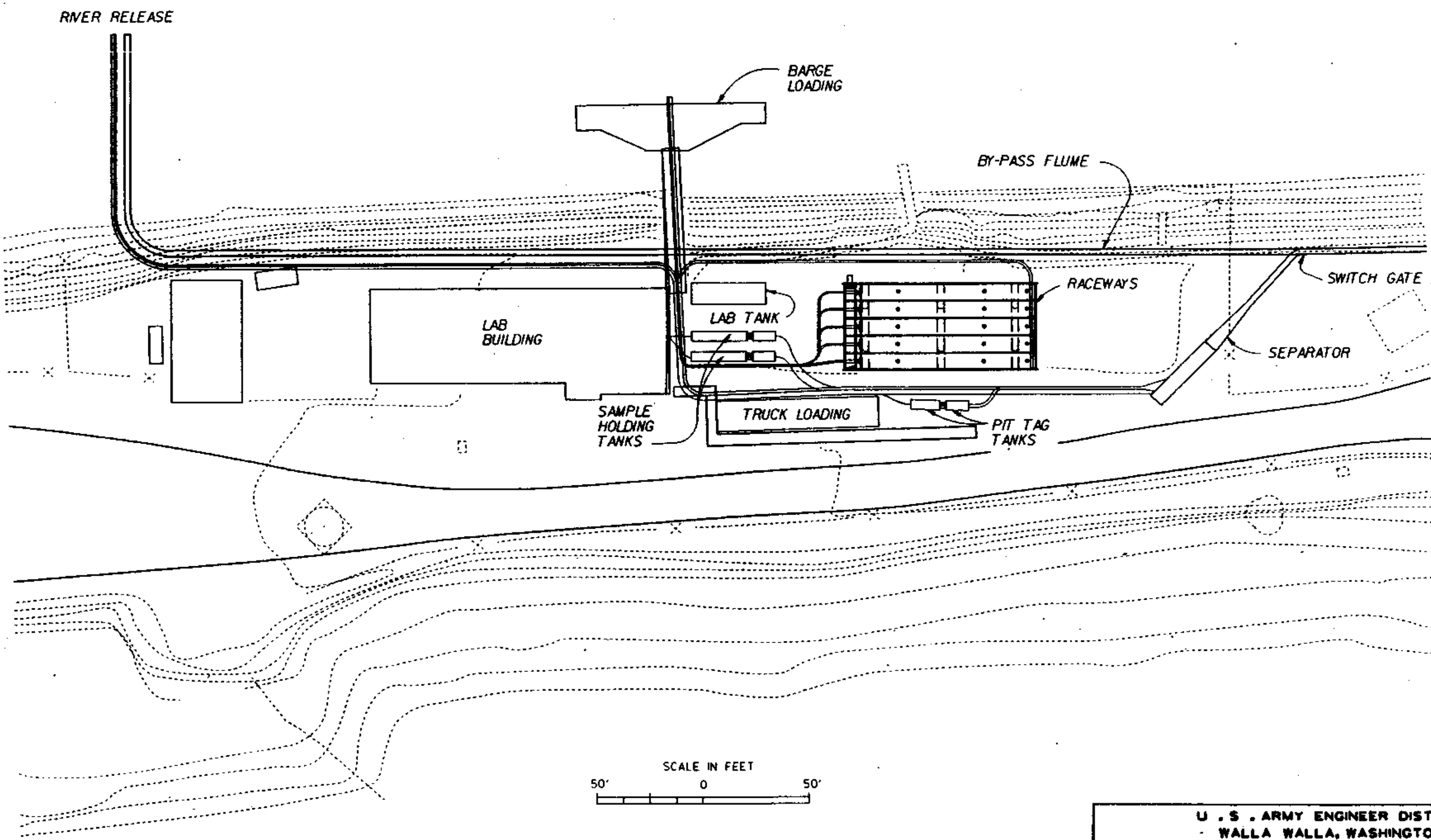
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS
LOWER GRANITE DAM - TRANSVERSE SECTION

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

PLATE 8.1

REFERENCE FILES: SCS:ESI.BLK PEN TABLES: NO MAIN SCALE: 1/8"=1'-0"



U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

SYSTEM CONFIGURATION STUDIES

EXISTING SYSTEM IMPROVEMENTS

IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS

LOWER GRANITE FISH FACILITY - DETAILS I

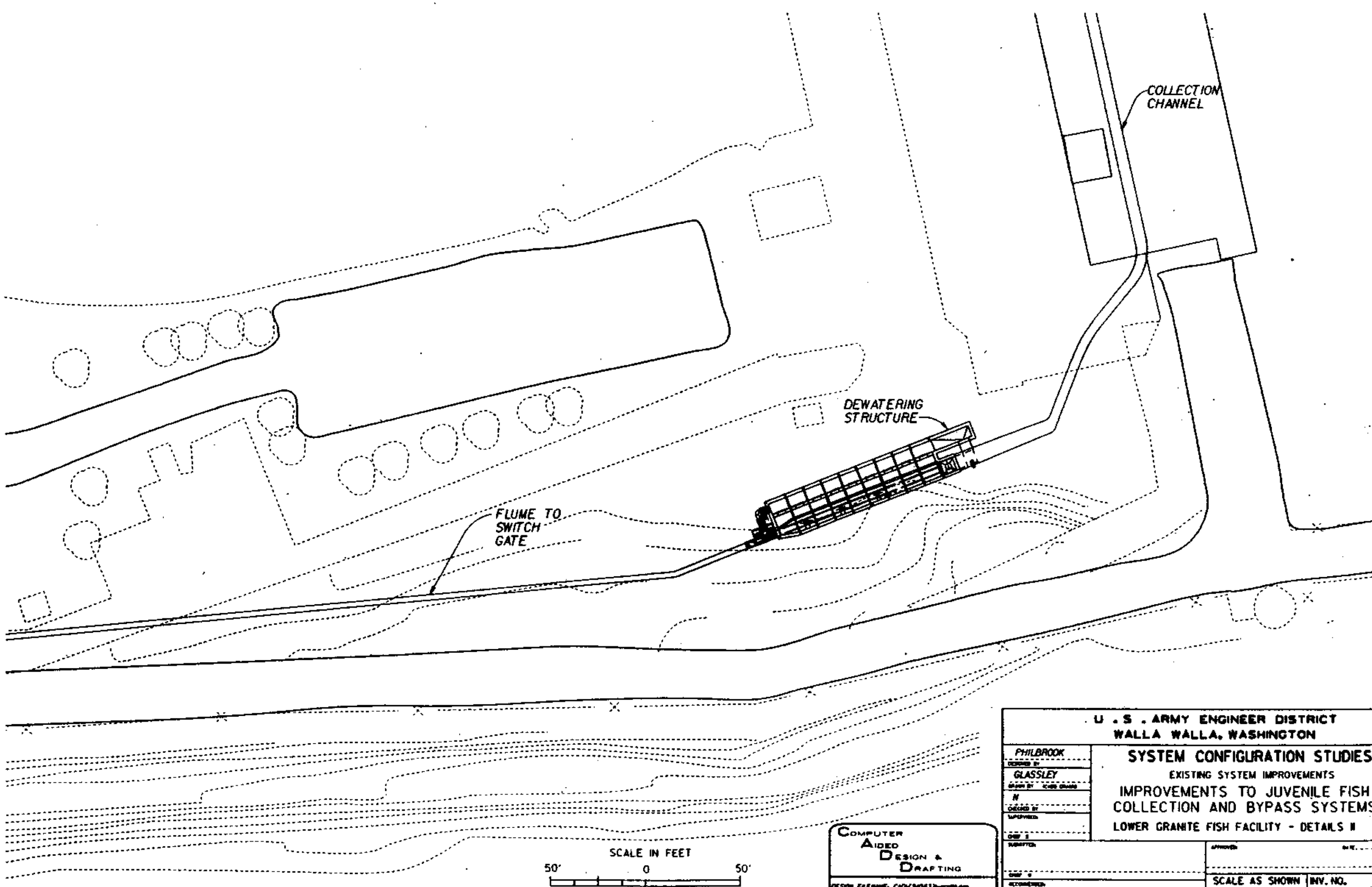
PHILBROOK
GLASSLEY

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

PLATE 9

CORPS OF ENGINEERS — SAFETY PAYS — U. S. ARMY



U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

PHILBROOK
GLASSLEY

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH COLLECTION AND BYPASS SYSTEMS
LOWER GRANITE FISH FACILITY - DETAILS II

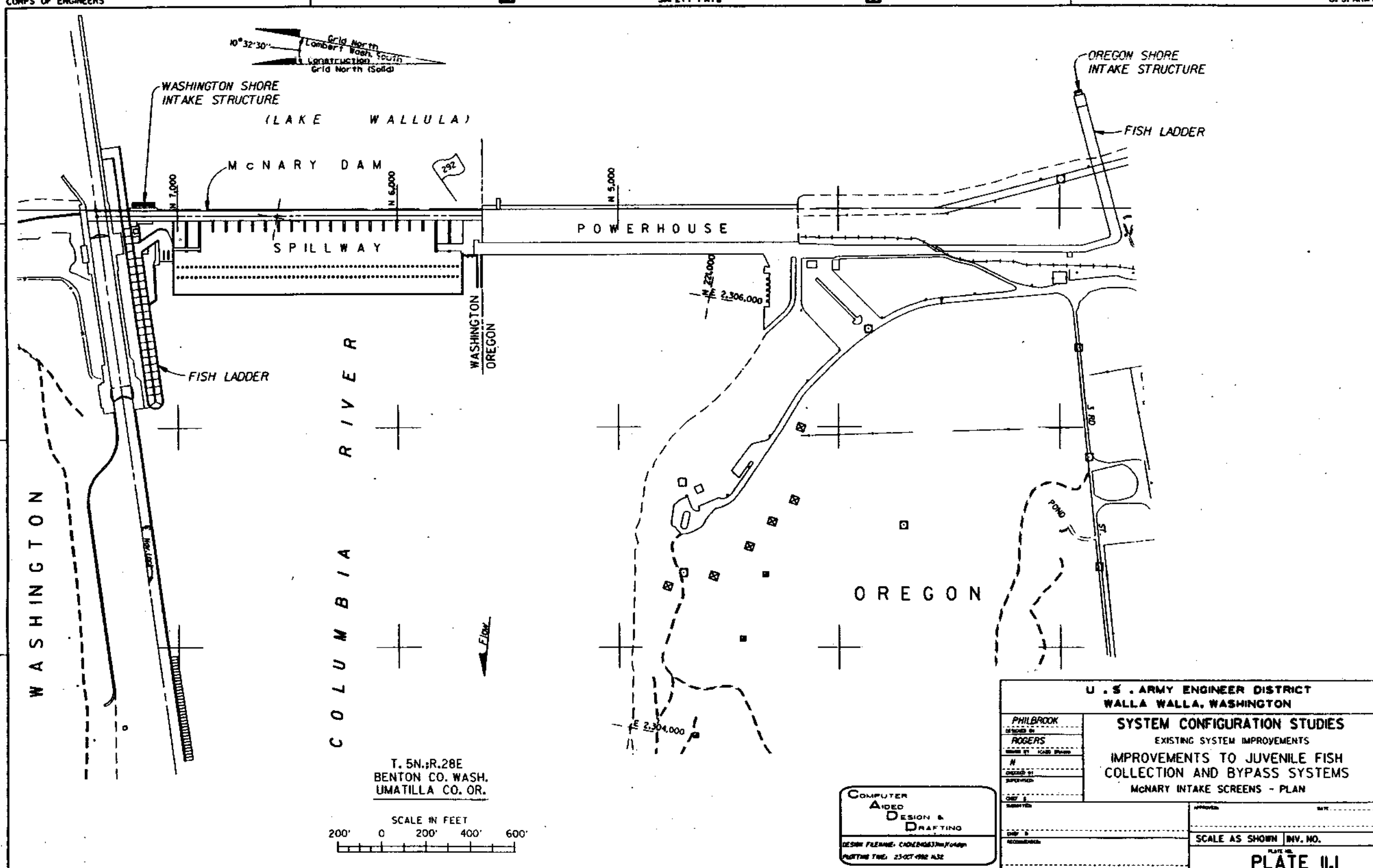
COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

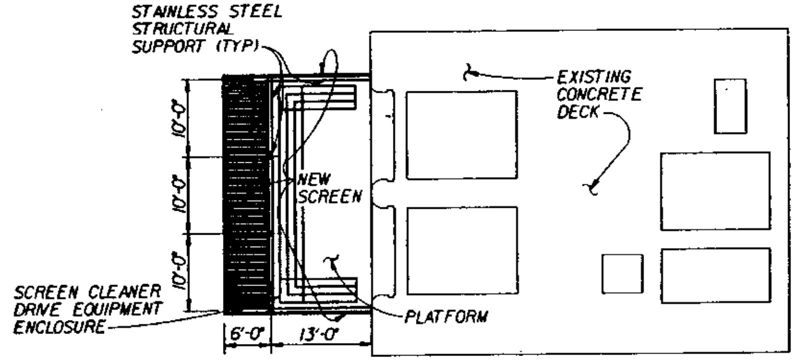
PLATE 10

VALUE ENGINEERING PAYS

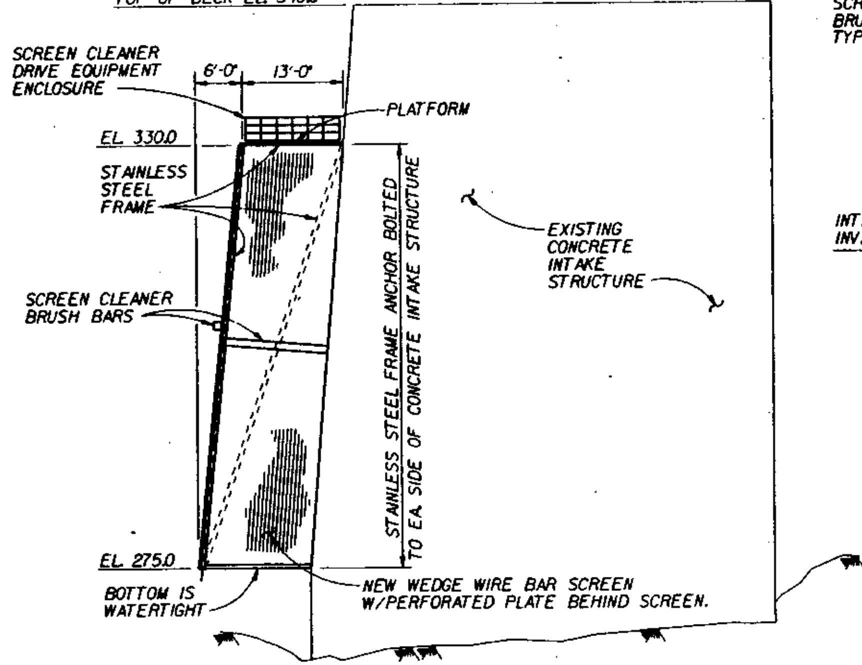
REFERENCE FILES: LGF.BLK
PEN TABLES: S
MAIN SCALE: 1:8


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
Grid North
Lambert Wash. South
Construction
Grid North (Solid)
10°32'30"
WASHINGTON SHORE INTAKE STRUCTURE
(LAKE WALLULA)
McNARY DAM
SPILLWAY
POWERHOUSE
N 7,000
N 6,000
N 5,000
292
OREGON SHORE INTAKE STRUCTURE
FISH LADDER
FISH LADDER
WASHINGTON
OREGON
N 22,000
E 2,306,000
E 2,304,000
COLUMBIA RIVER
Flow
WASHINGTON
OREGON
POND
Nav. Lock
T. 5N.;R.28E
BENTON CO. WASH.
UMATILLA CO. OR.
SCALE IN FEET
200' 0 200' 400' 600'
COMPUTER AIDED DESIGN & DRAFTING
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
PHILBROOK
ROGERS
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH
COLLECTION AND BYPASS SYSTEMS
McNARY INTAKE SCREENS - PLAN
SCALE AS SHOWN
INV. NO.
PLATE II.1
VALUE ENGINEERING PAYS
REFERENCE FILES: FSLBLK
PEN TABLES: NONE

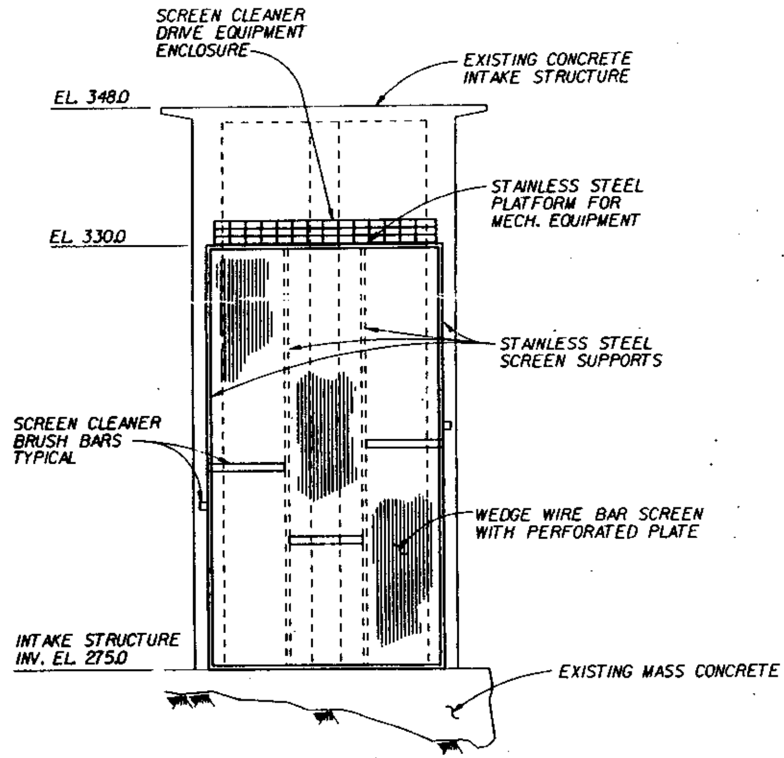
CORPS OF ENGINEERS — SAFETY PAYS — U. S. ARMY



PLAN AT ELEVATION 348.0



NORTH ELEVATION



UPSTREAM ELEVATION

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH
COLLECTION AND BYPASS SYSTEMS
MCNARY INTAKE SCREENS - OREGON SHORE

COLLISON
SHENEFIELD
H

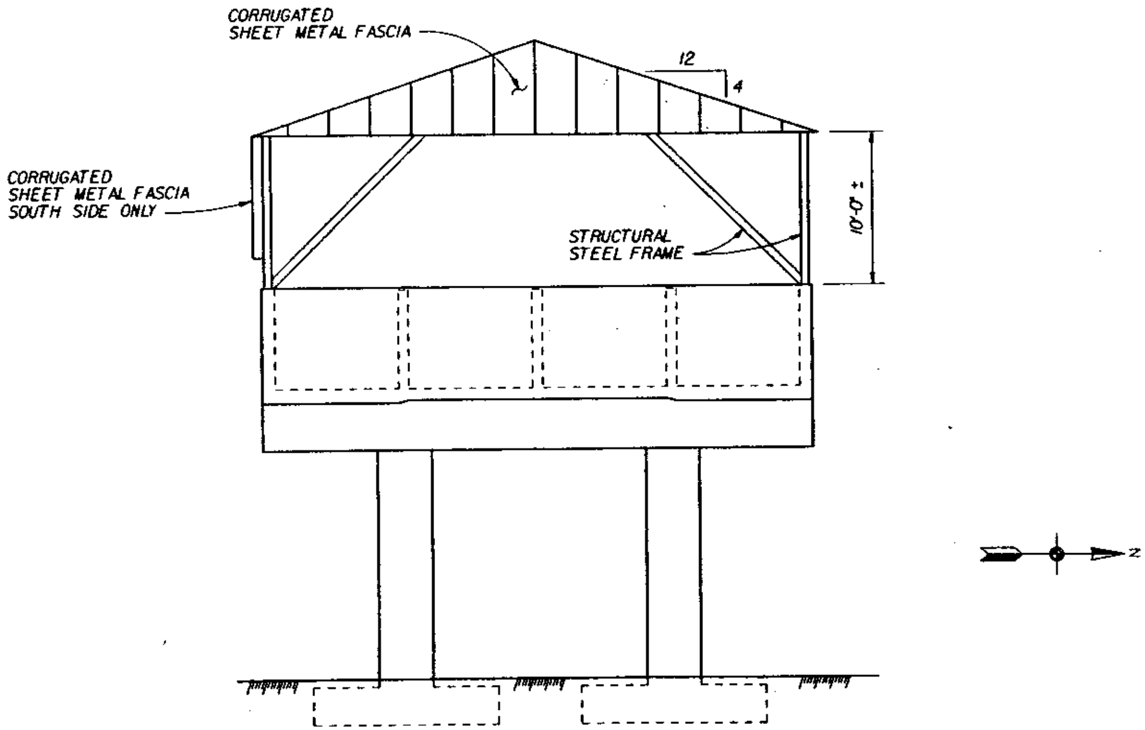
COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

PLATE 11.2

VALUE ENGINEERING PAYS

REFERENCE FILES: ESI.BLK,TB | PEN TABLES: S | MAIN SCALE: 1:8



ELEVATION

EXISTING RACEWAY WITH NEW SUNSHADE

SCALE IN FEET 0 5' 10'

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

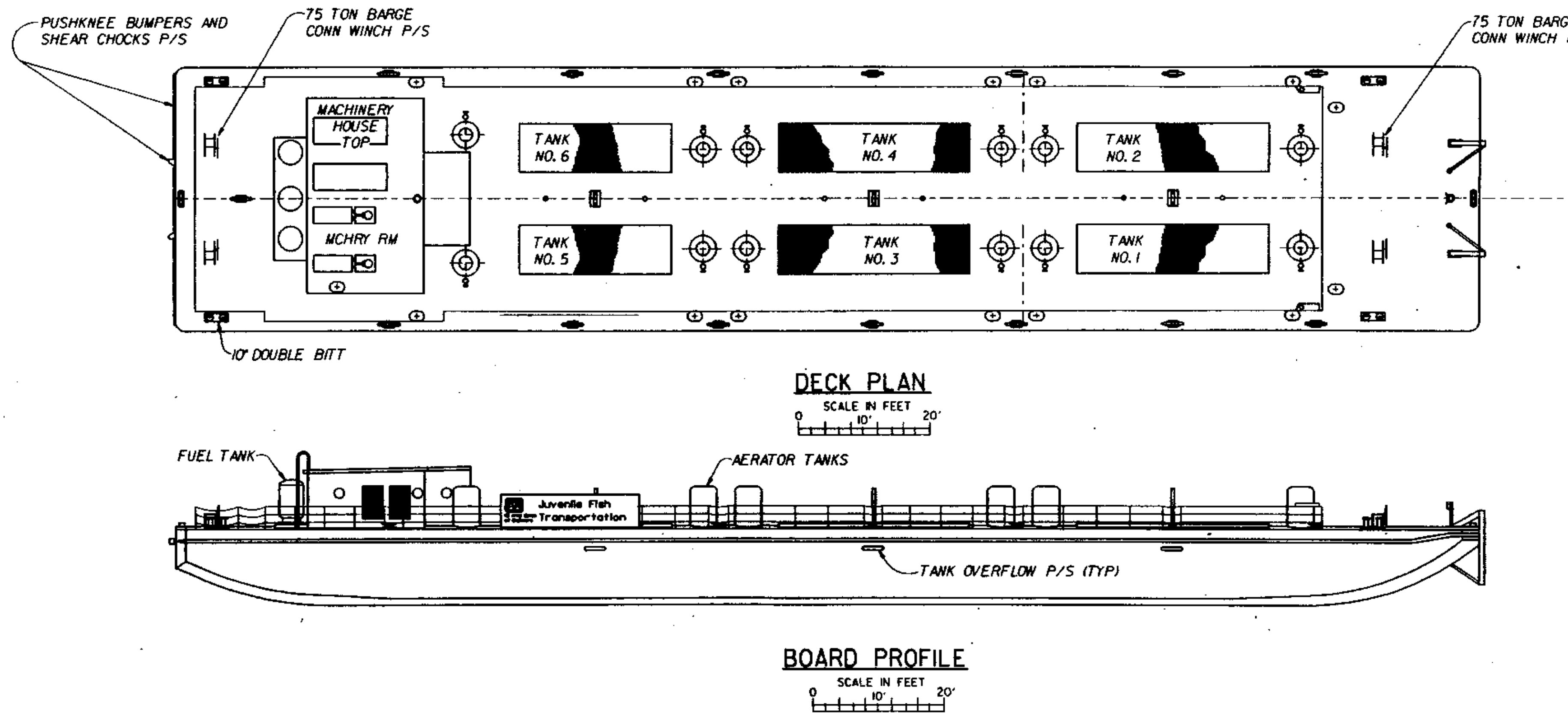
COLLISON
SHENEFIELD
N

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH
COLLECTION AND BYPASS
JUVENILE FACILITY SHADING

SCALE AS SHOWN | INV. NO.

PLATE II

REFERENCE FILES: ESI.BLK,TB PEN TABLES: S MAIN SCALE: 1:8



SCALED UP VERSION OF THE 75,000 LB. BARGE

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

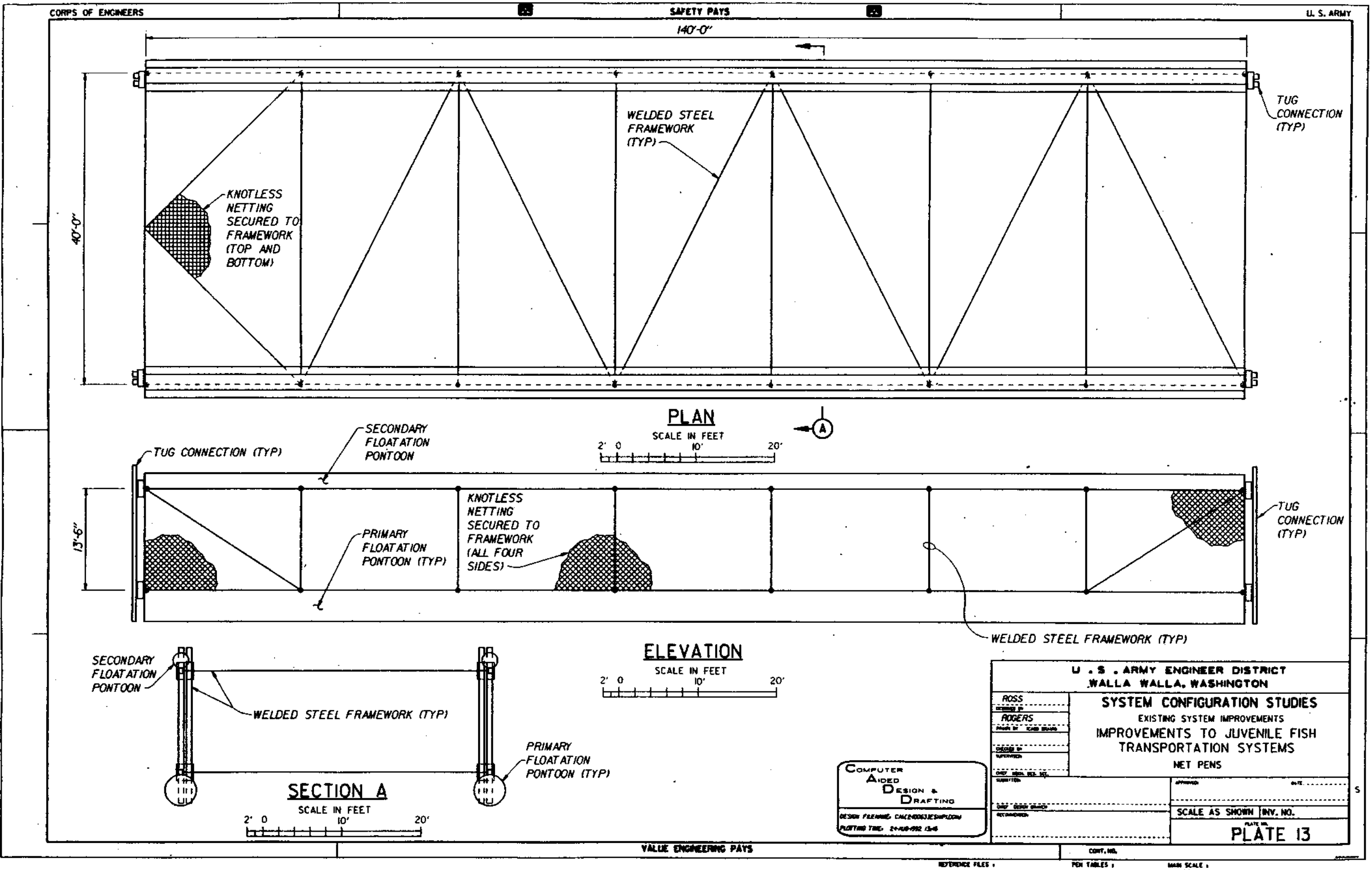
COULOMBE
ROGERS
N

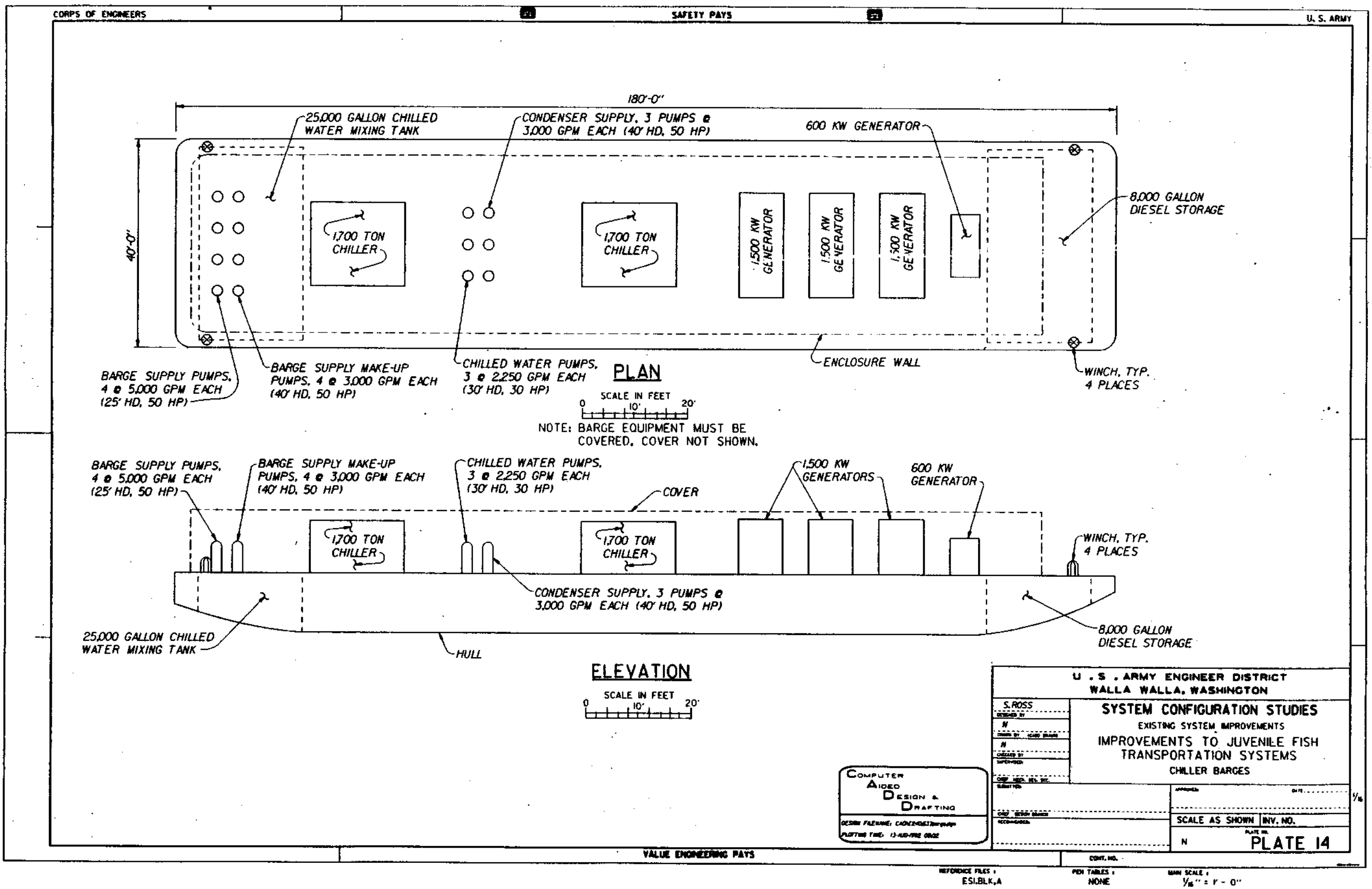
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH TRANSPORTATION SYSTEMS
NEW FISH BARGES

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

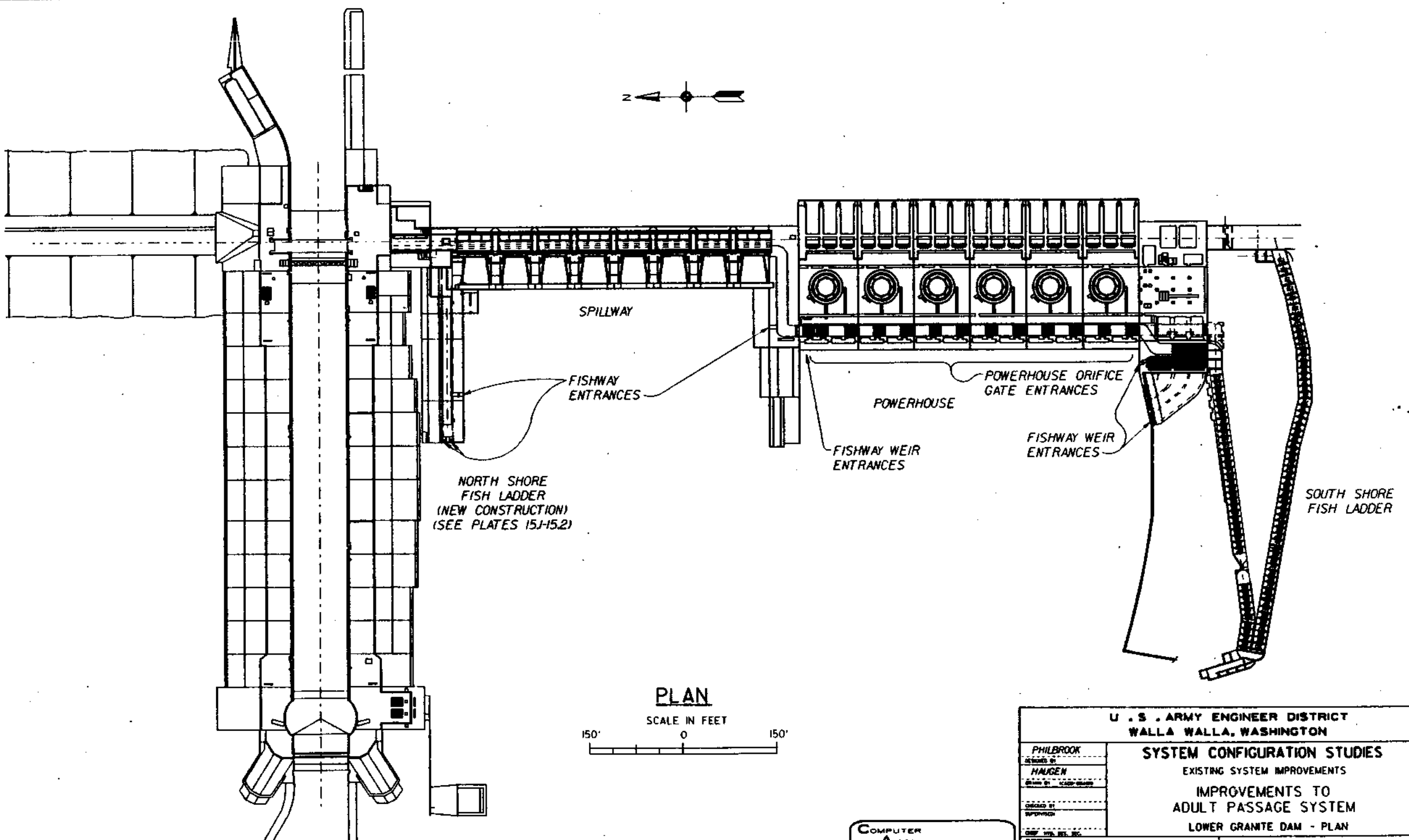
PLATE 12


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
140'-0"
40'-0"
TUG CONNECTION (TYP)
WELDED STEEL FRAMEWORK (TYP)
KNOTLESS NETTING SECURED TO FRAMEWORK (TOP AND BOTTOM)
PLAN
SCALE IN FEET
2' 0 10' 20'
A
SECONDARY FLOATATION PONTOON
TUG CONNECTION (TYP)
13'-6"
PRIMARY FLOATATION PONTOON (TYP)
KNOTLESS NETTING SECURED TO FRAMEWORK (ALL FOUR SIDES)
TUG CONNECTION (TYP)
WELDED STEEL FRAMEWORK (TYP)
ELEVATION
SCALE IN FEET
2' 0 10' 20'
SECONDARY FLOATATION PONTOON
WELDED STEEL FRAMEWORK (TYP)
PRIMARY FLOATATION PONTOON (TYP)
SECTION A
SCALE IN FEET
2' 0 10' 20'
COMPUTER AIDED DESIGN & DRAFTING
U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
ROSS
ROGERS
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH
TRANSPORTATION SYSTEMS
NET PENS
SCALE AS SHOWN
INV. NO.
PLATE 13
VALUE ENGINEERING PAYS
CONT. NO.
REFERENCE FILES :
PEN TABLES :
NO
MAIN SCALE :



CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
180'-0"
40'-0"
25,000 GALLON CHILLED WATER MIXING TANK
CONDENSER SUPPLY, 3 PUMPS @ 3,000 GPM EACH (40' HD, 50 HP)
600 KW GENERATOR
1,700 TON CHILLER
1,700 TON CHILLER
1,500 KW GENERATOR
1,500 KW GENERATOR
1,500 KW GENERATOR
8,000 GALLON DIESEL STORAGE
BARGE SUPPLY PUMPS, 4 @ 5,000 GPM EACH (25' HD, 50 HP)
BARGE SUPPLY MAKE-UP PUMPS, 4 @ 3,000 GPM EACH (40' HD, 50 HP)
CHILLED WATER PUMPS, 3 @ 2,250 GPM EACH (30' HD, 30 HP)
ENCLOSURE WALL
WINCH, TYP. 4 PLACES
PLAN
SCALE IN FEET
0
10'
20'
NOTE: BARGE EQUIPMENT MUST BE COVERED. COVER NOT SHOWN.
BARGE SUPPLY PUMPS, 4 @ 5,000 GPM EACH (25' HD, 50 HP)
BARGE SUPPLY MAKE-UP PUMPS, 4 @ 3,000 GPM EACH (40' HD, 50 HP)
CHILLED WATER PUMPS, 3 @ 2,250 GPM EACH (30' HD, 30 HP)
COVER
1,500 KW GENERATORS
600 KW GENERATOR
1,700 TON CHILLER
1,700 TON CHILLER
WINCH, TYP. 4 PLACES
CONDENSER SUPPLY, 3 PUMPS @ 3,000 GPM EACH (40' HD, 50 HP)
25,000 GALLON CHILLED WATER MIXING TANK
HULL
8,000 GALLON DIESEL STORAGE
ELEVATION
SCALE IN FEET
0
10'
20'
U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
S. ROSS
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO JUVENILE FISH TRANSPORTATION SYSTEMS
CHILLER BARGES
COMPUTER AIDED DESIGN & DRAFTING
SCALE AS SHOWN
INV. NO.
N
PLATE 14
VALUE ENGINEERING PAYS
REFERENCE FILES :
ESI.BLK,A
PEN TABLES :
NONE
MAIN SCALE :
$1/16" = 1' - 0"$

CORPS OF ENGINEERS SAFETY PAYS U. S. ARMY



PLAN

SCALE IN FEET

150' 0 150'

U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

PHILBROOK
HAUGEN

SYSTEM CONFIGURATION STUDIES

EXISTING SYSTEM IMPROVEMENTS

IMPROVEMENTS TO
ADULT PASSAGE SYSTEM

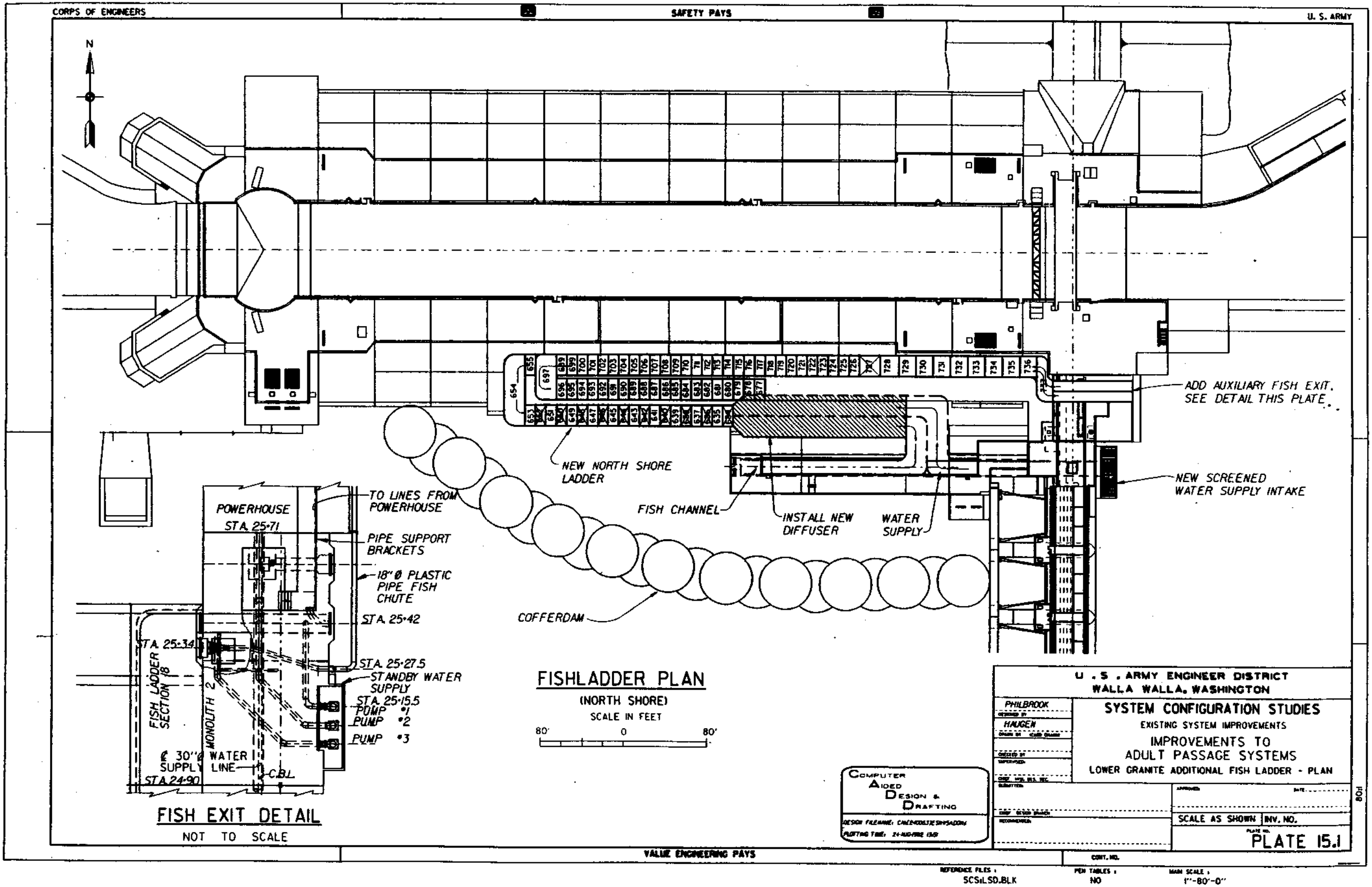
LOWER GRANITE DAM - PLAN

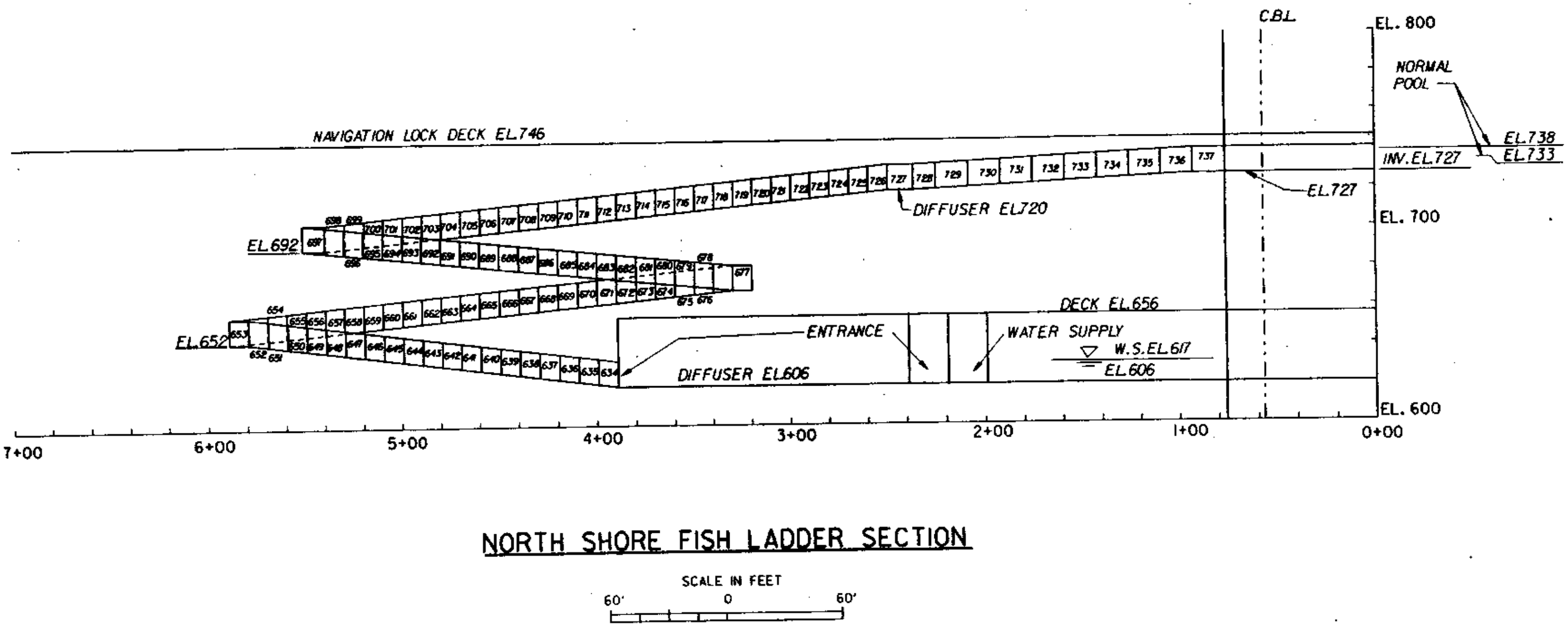
SCALE AS SHOWN INV. NO.

PLATE 15

COMPUTER AIDED DESIGN & DRAFTING

VALUE ENGINEERING PAYS


CORPS OF ENGINEERS
SAFETY PAYS
U. S. ARMY
N
ADD AUXILIARY FISH EXIT. SEE DETAIL THIS PLATE
NEW SCREENED WATER SUPPLY INTAKE
NEW NORTH SHORE LADDER
FISH CHANNEL
INSTALL NEW DIFFUSER
WATER SUPPLY
COFFERDAM
POWERHOUSE STA 25+71
TO LINES FROM POWERHOUSE
PIPE SUPPORT BRACKETS
18"Ø PLASTIC PIPE FISH CHUTE
STA 25+42
STA 25+34
STA 25+27.5
STANDBY WATER SUPPLY
STA 25+15.5
PUMP #1
PUMP #2
PUMP #3
FISH LADDER SECTION 18
MONOLITH 2
℄ 30"Ø WATER SUPPLY LINE
C.B.L.
STA 24+90
FISH EXIT DETAIL
NOT TO SCALE
FISHLADDER PLAN
(NORTH SHORE)
SCALE IN FEET
80' 0 80'
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON
PHILBROOK
HAUGEN
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS
LOWER GRANITE ADDITIONAL FISH LADDER - PLAN
COMPUTER AIDED DESIGN & DRAFTING
SCALE AS SHOWN
INV. NO.
PLATE 15.1
VALUE ENGINEERING PAYS
REFERENCE FILES : SCS1LSD.BLK
PEN TABLES : NO
MAIN SCALE : 1"-80'-0"



NORTH SHORE FISH LADDER SECTION

U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

PHILBROOK
LEIGH

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS
LOWER GRANITE ADDITIONAL FISH LADDER - ELEVATION

Computer Aided Design & Drafting

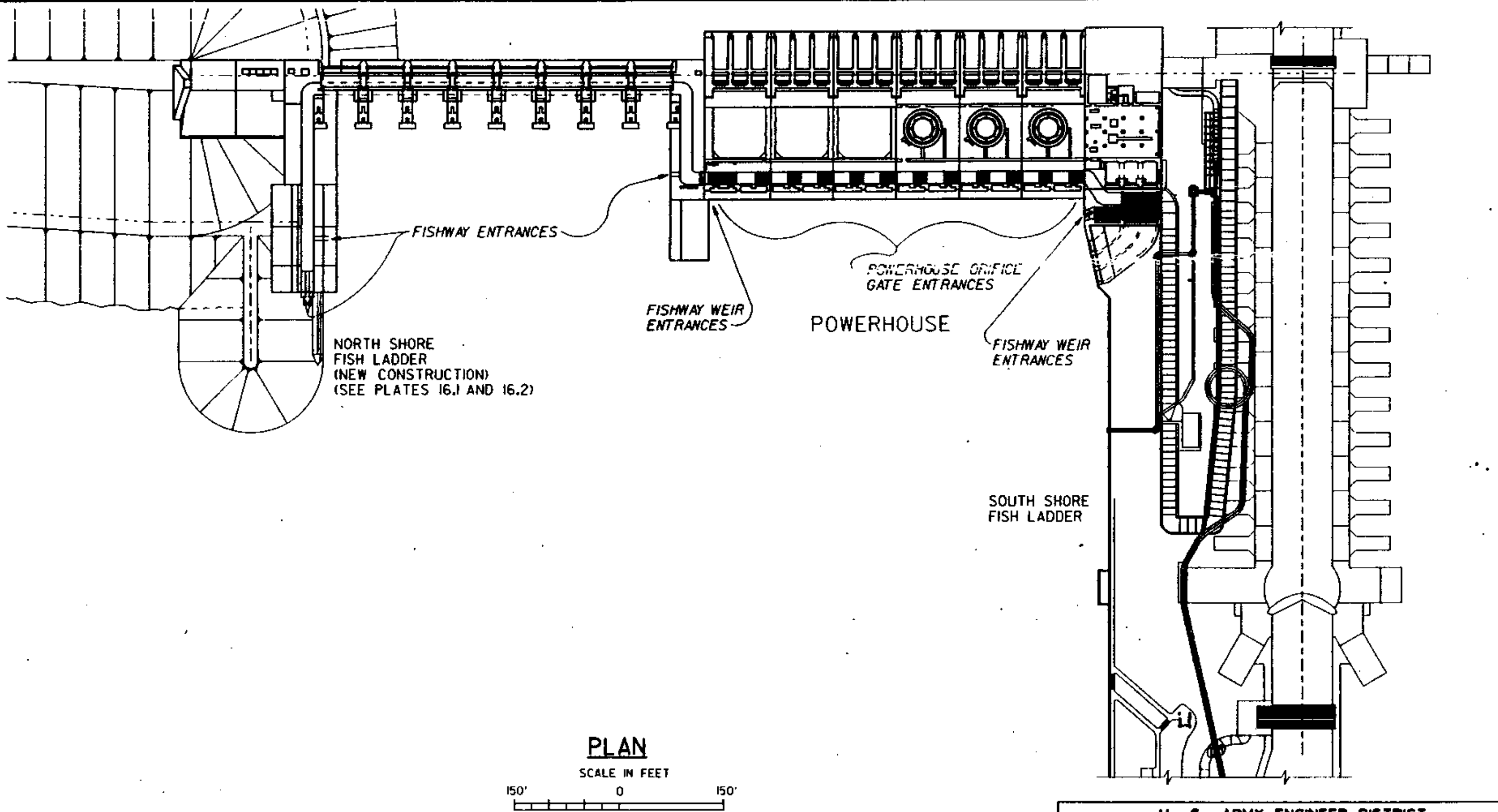
SCALE AS SHOWN | INV. NO.

PLATE 15.2

094

REFERENCE FILES : SCSd.SD.BLK
PEN TABLES : NO
MAIN SCALE : 1"=60'-0"

CORPS OF ENGINEERS | SAFETY PAYS | U. S. ARMY



PLAN

SCALE IN FEET

150' 0 150'

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

PHILBROOK
HAUGEN

SYSTEM CONFIGURATION STUDIES

EXISTING SYSTEM IMPROVEMENTS

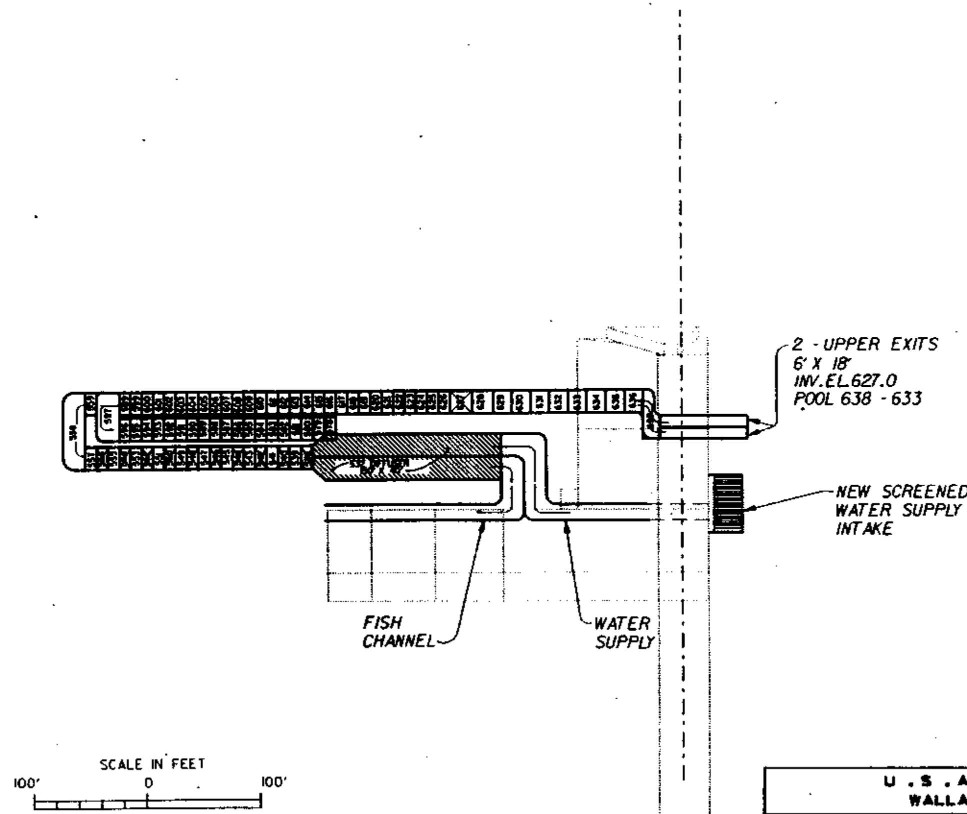
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS

LITTLE GOOSE DAM - PLAN

SCALE AS SHOWN | INV. NO.

PLATE 16

VALUE ENGINEERING PAYS



U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

PHILBROOK
LEIGH
N

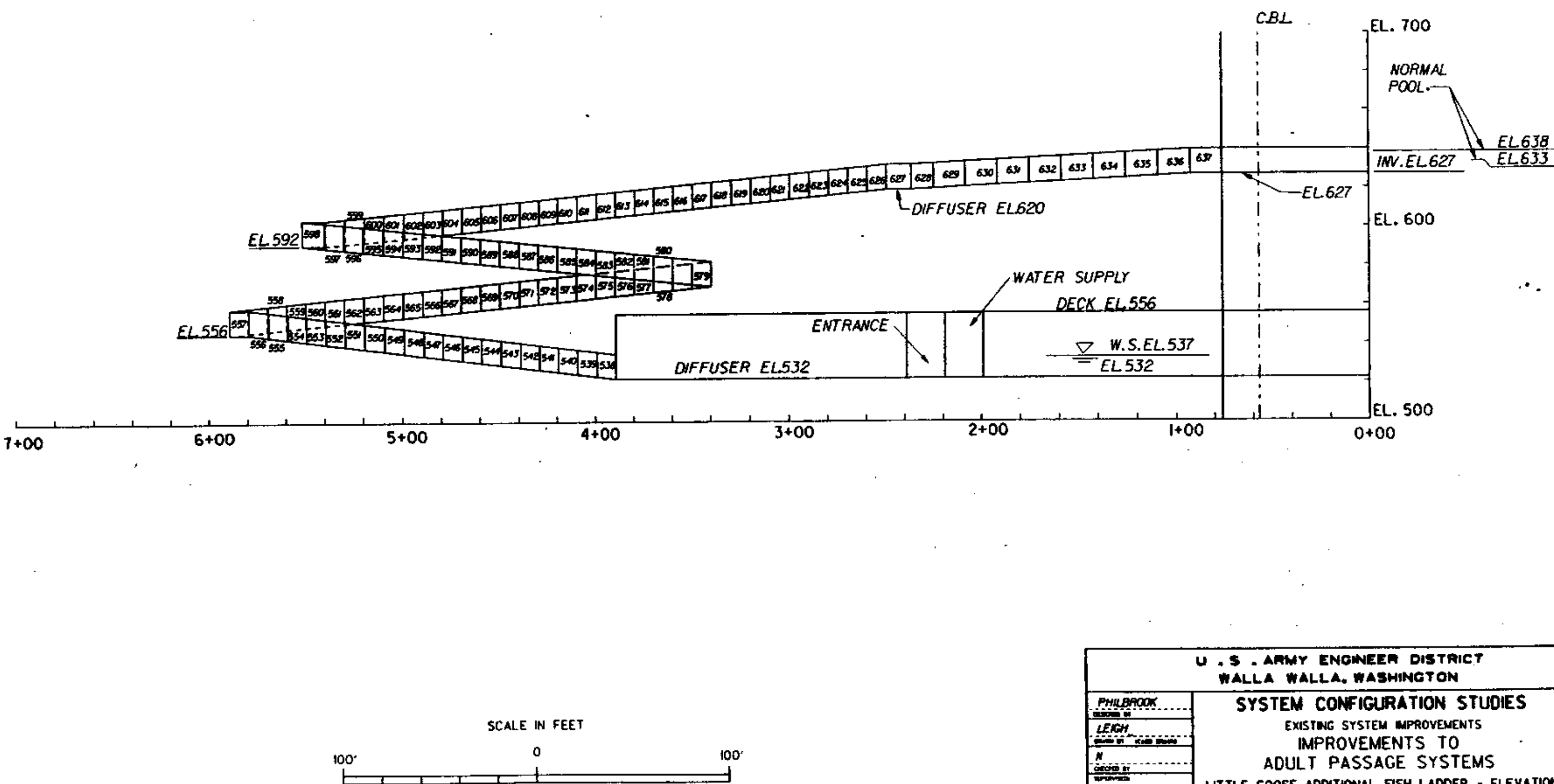
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS
LITTLE GOOSE ADDITIONAL FISH LADDER - PLAN

Computer Aided Design & Drafting

SCALE AS SHOWN | INV. NO.

PLATE 16.1

REFERENCE FILES: MONOLITH.DGN MONOLTH2.DGN
PEN TABLES: NFLP.IPL
MAIN SCALE: S



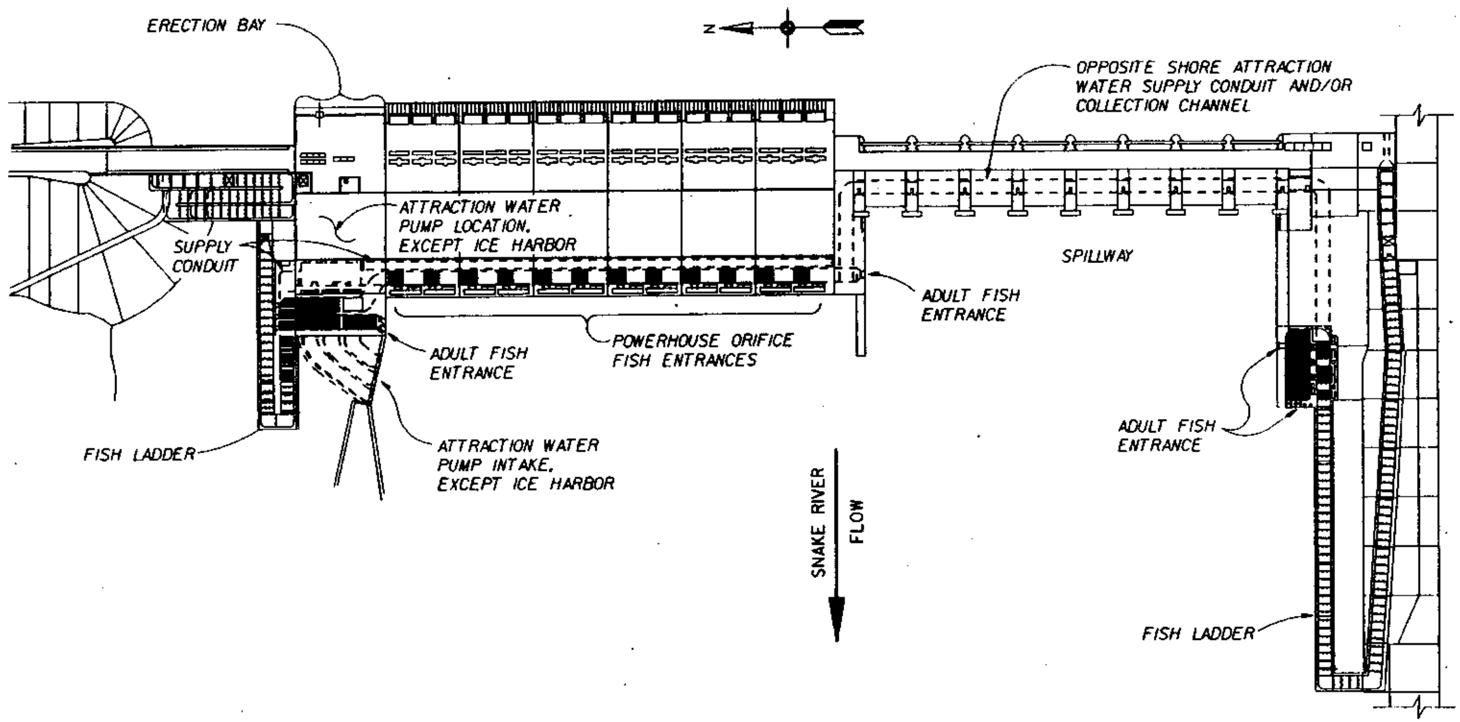
U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

PHILBROOK
LEIGH

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS
LITTLE GOOSE ADDITIONAL FISH LADDER - ELEVATION

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN
INV. NO.
PLATE 16.2



NOTES:

- LOWER MONUMENTAL DAM IS SHOWN AS A REPRESENTATION, OTHER PROJECTS ARE SIMILAR WITH DIFFERENCES DISCUSSED IN THE TEXT

■ - DENOTES TYPICAL DIFFUSER LOCATION

TYPICAL DIFFUSER LOCATIONS

SCALE IN FEET
150' 0 150'

U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

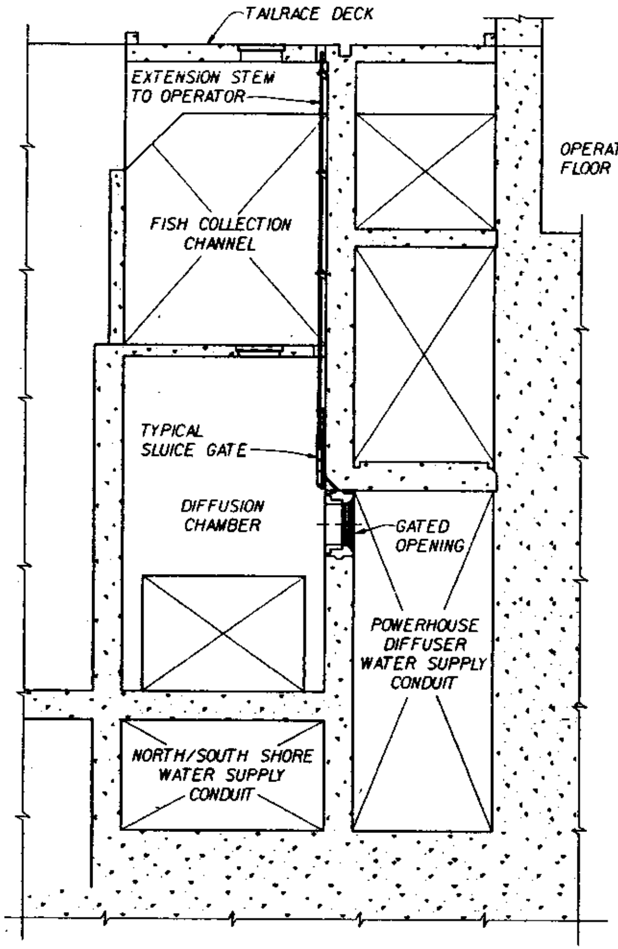
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO ADULT PASSAGE SYSTEMS
ADULT ATTRACTION WATER - TYPICAL DIFFUSER LOCATIONS

C. PALMER
HAUGEN

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

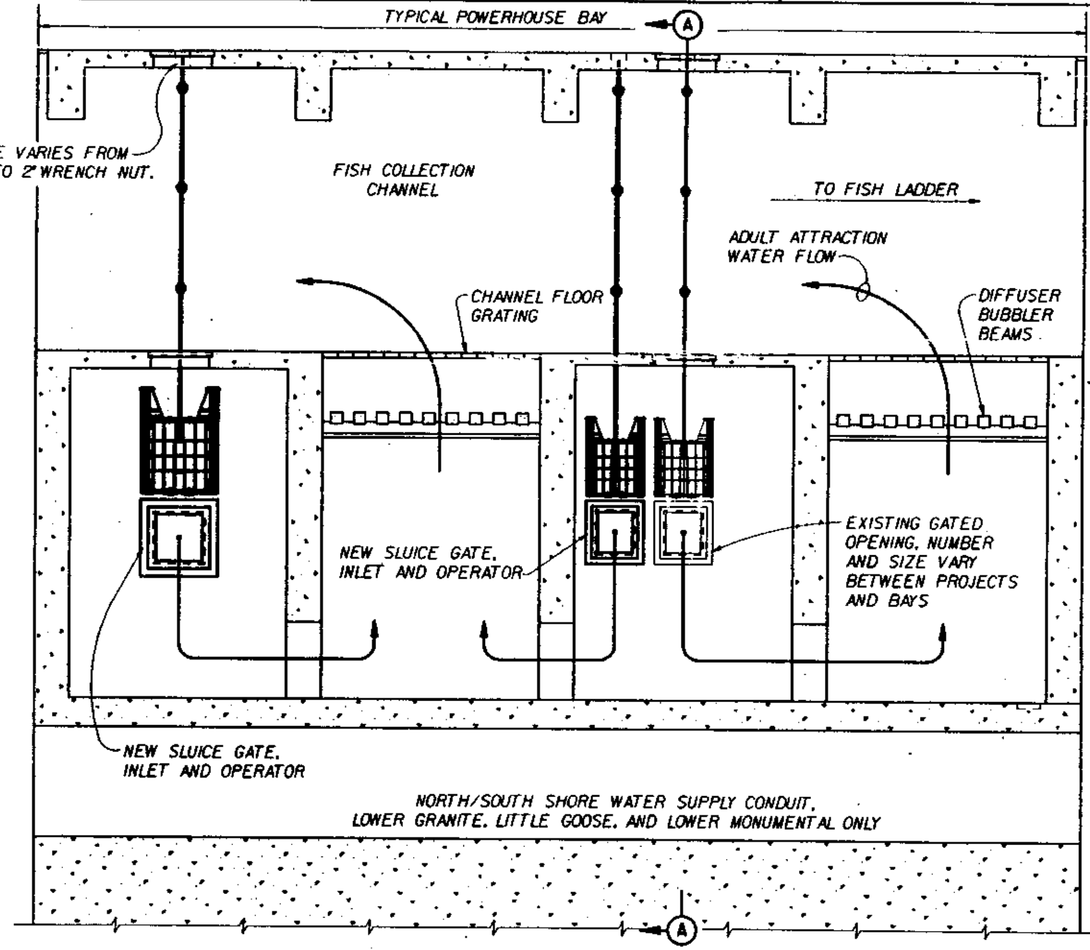
PLATE 17



SECTION A

SCALE IN FEET 12" 0 5' 10'

NOTE: ACTUAL CONFIGURATIONS INCLUDING NUMBER AND SIZE OF GATED OPENINGS VARIES.



SECTION THRU POWERHOUSE BAY

(TYPICAL DIFFUSER LOOKING UP-RIVER)

SCALE IN FEET 12" 0 5' 10'

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

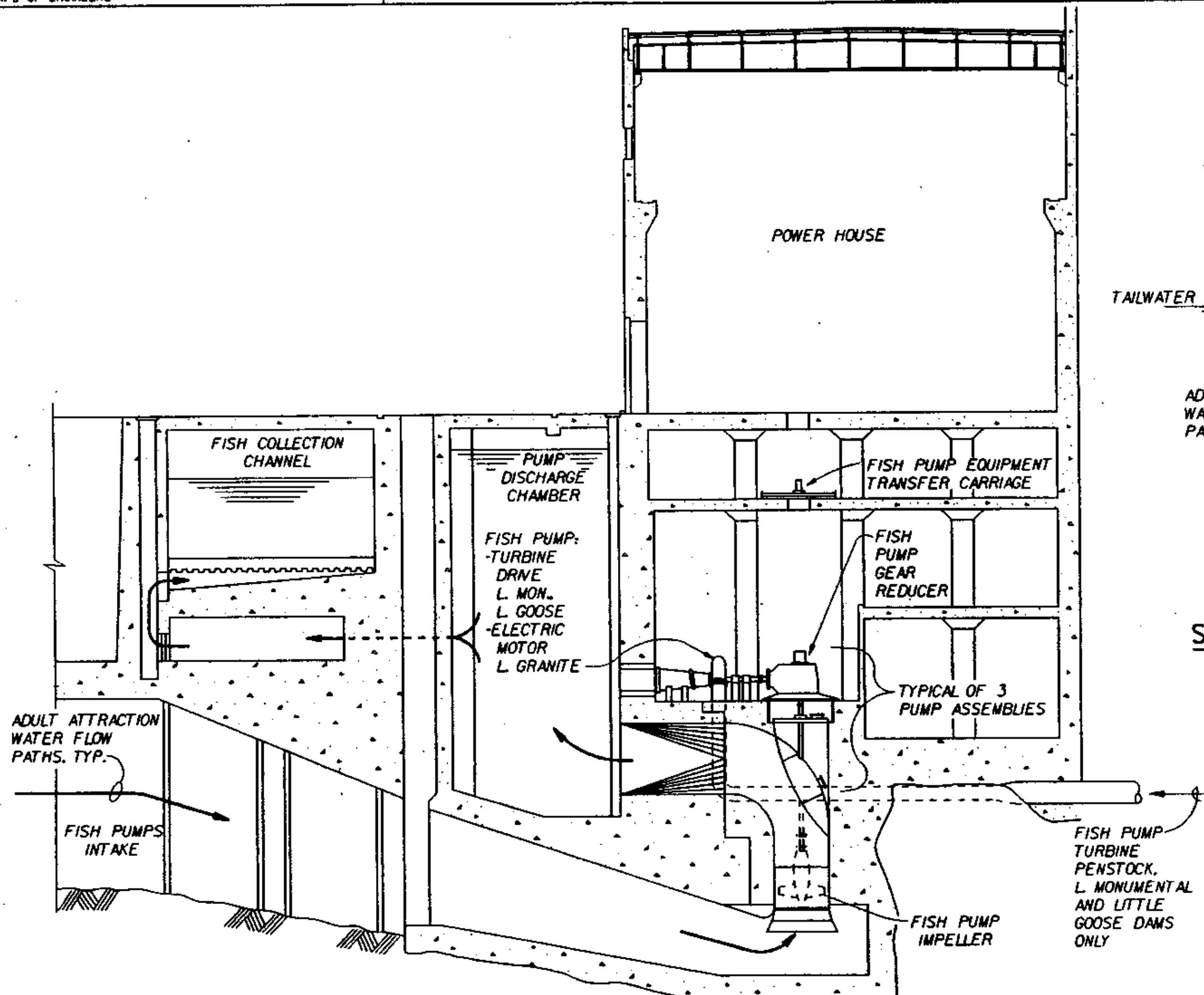
PALMER
ROGERS

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS
ADULT ATTRACTION WATER -
DIFFUSER AND GATE DETAILS

SCALE AS SHOWN | INV. NO.

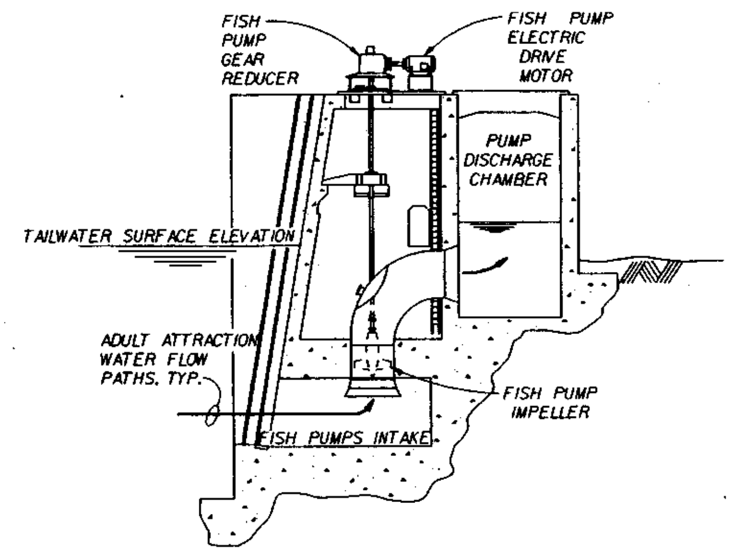
PLATE 18

REFERENCE FILES: ESLBLK
PEN TABLES: NO
MAIN SCALE: 1/8"=1'



SECTION THRU ATTRACTION WATER PUMP

(LITTLE GOOSE SHOWN, LOWER GRANITE AND LOWER MONUMENTAL ARE SIMILAR)



SECTION THRU ATTRACTION WATER PUMP

(ICE HARBOR SOUTH SHORE SHOWN, NORTH SHORE INSTALLATION SIMILAR)

COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

C. PALMER
HAUGEN

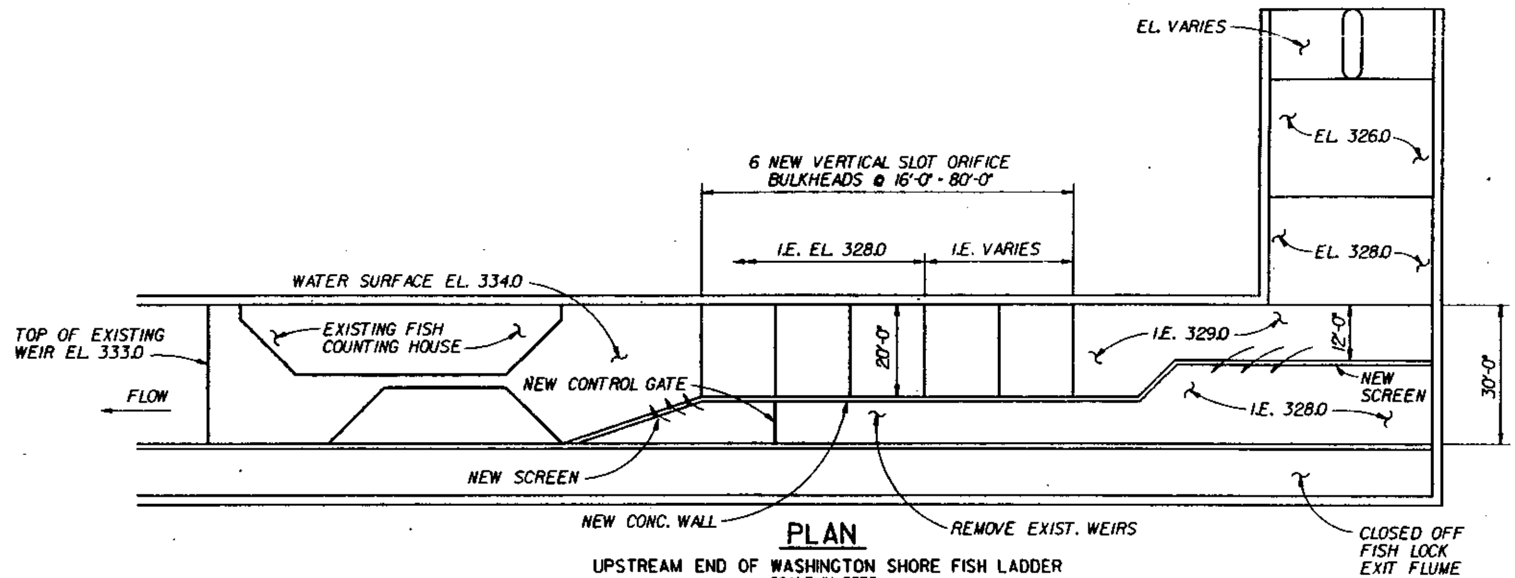
SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS
ADULT ATTRACTION WATER - TYPICAL PUMP INSTALLATION

SCALE AS SHOWN | INV. NO.

PLATE 19

3:64

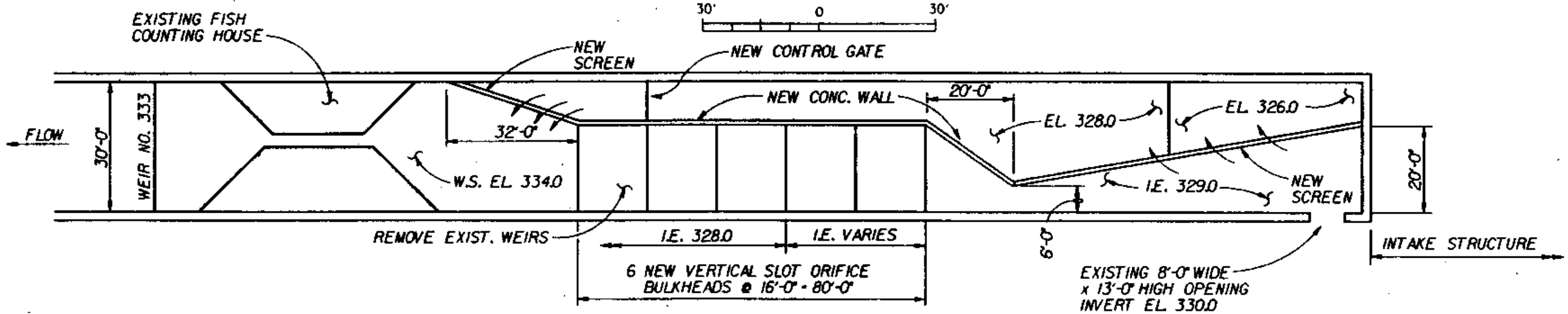
REFERENCE FILES: SCS:ESLBLK,TB PEN TABLES: NO MAIN SCALE: 3/64"=1'-0"



PLAN

UPSTREAM END OF WASHINGTON SHORE FISH LADDER
SCALE IN FEET

30' 0 30'



WHEN RAISED, GATE BOTTOM MUST REACH EL. 337.0 OR HIGHER.
WHEN LOWERED, TOP AT EL. 338.0.

PLAN

UPSTREAM END OF OREGON SHORE FISH LADDER
SCALE IN FEET

30' 0 30'

COMPUTER AIDED DESIGN & DRAFTING

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

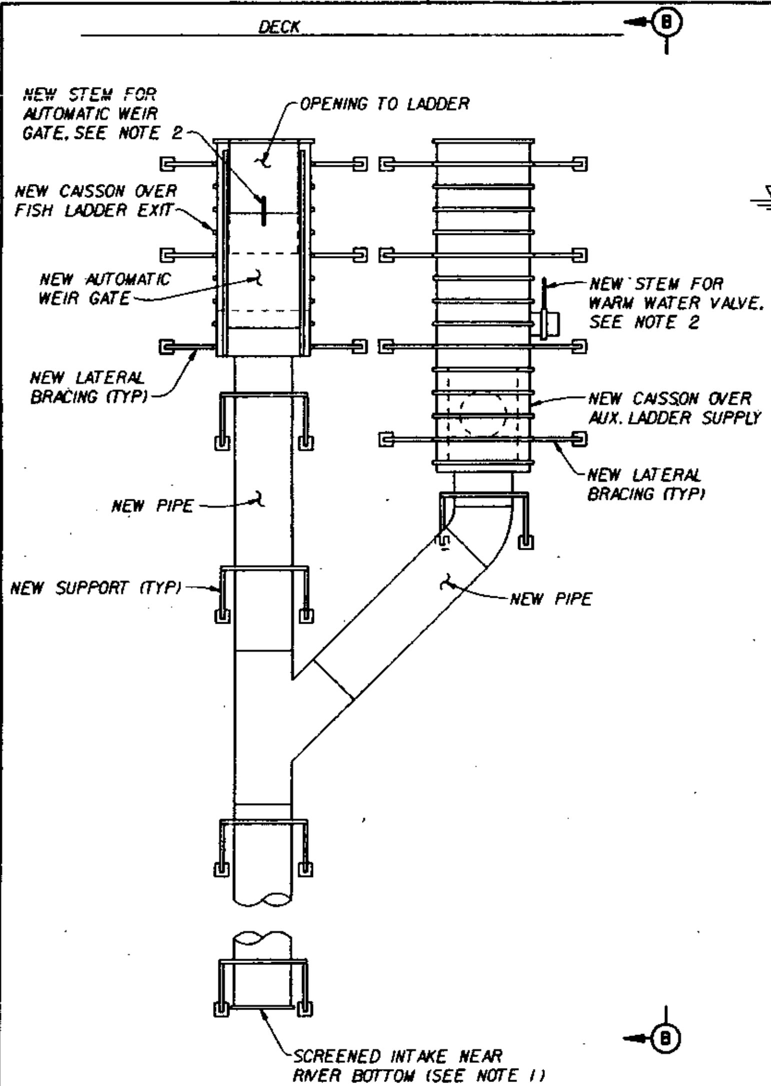
PHILBROOK/COLLISON
SHENEFIELD

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS
McNARY FISH LADER EXITS

SCALE AS SHOWN | INV. NO.

PLATE 20

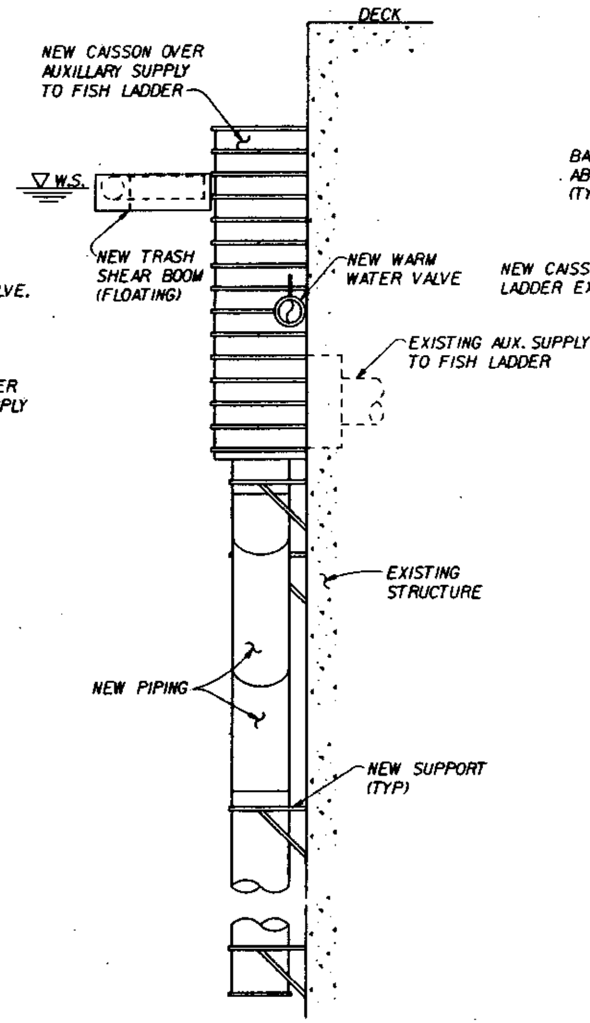
REFERENCE FILES: ESI.BLK,TB PEN TABLES: 5 MAIN SCALE: 1:8



SECTIONAL ELEVATION A

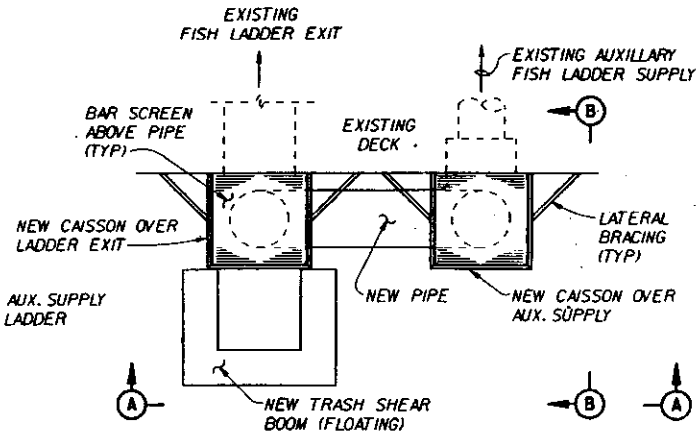
SCALE IN FEET
0 10' 20'

NOTE:
TRASH SHEAR BOOM
NOT SHOWN



SECTIONAL ELEVATION B

SCALE IN FEET
0 10' 20'



PLAN

SCALE IN FEET
0 10' 20'

NOTES:

1. SCREENED SURFACES WILL REQUIRE SOME FORM OF CLEANING DEVICE SUCH AS A CABLE OPERATED RAKE OR WATER BACK-FLUSH SYSTEM.
2. EXTEND GATE/VALVE STEMS TO OPERATOR (NOT SHOWN) LOCATED AT DECK ELEVATION.

U . S . ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

S.ROSS
S.ROSS
N

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO ADULT
PASSAGE SYSTEMS
FISH LADDER TEMPERATURE CONTROL

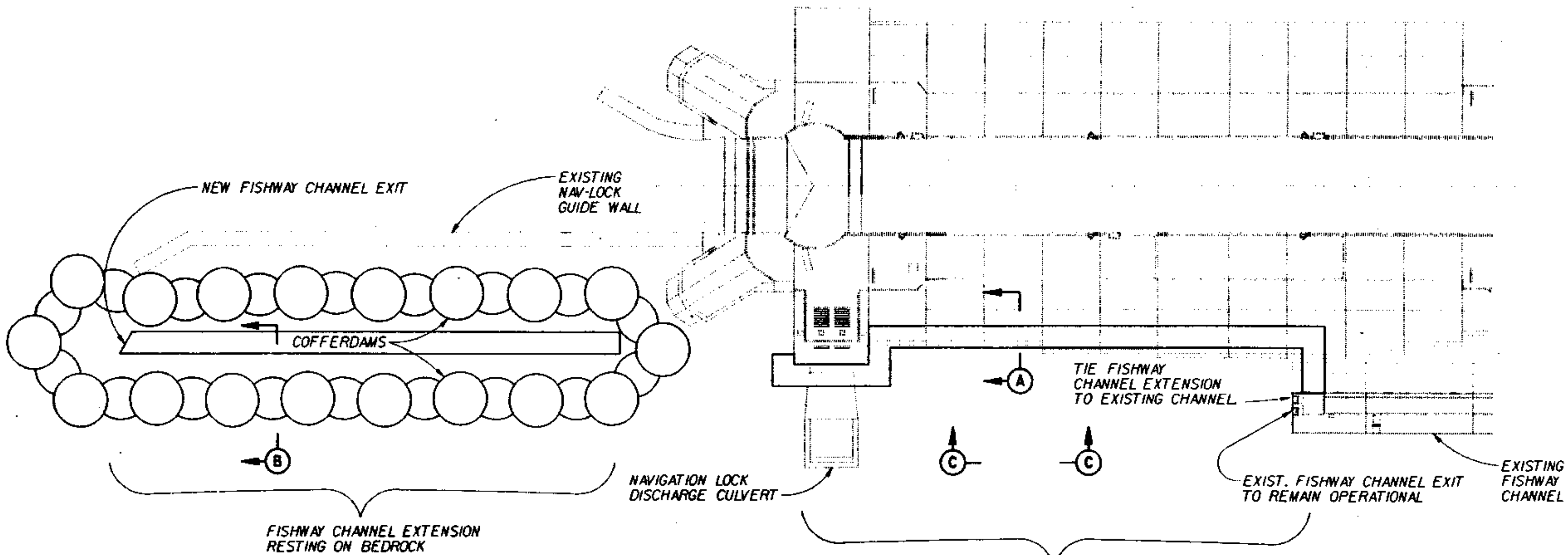
COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

PLATE 20.1

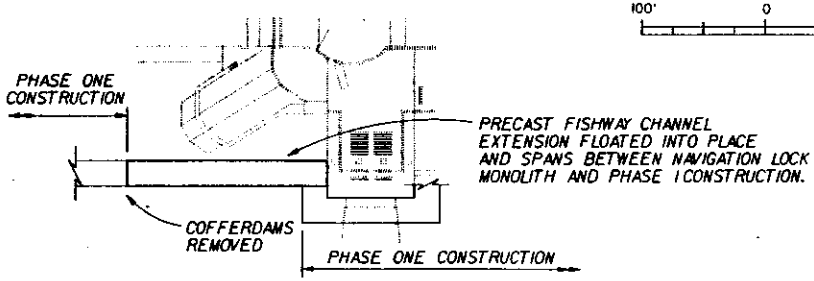
REFERENCE FILES: ESI.BLK, A
PEN TABLES: NONE
MAIN SCALE: 128:1

CORPS OF ENGINEERS — SAFETY PAYS — U. S. ARMY



PHASE ONE CONSTRUCTION - PLAN

SCALE IN FEET
100' 0 100'



PHASE TWO CONSTRUCTION - PLAN

SCALE IN FEET
100' 0 100'

NOTE :
1. EXISTING FEATURES SHOWN IN LIGHT LINES.
2. SECTIONAL VIEWS SHOWN ON PLATE 22.

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

COLLISON
SHENEFIELD

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS
LOWER GRANITE DAM FISHWAY CHANNEL EXTENSION
PLAN

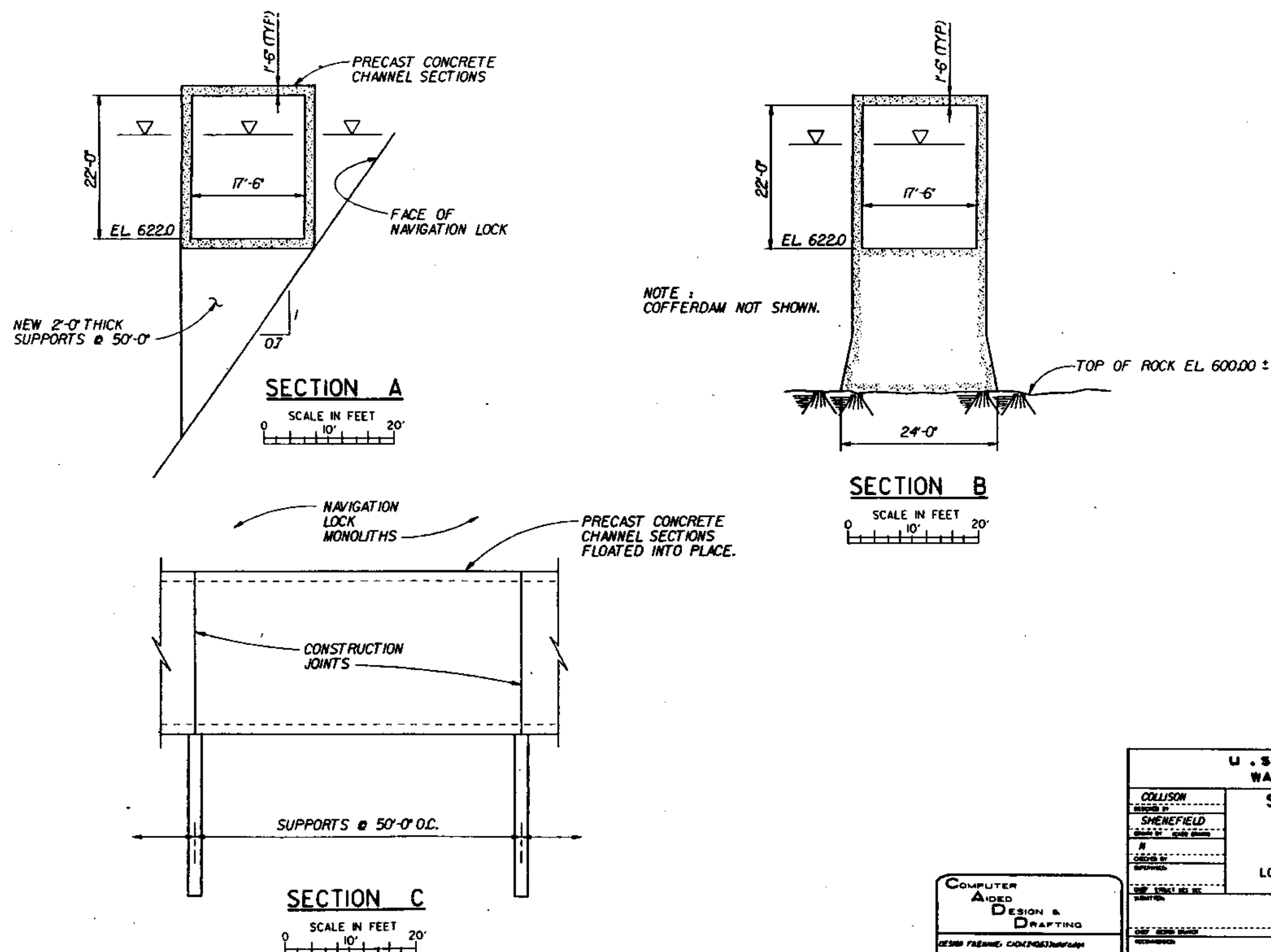
COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

PLATE 21

VALUE ENGINEERING PAYS

REFERENCE FILES : ESLBLK esligran.dgn,lg
PEN TABLES : ESKEV.IPL
MAIN SCALE : 1:100



COMPUTER AIDED DESIGN & DRAFTING

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

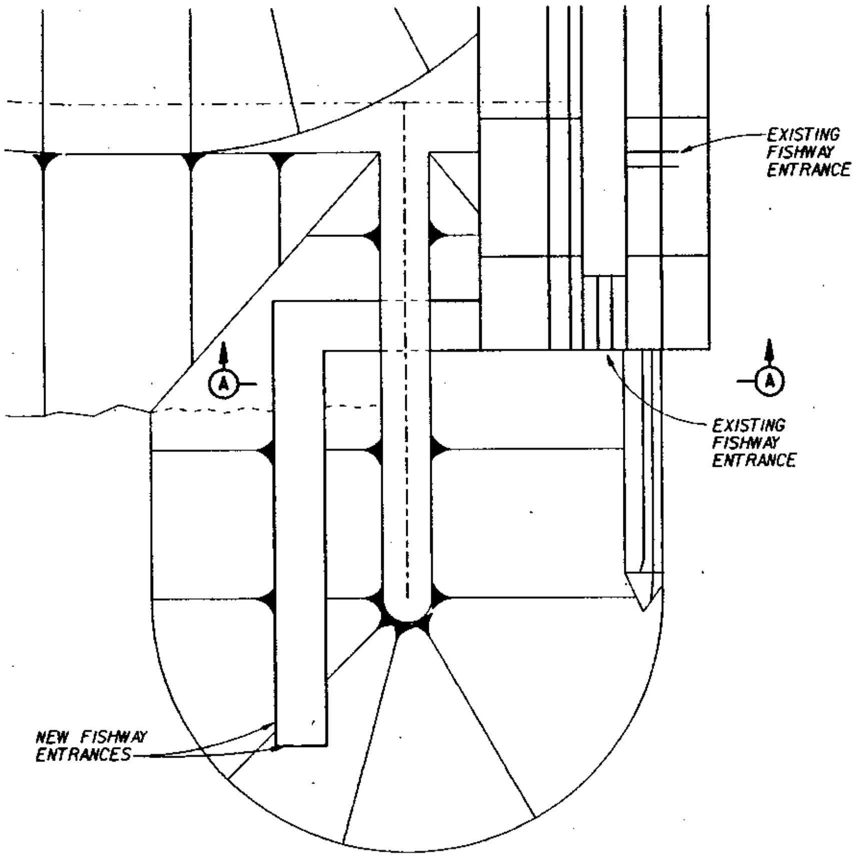
COLLISON
SHENEFIELD

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS
LOWER GRANITE FISHWAY CHANNEL EXTENSION
SECTIONS

SCALE AS SHOWN | INV. NO.

PLATE 22

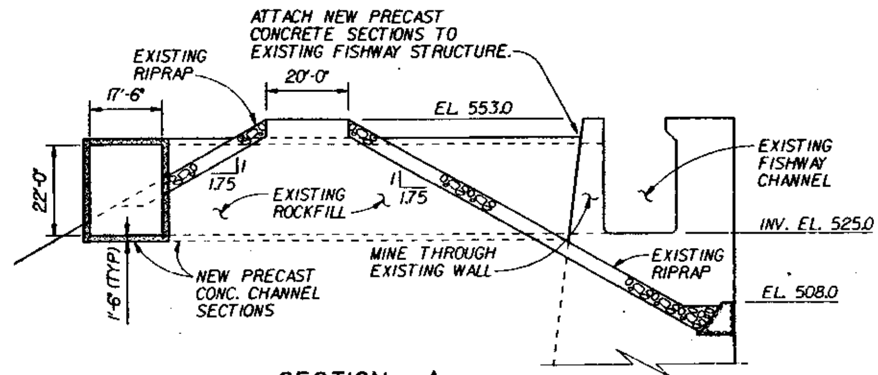
REFERENCE FILES : ESI.BLK.TB
PEN TABLES : S
MAIN SCALE : 1:8



PLAN

SCALE IN FEET

50' 0 50'



SECTION A

SCALE IN FEET

30' 0 30'

COMPUTER AIDED DESIGN & DRAFTING

U.S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

COLLISON
SHENEFIELD
N

SYSTEM CONFIGURATION STUDIES

EXISTING SYSTEM IMPROVEMENTS

IMPROVEMENTS TO
ADULT PASSAGE SYSTEMS

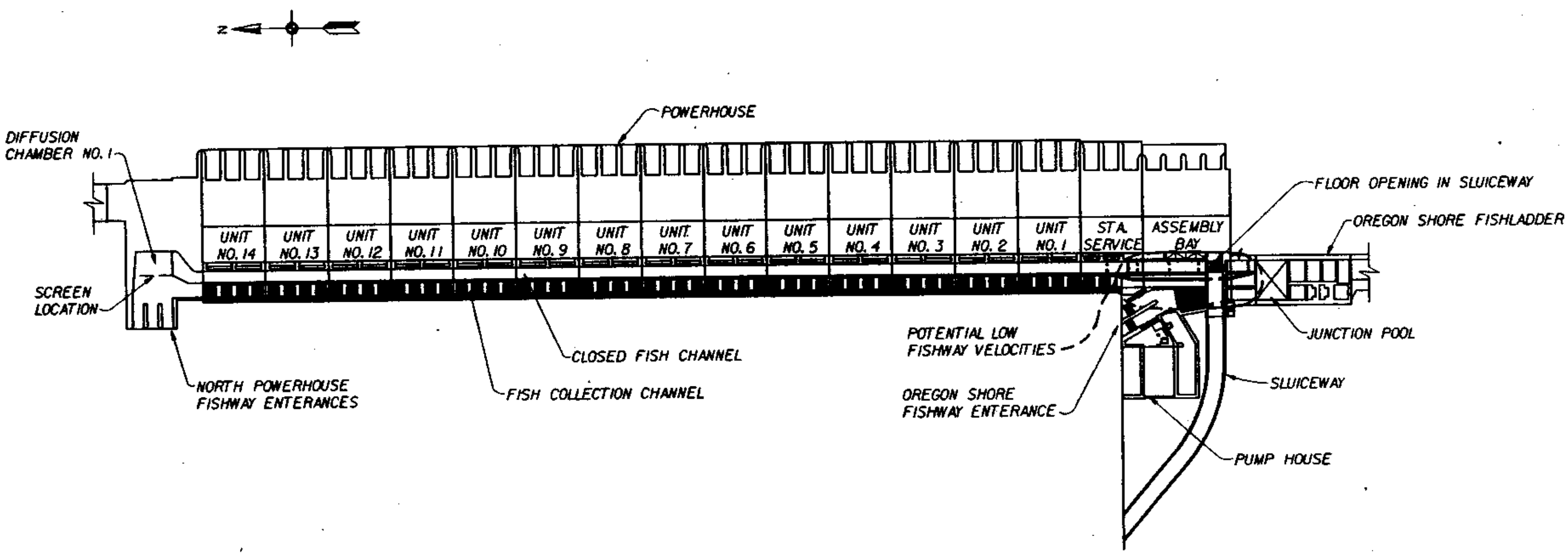
LITTLE GOOSE FISHWAY CHANNEL EXTENSION
PLAN AND SECTION

SCALE AS SHOWN | INV. NO.

PLATE 22.1

REFERENCE FILES: ESI.BLK.TB
PEN TABLES: FSISFC2.IPI
MAIN SCALE: 1:50

CORPS OF ENGINEERS SAFETY PAYS U. S. ARMY



PLAN

SCALE IN FEET

50' 0 50'

U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

PHILBROOK
HAUGEN

SYSTEM CONFIGURATION STUDIES

EXISTING SYSTEM IMPROVEMENTS

DAM MODIFICATIONS

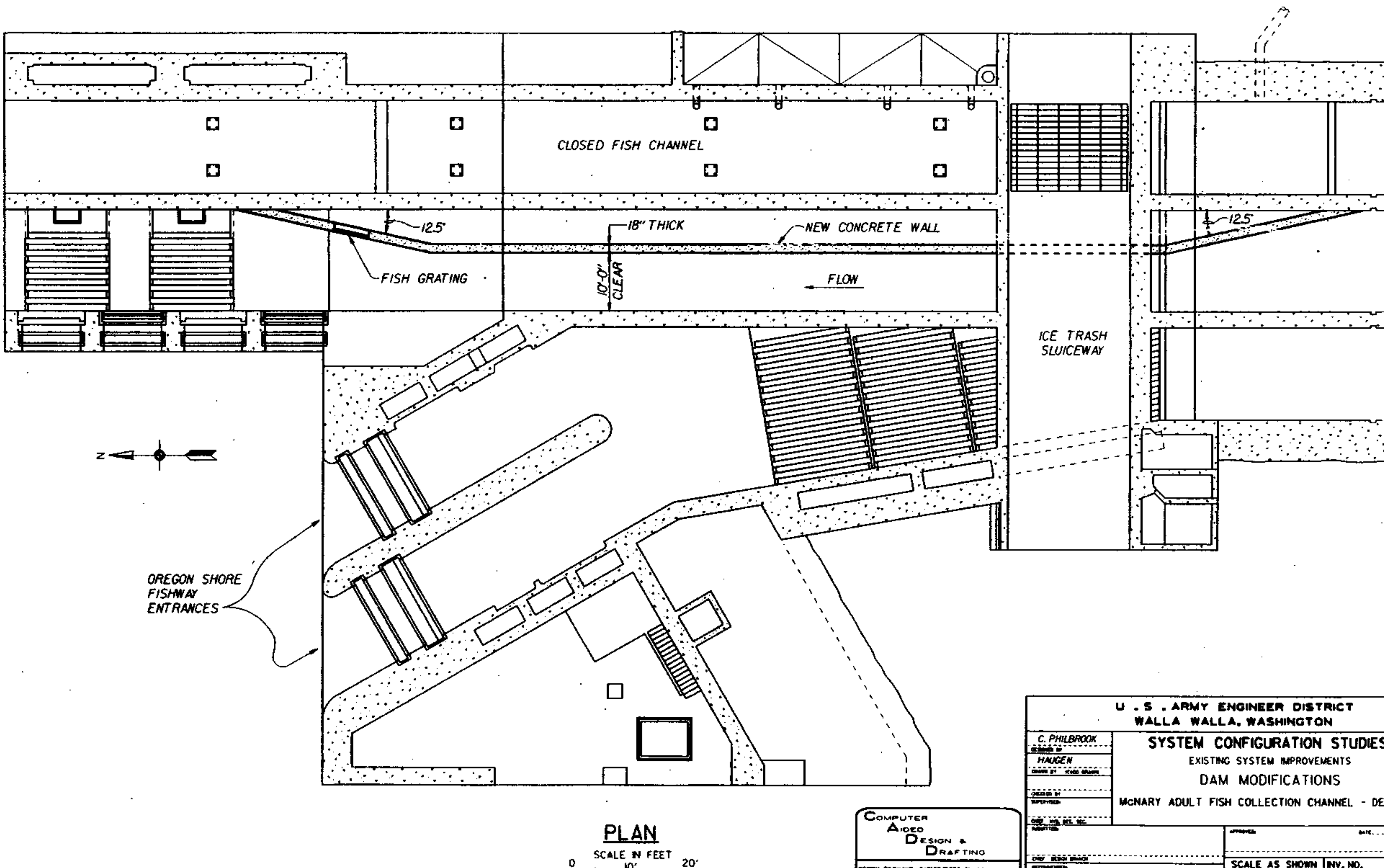
McNARY ADULT FISH COLLECTION CHANNEL - PLAN

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

PLATE 23

VALUE ENGINEERING PAYS



U. S. ARMY ENGINEER DISTRICT
WALLA WALLA, WASHINGTON

C. PHILBROOK
HAUGEN

SYSTEM CONFIGURATION STUDIES
EXISTING SYSTEM IMPROVEMENTS
DAM MODIFICATIONS
McNARY ADULT FISH COLLECTION CHANNEL - DETAILS

COMPUTER AIDED DESIGN & DRAFTING

SCALE AS SHOWN | INV. NO.

PLATE 24

REFERENCE FILES: SCS:ESI.BLK,TB
PEN TABLES: NO
MAIN SCALE: 1/8"=1'-0"

APPENDIX A

AGENCY CORRESPONDENCE

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Office of Columbia River Coordinator
9317 Highway 99, Suite A
Vancouver, Washington 98665

September 17, 1992

Ms. Sarah Wik
U. S. Army Corps of Engineers
Walla Walla District Office
Bldg. 602, City-County Airport
Walla Walla, Washington 99362-9265

Subject: Comments on Draft Lower Snake River Drawdown, Existing System Improvements and the Upstream Collector/Migratory Canal/Pipeline Reports

Dear Ms. Wik:

I have reviewed the subject report and forward the following comments. These comments are not meant to be inclusive, and they have not been coordinated with any other agencies or Fish and Wildlife Service offices.

Snake River Drawdown

1. Executive summary. Biological studies to help identify impacts on fish guidance efficiency (FGE) and orifice passage need to be included, along with the hydraulic studies that are mentioned.

   Due to the protracted construction periods, there will be impacts to adult passage. These impacts need to be pointed out here.

2. Page 47, summary. This paragraph states impacts to adult passage will occur during the construction phase of alternative 4A. As per the above, adult fish passage impacts need to be clearly stated.

3. Page 54, Adult Fishway Systems. Same comment as above.

4. Page 62, Unknowns and Future Studies. Impacts on the existing juvenile bypass system (JBS) need to be added. Concern about vertical distribution, water velocities, FGE changes and other hydraulic conditions should be mentioned.

Upstream Collector/Migratory Canal/Pipeline

1. The biological uncertainties are not addressed. Again, attempting to develop this new technology and have it benefit the species of concern in a relatively short time period is very doubtful.

   As I mentioned at the TAG meeting in July, extending existing screening criteria, assuming we know enough about fish behavior in a 400 mile long tube and attempting to recreate a stream suitable for anadromous fish needs are not reasonable or prudent.

Existing System Improvements

1. Page 3-1, Improvements to Fish Hatcheries. Due to concerns over fish health and fish quality, the inclusion of providing disease free water supplies for egg and early rearing should be considered.

   Consideration should also be given to modifying the water supply at Dworshak National Fish Hatchery (NFH) to allow water temperature control for the production facilities.

2. Page 3-2. The tribes and agencies have recommended direct loading in barges. This would eliminate or reduce handling and loading stresses experienced by fish in the existing facility configuration.

3. Page 4-24, Net Pens. This idea should be dropped from consideration as a long-haul possibility due to existing information.

Thank you for the opportunity to comment on this draft document. If you have any questions please call me at (206) 696-7888.

Sincerely,

Craig A. Tuss

Craig A. Tuss
Acting Columbia River Coordinator

cc: John Grettenberger, OFO, Olympia, WA
Frank Young, ODFW, Portland, OR
Steve Pettit, IDFG, Lewiston, ID
FPAC

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
ENVIRONMENTAL & TECHNICAL SERVICES DIVISION
911 NE 11th Avenue - Room 620
PORTLAND, OREGON 97232
503/230-5400 FAX 503/230-5435

September 15, 1992 F/NW03

MEMORANDUM FOR: Sarah Wik, TAG Coordinator

FROM: Bob Pearce and Jim Ceballos, TAG Members

SUBJECT: Comments on Draft Reports on Lower Snake Reservoir Drawdown, Upstream Collector/Migratory Canal/Pipeline, and Existing System Improvements.

This memo responds to your letters requesting comments on the three draft reports on Lower Snake Reservoir Drawdown, Upstream Collector/Migratory Canal/Pipeline and Existing System Improvements. These comments are not to be construed as final comments on the various configuration alternatives due to the rather limited time available for review, and the preliminary nature of the reports. They do not represent a comprehensive listing of NMFS concerns, nor have they been coordinated with other fishery agencies or tribes with expertise in these areas.

Report on Lower Snake Reservoir Drawdown

1. Comments provided in my 6/16/92 memo to you, both general comments and specific comments on drawdown alternatives, are pertinent to this document. Generally the draft report adequately describes the proposed drawdown alternatives and their potential impacts, subject to the following items.

2. Pertinent Data Sheets: Recommend adding more information about adult passage facilities for Little Goose and Lower Granite dams and brief information on juvenile passage facilities for all four dams.

3. Executive Summary - Evaluations and Additional Required Studies: The need for hydraulic studies of drawdown impacts on FGE are mentioned several times, but no mention is made of the need for important biological studies to define potential impacts, including impacts on FGE and OPE.

Also, the summary should point out the likelihood that adult passage conditions throughout the long construction periods will suffer significant adverse impacts due to specific units or spill bays being out of operation, the presence of cofferdams, temporary passage facilities in lieu of permanent facilities, and other factors. Adult passage disruptions during construction of various alternatives should not be underestimated and may be one of the largest drawbacks to any alternative.

The Executive Summary Recommendations appear generally appropriate as to the alternatives that most likely warrant further study (alternatives 4A and 13/17), based on the information developed to date in the draft report.

4. Page 40, Adult Fishway Criteria: Concerning statement 5, there is need for trapping and monitoring facilities at a new north ladder at Lower Granite Dam, but no apparent need for such facilities at a new Little Goose north ladder.

5. Page 114: The spillway tailwater control structure (drum gates in place of the end sill) was selected for purposes of concept design and cost estimates, but the report recommends that other modifications including adjustable flow deflectors and shallow stilling basins with additional baffles be pursued in later stages of the study. We support that recommendation. However, in addition to studying these alternatives with respect to effect on dissolved gases and energy dissipation, the study should include potential for adverse impacts to adult passage conditions below the spillway and juvenile passage conditions relative to survival through the spillway (especially for a shallow baffled basin). The proposed model studies should be useful in this regard. If the control structure is to be designed to block adult passage, the head differential across the structure would need to be maintained at 10 feet or more.

6. Page 47, Summary: This paragraph notes that "Adult passage will not be ideal during the construction process" for alternative 4A. The potential for adult passage disruptions should be stated more clearly, and for all the alternatives. See second paragraph of comment 3 above.

7. Page 54, Adult Fishway Systems: Again, anticipated adverse construction impacts on adult passage should be noted. This comment also applies to similar paragraphs for the other alternatives.

8. Page 62, Unknowns and Future Studies: The potential for effects on JBS performance should be noted, including vertical distribution and intake hydraulic conditions affecting FGE, and OPE. This comment applies to similar paragraphs for the other alternatives also.

Report on Upstream Collector/Migratory Canal/Pipeline

1. The draft has very little discussion of biological concerns and uncertainties as yet incorporated into it. There is very limited information provided, and thus the following comments are limited. These comments are not intended to indicate modifications that would, if included in the report, make the alternatives feasible. They are provided to assist you only in completing the report. Comments provided to you in my 6/16/92 memo, both general comments and specific comments on these alternatives, are pertinent to this document. These alternatives continue to raise many concerns and serious doubts about their feasibility, especially when biological considerations are considered in addition to engineering considerations. The collector component of these alternatives would require extending current criteria and technology beyond the bounds within which we have a high level of confidence.

The migratory canal and pipeline components of the alternatives would be attempts to develop new technology, involving many years of research. Based on experience at existing and past juvenile bypass systems, alternatives involving pressure pipelines would not be acceptable. This report should provide the basis for recommending the migratory canal/pipeline alternatives be dropped from any further consideration.

2. Third page of the Executive Summary, Uncertainties and Research Required: The use of the word "---some---" falls far short of adequately describing the research needed to determine the most effective INEL floating conduit design. Numerous difficult problems are anticipated, such as development of a pumping method not injurious to fish, impacts of pressure changes, water quality, predation potential between salmonids, etc. Also, "Some---" does not adequately describe the uncertainty about the overall success of these canal/pipe alternatives. The summary should be written to more accurately describe the unknowns and concerns.

3. The Executive Summary and the Design Criteria on page 10 state that 75 degrees F would be the maximum water temperature. Maximum temperature criterion for juvenile salmonids would need to be much lower, probably less than 70 degrees F, based on collection/transport experience at McNary Dam.

4. Page 7, Upstream Collector: The draft does not provide much additional information on the upstream collection facility beyond that reviewed earlier and commented on in my 6/16/92 memo. The second paragraph does state that debris collection would be accomplished primarily by the floating boom or raked off the screens and dumped downstream, with the captured smolts passed

Report on Existing System Improvements Design & Operation Plan

The document does a good job of identifying in general terms needed improvements and providing a basis for evaluating their technical feasibility. Much detail is also included, which we will review in a more comprehensive manner when the document is finalized and coordination begins with fishery agencies and tribes to more fully develop plans for these improvements.

Page 2-3, Item 3: Relative to Little Goose Dam, all but Unit 1 orifices are partially or fully submerged.

________, Item 6: Excess water from the Lower Monumental primary dewatering structure is piped to the north shore fishway to provide auxiliary attraction for upstream migrants.

Page 2-4, Item 9(c): Bulkhead slot orifices at Lower Granite Dam have 10-inch diameter orifices. Note other major difference; the Lower Granite project is unique in that it has upstream fish screen slots. These slots are equipped with 8-inch orifices.

Page 2-5, top para.: You might note that stated 70% collection is only for spring migrants.

________, Item 4, last sentence: You should note that tagged wild fish losses include over-winter mortality. Studies are not similar unless both groups are tagged the previous summer/fall.

Page 2-8, Item c(1): Typo - Tanker truck hauling capacity should be 1,750 pounds, not 1,705.

Page 3-1, Improvements to Fish Hatcheries: Consideration should be given to providing pathogen-free water supplies for egg incubation and early rearing. This could substantially improve fish health and quality.

Page 3-2, The agencies and tribes have requested modifications to allow direct-loading into barge compartments to eliminate the need for subjecting collected fish to the stresses of loading from raceways.

The new wet separator design for use at Lower Monumental will become the "standard" if evaluation results indicate better size separation efficiency and less delay.

Page 3-2, Item a: Consideration should be given to reducing fish ladder water temperature by simply using existing air bubbler systems at ladder exits to raise cooler water to the surface.

into a fish lift or lock and lifted to the canal. This reflects an unrealistic understanding of the debris problem that would occur with such a facility. Screens of this type require an upstream trashrack. Most of the smaller debris reaching the screen face then could be expected to be channeled into the fish collection area (rather than sticking on the screen mesh as stated in the draft), where it would cause major problems for fish sorting and holding. Research would be needed to determine if sorting and holding facilities could be developed that would function under such a debris loading.

Alternative guidance systems that would use acoustics, light or other non-obstructive devices are discussed briefly on pages 8 and 13, noting they would not collect 100 percent of the smolts. These devices should not be considered. Despite years of study, there is no information that indicates such devices could be developed to be a feasible option within a reasonable time frame.

5. Page 10, Design Criteria: The water flow requirements (fish density), water quality requirements, resting area requirements, and the (minimal) use of pressure pipe are noted as being preliminary criteria, but the lack of sound technical basis for such criteria should be stressed more.

6. Page 13, first paragraph: The alternative of collectors in the Snake and Clearwater rivers above Lewiston would for any conceivable plan require major dam structures to create reservoir velocity conditions to allow screening. This requirement, and the associated implications for adult passage, should be stated.

7. Page 14, Sorting Facilities: This discussion totally ignores the major problem of debris accumulation that would occur in such a collection facility and how it would impact sorting facilities. See comment 4 above. Also, it is not possible to eliminate non-salmonid species from the canal by a sorting facility of the type developed to date that is based on physical size.

8. Page 14, Lift Facilities: The mechanical lift system appears even more complex and damaging to fish than the hopper system used at Little Goose collection facility during the late 1970's to load trucks. The hopper system was unacceptable and was replaced with gravity loading.

9. Figures 2 and 3, Conceptual Plan for INEL Pipe Passage: The concept shown includes a downwell and pressure pipe system of the type that is no longer considered acceptable design.

10. Page 57 and Figure 4: The time requirements given for design/research/construction are grossly underestimated.

Report on Existing System Improvements Design & Operation Plan

The document does a good job of identifying in general terms needed improvements and providing a basis for evaluating their technical feasibility. Much detail is also included, which we will review in a more comprehensive manner when the document is finalized and coordination begins with fishery agencies and tribes to more fully develop plans for these improvements.

Page 2-3, Item 3: Relative to Little Goose Dam, all but Unit 1 orifices are partially or fully submerged.

________, Item 6: Excess water from the Lower Monumental primary dewatering structure is piped to the north shore fishway to provide auxiliary attraction for upstream migrants.

Page 2-4, Item 9(c): Bulkhead slot orifices at Lower Granite Dam have 10-inch diameter orifices. Note other major difference; the Lower Granite project is unique in that it has upstream fish screen slots. These slots are equipped with 8-inch orifices.

Page 2-5, top para.: You might note that stated 70% collection is only for spring migrants.

________, Item 4, last sentence: You should note that tagged wild fish losses include over-winter mortality. Studies are not similar unless both groups are tagged the previous summer/fall.

Page 2-8, Item c(1): Typo - Tanker truck hauling capacity should be 1,750 pounds, not 1,705.

Page 3-1, Improvements to Fish Hatcheries: Consideration should be given to providing pathogen-free water supplies for egg incubation and early rearing. This could substantially improve fish health and quality.

Page 3-2, The agencies and tribes have requested modifications to allow direct-loading into barge compartments to eliminate the need for subjecting collected fish to the stresses of loading from raceways.

The new wet separator design for use at Lower Monumental will become the "standard" if evaluation results indicate better size separation efficiency and less delay.

Page 3-2, Item a: Consideration should be given to reducing fish ladder water temperature by simply using existing air bubbler systems at ladder exits to raise cooler water to the surface.

Page 4-5, Additional Containment Facilities: This discussion notes that at many hatcheries, there is limited room and water supply for expansion. Consideration could be given to off-site long term acclimation ponds, in addition to additional hatcheries mentioned. However, it should be noted that at this time, it is not known whether NMFS will support new hatcheries in the Snake River Basin.

Page 4-10, Assumption 3: Suggest you talk with Tom Poe, U.S. Fish and Wildlife Service, relative to spacing of flume drop gates. We understand squawfish react quite rapidly to changes in operations and spacing them 100 feet apart may be too close. Random timing for operation of drop gates should be considered.

_________, Assumption 4: Only small fish, predominantly yearling salmon, are bypassed. Therefore, steelhead would be held for transport.

Page 4-14, 4(b)2: same comment as above.

Page 4-15, Item 3, last sentence: It has been shown that much less than 100% of the fish are being guided with the extended screens.

Page 4-18, Item b(1): Given ESA and the occasional observance of fry in April, we recommend 0.4 fps velocity, since that is our updated screening criterion.

Page 4-20, Item c: Now that 100% sampling occurs in the summer, a direct line from the sample holding tank for truck loading would be necessary in case water temperatures are too high for sample processing.

Page 4-21, Item 5(b): Direct-barge loading may negate/reduce the need for increasing raceway capacity.

Page 4-24, Net Pens: There is enough evidence given here to recommend dropping this concept from further study as a long haul transport vehicle.

Page 4-28, Barge Water Temperature Control: Perhaps simply adding the capability to lower/raise a water intake pipes 5-10 feet would afford access to cooler water.

cc: F/NWC1
FPAC