GLEN CANYON DAM

DISCHARGE TEMPERATURE CONTROL

DRAFT APPRAISAL REPORT

ENVIRONMENTAL EVALUATION

AUTHORITY/LEGISLATIVE ISSUES

STUDY OPTIONS

PLANS, SCHEDULES, BUDGETS

U.S. Bureau of Reclamation

Attch 3

REPORTS REVIEWED

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SUMMARY

The purpose of this report is to evaluate ways to study and implement temperature controls at Glen Canyon Dam for the recovery of native and endangered fishes below the dam. Main channel spawning of native fishes is severely limited by cold water discharges from Glen Canyon Dam.

This report finds that feasibility study and construction authority is provided under section 8 of the Colorado River Storage Project Act. Section 8 activities authorize Reclamation to "...investigate, plan, construct, operate, and maintain...(2) facilities to mitigate losses of, and improved conditions for, the propagation of fish and wildlife..." Use of this authority would be consistent with the retrofit of a temperature control device at Flaming Gorge Dam, another CRSP dam.

Although alternatives to modification of the penstock intakes through selective level withdrawal may exist, it is very unlikely that any of them would be as effective. Selective level withdrawal is usually the method of choice for temperature controls.

Preliminary construction and study costs are estimated at $75 million. Construction costs for a selective level withdrawal structure would be about $60 million (scaled and indexed from Flaming Gorge costs). Planning studies, post-construction testing, and NEPA compliance could cost $15 million or more. Under section 8 of the CRSP Act, funds would need to be appropriated from Congress. An appropriation ceiling increase would be needed before major construction. Section 8 funds are non-reimbursable under the CRSP Act.

The major concerns identified in this preliminary evaluation include:

* Impacts to lake fishery. Temperatures in Lake Powell are already low enough to cause occasional winterkill of threadfin shad, an important forage fish for the lake (game) fishery. If needed, this impact could be mitigated by either minimizing the release of warm water or stocking more cold tolerant species in the lake. Computer modelling studies might help define magnitude of impacts.

* Changes in the primary productivity of the river. Warmer water discharges could impact the aquatic system, but the small, 5-6°C change proposed should not impact this system to any great extent. Laboratory testing might help evaluate this impact further.

* Competition from other species. The endangered fish in the Little Colorado River are isolated from competition with non-natives by cold water discharges. Warming the river to promote mainstem spawning would remove one of the barriers preventing warm water competitors from moving up into the river system from Lake Mead. Other environmental (life history) factors are thought to limit this problem. Testing and optimizing temperature discharge patterns could help minimize this problem.

* Impacts to the trout fishery below Glen Canyon Dam. Extremely warm releases could damage this resource, but the proposed release temperatures are only 5-6°C warmer and may improve growth rates.

Post-construction studies would need to carefully monitor the impacts to these and other resources to determine the optimum release pattern.

Planning and National Environmental Policy Act (NEPA) compliance would be phased. Phase 1 would include an analysis of the potential range of impacts that might be expected from selective withdrawal and temperature

modifications. Phase 2 would include post-construction testing and detailed environmental analysis for an environmental impact statement (EIS). The EIS would include alternative temperature discharge operations and their impacts.

In the Glen Canyon Selective Level Withdrawal Work Group meeting, it was observed that, "In almost every case, additional effects occurred (from temperature controls) that were either unpredicted or resulted in changes greater or lesser than anticipated." It is unreasonable to expect scientists to be able to predict in great detail what could be measured with a test facility. If we recognize that the critical NEPA issue is not the construction of the facility, but its operation, we can significantly shorten the planning process. The savings should be used to test the facility and find the optimum temperature release pattern.

Pre-construction planning could be accelerated even further by preparing an environmental assessment (EA) and finding of no significant impact (FONSI) on the construction of a "test" facility. It is the operation of the structure that will cause impacts. The physical construction of the facility should have no impacts. Testing of the facility would directly measure the impacts of various operational scenarios. A full planning report/EIS would then be prepared to select the recommended operation for the facility based on known, "measured" impacts rather than predictions.

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INTRODUCTION

Acknowledgments

This report draws heavily upon the work of Dr. Lechleitner for the literature review of the thermal requirements of fishes below Glen Canyon Dam and Dr. Richard Valdez for his analysis of the potential impacts and benefits of temperature augmentation on the native and non-native fishes in the Grand Canyon.

Most of the environmental impacts discussed in this report were identified by the Glen Canyon Environmental Studies, Reservoir Workshop Participants and Glen Canyon Selective Withdrawal Investigations Work Group.

Potential operations and impacts to native and non-native fishes were discussed by Clarkson (Arizona Game and Fish), Gorman (Fish and Wildlife Service), Kubly (Arizona Game and Fish), Marsh (Arizona State University), and Valdez (Bio/West Inc.) in their report *Management of Discharge, Temperature, and Sediment in Grand Canyon for Native Fishes*.

Report Authority

This preliminary evaluation is being conducted under the Bureau of Reclamation's Investigation of Existing Projects (IEP) program. IEP funds are used for initial investigations and exploring viable improvements on existing projects. Under the IEP program, Reclamation surveys existing water resource projects to determine the viability for two types of improvements: (1) remedial action to modify, replace, or repair features on older projects and (2) possible operational adjustments of existing projects to increase benefits and purposes.

Purpose of Report

The purpose of this document is ultimately to evaluate ways to complete detailed studies of alternatives that promote the recovery of the endangered fish through temperature controls in the Colorado River below Glen Canyon Dam. To accomplish this objective, the report is intended to:

(1) briefly **review existing data and research** applicable to the problem;

(2) **identify critical issues**;

(3) **survey experts** on the issues, possible impacts, and potential approaches to evaluating alternatives;

(4) **scope alternatives** for controlling the outflow temperature from the dam;

(5) **scope environmental effects** of implementing outflow temperature control and their relative importance;

(6) **evaluate funding alternatives and legislative authorities** to conduct feasibility studies and proceed with construction;

(7) evaluate and recommend a **plan of study** for future activities;

(8) develop **study plans, research requirements, schedule, and cost estimates** to support funding of future detailed feasibility and

environmental studies.

Location/Setting

The affected area encompasses the Colorado River corridor in northern Arizona from Lake Powell, through Glen and Grand Canyons, and on down into Lake Mead. The river is nearly 300 miles long through the canyons.

Glen Canyon Dam stores and releases water from Lake Powell, which has an active capacity of almost 25 million acre-feet. The powerplant has a release capacity of 33,200 cfs.

Need for Action

It is thought that cold water releases from Glen Canyon Dam may limit growth rates and prevent spawning of native and endangered fishes in the mainstem of the Colorado River in the Grand Canyon.

Deep, hypolimnetic releases from Glen Canyon Dam have cooled the temperature of the river in the Grand Canyon. Because its penstocks draw on water from deep in the reservoir; spring, summer, and fall releases are much colder than before the dam. This has created an excellent cold water (trout) fishery below the dam, but prevents native fish from thriving and spawning in the river.

For the most part, it is believed that the endangered humpback chub only spawn in the Little Colorado River, a warm water tributary to the Colorado River below Glen Canyon Dam. The fish thrive in the warm waters of the Little Colorado River, but may be vulnerable to catastrophes because the range of their habitat is extremely limited. Some spawning may occur in the mainstem (near hotsprings) and in other small tributaries, but only to a limited extent.

The Fish and Wildlife Service draft biological opinion identified outflow temperature control at Glen Canyon Dam as an important component in their recovery plans for the chub. The goal of the Service's recovery plan is to develop a second spawning population in the mainstem river below Glen Canyon Dam. It is believed that a temperature control scheme could be developed to improve conditions in the mainstem river.

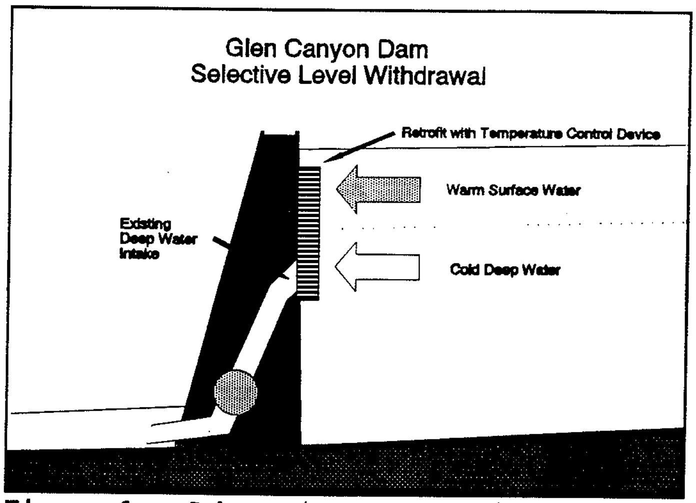

Figure 1 - Schematic of Selective Level Withdrawal.

At least one operational scheme for temperature control operations would create suitable temperature conditions for spawning of humpback chub while protecting the existing blue ribbon trout fishery below Glen Canyon Dam. By coupling warm(er) water releases from the dam with downstream warming, the Colorado River near the Little Colorado River would reach suitable spawning temperatures for the humpback chub. Outflow and river temperature modeling studies (Ferrari) show that this is an achievable goal technically. How other chemical and biological factors might complicate this issue are poorly understood. Temperature may only be one factor limiting spawning in the mainstem.

Temperature Control Alternatives

The typical method of warming the river below dams is to construct a selective withdrawal structure over the intakes of the power penstocks on the face of the dam. Power generating stations also

No Action - This alternative would consider continuing to release water from the existing intake on the penstocks.

Selective Withdrawal Structure - This alternative would retrofit the dam with a device to control the inflow to the power penstocks so that warm water (a potentially cooler water) could be discharged from the dam. Almost infinite options exist for the operation of the selective withdrawal structure.

Non-structural/Re-operation Alternatives - All of these alternatives would include major operational changes to the reservoir in an attempt to release warm water from the spillway or penstocks or outlet works. All would lack the discharge flexibility of selective withdrawal. None are likely to be economic because of the loss of power revenues. Holding the reservoir water surface low enough for warm water to be discharged from either the penstocks or outlet works would have significant impacts in Lake Powell. Control of reservoir system to discharge over the spillway would be extremely difficult to achieve. Outflows would have to match inflows. Flood control capabilities would be reduced.

Navajo Powerplant Alternative - A possible alternative to selective withdrawal would be to use waste heat from the Navajo Powerplant. The powerplant currently uses cooling towers to condense their steam. Cooling tower wastewater is then evaporated in ponds. In theory, the powerplant could be modified for flow-through cooling. This would potentially save about 20,000 acre-feet of evaporation a year. Water discharged below the dam from a pipeline could be run through a generator(s) to reclaim the power lost (or plumbed into the existing turbine system).

Based on studies conducted for the EPA, the energy produced from a 2,250 MW power plant would be about 810,000 kcal/s (360 kcal/s-MW) and would warm 4,000 cfs by about 7°C. The powerplant is at approximately elevation 4,350 feet. Lake Powell high water is about 3,660 feet, but minimum power pool is 3,490 feet, a potential lift of 860 feet. Assuming a temperature increase of 50-70°C, the minimum flow through would be 400-600 cfs. It is fairly clear that to construct facilities to lift this amount of water and then pipe/tunnel it back to the river/penstocks would likely be extremely expensive, much more expensive than constructing a relatively simple set of inlet control gates on the face of the dam.

The major drawback to using waste heat from Navajo would be the lack of flexibility. If the plant were to be tripped off-line by some power problem, no warm water would be available for discharge. On the other hand, once in place, the facility would have to be used so that Navajo could operate. There will be times when warm water releases would not be desirable. There are ways to offset these complications, but they would require more facilities, increasing their costs even more.

Previous and Related Studies/Programs

Colorado River Temperature Modeling below Glen Canyon Dam - This study conducted by Reclamation (Ferrari 1987) presents an analysis of raising the water release temperatures below Glen Canyon Dam by modifying dam penstocks with multi-level intakes. Predicted temperatures of waters drawn from Lake Powell were calculated with a computer model. The temperature change of this warmer water as it moves downstream was evaluated using both a computer-generated temperature function and a simplified graphical method. The study concluded that multi-level intakes could increase river temperatures by up to 18°F (10°C), depending upon the time of year.

Flaming Gorge Outflow Temperature Control Study - The Green River below Flaming Gorge Dam is one of the premier trout fisheries in the United States due to the retrofit of the power penstocks to control discharge temperature. The dam, as originally constructed, released cold water from relatively deep levels in the reservoir. These cold water releases created an excellent trout fishery below the dam, but limited growth rates. More optimal temperatures for the trout were achieved through the addition of temperature control.

Under the authority of section 8 of the Colorado River Storage Project Act, the dam was retrofitted with a series of shutter gates to improve temperatures downstream of the dam for the enhancement of the river fishery. Base on modelling studies, the Environmental Assessment/Determination of No Significant Impact on Flaming Gorge reported the following predicted impacts:

(1) downstream temperatures would be increased by up to 14°F (8°C).

(2) reservoir temperatures in the top 30 feet would be reduced by 1 to 2 degrees F (0.5-1°C) near the dam,

(3) because of small temperature change in reservoir, impact on aquatic life would be minimal,

(4) slight delay, perhaps a few days, in the first spring plankton blooms,

(5) surface currents would develop near intakes and would facilitate passage of aquatic organisms downstream, most fish would be killed, plankton would be passed downstream,

(6) the surface layer of warm water would become thinner, the hypolimnion would increase in depth, possibly more stagnation in the hypolimnion,

(7) most impacts would be beneficial, adverse impacts would be small and in many cases only temporary.

Shasta Dam Outflow Temperature Control Study - The upper Sacramento River is the largest and most important salmon stream in California and provides more spawning habitat for chinook salmon than any other river in the state. Elevated temperatures negatively impact the fish. In 1987, Reclamation began releasing water from the river outlet works to cool release temperatures. While improving river temperatures, this measure cost nearly $9 million in power generation over 3 years.

A planning report/final environmental statement titled *Shasta Outflow Temperature Control* was prepared and filed in 1991 to evaluate alternatives for retrofitting outflow temperature control to Shasta Dam and eliminate bypassing the powerplant. Planning and advanced design costs were $2.5 million. The estimated total cost of the shutter device (for temperature control) is $50 million to be allocated over the estimated 25-month construction period. Discharge capacity for the shutter device is 19,500 cfs. Annual OM&R is estimated at $4,500 per year. The benefit-cost ratio is

2.28:1.00 based on the value of the fishery. The current cost-sharing proposal is 75 percent Federal (50 percent reimbursable by authorized project purposes and 25 percent nonreimbursable) and 25 percent non-Federal. The PR/FES concluded no significant impact to the environment other than the improvement in river temperatures for the fisheries.

Lake Mead Limnology Study - A study by Baker et al. (1977) on Lake Mead reported that thermal stratification develops in May and June and a classical thermocline becomes established between a depth of 10 to 15 m in July. A turnover begins in October and the lake is completely destratified in January and February. Turnover was described as weak. Boulder Basin is considered mesotrophic based on primary productivity estimations and comparable to other tropical or subtropical lakes. Dissolved oxygen levels above the thermocline were generally above 8 mg/L. Surface temperatures were above 20°C June through October.

Lake Mead Outflow Temperature Control Study - A computer modelling study by Edinger and Buchak (1983) of surface discharge at Lake Mead suggested the following results:

(1) downstream temperatures would be up to 15°C warmer,

(2) more entrainment of cooler inflow water into the surface layers,

(3) slight decrease (up to 4°C) in summertime surface temperatures,

(4) no noticeable effect on winter surface temperatures,

(5) shallower thermocline, thinner epilimnion (surface layer), thicker hypolimnion (bottom layer),

(6) annual evaporation is reduced by about 4 percent.

Hungry Horse Dam Selective Withdrawal System - The draft environmental assessment by Reclamation (1994), states that construction and operation of a selective withdrawal system would increase the downstream trout growth rates by two to five times. No adverse impacts were predicted for water quality or power production. Modeling studies indicated that phytoplanton and zooplankton would be entrained in the discharge, but that overall productivity in the reservoir would increase somewhat. Warm water discharge would destabilize the temperature stratification of the reservoir, promoting a stronger turnover, cycling more nutrients into the surface water. Some minor impacts to the lake fishery are expected, but are thought to be avoidable through careful operation. Fish entrainment in the turbines is not expected because fish stay near shoreline.

POTENTIAL EFFECTS OF TEMPERATURE CONTROLS

Introduction

This report attempts to identify and discuss issues that might impact the decision on whether or not (or how) to study and implement temperature controls at Glen Canyon Dam. This report will begin to explore the primary effects (on water quality) of releasing warmer water from Glen Canyon Dam through a selective withdrawal structure and then summarize the potential impacts on the biological resources in the area. The impacts discussed in this section were identified by the Glen Canyon Dam Selective Withdrawal Workgroup (1993), a multi-disciplinary workgroup made up of private, state, and federal specialists in the field.

Effects on Water Quality

River Temperatures - River temperatures pre-dating the dam ranged between just above freezing to about 30°C. Records show that present release temperatures vary little from 8-10°C. Using a computer model, Ferrari (1987) predicted that selective withdrawal could increase discharge temperatures by up to 10°C (18°F) in the summer months.

Lake Temperatures - Based on past experiences, the temperature profiles and circulation patterns in both Lake Powell and Lake Mead would change. Surface withdrawal from Lake Powell would deplete the surface layer of warm water during the summer months. Winter temperatures in Lake Powell may be cooler, but this would be complicated by destratification and turnover in the reservoir late in the fall. The opposite would probably be true for Lake Mead. Warm water inflows would increase temperatures and the thickness of the surface layer in the summer, increasing stratification, stability, and stagnation deep in the water column.

Nutrients (Nitrogen/Phosphorus) - A balance of nutrients is critical to the ecology of any aquatic system. Low levels of nutrients generally limit the productivity higher up in the food chain (fisheries). High levels of nutrients cause systems to strangle on their own wastes, depressing dissolved oxygen levels. Large, long reservoirs like Lake Powell are very efficient at retaining nutrients in the reservoir through biological processes and settling. Nutrients discharged from Glen Canyon Dam are already extremely low, although the trout fishery below the dam is quite good.

Data from the Glen Canyon Environmental Studies show nitrogen and phosphorus levels are extremely low in the deep water near the dam, but even lower near the surface where withdrawals would occur. Surface withdrawal could significantly reduce the nutrient load to the downstream environment, reducing its productivity and impacting its ecology. The downstream environment, including Lake Mead, is relatively nutrient poor. Lake Mead's nutrient loading was greatly reduced by the construction of Glen Canyon Dam and trapping of nutrients in Lake Powell.

Dissolved Oxygen - Under existing conditions, deep water low in dissolved oxygen is continuously entrained into the discharge from the reservoir. The resulting dissolved oxygen discharges from the dam are mildly undersaturated (about 5 mg/L) in the summer months and sufficient for the downstream fishery.

Selective withdrawal from the surface layer would increase dissolved oxygen discharges from the dam during warm water releases. But, later in the year, if the discharges are moved down from the surface layer to the lower layer of cold water, dissolved oxygen levels could decrease down to 2 to 4 mg/L (critically low for the trout fishery). Postponing cold water releases until after the reservoir turns over in the fall could help offset this potential problem. Alternative operations should be evaluated.

Salinity - Generally the surface layer in Lake Powell has the lowest salinity levels found in the lake. Release from the surface layer during the summer months would reduce salinity for that season. Salinity discharged from the dam during the remaining months of the year would be higher, but the maximum salinity of the river in the Grand Canyon will not approach pre-dam levels (1,200 mg/L) nor impact fish and wildlife at these levels.

The warm, summer inflows to Lake Mead would have slightly reduced salinity levels, reducing the salinity of the surface layer in Lake Mead somewhat. But, no change in the average salt loading to Lake Mead will occur. The range of variation in salinity should not approach those observed before impoundment by Glen Canyon Dam. Even under extreme conditions, maximum salinity levels will not approach levels that would impact fish and wildlife.

Effects on Resources

Primary Productivity of River (aquatic food chain) - The potential impact to the primary productivity in the river system is a major concern. The existing, post-impoundment, aquatic system has developed around near year-round releases of 8-10°C water with low nutrient and sediment levels. Warmer discharge temperatures could potentially change the food base away from favorable species.

Another concern is that surface withdrawals may decrease nutrients discharged to the downstream environment. Nutrients are important to the aquatic system because they are required for algae growth, the base of the food aquatic food chain. Low productivity in the reservoir/river system is often linked to poor nutrient availability.

From past experience, surface discharge may also increase the export of algae and other small organisms from the surface layer in Lake Powell, somewhat offsetting the loss in nutrients by supplementing the food base.

Native and Endangered Fishes - Valdez reported that humpback chub, flannelmouth sucker, bluehead sucker, and speckled dace require 16-23°C for spawning, egg incubation, and survival of larvae, while razorback sucker spawn successfully at 10-22°C. Temperatures released from the dam are about 8-10°C and warm longitudinally (240 miles downstream) to about 16°C. These temperatures are not sufficient for spawning of native fish. All documented spawning of native fishes has occurred in warm tributaries.

Humpback Chub is a native fish which evolved in the Colorado River before water development and regulation. Studies report that the Little Colorado River is the main spawning area for the humpback chub. The Little Colorado River is a small, unregulated tributary to the Colorado River located about 77 miles below Glen Canyon Dam. Some spawning has been reported to a lesser extent in other minor tributaries. Selective withdrawal could increase summer release temperatures from the present steady 8°C (46°F) to a maximum of about 21°C (69°F). With warming in the backwaters, temperatures might be high enough to support spawning along the mainstem.

Under existing operations, the Humpback Chub are isolated from warm water competition by the cold river temperatures. It has been theorized that non-native, warm water competitors from Lake Mead have not been able to move up into the Little Colorado because of the cold water and any change to warm the river may allow competitors threaten the chub. However, Lake Mead and its warm water fishery existed long before Glen Canyon Dam cooled the river temperatures in the Grand Canyon. For whatever reason, the chub were able to successfully compete with the warm water predators/competitors moving upstream from Lake Mead. No new, non-natives have been introduced to the system. If competition moving upstream became a problem, Valdez suggests that cold water releases could be used in most years to hold competitors in Lake Mead, with 1-in-5 year warm water releases being made to induce spawning in the river by chub.

Valdez concluded that warming the temperature of the river to 16-22°C from May to September provides favorable thermal conditions for a number of non-native fishes. However, other components of their life history requirements may be lacking in the Grand Canyon that would limit invasion and expansion.

Table I - Effects of warmed releases on fishes (Valdez).

EFFECT	NATIVE FISH	NON-NATIVE FISH	
		Salmonids	Non-Salmonids
Immigration from Mead, Powell, Tribs	+	o	+
Higher Growth Rates	+	+	-
Mainstem Reproduction	+	+	-
Increased Survival of Eggs/Larvae	+	-/o	-
Changes in Algae/Diatoms	?	?	?
Changes in Macroinvertebrates	+	-	?
Increased Incidence of Parasites	-	+	-
Warmer Backwaters	+	-	o

Past and future spills from Glen Canyon Dam will entrained non-natives from Lake Powell into the downstream river environment. Selective withdrawal would have this same effect but increase its frequency. It may force non-natives to move downstream through the system or allow poor swimmers to invade the tributary system. Cold water releases from Glen Canyon Dam might not mitigate this problem after the fact, but natural flooding by the tributaries may.

Non-Native, Fishery below Dam (Valdez) - The cold water discharge from Glen Canyon Dam has created an excellent trout fishery. Water temperatures and dissolved oxygen levels are slightly below optimal. Some increase in water temperature would enhance the growth rates, but competition, parasites, and disease may become a problem as water temperature increase. Higher dissolved oxygen levels would benefit the fishery.

Trout - Thermal regulation is likely to benefit the tailwater trout fishery by providing more optimal temperatures for growth by rainbow trout, cutthroat trout, brook trout, and brown trout. However, downstream populations of trout would be detrimentally affected by above optimum temperatures, thus reducing downstream distribution and abundance of trout, which in turn would reduce possible competition and predation with native fishes.

Channel Catfish - The greatest potential threat to endangered fishes is from channel catfish, which prey upon and compete with native species. Channel catfish have been observed feeding on chub at the mouth of the Little Colorado River. Under temperature augmentation, the suitable spawning temperature for this species of 21-29°C would occur only in the lowermost reaches of the canyon. Optimum growth temperature of 26-30°C is not likely to occur.

Carp - The effect of carp on native fishes is expected to be insignificant with those species that deposit their eggs in deep, swift cobble where eggs drop into protected crevices, removed from the suction feeding of carp. This species is likely to have suitable spawning temperatures in the mainstem under temperature augmentation, but since carp require vegetation or structure for attaching their eggs, their spawning sites are likely to be limited to warm quiescent areas such as flooded lowlands or stable backwaters. These features are likely to be available to carp under flow management scenarios that favor long-term stability of backwaters, even without temperature augmentation.

Fathead Minnows - The small numbers of fathead minnows that occur in the Grand Canyon could be expected to increase in abundance and distribution with warm flows, but because of the inability of this species to tolerate even moderate current and riverine conditions, its numbers could be easily controlled with flow management, possibly even of the magnitude seen under existing interim flows.

Red Shiners - Red Shiners may exclude other species, although the mechanisms are not fully understood. Like fathead minnows, red shiners experienced dramatic decreases in density during high flows, but this species is more tolerant to current and riverine conditions. High fluctuating releases from the dam prevented stable backwaters, the primary habitat for this species. Minckley reported that red shiners were common in the Grand Canyon prior to completion of Glen Canyon Dam.

Plains Killfish and Mosquitofish - These species are not expected to increase in great numbers in the mainstem. They are relatively intolerant of high velocity conditions.

Striped Bass - Thermal augmentation may allow for greater numbers of striped bass to ascend into the Grand Canyon, but it is unlikely that these would become resident any further upstream than their current distribution. It is likely that stream velocity and the absence of deep lentic habitat limits upstream distribution of striped bass in the Grand Canyon, not cold water releases.

Walleyes - Although highly predaceous, walleyes are not expected to invade the Grand Canyon with warmer releases since present releases already provide optimum spawning temperatures.

Lentic Fish - Other lentic fish species that pose a possible threat to native fishes in the Grand Canyon are black bullhead, green sunfish, smallmouth bass, and largemouth bass. These species are highly predaceous if they gain access to backwaters. Except for smallmouth bass, these species are relatively weak swimmers and are unlikely to gain access into the Grand Canyon in large numbers. They rarely occur in the main river channel in the upper basin, and rely almost exclusively on backwater habitats.

The other lentic species--bluegill, black crappie, and threadfin shad--are extremely weak swimmers and very intolerant of swift riverine conditions, and would not be expected to invade Grand Canyon.

Flathead Catfish - This species is common and problematic in many tributaries below Hoover Dam, but has not been reported in Lake Mead. This species prefers warmer temperatures and more quiescent flooded lowlands than are available in Grand Canyon.

Fish Parasites - Valdez reported that two parasites are of particular concern in Grand Canyon. Asian tapeworm was reported from humpback chub in Grand Canyon. The absence of the tapeworms in 1989 suggest that this parasite has only recently entered the region, or that the parasite had been present and stressfull conditions for the fish allowed for the proliferation of individual cestodes. Asian tapesworms lack host specificity and have been found in fathead minnows, red shiners, and mosquitofish. Valdez concluded that egg maturation would probably not occur in the mainstem even under temperature augmentation although temperatures would be suitable for survival of the tapeworms.

The second parasite of concern is the anchor worm which occurs in native and non-native fishes in the Upper Colorado River Basin. Infestation of Colorado squawfish, razorback suckers, and humpback chub are common. The effect of anchor worms on fishes in the upper basin is unknown, but does not appear to lead to significant numbers of fish mortalities.

Lake Powell Fishery - Threadfin shad were introduced to Lake Powell as a forage base for the fishery. The shad already experience occasional winterkill from low reservoir temperatures. State wildlife agencies have proposed replacing the threadfin with a more cold tolerant species. A decrease in winter lake temperatures can be expected from warm water releases, aggravating this problem. A more cold hardy forage fish could be introduced as a substitute if needed. This would violate the present FWS moratorium on introduction of new, exotic species to the system.

The slightly higher rate of nutrient retention might cause a very small increase the productivity of the food chain in the lake. This in turn might decrease oxygen levels in the lake slightly, especially just below the thermocline. The shallower thermocline, caused by selective withdrawal, would tend to compress the fishery into a thinner layer.

Lake Powell does not seem to have any significant problems with high nutrient inflows or algae blooms. Due to the length of the reservoir, it is unlikely that changes in the release level at the dam would have much of an effect on the inflow zone where problems would first arise.

Lake Mead Fishery - Higher nutrient retention by Lake Powell would somewhat reduce the productivity (algae/fishery) of the downstream river/reservoir system. The productivity of Lake Mead has already been reduced by nutrient retention in Lake Powell. Surface withdrawal might aggravate this problem somewhat. Warmer, surface inflows to Lake Mead would offset this effect to some degree.

Summer surface temperatures at Lake Mead are usually above 20°C while inflows are about 16°C. Existing inflows to Lake Mead flow under the reservoir's surface layer making nutrient inflows less available to algae. Warming the river would lighten the inflows to Lake Mead, increasing the loading of summer nutrients in the inflow zone. This, in turn, would increase the primary productivity in Boulder Bay, a relatively poor area of productivity in the lake.

Reservoir Evaporation - the alternative would decrease evaporation at Lake Powell and increase evaporation at Lake Mead. Discharge of warmer water from the surface of Lake Powell would cool the reservoir and decrease evaporation. A computer modelling study of Lake Mead predicted that reservoir evaporation could be reduced by up to 4 percent if warm water were discharged off the surface of Lake Mead. Similar results might be expected by cooling Lake Powell. Any small savings in evaporation at Lake Powell would likely be offset by increases in evaporation at Lake Mead due to the warming of the lake.

Recreation - Recreation, primarily rafting, should benefit from any warming in the river below Glen Canyon Dam. Warmer water temperatures would be safer. In 8°C (46°F) water, such is now prevalent immediately below the dam, only a few minutes are needed to numb and impair body movements should an individual accidentally fall in. Water temperatures could be increased in the summer months (by up to 18°F) with the addition of outflow temperature control, reducing the chances of hypothermia somewhat.

Compliance with Water Quality (Salinity) Standards - No impact is expected. Even now, salinity in the Colorado River varies more from changes in hydrologic conditions (run-off) than from any other single factor. Any change in the operation of the outlets may slightly influence the salinity of the river, but only in minor ways. Salinities in the Grand Canyon may vary, but will not be as extreme as before impoundment by Glen Canyon Dam. Most of the economic impacts from salinity occur below Lake Mead, where little impact is expected due to the buffering effects of the Lake.

The salinity standards are based on longterm (multi-year) averages. Since no salt loading is expected from temperature augmentation, there should be no effect on compliance with the standards.

Power Generation - only extremely minor (insignificant) headloss might be expected from the addition of a well designed selective withdrawal structure.

Discussion

Clarkson (Arizona Game and Fish), Gorman (Fish and Wildlife Service), Kubly (Arizona Game and Fish), Marsh (Arizona State University), and Valdez (Bio/West Inc.) produced a report in 1994 titled *Management of Discharge, Temperature, and Sediment in Grand Canyon for Native Fishes*. Among their recommendations they state, "Water temperature modification and sediment augmentation are additional elements likely required to complete the restoration process. Incorporation of these elements into dam operations would provide greater flexibility and offer more opportunities to use the dam as an effective tool to foster the multiple uses for which it was constructed."

In an analysis of temperature controls, Clarkson et.al. concluded that:

- **Native Fishes** - Temperature modification is the only way to alleviate the known restriction by cold water temperatures to successful mainstem reproduction of native fishes. Releases of 15°C in June and July should warm to 19-20°C--optimum for spawning, incubation, and rearing--in the mainstem reach beginning some 200 km below the dam.

- **Trout** - Such a temperature regime would likely benefit the Lee's Ferry tailwater fishery by providing more optimal temperatures for trout growth.

- **Competition from Non-Natives** - A lack of important environmental requirements, other than water temperatures, serves to restrict non-native fishes. These conditions should continue to limit the invasion and expansion of the non-natives.

- **Ecosystem** - Potential effects include: (1) alteration of algal species composition and productivity; (2) alteration of invertebrate species composition and productivity; (3) invasion and enhancement of additional non-native fishes from Lake Mead, Lake Powell, or internal tributaries, and; (4) increases in the incidence of fish diseases and parasites. Clarkson et al. emphasize, however, the proposed maximum release temperatures are only 5-6°C higher than present, and that cold water releases will continue during autumn and winter.

LEGISLATIVE/AUTHORITY ISSUES

Introduction

Major planning studies leading to construction of facilities requires several levels of Congressional action. Legislation is required to authorize planning studies and construct facilities. Annual appropriations are required to fund these activities. Appropriations and authorizations are addressed by separate committees of Congress.

This report will look at the authorities and funding mechanisms used to implement selective withdrawal at Flaming Gorge and evaluate existing authorities which may be used to study and construct the facilities at Glen Canyon Dam, another CRSP dam.

Requirements for Feasibility Studies

The Federal Water Project Recreation Act of 1965 requires specific authorization by law for the preparation of any feasibility report for a water resource project under Reclamation Law.

Federal Water Project Recreation Act - the Act states:

> "...neither the Secretary nor any bureau...shall engage in the preparation of any feasibility report...unless specifically authorized by law..."

The Act requires that Reclamation be specifically authorized to conduct feasibility level studies. Feasibility level studies are studies that contain detailed cost estimates which would be used for construction authorization. Planning reports/EIS's are generally considered feasibility reports.

Review of Existing Study and Construction Authorities

New legislation would normally be requested by Interior to specifically authorize an investigation of this magnitude. Congressional approval of the investigation would potentially delay the start of the investigation several years. Pursuing new authorities would require multiple acts of Congress (one for investigation, another for construction, as well as annual appropriations). Because of the urgent need to recover an endangered fish, existing authorities and precedents are evaluated in the following section to see if they may be applied to meet the requirements of the Federal Water Project Recreation Act.

Endangered Species Act - Section 4(f) of the Act states:

> "The Secretary (of the Interior) shall develop and implement plans for the conservation and survival of endangered and threatened species... The Secretary shall...give priority to those endangered species...in conflict with construction...development...or other economic activity..."

Reclamation proposes using this authority in combination with the Fish and Wildlife Coordination Act to fund its endangered fish recovery plans in the Green River Basin and upper portion of the Colorado River. A recent solicitor's opinion found that the Endangered Species Act can not be used for construction authority by itself.

Colorado River Storage Project Act (CRSP Act) - The CRSP Act provides clear authority to conduct studies, construct facilities, and operate them for fish and wildlife purposes.

Section 8 - Study and Construction Authority - Section 8 states:

> "In connection with CRSP, the Secretary is authorized to investigate, plan, construct, operate, and maintain...(2) facilities to mitigate losses of, and improved conditions for, the propagation of fish and wildlife..."

This section provides the authority used to investigate and construct a selective withdrawal structure at Flaming Gorge Dam and could be used to investigate and construct the outflow temperature control structure at Glen Canyon Dam, another CRSP Dam.

Section 5 - Limitations on the Use of Power Revenues - In using this authority, it should be noted that Section 5 of the CRSP Act makes section 8 funds non-reimbursable and prohibits the use of Basin Funds (CRSP power revenues) for section 8 activities. Consistent with sections 5 and 8, implementation of temperature controls at Flaming Gorge was funded through section 8 construction appropriations.

Section 12 - Appropriations Ceiling - Section 12 of the CRSP Act sets an appropriation ceiling (expenditure limit) for construction, including section 8 construction costs. According to recommendations made by the Office of the Inspector General and Office of Management and Budget, and with the Department of the Interior's concurrence, ceiling should be allocate by CRSP facility. It is unlikely any ceiling remains to modify Glen Canyon Dam. Legislation would be needed to increase the ceiling authorized for Glen Canyon Dam. Since planning and design of the facility will take several years, sufficient time is available for Congress to authorize a ceiling increase. Planning activities will consume CRSP ceiling, aggravating the ceiling problem for other portions of the project.

Section 15 - Quality of Water Studies - Section 15 authorizes water quality studies and states:

> "The Secretary of the Interior is directed to continue studies and make a report to the Congress and the States of the Colorado River Basin on the quality of water of the Colorado River."

The Quality of Water, Colorado River Basin, Progress Report is prepared every two years, in part, to comply with this section of the Act. Studies are funded from CRSP power revenues as authorized by the Act. Since temperature is a water quality parameter, sub-feasibility level studies could (in theory) be conducted under this authority. Neither feasibility study authority nor construction authority is provided by this section.

Recommendations

Any alternative authority/funding source considered would ultimately require some form of legislation (whether amending the CRSP Act or creating separate authorities). Using CRSP section 8 authorities would not immediately require Congressional action to begin planning/feasibility study activities (other that the appropriation of funds). Planning and construction activities are authorized under section 8, but additional ceiling would likely be required to begin construction. This request for legislation could be supported by a planning report/NEPA document and feasibility level cost estimates. Section 8 activities are non-reimbursable, a federal expense. Use of section 8 authorities and funding mechanisms would be consistent with the investigation and construction of the selective withdrawal structure at Flaming Gorge. Appropriations to conduct the initial investigations could be planned as early as FY-96.

OPTIONS AND RECOMMENDATION FOR FURTHER STUDY

Without actual field measurements of the impacts of warm water discharges, it would be extremely difficult to completely define the impacts of warm water releases on the entire reservoir/river ecosystem and develop operational alternatives. For the most part, attempts to dissect the system into components for theoretical or laboratory analysis is likely to be slow, expensive, and inconclusive. Laboratory experiments may not translate well into the river environment. How all the components of water quality and biology will react, interact, compete, and evolve is probably too dynamic and complex to predict with any accuracy. It will be difficult enough to measure post-construction effects.

In reviewing other studies, Reclamation's limnologists and fishery experts generally agree that our ability to accurately predict the water quality effects of temperature controls is limited. This is even more true for the biological effects which depend upon the accuracy of the water quality predictions. The errors compound as the system becomes more complex.

National Environmental Policy Act Compliance Implications

Because of the potential impacts of the alternative, NEPA compliance would be required. In past NEPA compliance, both environmental assessments and environmental impact statements have been used. An Environmental Assessment and Negative Determination of Environmental Impact was completed on Flaming Gorge in 1976 for the outflow temperature controls, but few negative impacts were expected. The parallel between the situations at Flaming Gorge Dam and Glen Canyon Dam is very strong. Trout fisheries exist below both dams. Selective withdrawal was installed at Flaming Gorge Dam to warm downstream temperatures. Endangered fish spawn in the Yampa River below the dam, much like humpback chub do in the Little Colorado River. The operation of the facility continues to evolve, much like we would expect the operation at Glen Canyon would.

Due to the magnitude of potential effects, an EIS would ultimately be needed for operation of a selective withdrawal structure at Glen Canyon Dam. The most recent example of NEPA compliance for a project of this magnitude was the outflow temperature control study at Shasta Dam, CVP were a planning report/final environmental statement was prepared in 1991.

Planning Options

Option 1 - Traditional Planning and Construction - This option would include a very deliberate sequence of events typical of Reclamation's planning and development of major water resource projects. This would include:

- study funding request
- comprehensive study and analysis of all impacts
- plan formulation
- draft planning report/environmental impact statement
- final planning report/environmental impact statement
- record of decision
- Congressional action (authorization to construct)
- appropriations (funding from Congress)
- construction

Option 2 - Phased with EA/FONSI on Test Facility - An EA/FONSI could, in theory, be used to construct a "test facility" since it is the operation of the facility, not its construction, which will cause impacts to the system. The results of the testing program would be used to complete NEPA compliance. A full EIS would be completed after testing of the facility to evaluate its operation, its impacts, and select one of the alternative discharge schemes. The alternatives evaluated would include a No Action Alternative which could return the discharge temperatures back to the way they are now.

The main advantage of this method, is that it would be extremely fast and inexpensive to implement. It recognizes that selective withdrawal is very likely to be the only feasible alternative warm discharge temperatures and that the ability of science to accurately predict complex chemical and biological interactions is very limited. A post-construction testing program would be a direct and effective way to measure the impacts of various discharge temperature alternatives and select the best alternative.

Ecological sciences are much better at measuring effects than predicting them. Quoting from a Reclamation workshop on the effects of selective level withdrawal, it was stated that "in almost every case additional effects occurred (from temperature controls) that were either unpredicted or resulted in changes greater or lesser than anticipated." The main strength of Option 2 is that it recognizes this fact.

Project Planning and Construction

- study funding request
- limited studies critical issues
- EA and potential FONSI on construction and testing of structure
- Congressional action (authorization to construct)
- appropriations (funding from Congress)
- construction

Post Construction Testing Program

- test various temperature release alternatives and their impacts
- draft planning report/environmental impact statement
- final planning report/environmental impact statement
- record of decision

Option 2 is essentially the method used to modify Flaming Gorge Dam for selective withdrawal. An EA/FONSI was used to construct the facility. Now post-construction monitoring is refining its operation for endangered fish downstream.

Comparison of the project schedules in Figure 2 on the following page shows that Option 2 is particularly attractive if the goal of the program is to quickly implement temperature changes and a testing program. Certainly the potential of a jeopardy opinion on the operation of Glen Canyon Dam with respect to endangered fish is reason enough to justify this option.

Most experts would agree that the construction of the facility will only add flexibility in river management. An EA/FONSI for the "test facility" would allow construction to proceed very quickly. The testing and PR/EIS in Option 3 would take over 80 months to complete. Option 2 would reduce this to about 12 months. Money saved by using an EA/FONSI could be used in testing, improving the operation of the facility.

Option 3 - Phased with PR/EIS on Test Facility - This option is variant of Option 2, replacing the EA/FONSI with an EIS to evaluate the potential range of impacts that might be expected from operation of the structure. Construction would then be completed. Testing of the facility would be conducted to measure the impacts of various discharge schemes. A

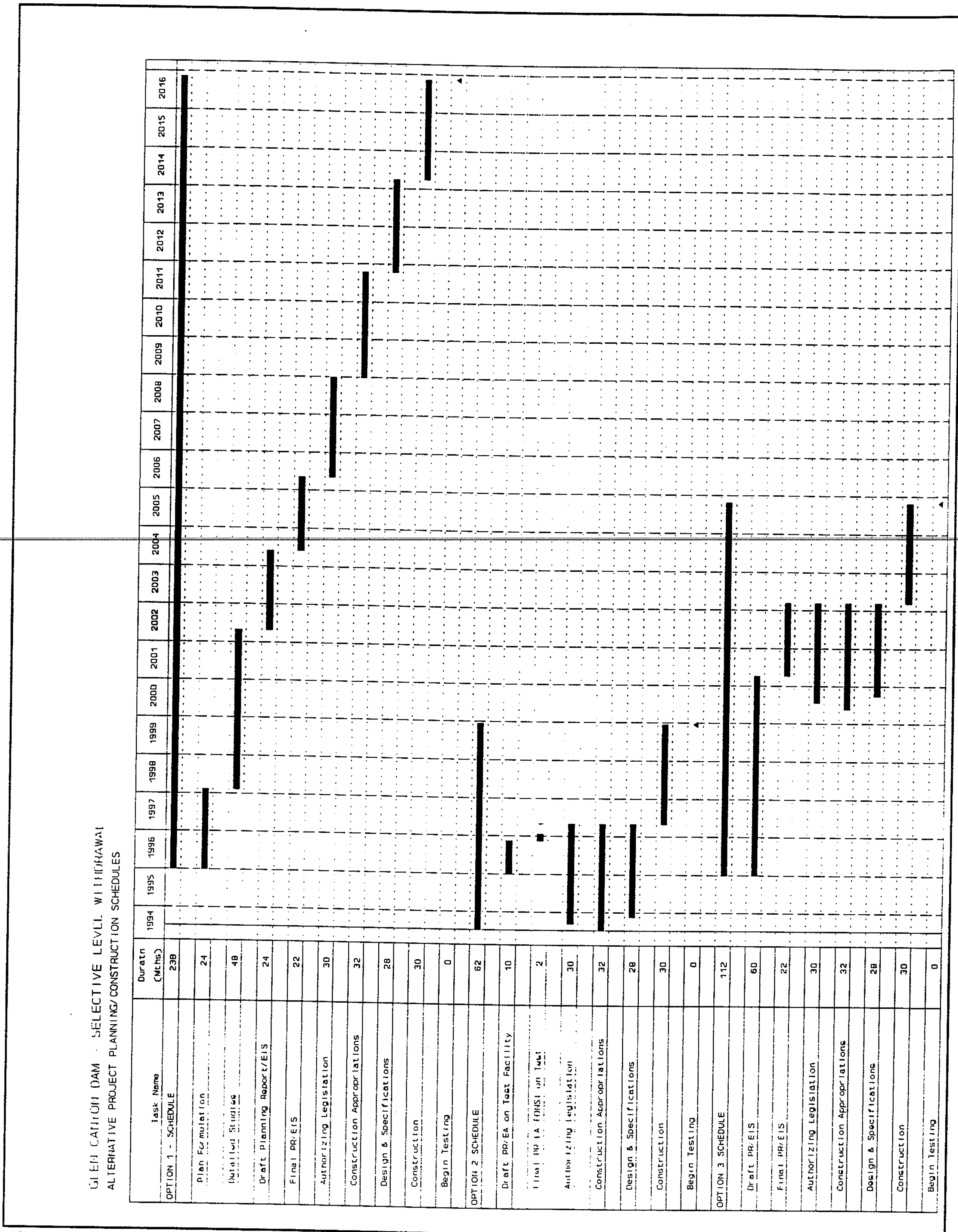

Figure 2 - Comparision of Project Schedules for Options 1, 2, and 3

supplement to the EIS would be prepared for these temperature release alternatives.

Project Planning and Construction

- study funding request
- studies to identify the potential range of impacts
- PR/EIS on potential range of impacts of SLW structure
- Congressional action (authorization to construct)
- appropriations (funding from Congress)
- construction

Post Construction Testing Program

- test various temperature release alternatives and their impacts
- draft supplement to EIS
- final supplement to EIS
- record of decision on operation

Recommendations - Either option 2 or 3 would be effective. From the preliminary evaluation of selective withdrawal, significant impacts might occur with the operation of the facility, but not from its construction. An environmental assessment could be used to evaluate/report the potential impacts and involve the public in the decision making process. The environmental assessment in phase 1 would not evaluate individual operational alternatives for the selective withdrawal structure, but would attempt to evaluate the range of potential impacts that might be expected from its operation. It might also include some pre-project testing.

Postproject testing and monitoring of the actual impacts of various alternative operations is critical to the success of the program. Options 2 and 3 anticipate that an EIS would be needed after the results of the testing program are analyzed. The EIS would include an evaluation of the impacts of various "operational" alternatives for selective withdrawal structure and select a recommended operation for the structure.

Option 3 is included in the project schedules in the Plan of Study. Option 2 should be evaluated further with the EPA, FWS, and other concerned parties.

Future Special Studies

There are two levels of studies that are recommended. Phase 1 studies would evaluate the potential impacts to be included in planning and NEPA compliance documents. Phase 2 studies will measure the impacts to the ecosystem from temperature modifications made possible by construction of the facility. The goal of the phase 2 studies will be to evaluate the impacts of various temperature release schemes. The impacts will then be evaluated in further NEPA compliance documents and an operation selected.

The recover of the endangered species will drive the decision process on whether or not to implement selective withdrawal. The potential bounds of the secondary impacts have already been identified; there are only a few key issues listed under "Preliminary Studies" that need to be resolved before a decision can be made on whether or not to construct the facility and test management alternatives. The balance of studies listed under "Testing and Impact Studies" would evaluate the impacts of the operation of the facility to determine their impacts for an EIS. Alternatives could then be developed and tested for inclusion in the EIS.

Phase 1 Planning Studies (optional):

- Impact on primary productivity below dam.
- Computer temperature modeling of lake/river system.

Phase 2 Post-Construction Testing/Monitoring/Impact Analysis:

- Water quality surveys in river/lake system
- Non-native river fishes: parasitism, growth rates
- Native fishes
- Competition/invasion by non-native fishes
- Forage base (threadfin shad)
- Lake fisheries
- Other issues identified by public scoping

An adaptive management strategy may be evaluated and implemented to optimize release temperatures from the dam after construction. Recovery programs elsewhere in the Basin are using this method to test and modify their hypotheses in attempts recover endangered fishes.

Project Scheduling Alternatives

Figure 3 on page 21 shows a comparison of two methods of project scheduling. For lack of a better term "Sequential" scheduling follows a process typical of the development of large water resource construction projects. It is heavily regulated, very deliberate, methodical, and extremely slow. The process develops plans, uses these plans to request enactment of laws to authorize construction, requests funding after authorization, and proceeds to design and construction when funding allows. This process is not typical of water quality improvement programs. These types of programs are usually authorized in fairly general terms by setting water quality goals and objectives. Spending limits (appropriations ceilings) are sometimes imposed.

To accelerate the project schedule using existing authorities, a form of "Parallel" scheduling is recommended. This is something of a hybrid of different planning methods. Planning would begin as soon as funds can be programmed (potentially FY-96). Within just a few years after that, requests for major construction appropriations will be required. At best, Parallel scheduling has the potential to shorten the process significantly or, at worst, it can take every bit as long as Sequential scheduling. The success of Parallel scheduling depends on the willingness of the government (Congress and the administration) to request funds and legislation based on the likely outcome of the planning process using draft reports and preliminary findings.

Figure 3 shows that Parallel scheduling could potentially reduce the study/construction schedule by 8 years. This comparison assumes equal times for task in the project schedule, but parallel scheduling assumes that legislation, construction funding, and design work can be completed concurrent with the preparation of the planning report/EIS. This figure does not display the Phase 2 monitoring and testing program which would follow construction. This schedule would be shortened significantly if an EA/FONSI were used for construction of the "test" facility.

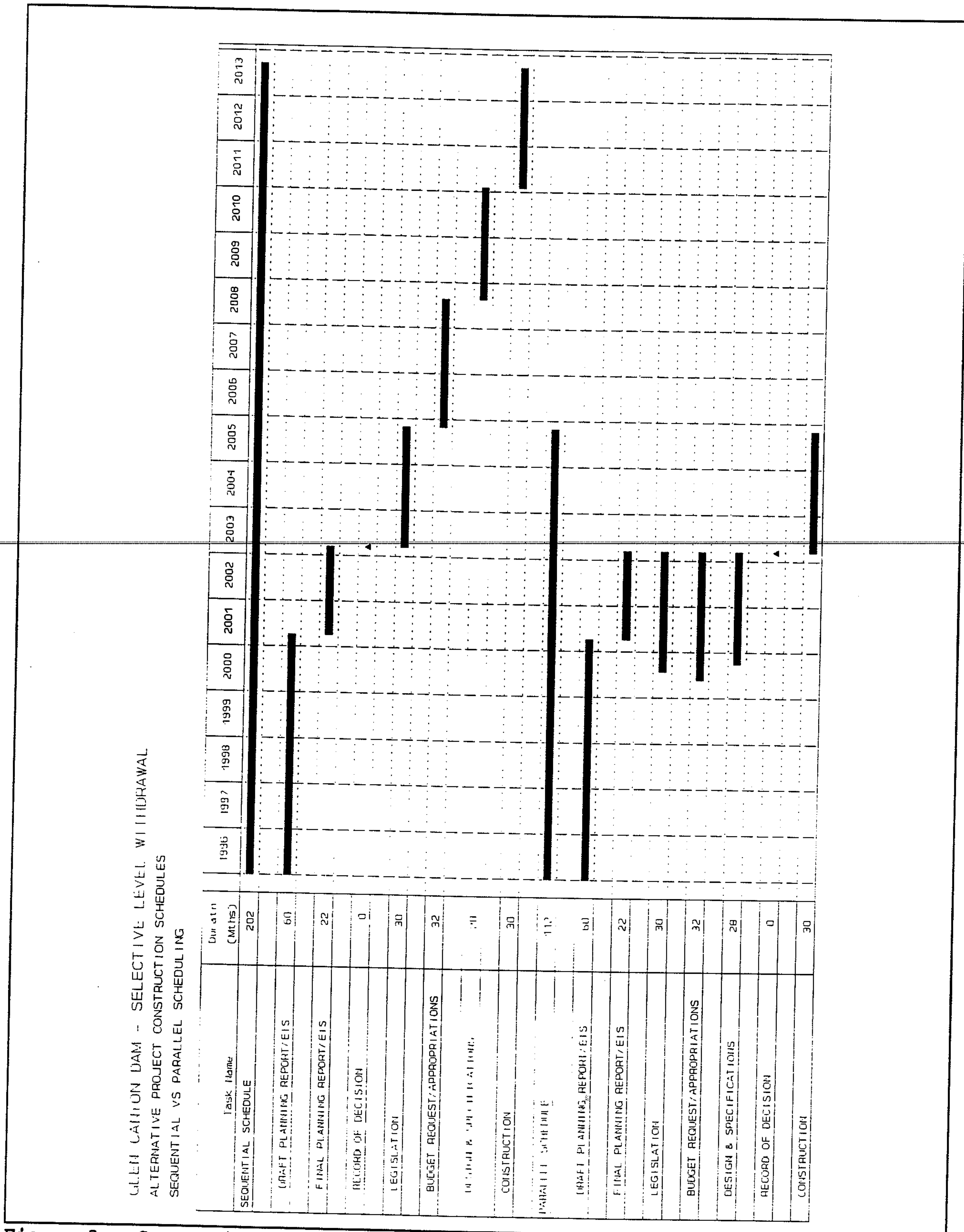

Figure 3 - Sequential vs Parallel Schedules

PLAN OF STUDY

Purpose and Scope

The purpose of this plan of study is to budget from beginning to end the amount of resources (time, staff, and dollars) that might be needed to implement temperature controls at Glen Canyon Dam. One can expect the plan of study to change. As data and studies are completed in the future, the study plan will evolve with the facts and findings.

This plan recognizes that after construction, testing of the facility will be essential to its success. It is unlikely that the subtle tradeoffs and impacts of various temperature release schemes can be predicted with any reliability. A testing program would allow management options to be evaluated based on fact rather than speculation.

Optimizing the system will be the goal of a post-construction monitoring/testing program (Phase 2) designed to evaluate the impacts and tradeoffs of various operational alternatives. A detailed plan for this testing program should be included in the PR/EIS. After the testing/monitoring program is completed, additional public involvement and NEPA compliance should be used to select a temperature release scheme for the selective withdrawal structure.

Funding and Authority

Funding - Using the recommended authorities provided under section 8 of the CRSP Act, annual funding requests should be made through Reclamation's CRSP section 8 construction appropriation's budget. All section 8 activities are presently appropriated through Reclamation's construction budget and are nonreimbursable under the Act. This method of funding would be consistent with the planning and construction of the selective withdrawal structure at Flaming Gorge retrofit.

Study and Construction Authorities - Although study and construction authorities exist under section 8 of the CRSP Act to complete the selective withdrawal facility, legislation will be needed to increase the appropriation ceiling (expenditure limit) set by Congress for the project so that additional funds may be appropriated for construction of the selective withdrawal structure at Glen Canyon Dam. Section 12 of the CRSP Act sets an appropriation ceiling for construction, most all of which has been used or reallocated to other projects. It appears that section 8 construction costs for selective withdrawal (over $60 million) would be included in the appropriation ceiling. This would be consistent with the work done at Flaming Gorge and requirements of the Act. Planning studies would consume a portion of the CRSP appropriation ceiling.

Alternatives to be Studied

Under Reclamation's normal planning process, alternative plans would be formulated and those that were viable would be taken into the next higher level of analysis, a planning report/environmental impact statement (PR/EIS). In the interests of time, this process can be shortened by conducting plan formulation as a part of the PR/EIS process. This accelerated approach is proposed for this study.

In a brief review of the alternatives, it is reasonable to predict that some form of selective withdrawal will be favored over other alternatives due to the obvious problems with those alternatives. Dam operations like holding water surface levels extremely high or low to allow warm water discharge would totally eliminate power production and water storage. Using waste heat from Navajo Powerplant would likely be more expensive and much less flexible than selective withdrawal. These alternatives should be and will be analyzed in detail to confirm whether or not they are viable. If they are, the scope and direction of future studies will need to be adjusted accordingly.

The objective of the next level of study will be to complete a planning report/environmental compliance document to evaluate the costs and impacts of temperature control below Glen Canyon Dam. This document would be used for NEPA compliance, construction authorizations, and appropriations requests as needed.

Tasks/Schedule/Funding Requirements

Scheduling and funding requirements shown in this plan are for a full planning report/enviromental impact statement in phase 1. If an environmental assessment is substituted, the timeline shortens considerably.

Project Tasks/Schedules - Figure 4 on page 24 shows the program broken into two major phases. Detailed schedules for Phase 1 and 2 are shown on page 25 and 26 respectively. Phase 1 includes activities through construction of the facility including: studies, planning reports, NEPA compliance, legislation, design, and construction. Phase 2 includes post-construction testing, monitoring, additional environmental reporting, and selection of a temperature release alternative for the operation of the facility.

To shorten the time to construction, the tasks in the critical path were uncoupled. Under normal conditions most of the major tasks shown in the schedule would occur sequentially (see page 21). This schedule proposes that as soon as the Final PR/EIS is completed and a ROD signed, everything needs to be in place to allow construction to begin. To allow this, the schedule shows:

(1) Authorizing legislation for an increase in the construction ceiling is moved through Congress based on preliminary data and as the draft planning report comes available. This works well with the acceleration of preconstruction activities which define the costs used for the ceiling increase.

(2) Preconstruction activities including design, specifications, and costs are conducted in parallel with the preparation of the PR/EIS,

The critical path for this schedule goes through the PR/EIS, ROD, construction, and into testing and further NEPA compliance. Legislation, funding, and preconstruction activities are timed to avoid delays.

Legislative/Budget Process - Figure 7 on page 27 shows a breakout of the budget request process needed for construction of the facility. Construction costs programmed under this budget would likely exceed $20 million per year, a major request for funds.

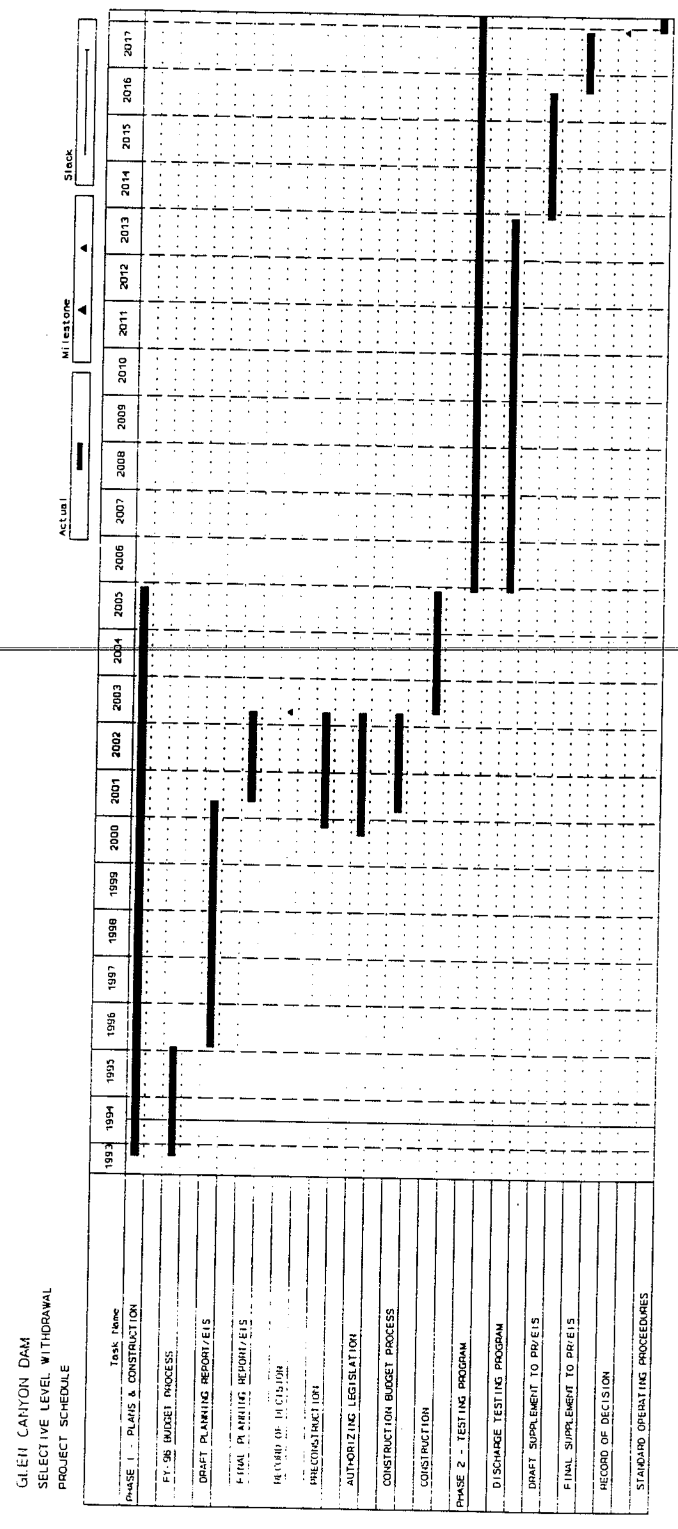

Figure 4 - Project Schedule - Overview of Phase 1 & 2

GLEN CANYON DAM
SELECTIVE LEVEL WITHDRAWAL
PROJECT SCHEDULE

Task Name	Duratn (Mths)	Effort (Mths)	Task Type
PHASE I - PLANS & CONSTRUCTION	138.7	225.9	SUMMARY
FY-96 BUDGET PROCESS	26.6	0	SUMMARY
DRAFT PLANNING REPORT/EIS	60	73.5	SUMMARY
Federal Register Notice	1	0.1	ASAP
Public Scoping	3	0.9	ASAP
Preliminary Studies	23	7.5	SUMMARY
F&WS/NBS Coordination	4	4	ASAP
Workplans for Studies	3	1.5	ASAP
Service Agreements/Contracts	4	2	ASAP
Downstream Productivity	8	0	ASAP
Temperature Modeling	12	0	ASAP
F&WS Coordination on DEIS	24	3.5	SUMMARY
Biological Assessment	4	2	ASAP
Biological Opinion	3	1.5	ALAP
Prepare Draft PR/EIS	30	61.5	SUMMARY
Report Preparation	24	60	ASAP
Review, Approval, Edit	3	1.5	ASAP
Printing	3	0	ASAP
File Draft PR/EIS	0	0	ASAP
Public Comment Period	3	0	ASAP
FINAL PLANNING REPORT/EIS	22	27.5	SUMMARY
Further Studies	6	6	ASAP
Prepare Final PR/EIS	14	21.5	SUMMARY
Respond to Comments	4	4	ASAP
Report Preparation	8	16	ASAP
Review, Approval, Edit	3	1.5	ASAP
Printing	3	0	ASAP
File Final PR/EIS	0	0	ASAP
Public Comment Period	2	0	ASAP
RECORD OF DECISION	0	0	ASAP
PRECONSTRUCTION	28	35.5	SUMMARY
Design	22	31	SUMMARY
Computer Modeling	6	3	ALAP
Hydraulic Lab Modeling	8	16	ALAP
Construction Design	8	12	ALAP
Specifications	6	4.5	ALAP
AUTHORIZING LEGISLATION	10	2.4	SUMMARY
Prepare Bill	2	0.5	ALAP
Submit Bill to Interior	2	0.4	ALAP
Submit Bill to OMB	2	0.3	ALAP
Authorization Process	24	1.2	ALAP
CONSTRUCTION BUDGET PROCESS	24	0	SUMMARY
BR Budget Formulation	6	0	ALAP
OMB/Interior Review	10	0	ALAP
President's Budget to Congress	0	0	ALAP
Congressional Review	8	0	ALAP
Appropriations	0	0	ALAP
CONSTRUCTION	30	3	SUMMARY
Contracting	6	3	ALAP
Award	0	0	ASAP
Construction	24	0	ASAP

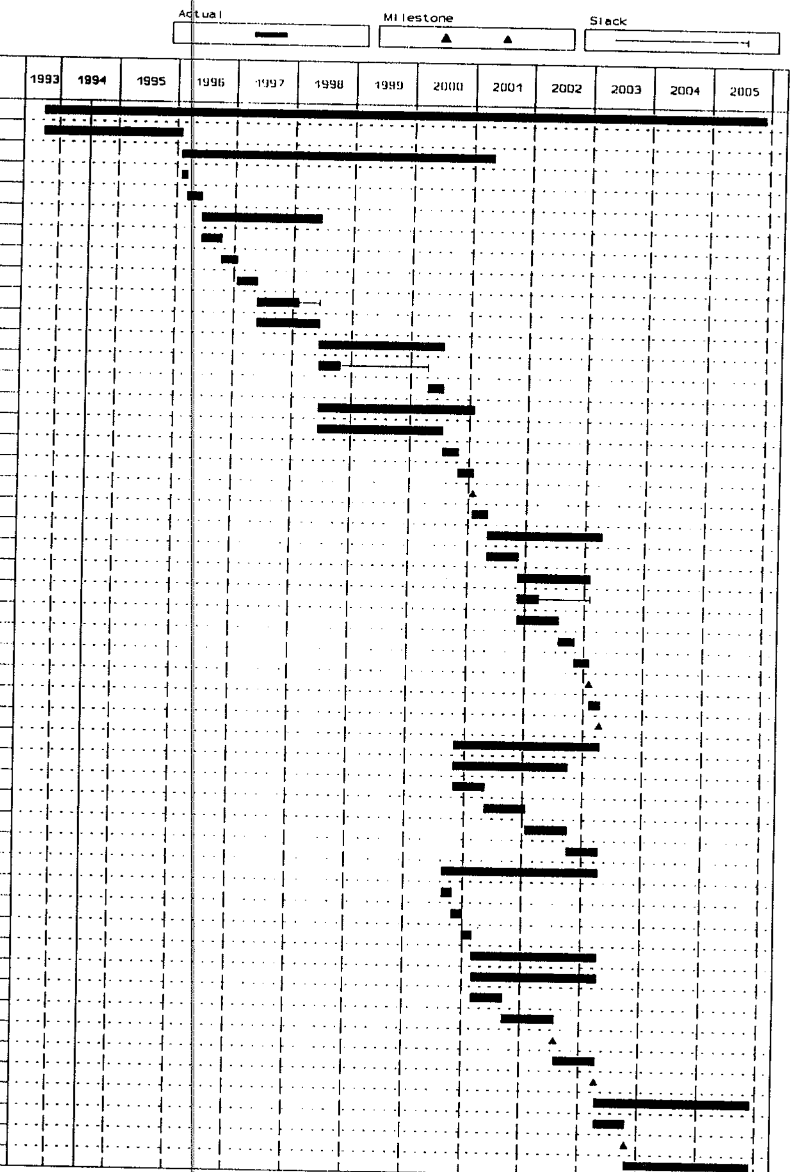

Figure 5 - Phase 1 Detailed Schedule

GLEN CANYON DAM
SELECTIVE LEVEL WITHDRAWAL
PROJECT SCHEDULE

Task Name	Duratn (Mths)	Effort (Mths)	Task Type
PHASE 2 - TESTING PROGRAM	141	145.6	SUMMARY
DISCHARGE TESTING PROGRAM	91	27	SUMMARY
Plan Development	31	15	SUMMARY
FWS/NBS Coordination	1	3	ASAP
Reservoir Ecosystem Study Plan	6	3	ASAP
Threadfin Replacement	6	3	ASAP
Endangered Fish Study Plan	6	3	ASAP
FWS/NBS Coordination	4	0	ASAP
River Ecosystem Study Plan	6	3	ASAP
Testing Program	48	0	SUMMARY
Native Fish	48	0	SUMMARY
Competition	48	0	ASAP
River Spawning	48	0	ASAP
Non-Native River Fish	48	0	SUMMARY
Parasites	48	0	ASAP
Growth Rates	48	0	ASAP
River Productivitiy	48	0	SUMMARY
Algae	48	0	ASAP
River Water Quality	48	0	SUMMARY
Nutrients	48	0	ASAP
Dissolved Oxygen	48	0	ASAP
Temperatures	48	0	ASAP
Lake Limnology & Fishery	48	0	ASAP
Management Plan Development	12	12	ASAP
DRAFT SUPPLEMENT TO PR/EIS	31	37	SUMMARY
Federal Register Notice - NOI	1	0.1	ASAP
Public Scoping	3	0.9	ASAP
Prepare Draft Supplement	24	36	ASAP
File Draft Supplement	0	0	ASAP
Public Comment Period	3	0	ASAP
FINAL SUPPLEMENT TO PR EIS	15	17	SUMMARY
Respond to Comments	6	6	ASAP
Prepare Final Supplement	15	11	ALAP
File Final Supplement	0	0	ASAP
Public Comment Period	0	0	ASAP
RECORD OF DECISION	0	0	ASAP
STANDARD OPERATING PROCEEDURES	4	0	SUMMARY
Prepare Manual	4	0	ASAP
Finalize Manual	0	0	ASAP

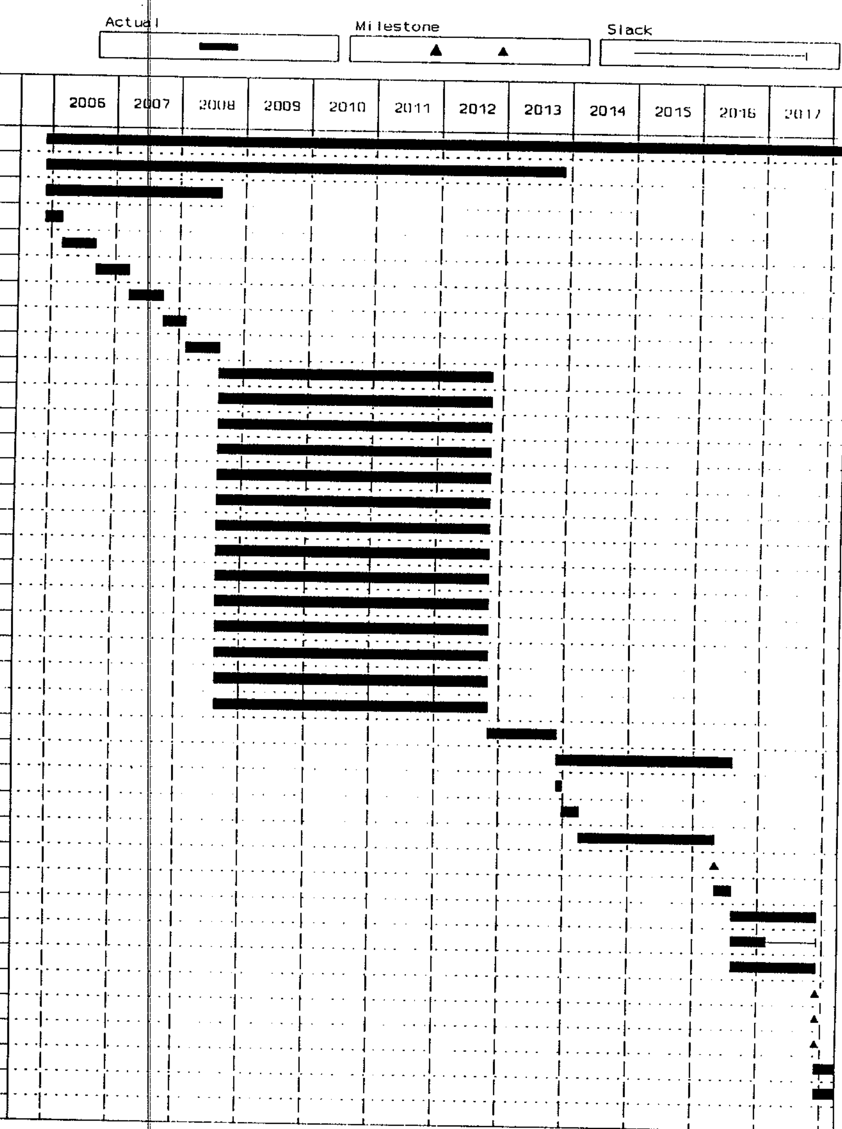

Figure 6 - Phase 2 Detailed Schedule

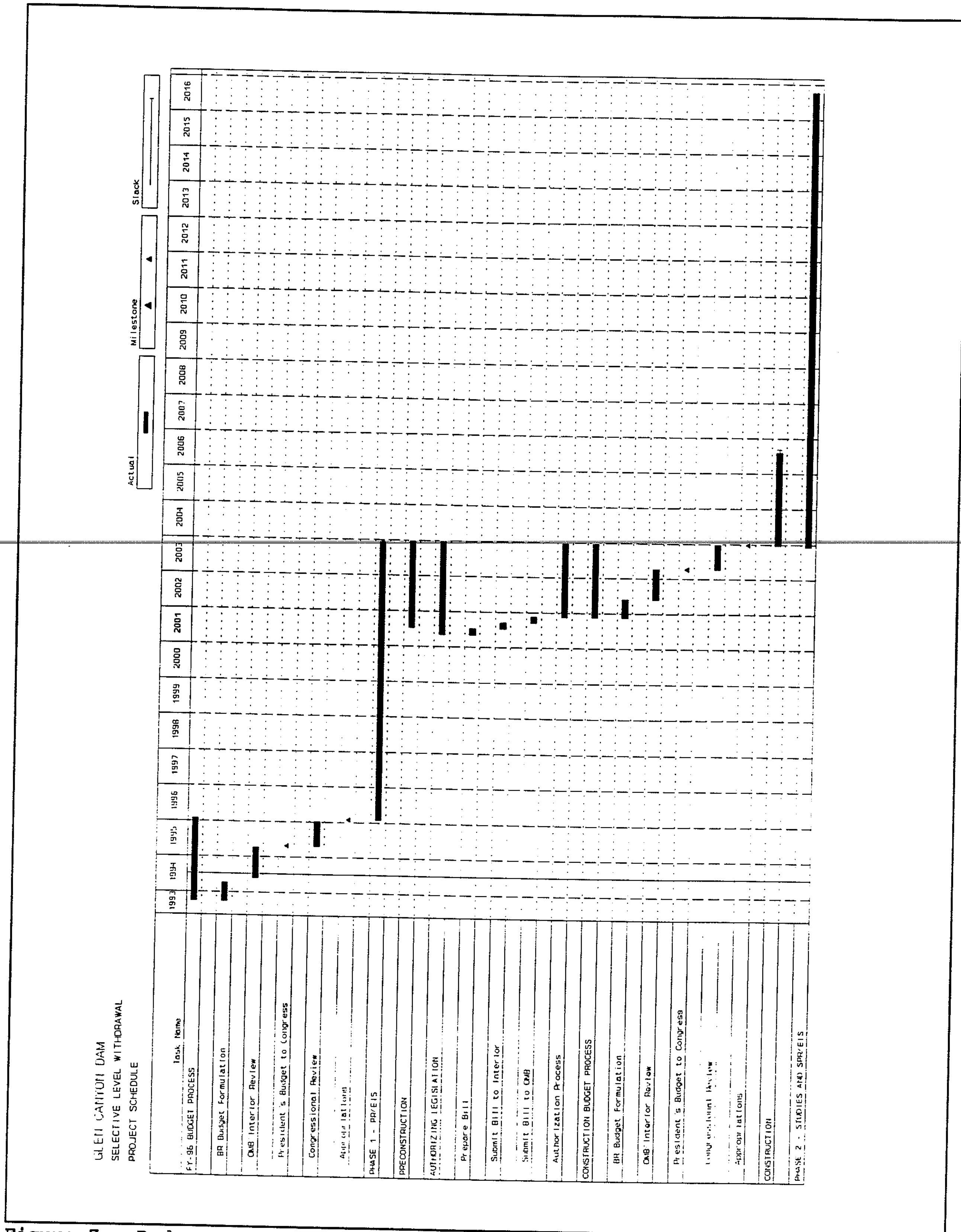

Figure 7 - Budget and Legislative Schedule

Table II - Costs by Task.

	Contract Costs	Staff Costs	Total
PHASE I - PLANS & CONSTRUCTION	60,410,000	1,560,900	61,970,900*
DRAFT PLANNING REPORT/EIS	395,000	808,500	1,203,500
Federal Register Notice		1,100	1,100
Public Scoping		9,900	9,900
Preliminary Studies	380,000	82,500	462,500
FWS/NBS Coordination		44,000	44,000
Workplans for Studies		16,500	16,500
Service Agreements/Contr		22,000	22,000
Downstream Productivity	200,000		200,000
Temperature Modeling	180,000		180,000
FWS Coordination on DEIS		38,500	38,500
Biological Assessment		22,000	22,000
Biological Opinion		16,500	16,500
Prepare Draft PR/EIS	15,000	676,500	691,500
Report Preparation		660,000	660,000
Review,Approval,Edit		16,500	16,500
Printing	15,000		15,000
FINAL PLANNING REPORT/EIS	15,000	302,500	317,500
Further Studies		66,000	66,000
Prepare Final PR/EIS	15,000	236,500	251,500
Respond to Comments		44,000	44,000
Report Preparation		176,000	176,000
Review,Approval,Edit		16,500	16,500
Printing	15,000		15,000
PRECONSTRUCTION		390,500	390,500
Design		341,000	341,000
Computer Modeling		33,000	33,000
Hydraulic Lab Modeling		176,000	176,000
Construction Design		132,000	132,000
Specifications		49,500	49,500
AUTHORIZING LEGISLATION		26,400	26,400
Prepare Bill		5,500	5,500
Submit Bill to Interior		4,400	4,400
Submit Bill to OMB		3,300	3,300
Authorization Process		13,200	13,200
CONSTRUCTION	60,000,000	33,000	60,033,000
Contracting		33,000	33,000
Construction	60,000,000		60,000,000

Table II - Costs by Task (continued).

	Contract Costs	Staff Costs	Total
PHASE 2 - TESTING PROGRAM	8,400,000	890,750	9,290,750*
DISCHARGE TESTING PROGRAM	8,400,000	297,000	8,697,000
Plan Development		165,000	165,000
FWS/NBS Coordination		33,000	33,000
Reservoir Ecosystem Study		33,000	33,000
Threadfin Replacement		33,000	33,000
Endangered Fish Study Plan		33,000	33,000
River Ecosystem Study Plan		33,000	33,000
Testing Program	8,400,000		8,400,000
Native Fish	4,000,000		4,000,000
Non-Native River Fish	400,000		400,000
River Productivity	1,500,000		1,500,000
River Water Quality	2,000,000		2,000,000
Lake Limnology & Fishery	500,000		500,000
Management Plan Development		132,000	132,000
DRAFT SUPPLEMENT TO PR/EIS		407,000	407,000
Federal Register Notice		1,100	1,100
Public Scoping		9,900	9,900
Prepare Draft Supplement		396,000	396,000
FINAL SUPPLEMENT TO PR/EIS		186,750	186,750
Respond to Comments		66,000	66,000
Prepare Final Supplement		120,750	120,750
Project Management		1,897,500	1,897,500
PHASE 1 & PHASE 2 - GRAND TOTAL	68,810,000	2,451,650	73,159,150*

Table III - Annual Budget.

	FY96	FY97	FY98	FY99	FY00	FY01	FY02
PHASE I - PLANS & CONSTRUCTION	154,750	393,670	394,080	407,875	332,555	405,445	466,468
FY-96 BUDGET PROCESS							
PROJECT MANAGEMENT	86,250	94,125	94,125	94,125	94,125	93,750	94,125
DRAFT PLANNING REPORT/EIS	68,500	299,545	299,955	313,750	217,205	4,545	
FINAL PLANNING REPORT/EIS						114,000	197,818
RECORD OF DECISION							
PRECONSTRUCTION					11,250	184,750	168,250
AUTHORIZING LEGISLATION					9,975	8,400	6,275
CONSTRUCTION BUDGET PROCESS							
CONSTRUCTION							
PHASE 2 - TESTING PROGRAM							
PROJECT MANAGEMENT							
DISCHARGE TESTING PROGRAM							
DRAFT SUPPLEMENT TO PR/EIS							
FINAL SUPPLEMENT TO PR/EIS							
RECORD OF DECISION							
STANDARD OPERATING PROCEEDUR							
Total	154,750	393,670	394,080	407,875	332,555	405,445	466,468

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
PHASE I - PLANS & CONSTRUCTION	5,843,000	28,616,852	25,880,205				
FY-96 BUDGET PROCESS							
PROJECT MANAGEMENT	94,500	94,125	84,750				
DRAFT PLANNING REPORT/EIS							
FINAL PLANNING REPORT/EIS	5,682						
RECORD OF DECISION							
PRECONSTRUCTION	26,250						
AUTHORIZING LEGISLATION	1,750						
CONSTRUCTION BUDGET PROCESS							
CONSTRUCTION	5,714,818	28,522,727	25,795,455				
PHASE 2 - TESTING PROGRAM			18,000	135,500	109,500	843,727	2,059,341
PROJECT MANAGEMENT			6,000	62,500	62,500	63,000	62,750
DISCHARGE TESTING PROGRAM			12,000	73,000	47,000	780,727	1,996,591
DRAFT SUPPLEMENT TO PR/EIS							
FINAL SUPPLEMENT TO PR/EIS							
RECORD OF DECISION							
STANDARD OPERATING PROCEEDUR							
Total	5,843,000	28,616,852	25,898,205	135,500	109,500	843,727	2,059,341

	FY10	FY11	FY12	FY13	FY14	FY15	FY16
PHASE I - PLANS & CONSTRUCTION							
FY-96 BUDGET PROCESS							
PROJECT MANAGEMENT							
DRAFT PLANNING REPORT/EIS							
FINAL PLANNING REPORT/EIS							
RECORD OF DECISION							
PRECONSTRUCTION							
AUTHORIZING LEGISLATION							
CONSTRUCTION BUDGET PROCESS							
CONSTRUCTION							
PHASE 2 - TESTING PROGRAM	2,059,341	2,059,341	1,745,500	176,250	215,000	251,000	252,500
PROJECT MANAGEMENT	62,750	62,750	62,500	62,750	62,750	62,750	63,000
DISCHARGE TESTING PROGRAM	1,996,591	1,996,591	1,683,000	111,500			
DRAFT SUPPLEMENT TO PR/EIS				2,000	152,250	188,250	64,500
FINAL SUPPLEMENT TO PR/EIS							125,000
RECORD OF DECISION							
STANDARD OPERATING PROCEEDUR							
Total	2,059,341	2,059,341	1,745,500	176,250	215,000	251,000	252,500