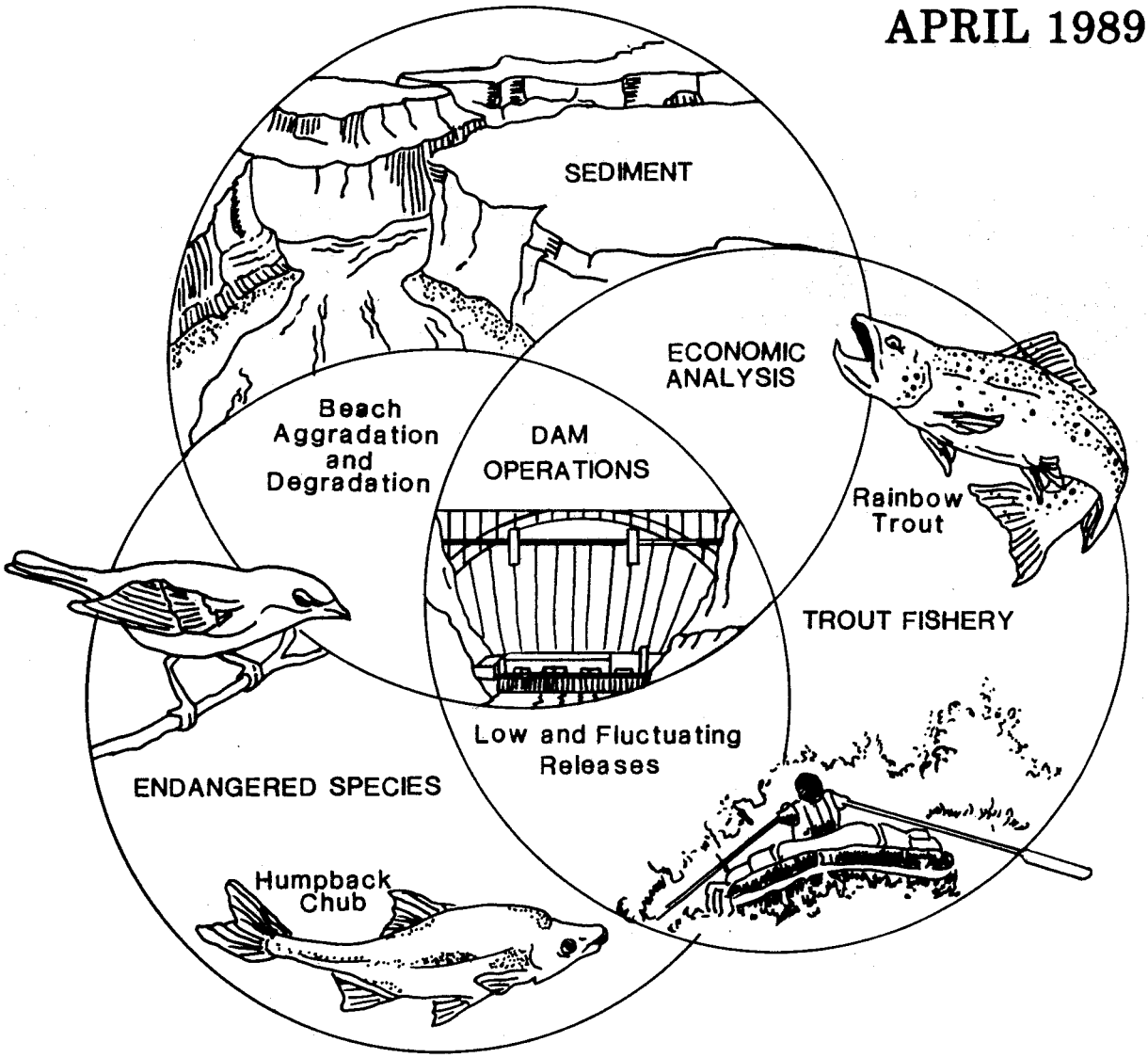
GLEN CANYON ENVIRONMENTAL STUDIES

PHASE II

TECHNICAL STUDY PLAN OUTLINE: FISCAL YEAR 1989 AND PROCESS FOR COMPLETION OF THE TECHNICAL STUDIES

APRIL 1989



GLEN CANYON ENVIRONMENTAL STUDIES

PHASE II TECHNICAL STUDY PLAN OUTLINE:

Fiscal Year 1989 and

Process for Completion of the

Technical Studies

APRIL 1989

United States Department of the Interior
Bureau of Reclamation
National Park Service
Fish & Wildlife Service
U.S. Geological Survey

Department of Energy
Western Area Power Administration

Colorado River Basin States
Colorado River Storage Project Power Customers
Arizona Game and Fish Department
Environmental Constituents
Private Consultants
Recreation Constituents

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PHASE II TECHNICAL STUDY PLAN OUTLINE:

Fiscal Year 1989 and
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I. INTRODUCTION

A. Objective

This study plan represents an initial attempt to outline the specific studies required to address the Phase II objectives of the Glen Canyon Environmental Studies (GCES). This information was developed in response to a directive from the Executive Review Committee to provide a more definitive outline of the technical requirements, the costs, and the time required to complete the environmental and economic portions of the GCES Phase II technical studies program.

This document begins with a brief discussion of the approach, the primary directives, and guidelines that the technical study teams are working under. A request is made to the Executive Review Committee for clarification of certain areas and directions. fiscal year 1989 studies are derived from the technical categories of studies addressed at the January 9-10, 1989 GCES Environmental Study Team meeting.

B. Approach

The Phase II Study Plan is presented in four sections: (1) fiscal year 1989 Monitoring, Data Analysis, and Integrated Study Plan, (2) Boundaries in the Design of the Technical Program, (3) Critical fiscal year 1989 Study Needs, and (4) Development of an Integrated Study Plan for fiscal years 1990-91.

The development of these technical categories of studies implements the focus identified by the GCES Environmental Study Team discussions on January 9-10, February 16-17, and March 20-21, 1989. In addition, the approach integrates the technically oriented environmental concerns raised by the resource bureaus and agencies associated with the GCES Program. The overall GCES process and policy boundaries are defined in the "GCES Phase II and III Program for Implementation" and are not discussed in this document.

C. Directives and Guidelines

Inherent in the development of any study plan is the knowledge that there are certain directives and guidelines that dictate the scope and direction of study. The GCES Phase II Environmental Study Plan is no exception. The directives and guidelines used in this plan are as follows:

1. The Executive Review Committee agreed, in concept, with the concerns raised in the INTERIM Technical Integration Team memorandum (Appendix 1, page 4).

2. The Executive Review Committee has directed that the environmental technical studies be designed and carried out in such a way as to yield a "75% Comfort Level" of decision. The level of risk associated with decision-making is a function of the length of time of study, the conditions during the study relative to the entire period of concern, the level of understanding prior to study initiation, and the intensity and quality of effort during the period of study. Risk assessment is the responsibility of scientists who carry out the technical studies, but risk management is the role of policy makers.

3. The Executive Review Committee directed that time, dollars, access, and required flows be estimated and the parties responsible for each category of study be identified.

4. The attainment of the 75% level of risk requires that the uncertainty (error) in conclusions drawn from results of initial studies must be defined as closely and quantitatively as possible. An assessment of the cumulative and interactive uncertainty will also be required.

5. In order to achieve a 75% level of risk on certain management decisions, the decisions for which a lower level of risk (an a higher level of certainty) is needed must be presented to the study planning team.

6. It is understood by all parties that some environmental resources depend on antecedent conditions. Therefore, it is necessary that antecedent conditions be documented prior to initiation and analysis of the collected data.

D. Need for Additional Clarification from the Executive Review Committee

Prior to the development and initiation of an additional environmental technical study plan, direction and clarification is needed from the Executive Review Committee. The primary areas are as follows:

1. Identification of all decisions for which a lower than 75% level of risk is needed, (i.e., are there decisions which require less error and more certainty?) Priorities (if these exist) for decisions are needed.

2. A commitment to ensure employment of a Senior Scientist who will assist in the design and over-sight of the integration of the GCES technical studies.

3. Outline the relationship of the Executive Review Committee, the GCES study teams, and the Senior Scientist in determining the scope and make-up of the scientific program of the Phase II efforts.

4. An outline of the decision-making process that will result in recommendations to the Secretary of the Interior, including the weighing of environmental impacts, some of which cannot be measured in dollars lost or gained, and economic impacts which do have a monetary basis.

5. Direction of a thorough review of Colorado River water law and other legal aspects which define the management of the resources of the Colorado River.

E. Process To Be Followed

This draft GCES Phase II Technical Study Plan represents work that is necessary for fiscal year 1989 and

outlines the components that need to be considered in the development of the remainder of the GCES technical study program.

This Technical Study Plan will be sent to the GCES National Academy of Sciences review committee and the Executive Review Committee for their information. This plan will be used to assist the GCES Technical Study Teams in the development of the integrated research plan and the fiscal year 1990-91 studies.

In order to expedite the fiscal year 1989 program requirements, work will begin on the major items identified in this plan. Meetings will be held as necessary with the technical study teams to ensure feedback, information transfer, and discussion on the technical program direction.

II. FISCAL YEAR 1989: MONITORING, DATA ANALYSIS, AND INTEGRATED STUDY PLAN

[Note: This list is not arranged by order of importance. Study plans are listed by study area: integration, sediment (including cultural resources and campsite studies), trout fishery, endangered fish, and economics.]

A. SEDIMENT STUDIES

1. Flow routing model.

Major Premise: A reanalysis of the Unsteady Flow Routing Model (original by Reclamation) is necessary to refine the prediction of flow routing through the Grand Canyon (the model does not yield the required precision for estimates of magnitude and timing of peaks and troughs of fluctuating flows). The model will be verified with gaging station data. A flow routing model is needed to understand stage/ discharge relationships throughout the study area, identify flow levels at specific sites, and refine sediment transport relationships. The analysis will use existing gaging station data and some additional stage and discharge data from the current study period and study sites. Hydrology studies require a high level of analysis (90%) in order to achieve the "75% Comfort Level" for biological studies. The model will be documented and will interface with U.S. Geological Survey models.

Estimated Cost: $10,000

Responsible Parties: Bureau of Reclamation (Reclamation), U.S. Geological Survey (USGS), Fish & Wildlife Service (FWS).

Time to Complete: 6 months.

2. Sediment transport program.

(a.) Step 1: Development of a sediment sampling strategy.

Major Premise: An analysis of uncertainty in estimation of sediment loads and sediment storage changes is required in order to determine the most cost effective scheme of sampling at gaging stations and the best means for estimating storage

changes in a reach. The analysis will use existing sediment records and will include investigation of the use of automatic sediment samplers and a flow event alert system on tributaries. [A draft of this study will be completed by June 30, 1989.]

Estimated Cost: $25,000

Responsible Parties: USGS, Glen Canyon Environmental Studies (GCES) Office.

Time to Complete: 1 year.

(b.) Step 2: Re-establish USGS Gaging Stations (Contingent upon completion of Step 1.).

Major Premise: Five mainstem gaging stations along the Colorado River and two tributary gaging stations may be necessary to understand sediment sources, sinks, and transport to beaches and riparian zones. Reinstallation of some gages may be required prior to initiation of data collection. Four surface-water gages are already in place (Colorado River at Lee's Ferry, near Grand Canyon, Paria River, and Little Colorado River), while other gages will require installation of surface-water gages (Colorado River above Little Colorado River, National Canyon, above Diamond Creek, and Kanab Creek). Tributary gages may require installation of sediment-sampling equipment.

Estimated Cost: $100,000

Responsible Parties: USGS, GCES Office.

Time to Complete: 6 months.

3. Determination of the relationship between power release records and Glen Canyon Dam discharge.

Major Premise: Discharge from Glen Canyon Dam is currently determined from power production records. A large and inconsistent difference between the power release records and the gaging station measurements at Lee's Ferry has introduced inconsistencies to the analysis of all technical study components. The work will involve reinstallation of the cableway, cablecar and associated equipment, and a staff gage at the gaging station 3/4 mile downstream from Glen Canyon Dam. Releases must be

held steady for a period sufficient to produce a reliable measurement (may be up to 12 hours) to allow for flows to stabilize.

Estimated Cost: $16,000

Responsible Parties: USGS; Reclamation; National Park Service (NPS), Glen Canyon National Recreation Area (GCNRA); Western Area Power Administration (Western).

Time to Complete: Data collection dependent upon availability of flows. Data analysis will be completed one month after data collection ends.

4. Development of technical hydraulic studies to address beach aggradation and degradation.

Major Premise: Further understanding of the complex system of water and sediment movement through Grand Canyon and the erosion and deposition of sand in recirculation zones is required to provide the basis for decisions about beaches, native fish, wildlife, vegetation, and cultural resources. A beach surveying monitoring trip is necessary to document changes from 1980 to the present.

Estimated Cost: $50,000

Responsible Parties: USGS, Reclamation, NPS, FWS.
Time to Complete: 6 months

5. Cultural archeological resource analysis.

Major Premise: Loss of cultural resources by the reinitiation of fluctuating flows and erosion along the river corridor is threatening important Grand Canyon National Park cultural resources along the river corridor. An archeological reconnaissance survey and impact report of these resources, prior to identifying actions, are necessary. Preservation of natural and cultural resources within Grand Canyon National Park is legislated by Grand Canyon National Park Master Plan (1976), its accompanying final environmental assessment (FES 75-97), Grand Canyon Enlargement Act (Public Law 93-620), and Archeological Resources Protection Act of 1979 (Public Law 96-95).

Estimated Cost: $18,000

Responsible Parties: NPS, Grand Canyon National Park (GCNP); GCES Office.

Time to Complete: 6 months.

6. Grand Canyon campsite stabilization and recovery.

Major Premise: Due to the removal of sediment and vegetation at certain Grand Canyon campsites by the high flows (1983-85) and the reinitiation of fluctuating flows from Glen Canyon Dam, critical campsites in narrow reaches of the river corridor in Grand Canyon National Park and Glen Canyon National Recreation Area are impacted. Evaluation of the potential for stabilization and recovery of campsites by revegetation and renovation in Grand Canyon (in addition to the sediment deposition studies) will be made at the Cremation Camp (River Mile 87) and Lower Bass Camp (River Mile 108).

Estimated Cost: $11,000

Responsible Parties: NPS (GCNP & GCNRA), GCES Office.

Time to Complete: 6 months.

B. TROUT FISHERY STUDIES

1. Development of studies of the effect of low and fluctuating flows on rainbow trout.

Major Premise: The Assistant Secretaries' directive letter (June 16, 1988) called for additional study of the trout fishery. This study will focus on the Glen Canyon Dam tailwater and the effect of low and fluctuation flow on the trout life stages, water quality, spawning, food base, and biologic productivity. These studies will also investigate nutrient loading from Lake Powell and tailwater trophic relationships. To equate operations with trout survivorship and growth requires development of the following technical information.

(a.) Development of specific technical studies: Estimated Cost: $7500; Responsible Parties: Arizona Game and Fish

Department (AGF), GCES Office, FWS, NPS, Salt River Project.

(b.) Statistical analysis of sampling effort: Estimated Cost: $5,000; Responsible Parties: AGF, GCES Office, FWS, NPS (GCNP).

(c.) Continuation of monitoring efforts on rainbow trout population in the Lee's Ferry tailwater: Estimated Cost: $10,000; Responsible Parties: AGF, GCES Office, FWS, NPS (GCNRA).

(d.) Age/growth studies of stocked rainbow trout: Estimated Cost: $7500; Responsible Parties: AGF, GCES Office, FWS, NPS (GCNRA).

(e.) Taxonomy and ecology of invertebrate (e.g., Chironomids) food resources: Estimated Cost: $20,000; Responsible Parties: AGF, NPS, GCES Office, FWS.

Total Estimated Cost: $50,000

Time to Complete: 6 months for initiation, 2-4 years for program completion.

2. Access to spawning habitat and stranding of fishes.

Major Premise: Access to spawning habitat (tributaries [e.g., Nankoweap Creek and Little Colorado River], gravel bars [Lee's Ferry tailwater], and backwaters [Grand Canyon National Park]) is important for trout and native fishes (including the endangered humpback chub). Stranding of fish by low and fluctuating flows occurs year-round. Stage/discharge relationships for the primary spawning areas need to be determined prior to analysis of impacts.

Estimated Cost: $15,000

Responsible Parties: Reclamation, NPS, USGS, AGF, FWS, GCES Office.

Time to Complete: 1 year.

3. Boating access to the Glen Canyon Dam tailwater fishery.

Major Premise: Access above Three Mile Bar (and other locations upstream) in the Glen Canyon National Recreation Area is restricted at flows less than 3,000 cfs. This 15 mile portion of the Glen Canyon Dam tailwater is visited by more than 6,000 (1985 use figures) anglers each year. Use of this blue ribbon trout fishery is expected to increase in the future. Important issues are safety, equipment damage, and impacts to the recreational experience by crowding when access is restricted. Development of a feasibility report on the relation of low and fluctuating flow to angler safety and a re-evaluation of historic data are necessary.

Estimated Cost: $15,000

Responsible Parties: HBRS, NPS (GCNRA), GCES Office.

Time to Complete: Dependent upon flows and installation of a gage. 1 year.

4. Recreational benefits of angling in the Glen Canyon Dam tailwater fishery.

(a.) Major Premise: Economic benefits may be dependent upon river releases. Recent changes in the productivity of the fishery and the institution of Arizona Game and Fish Department fishing regulations in 1986 (i.e., artificial lures only) may have significantly changed these recreation benefits outlined in the Phase I GCES efforts. If recreational impacts are to be correctly assessed, a re-evaluation of the fishery benefits is necessary. A report on future use patterns and other management practices will be developed.

Estimated Cost: $30,000; Responsible Parties: HBRS, AGF, NPS (GCNRA), GCES Office; Time to Complete: 1 year. Arizona Game and Fish Department will provide creel census support to the study effort. This support is estimated to be $15,000 and is not included in the GCES budget.

(b.) Major Premise: Another issue pertaining to the effect of low and fluctuating flows on recreation benefits and economics is the carrying capacity of the Glen Canyon tailwater reach for angling and boating activities. Data gathering to clarify carrying capacity issues will be carried out as a part of the study of the economic benefits of angling.

Estimated Cost: Inclusive with Item 4(a) above; Responsible Parties: Private consultants (Heberlein Baumgartner Research Services [HBRS]), NPS (GCNRA); Time to Complete: To be included in fiscal year 1990 studies.

(c.) Major Premise: The economic benefit values developed during GCES Phase I studies for the day-use rafting and whitewater boating recreational components are believed to be a correct representation for use in the 1989 study. These values will be reevaluated to ensure their validity.

Estimated Cost: Inclusive with Item 4(a) above; Responsible Parties: HBRS; Time to Complete: 2 years.

C. ENDANGERED FISH STUDIES

1. <u>Initiate conservation measures and monitor humpback chub</u>.

Major Premise: Initiation of the conservation measures (to be outlined in the 1989 Biological Opinion) is necessary to protect the endangered humpback chub. Monitoring trips to evaluate humpback chub population and habitat in the mainstem and Little Colorado River are required and will continue while specific conservation measure studies are developed. A decision on the conservation measures is expected by March 15, 1989 (as per Fish & Wildlife Service, Assistant Regional Director Jim Young, 2/1/89).

Estimated Cost: $25,000

Responsible Parties: Reclamation, AGF, FWS, NPS, USGS.

Time to Complete: 6 months for initiation, 3-4 years for program completion.

D. ECONOMIC STUDIES

1. Comparison of methods for measuring impacts of changes in operations at Glen Canyon Dam on power demands.

Major Premise: If changes are made in operation and management at Glen Canyon Dam, electrical resources will be affected. Decisions concerning changes in operations at Glen Canyon powerplant to enhance the downstream environment or recreational activities must consider the impact to the electrical resource as well. To understand and quantify these effects, it is first necessary to evaluate alternative methods for assessing the cost of meeting power demands. This study will only evaluate methodology. Additional studies will be necessary to provide an understanding of the full economic spectrum.

Estimated Cost: $50,000

Responsible Parties: Reclamation, Western, Colorado River Energy Distributors Association, HBRS.
Time to Complete: 6-12 months.

2. Recreational economics.

Major Premise: The recreational economics associated with the operation of Glen Canyon Dam can be separated into three broad categories: day-use rafting, whitewater rafting (both commercial and private), and fishing. Item C(4) addresses the need to refine the Glen Canyon Dam tailwater fishery economics. The integration of the recreational economics and the power economics will be included in the development of the integrated resource study plan, Item E(2).

Estimated Cost: None (to be included in other studies)

Responsible Parties: Reclamation, Western,

Colorado River Energy Distributors Association, NPS (GCNRA), AGF, FWS, HBRS.

Time to Complete: 6 months.

E. INTEGRATION STUDIES

1. Employment of a Senior Scientist.

Major Premise: It is important to bring a Senior Scientist in at the beginning of the environmental and economic studies and to establish a Research Advisory Panel (RAP). A Senior Scientist and the RAP would separate out scientific needs and requirements, and provide the focus for the development of an integrated resource plan.

Estimated Cost: Dependent upon level of effort.

Responsible Parties: Reclamation, NPS, FWS, USGS, AGF.

Time to Complete: Unknown.

2. Integration river trip.

Major Premise: Upon selection of a Senior Scientist and the development of a Research Advisory Panel, a field trip through the study site from Glen Canyon Dam to Diamond Creek is necessary. This would provide a forum for discussion, identification of specific areas of concern, understanding, and integration of all study components.

Estimated Cost: $8,000

Responsible Parties: GCES Phase II individuals from all affected bureaus and agencies, Senior Scientist, and National Academy of Sciences Review Committee.

Time to Complete: 2 weeks.

3. Develop an integrated resource plan.

Major Premise: An integrated resource plan is necessary due to the complexity, interactions, and indirect effects within the study area resulting from Glen Canyon Dam operations. The plan needs to address the concerns of the National Academy of Sciences' review panel on the Glen Canyon Environ-

mental Studies. It will provide a framework for technical and monitoring studies (i.e., "An Ecological Base Map Concept").

Estimated Cost: (Inclusive with involvement of Senior Scientist)

Responsible Parties: GCES Phase II Integration Team, Senior Scientist, and Research Advisory Panel.

Time to Complete: 6 months.

4. An analysis of the flooding ratio (risk), hydrologic requirements, and relationship to the marketing of hydropower.

Major Premise: The initiation of a thorough analysis of the risk of flood releases, an explanation of the Annual Operating Plan (AOP), and a study of hydropower marketing under post-filling conditions are important to understand the relationship between power production, economics, the environment, and future management of the system.

Estimated Cost: $20,000

Responsible Parties: Reclamation, FWS, NPS, Western, Colorado River Basin States.

Time to Complete: Unknown (dependent upon status of current lawsuits).

5. Develop a base map and a data base management system.

Major Premise: As recommended by the National Academy of Sciences, it is necessary to establish a data management, storage, and retrieval system to provide standardization, easy access, and quality assurance. A base map will facilitate identification of study sites, assure consistency in program actions, quantification of data, and efficient utilization of existing and future data. In addition, a thorough literature review of investigations on regulated and natural rivers is necessary.

Estimated Cost: $48,000

Responsible Parties: Reclamation, GCES Office.

Time to Complete: 12 months.

6. Aerial photography.

Major Premise: Aerial photography of the Colorado River corridor (from Glen Canyon Dam to Lake Mead, including approximately 14 miles of Little Colorado River above the confluence with the main stem) at a flow of 5,000 cubic feet per second (cfs) and scale of 1:3000 is necessary to provide a consistent data base for assessing change in channel geometry, beaches, backwaters, and vegetation. This photography will be compared to 1984 photography collected at 5,000 cfs and will be incorporated into the development and refinement of the data base map. A decision on type of photography (black/white or false color infra-red) will be based on technical study requirements.

Estimated Cost: $42,000 (This does not include costs of analysis of changes between 1984 and 1989.)

Responsible Parties: Reclamation, NPS, FWS, USGS, Western, Federal Aviation Administration, AGF.

Time to Complete: 1 week.

III. BOUNDARIES IN THE DESIGN OF THE TECHNICAL STUDY PROGRAM

A. Sediment Studies

The objective of this aspect of GCES Phase II is to evaluate the impact of low and fluctuating flows on the sediment transport and beach dynamics in Glen and Grand Canyons. Figure 1 outlines the sediment pathways and linkages.

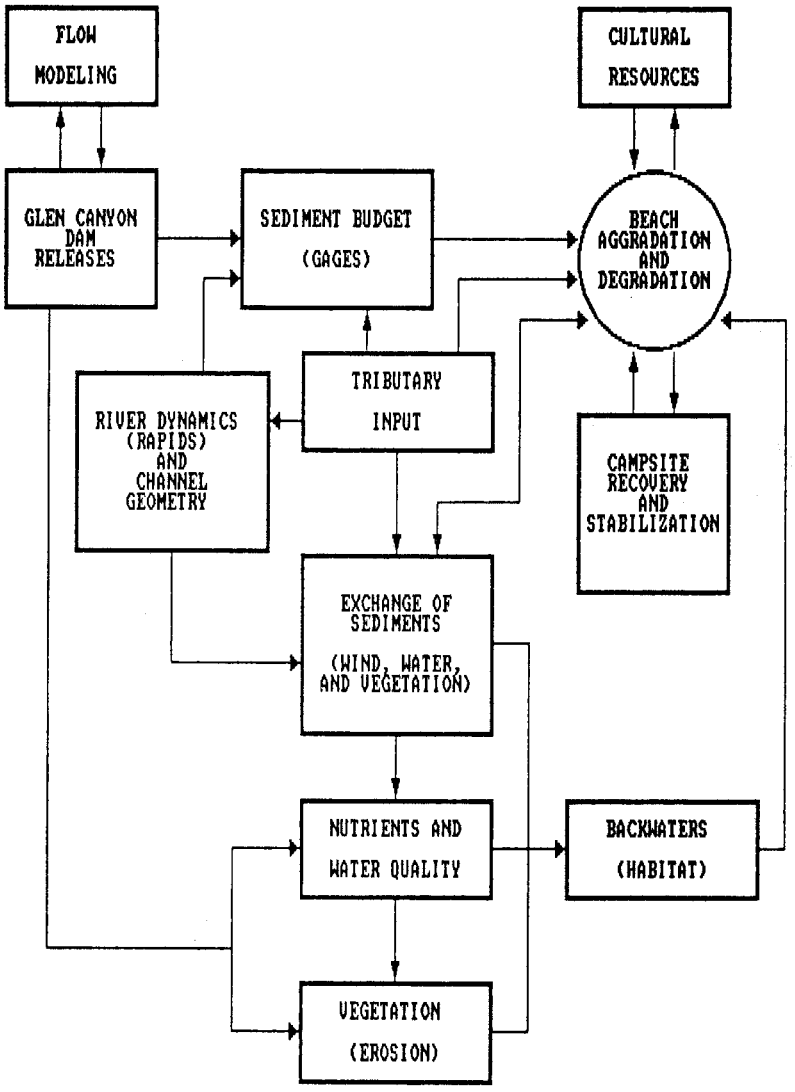

Figure 1. Sediment study flowchart.

B. Trout Fishery Studies

The objective of this aspect of GCES Phase II is to determine the areal measure of trout production as related to low and fluctuating dam operations. Flow releases directly affect trout through desiccation and dewatering, and indirectly through the food resources impacted by water quality and mortality/productivity. Figure 2 presents a simplified version of the complex dynamics of this aquatic study to determine the effects of dam operations (flows, temperature, multiple withdrawal) on nutrients, food resources, and trout production (life stages, hatching success, and mortality: egg, alevin, juvenile, and adult). The impact of dam operations on trout habitat (tributary and main channel) studies directly affect trout biomass through access, stranding, and forced evacuation of trout from spawning bars and channel habitats. Studies of stocked versus natural reproduction and the effect of Arizona Game and Fish management practices are also important. Questions to answer include: Is food limiting the trout population and growth rates? and Is artificial stocking limiting trout population and growth rates? A monitoring plan is necessary to evaluate the impact of operations.

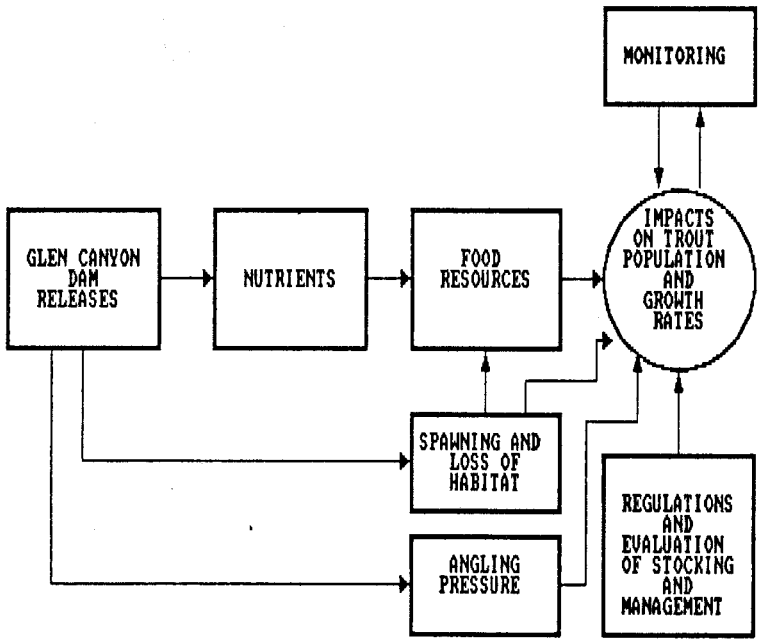

Figure 2. Trout fishery study flowchart.

C. Endangered Fish Studies

The objective of this aspect of GCES Phase II is to initiate the seven Conservation Measures as proposed by the 1989 Glen Canyon Dam Biological Opinion developed by the Fish & Wildlife Service and the Bureau of Reclamation in consultation with the Arizona Game and Fish Department. Figure 3 outlines the primary study process for the endangered fish studies.

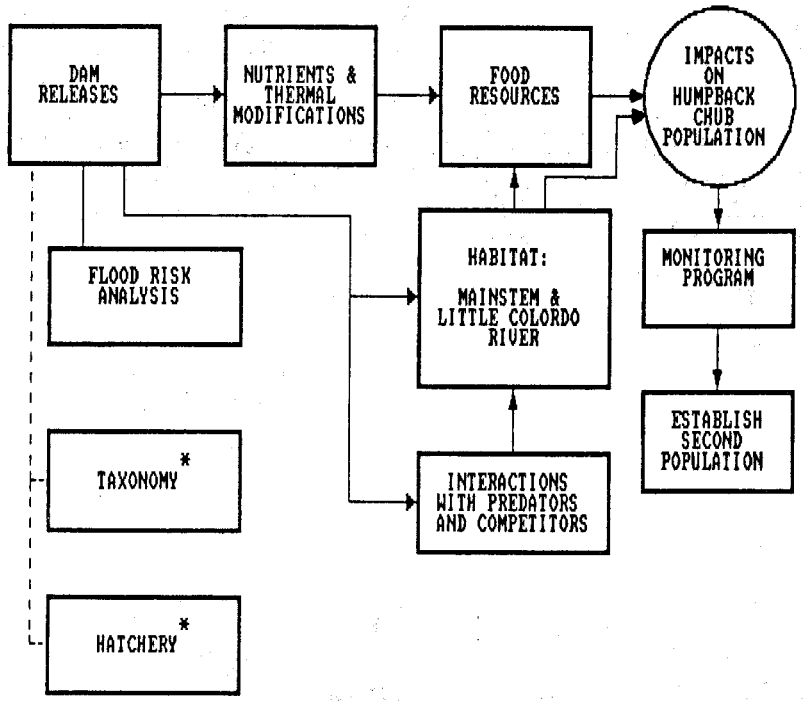

Figure 3. Endangered fish study flowchart.

D. Economic Studies

The objective of this aspect of GCES Phase II is to determine dollar based measures of the impacts of additional restrictions on the operation of Glen Canyon Dam. Figure 4 represents the process by which this goal will be achieved. The initial effort (Part A) of the Economic Study Team will be to focus on the evaluation of three alternative methods of quantifying economic relationships: a generation expansion model (EGEAS); a production cost model (ELFIN); and a non-power system model method, developed by the Western Area Power Administration.

All three methods will be evaluated (in Part B) using a common data set (power system data as well as hydrologic data), similar electrical entities for which the impacts are evaluated, and the same operational alternatives. The evaluation process will include three prototype Colorado River Storage Project (CRSP) power systems with high, medium, and low amount of CRSP penetration. The period of evaluation will be for 50 years.

After the three methods are evaluated, the Economic Study Team will select one method and use it to provide the detailed economic analyses of potential operation changes identified by the Environmental Study Team.

In Part C, the economic model will be used in coordination with the Environmental Study Team to identify operational alternatives that satisfy environmental and/or recreational goals with a minimum impact on purchasers of power from Glen Canyon Dam.

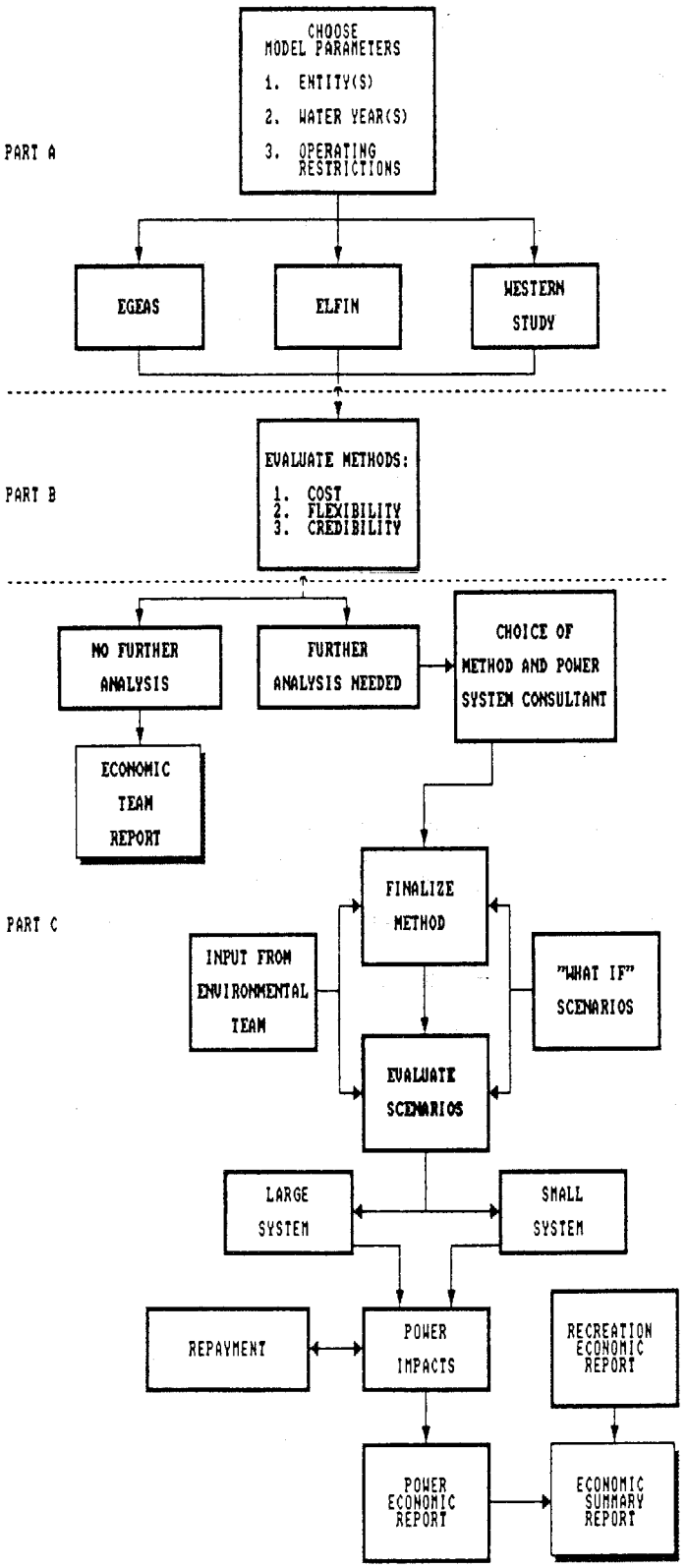

Figure 4. Economic study flowchart.

E. Integration of Phase II Studies

Phase II Studies will follow three stages as outlined in Figure 5. Stage I, the fiscal year 1989 plan will be developed and reviewed. The technical study components will be identified; selected resources will be monitored; and the Senior Scientist, Research Advisory Panel, and integration team will develop an integrated resource plan.

Stage II, the technical studies will be prepared. Technical reports will be written for the fiscal year 1989 studies and fiscal years 1990-1991 technical studies will be developed, field work accomplished, and technical reports written. The Economic and Environmental Study Teams will produce separate summary reports.

Stage III, the report development period will complete the Phase II activities. A draft integrated report written by the GCES Integration Team will summarize the Phase II studies and will receive peer review by experts in each field and the National Academy of Sciences review committee. A final integrated report will then be prepared and forwarded to the Executive Review Committee (ERC) and circulated for constituent review. The ERC will prepare a final report outlining recommendations for action. The ERC report will be reviewed by the Integration Team and constituents. The ERC and the National Academy of Sciences review reports will be forwarded to the Department of the Interior.

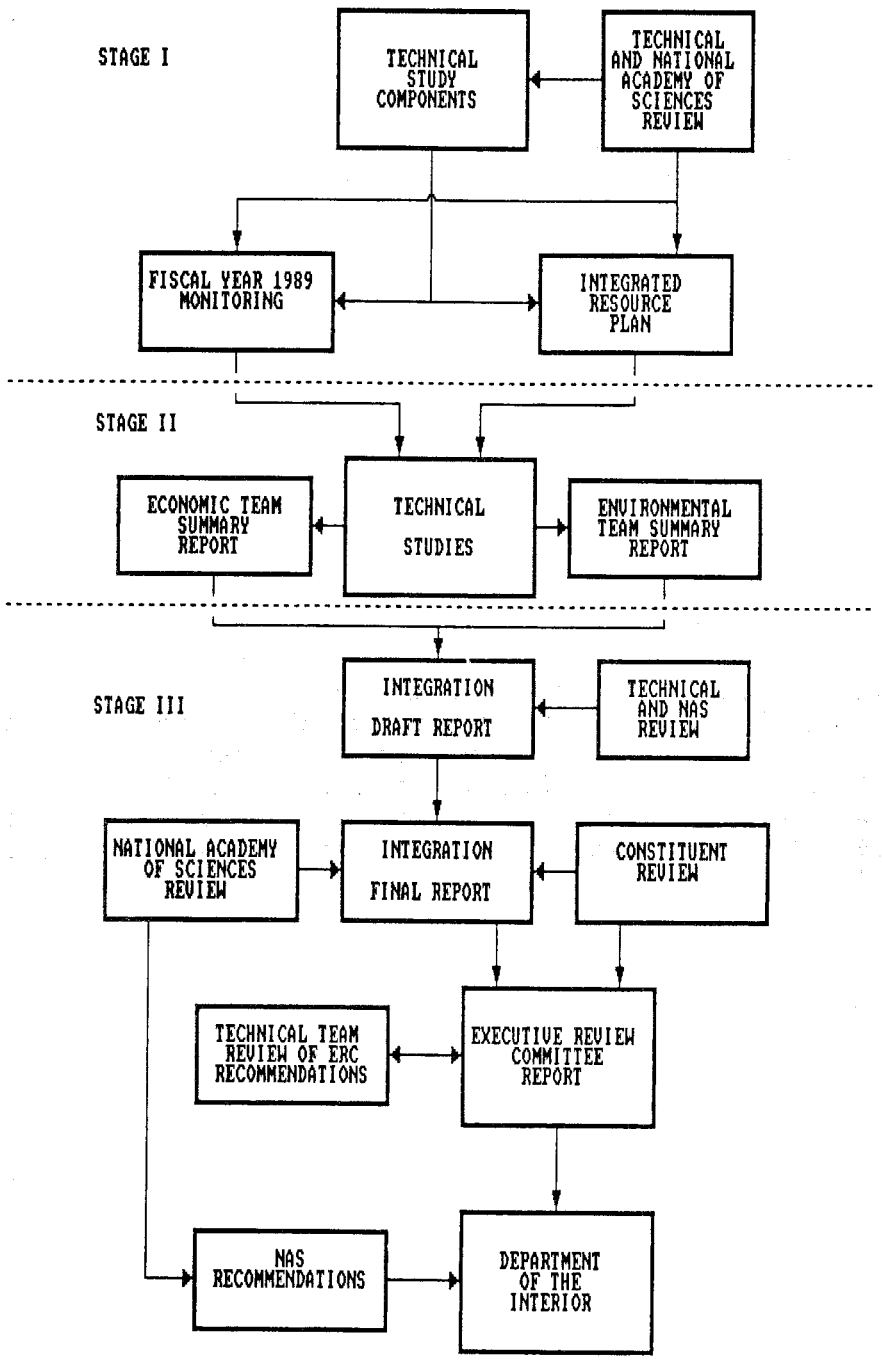

Figure 5. Integration of the Glen Canyon Environmental Studies Phase II program flowchart.

IV. CRITICAL FISCAL YEAR 1989 STUDY NEEDS

A. Flow Regulation

1. Flows of 5,000 cfs for a continuous period of three to five consecutive days will be necessary to allow for equilibration of the flows (return of bank storage) necessary to match the 1984 aerial photography. The aerial photography is planned for October 1989 when the average discharge range is 4,000 to 13,000 cfs. An official letter of request will be made to the Western Area Power Administration.

2. An additional two to ten consecutive days of flow regulation of less than 12 hours at steady flows other than 5,000 cfs may be required in fiscal year 1990 for verification of the power production discharge relationship, angler access, and trout stranding studies. The determination of the need for additional flow regulation will be made after Step 1 is completed.

3. Field work and aerial photography are being designed and studied to take advantage of and to integrate with normal operations at Glen Canyon Dam. However, it should be noted that extrapolation of experimental data to actual river conditions introduces uncertainty. Hypotheses based on experimental results from other than actual field measurements should be verified with field data where possible.

4. Establish a formal process so that requests for specific flow regulation can be negotiated. Western Area Power Administration will be responsible for coordination with the power customers to determine short-term costs and electrical system impacts.

B. Summary of Fiscal Year 1989 Funding for Each Study Segment (Estimated)

1. Sediment Studies: $230,000
2. Trout Studies: $110,000
3. Endangered Fish Studies: $25,000
4. Economic Studies: $50,000
5. Integration Studies: $118,000
6. National Academy of Sciences: $40,000
7. Senior Scientist: $23,000

C. Additional Costs (As Yet Undetermined)

1. Reclamation Denver Office Coordination

D. Total Estimated Cost for Fiscal Year 1989 GCES Technical Studies: $596,000

V. DEVELOPMENT OF AN INTEGRATED STUDY PLAN FOR FISCAL YEARS 1990-91

The environmental technical studies need to satisfy the requirements of the Assistant Secretaries' directive (June 16, 1988) and the direction of the Executive Review Committee. The program will focus on four primary areas:

1. Impacts of low and fluctuating flows on the trout fishery.

2. Impacts of low and fluctuating flows on the endangered fish populations.

3. Impacts of low and fluctuating flows on beach aggradation and degradation.

4. Relationship of Glen Canyon Dam operations to power and recreation economics.

The intent is to design technical studies to meet the Executive Review Committee's verbal request for a minimum "75% Comfort Level" as well as the recommendations of the National Academy of Sciences (River and Dam Management: A Review of the Bureau of Reclamation's Glen Canyon Environmental Studies, National Academy Press, Washington, D.C., 1987, 203 pp.)

The Phase II Study Plan identifies the primary areas of importance necessary to understand the impacted areas, but without a thorough analysis of the cumulative relationships and interactions, a listing of studies cannot be developed. If the Senior Scientist is to provide meaningful support to the GCES technical study program, it is imperative that the Senior Scientist be involved in the development of the specific study requirements.

It is equally important that the GCES Phase II studies be scientifically sound, rigorous, and quantitative. They must also be able to make accurate predictions based on a knowledge of ecological and economic principles. Prediction with specified and reasonable accuracy (to the "75% comfort level") requires a quantitative understanding of the variables and processes that interact to determine the structure and dynamics of the complex ecological system of Glen and Grand Canyons. It is imperative that the Senior Scientist and the technical representatives of the impacted resource bureaus and agencies be able to discuss and review the most appropriate means of field,

administrative, and technical support before firm decisions are made on specific technical studies.

APPENDIX 1:

GLEN CANYON ENVIRONMENTAL STUDIES

INTERIM TECHNICAL INTEGRATION TEAM

MEMORANDUM (NOVEMBER 28, 1988)

Memorandum November 28, 1988

To: Dave Wegner, Study Manager

From: Glen Canyon Environmental Studies Interim Technical Integration Team

Subject: Glen Canyon Environmental Studies - Program Direction and Schedule

Action Requested: Response on Adequacy of Program Direction and Schedule

The Glen Canyon Environmental Studies (GCES) were initiated in December 1982 by the Department of the Interior with two major goals (1) to determine if the operations of Glen Canyon Dam affect downstream natural and recreational resources; and (2) to determine if modifications to dam operations could diminish adverse impacts on these resources. Field studies were conducted from 1983 through 1986 and results were presented in the GCES Final Report (January 1988).

The final technical report was reviewed by the National Academy of Sciences (NAS) and the Executive Review Committee (ERC), comprised of representatives from the Bureau of Reclamation, Fish and Wildlife Service, National Park Service (NPS), Department of the Interior Office of Environmental Project Review, and Western Area Power Administration (Western). All reviews agreed that the GCES had found that operations do impact the riverine environment below the dam. The technical information collected was deemed insufficient by the ERC to support recommendations for specific changes in operating criteria. However, Department of Interior members did recommend revising the current low flow limit to operations for an interim period, while all ERC members recommended further studies be conducted.

Critical limitations to the development and completion of the first phase of the GCES were time, geographical boundaries, hydrologic conditions, and institutional constraints. The involved agencies, groups, and the NAS recognized that the boundary of time limited the level and quality of the analysis and recommendations. In particular, there was limited opportunity to study the effects of low and fluctuating flows because high runoff conditions in the Upper Basin generally precluded those operating regimes during the study period. The constraints that limited Phase I should not be perpetuated in Phase II.

A memorandum (June 16, 1988) from the Assistant Secretary for Water and Science and the Assistant Secretary for Fish and Wildlife and Parks directed the GCES to follow NAS and ERC recommendations for further studies and to monitor critical resources and fill in critical data gaps, particularly those related to the effects of low and fluctuating flows. Issues for which further study were deemed necessary by the ERC included endangered fish species, introduced trout, beach stability, and the economics of hydroelectric power production. The NAS recommended securing the services of a research advisory panel under the direction of a senior scientist to oversee the research effort, direct an extensive literature review, and to ensure data preservation by establishing a data base management and storage system. The memorandum stated that "the duration of the studies will be for a minimum of one year, with the end point to be determined by flow levels and the technical effort required". Verbal directives were given to the Interim Technical Integration Team (Interim Team) that set a limit of two years on Phase II of GCES.

The objective of this letter is to outline the consequences of this time limitation on the critical research and monitoring questions raised by the ERC, the Department of the Interior, and the NAS.

The Interim Team was created to coordinate study efforts for Phase II and has been composed of representatives from Bureau of Reclamation (Upper Colorado Regional Office), U.S. Fish and Wildlife Service (Phoenix Field Office), U.S. Geological Survey (Water Resources Division, Arizona District), National Park Service (Grand Canyon National Park and Glen Canyon National Recreation Area), Arizona Game and Fish (AGF) Department, and consulting economists. The membership of the Technical Integration Team is being expanded to include representatives from the Colorado River Basin States, Western, power users, environmental organizations, and the recreational community. This expansion will result in a research effort acceptable to all concerned agencies and organizations. However, the increased size of the team will require additional time for resolution of differences among individual representatives.

The Interim Team has also been informed that the decision on whether to proceed with recommended studies during Phase II will be made by the Upper Colorado Regional Director of the Bureau of Reclamation after consultation with representatives of the power users. In the event that particular studies are considered infeasible because of negative impacts to power users, alternative means must be devised to provide information required to answer management questions. Resolution of these difficulties will, of course, increase the time necessary to complete the needed studies.

The Interim Team has determined that several concerns expressed by the NAS, ERC, and the Assistant Secretaries can be adequately assessed during the next two years, but that major questions relating to potential impacts of dam operations (low, fluctuating, and some high flows) on endangered species, trout, beach stability, and hydroelectric power economics are complex and will require a more extended period of research. This memorandum outlines the tasks that can be accomplished over the next two year period and provides a schedule of delivery for these products. It also outlines important research questions that cannot be answered by short-term studies and which are very important to the determination of impacts by dam operations. The products may be modified and others added by the senior scientist after he/she is hired in February 1989.

A concern of the Interim Team is that the specific directives of the Assistant Secretaries' memorandum, subsequent verbal directives, and the NAS recommendations are in conflict. The NAS recommended that study boundaries be set on the basis of the physical system and not be imposed for other reasons (i.e., policy considerations) and that complexity, interactions and indirect effects should be considered in future studies. By directing that specific studies of narrow scope be investigated within a limited amount of time, it will be impossible to address the management questions that depend on knowledge of complex processes that control environmental response to flows.

The Interim Team concludes that the goal of GCES is to gain sufficient knowledge on impacts of flows on environmental and economic resources to make possible the development of operating criteria that would balance the impacts to all resources. A two-year study plan to answer all operational concerns is inconsistent with the NAS conclusion that "some categories of problems cannot be resolved in two or three years, and will require commitment to long-term studies..." (River and Dam Management (1987), Water Science and Technology Board, National Research Council, page 120).

Elements of the operations which should be addressed include monthly volume of releases, management of flows exceeding powerplant capacity, peak daily flow, minimum daily flow, daily average flow, rate of change of flow within the day and over longer periods, and pattern of daily flow releases throughout the year. Specific studies done over a short period will not provide a sound scientific basis for development of specific criteria for all these aspects of flow releases. Therefore, an important part of the activities of the Technical Integration Team over the next two years will be the development of a plan for studies which will provide the information and a mechanism for integrating that information with the operating criteria on a periodic basis.

The Interim Team recommends that the GCES research provide information for the Section 7 studies (conservation measures) on the endangered humpback chub (Gila cypha) which are anticipated to be completed about four years after studies are initiated. A decision to modify operation of Glen Canyon Dam will probably not be made in advance of the conclusions of the Section 7 studies. Because questions related to the impact of the dam on the humpback chub will require work beyond the short-term effort, we recommend all GCES studies related to flows should be extended to cover a common period of time. Therefore, we ask that the senior scientist prepare a study plan consistent with NAS recommendations and allow for a careful assessment of critical data gaps and a more accurate understanding of the effects of elements of Glen Canyon Dam operations. It would be advantageous if all studies on the effects of dam operations on critical resources be coordinated and the information integrated.

The studies and products that can and cannot be addressed during the GCES Phase II activities are outlined below.

Short-term Studies and Products:

1. Selection of a senior scientist to provide GCES technical oversight.

2. Preliminary economic analysis and the selection of methods or models to evaluate the costs and benefits to power users of modifications to current dam operations.

3. Interim data collection to address some policy/management questions posed by the Assistant Secretaries and Executive Review Committee (Table 1).

4. Development of a symposium on the current knowledge of environmental and economic effects of Glen Canyon Dam operations as applied to GCES activities.

5. Development of the basis for a long-term monitoring program of selected environmental, recreational, and economic variables. The monitoring program would include identification of future studies to refine the relationship between dam operations and the dynamic Grand Canyon resources and would include the development of contingency plans for flow regimes not conducive to proposed studies.

6. Development of an integrated resource analysis plan based on a conceptual ecosystem model to determine the effects of dam operations,

including low and fluctuating flows, and to include contingency plans for unforseen hydrologic events.

7. Development of a data and hard copy archival and retrieval management system to ensure availability of previously collected data for future studies.

Questions that Short-term Studies Cannot Answer:

1. What are the effects of setting specific flow limits (such as low flow limits) to benefit a specific resource on the other resources of the system?

2. What are the impacts of low and fluctuating flows on humpback chub, native fishes, trout, and other critical resources?

3. What are the impacts of low and fluctuating flows on aquatic and terrestrial food chains and populations of wildlife dependent upon these resources?

4. What are the long-term impacts of low and fluctuating flows on the stability of camping beaches and other sediment deposits?

5. What is the magnitude and/or frequency of flooding that camping beaches and other terrestrial resources can tolerate without long-term loss?

6. What is the long-term efficiency of AGF Department stocking and management practices as they are affected by dam operations?

7. What are the impacts of dam operations on the environmental and recreational resources of Lake Powell?

To address these broad questions, it will be necessary to initiate additional studies beyond the narrow scope of the GCES Phase II activities. Development of the short-term items 5 and 6 (on page 3) will allow us to identify the key aspects and direction upon which any future efforts should be focused. Development and enactment of a coordinated long-term plan could provide the following products:

Potential Long-term Studies and Products:

1. Determination of the direct and indirect impacts of low and fluctuating flows on native fish, trout, and the aquatic and terrestrial food resources.

2. Determination of the impacts of low and fluctuating flows on beaches and sediment transport in the Colorado River in Glen and Grand Canyons.

3. Determination of the effects of floods (flows greater than powerplant capacity) on beaches.

4. Development of an economic model that will provide a sensitivity analysis to evaluate costs and benefits of different flow regimes considering power revenues, recreation, and natural resource values.

5. Assessment of the effects of dam operations on long-term AGF Department trout stocking and management practices to sustain the Lees Ferry fishery.
6. Development of the framework for Department of Interior interagency action to determine annual programs for the routing of water through Glen Canyon Dam as recommended in the GCES Final Report.

7. Refine and integrate the knowledge of how tradeoffs associated with different discharge and thermal regimes affect critical resources (e.g., endangered species, trout, and beaches) in the Colorado River system.

To achieve the objectives of the GCES Phase II program, the following tentative timetable has been developed:

TENTATIVE SCHEDULE

01 FEB 1989 Senior Scientist hired and begins review of data.

01 MAY 1989 Draft Interim Work Plan and Draft Integrated Resource Analysis Plan

01 SEP 1989 Final Interim Work Plan and Integrated Resource Analysis Plan

30 SEP 1989 Draft Economic Study

01 OCT 1989 Begin Integrated Resource Analysis Plan

01 JAN 1990 Draft 1989 Monitoring/Research Reports and Draft Literature Review

01 MAR 1990 Final 1989 Monitoring/Research Reports

01 MAY 1990 Draft Interim Report and Final Literature Review

01 JUL 1990 Final Interim Report

SUMMARY AND REQUIRED ACTION

The completion of the GCES Phase II short-term studies and products and the meeting of the Assistant Secretaries June 16, 1988 memorandum objectives, is contingent upon the ability to:

A) Schedule specific flow releases from Glen Canyon Dam,
B) Initiate the necessary contracts and agreements, and
C) Acquire the services of the senior scientist.

Delays in any of these aspects will negatively affect the above schedule.

The Interim Team concurs that the goal of the GCES should be to gain the knowledge of environmental, recreational, and economic resources necessary for Federal Managers to develop operational criteria for Glen Canyon Dam which will take into account all resources. That knowledge can be gained only through a carefully considered research plan in which time and scope of studies are determined by the processes studied and

through a continued monitoring effort that will provide information for revising operations criteria as more is learned about long-term processes.

The Technical Integration Team is developing study plans for review and comment. Prior to the initiation of the defined plans, the Interim Team recommends that it is necessary for you, the Executive Review Committee, and the Department of the Interior to review the proposed program direction and schedule. Your response and/or recommendations are needed as soon as possible for study efforts to move forward.

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GLEN CANYON
NATIONAL PARK SERVICE · GEOLOGICAL SURVEY · ARIZONA GAME & FISH
BUREAU OF RECLAMATION · COMMERCIAL RIVER COMPANIES · PRIVATE CONTRACTORS · FISH AND WILDLIFE SERVICE
ENVIRONMENTAL STUDIES