

THE GRAND CANYON MONITORING AND RESEARCH CENTER

FISCAL YEAR 2000

MONITORING AND RESEARCH PLAN

by

THE GRAND CANYON MONITORING AND RESEARCH CENTER

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June 25, 1999

FINAL

**GRAND CANYON MONITORING AND RESEARCH CENTER
FY 2000 MONITORING AND RESEARCH PLAN**

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FY 2000 MONITORING AND RESEARCH PLAN

STATEMENT

At the request of the Technical Work Group, Chapters 1-3 are not included in this plan. Chapter 4 represents the FY2000 Work Plan and is a step-down of the FY1998-2002 work plan. The chapter has been revised to respond to comments from the Technical Work Group.

INTRODUCTION

The Fiscal Year 2000 Grand Canyon Monitoring and Research Center (GCMRC) Monitoring and Research Plan (FY 2000 Annual Plan) describes the scientific activities proposed by the GCMRC for FY 2000 for the Colorado River ecosystem.¹

The FY 2000 Annual Plan is designed to implement the adaptive management and ecosystem science approaches called for in the 1992 Grand Canyon Protection Act (GCPA), Glen Canyon Dam Environmental Impact Statement (GCDEIS, 1995) and the Record of Decision (ROD, 1996). Monitoring, research and information technology activities to be accomplished in FY 2000 are described for physical, biological, cultural, socioeconomic, and recreational resources.

¹ The Management Objectives and Information Needs have been used by GCMRC as the basis for developing the FY 2000 Annual Plan.

CHAPTER 4
FISCAL YEAR 2000
MONITORING AND RESEARCH ACTIVITIES

INTRODUCTION

This chapter contains a description of the FY 2000 program activities to be conducted in the following areas:

1. Conceptual Modeling
2. Physical Resource Program
3. Socio-cultural Resource Program
4. Biological Resources Program
5. Information Technology Program
 - Remote Sensing Evaluation & Implementation

Conceptual Modeling:

An Adaptive Environmental Assessment Model (conceptual model) of the Colorado River ecosystem was developed in FY 1998 and FY 1999. This conceptual model focuses on the specific management objectives and prioritized information needs articulated by the AMWG. The conceptual model is being used to provide critical input into the selection of parameters to be monitored and will also be used, through “policy screening” exercises to evaluate proposed management actions for their potential effect on downstream resources of concern. Since the conceptual model represents a simplification of the Colorado River ecosystem, containing only the level of complexity needed to describe the behavior being modeled, predictions resulting from the conceptual model will often be incomplete and therefore require validation through monitoring, experimentation and testing.

The benefit of the conceptual modeling approach has been its ability to organize complicated relationships into an understandable framework of study. The process of building the conceptual model has provided an opportunity to test assumptions and to develop a shared view of the resources being managed and the potential effects of

management actions. The conceptual model has also provided a general framework for understanding how the Colorado River ecosystem works, requiring the organization of many scattered pieces of information into an integrated framework.

The step down approach proposed by Davis et. al. (1994), Figure 4.1 which incorporates a conceptual model, is being used to develop the long-term monitoring and research program. The conceptual model and long-term monitoring program are being designed to account for the spatial and temporal characteristics of the Colorado River ecosystem, and to provide information, over the long-run, on the responses of the Colorado River ecosystem to alternative dam operations.

In FY 2000, the conceptual model will continue to be refined, parameter estimates will be improved, and specific additional modules will be developed. For example, integration and analysis of the PIT tag database for humpback chub may result in refined parameter estimates and changes in the structural relationships contained in the model. Similarly, completion in FY 1999 of the humpback chub diet analysis work will provide additional information on trophic linkages within the Colorado River ecosystem that will be incorporated into the conceptual model. In addition, GCMRC will work to develop the in-house expertise needed to continue model development and to conduct "policy screening" exercises. These activities are funded from the individual program accounts.

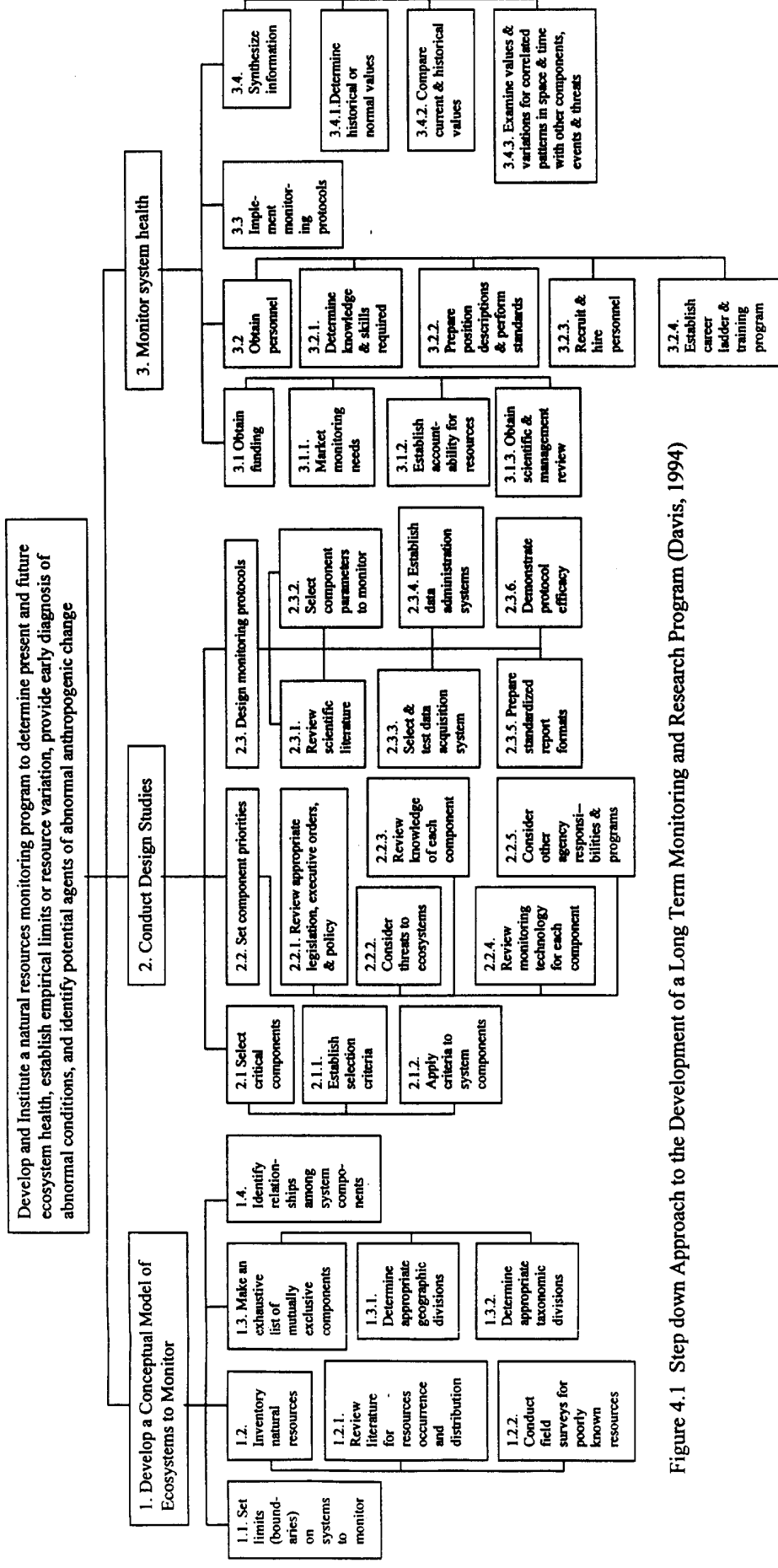


Figure 4.1 Step down Approach to the Development of a Long Term Monitoring and Research Program (Davis, 1994)

THE PHYSICAL RESOURCES PROGRAM

Introduction

Physical resources of the Colorado River ecosystem consist primarily of sediment and streamflow. These resources interact within the geomorphic framework of an alluvial channel in some reaches, and a bedrock controlled channel in other reaches. In both of these settings, streamflow and sediment exhibit dynamic process responses to changes in operations of Glen Canyon Dam over relatively short and long time scales. Because of this fact, research and monitoring of sediment and streamflow is vital for establishing cause and effect relationships between releases from Glen Canyon Dam and changes in both sediment and related resource parameters of the ecosystem downstream. Where cause and effect can be established, physical resource trends may then be interpreted as being caused, at least partially, by dam operations. As a result, understanding how physical resources respond to the Secretary's actions under the ROD (DOI, 1996), is vital if linkages are to be understood between those actions and social, cultural and biological resources that depend on streamflow, sediment and their related geomorphic processes system-wide.

Streamflow in the mainstem occurs mostly from dam releases. However, dam releases interact with additional streamflow and sediment inputs from gaged and ungaged tributaries downstream, as well as reach-varied channel geomorphology, to structure aquatic and terrestrial habitats. Also influenced by these interactions are physical settings in which cultural resources are preserved and where social activities occur, such as recreation.

Water quality is another vital component of downstream ecology that relates mostly to social and biological resources, such as recreation, life histories of fish, and primary productivity. Because of the direct linkages between social and biological resources and water quality, monitoring and research of water quality will be moved into the biological resources program beginning in FY 2000. Additional information on proposed water quality programming can be found in the section entitled "The Biological Resources Program."

Goals and Objectives - The main objective for the physical resources program during FY 2000 is to further develop long-term monitoring strategies and methods that support implementation of a long-term monitoring program for tracking streamflow and related sediment-transport and storage trends. The goal of long-term monitoring is to provide

AMWG members with sufficient information to make recommendations to the Secretary on the effectiveness of his or her actions under the ROD, with respect to preservation of downstream resources. Once designed and implemented, the long-term monitoring program will provide key information on relationships between the Secretary's actions and physical resources of the ecosystem in a timely schedule that supports effective adaptive ecosystem management. Timely transfer of information on resource trends allows managers to make annual-to-semi-annual recommendations to the Secretary on critical management issues such as implementation of controlled flood flows (BHBFs), additional research and monitoring needs, or longer range strategies such as modification of the ROD to achieve the preservation of ecosystem resources.

A critical objective of the initial five-year strategic plan for the GCMRC (FY 1998 through 2002) is to develop a long-term monitoring plan for the physical resources of the Colorado River ecosystem. Decisions on how physical resources will be monitored under the long-term monitoring program, including individual protocols, sampling frequency, location and spatial scale strategy, are currently being considered through an ongoing process by the GCMRC using information from its Protocols Evaluation Program (PEP). These activities will continue during FY 2000.

Efforts aimed at achieving an effective and efficient streamflow and sediment monitoring program are being supported by at least four informational components:

- 1) *Review and Interpretation of Existing Knowledge* - about the physical resources and the processes that govern them in the Colorado River, including information found the final EIS, 1996 flood results, general science knowledge on hydrology and geomorphology of large rivers, and existing reports describing methods and results on effectiveness of currently used monitoring protocols below Glen Canyon Dam;

- 2) *Geomorphic Synthesis on the Ecosystem's Critical Reaches* – with emphasis on historical information that can better focus monitoring with respect to critical resource parameters that provide decision support on sampling strategies;
- 3) *External Peer Review (PEP)* - of existing, previously used and new alternative monitoring methodologies for physical resources;
- 4) *Conceptual Model Development* – including activities that focus existing knowledge about the ecosystem and allows for discussions on how to better monitor and manage the downstream resources of interest.

During FYs 1998 and 1999, the GCMRC established cooperative agreements with Federal, State, Native American Tribes and private institutions to monitor and research downstream resources. One Federal (USGS) and two academic institutions (USU and NAU) were given awards to monitor and conduct research on physical resources. Cooperation from these currently funded technical experts also supports the Protocol Evaluation Program (PEP) for evaluating the effectiveness of existing and alternative monitoring protocols for all resources below Glen Canyon Dam. The PEP, is described in a draft prospectus entitled “Draft Prospectus for Evaluating GCMRC Monitoring Protocols for the Colorado River Ecosystem,” (Appendix C).

The PEP process for evaluating current and new alternative protocols in the physical resources area, is scheduled for completion by the end of FY 2002, when the long-term monitoring program should be fully implemented. The first of two PEP review workshops on physical resource monitoring was completed in August 1998, and an interim review report has been submitted to the GCMRC and distributed to the Glen Canyon Adaptive Management Group. Ongoing physical resource PEP activities in FYs 1999 and 2000 (second meeting set for August 29-31, 1999) are aimed at evaluating suggestions and recommendations from the review panel's interim report on how existing monitoring might be improved with respect to tracking the ecosystem's sediment budget. During the PEP process, key elements related to MOs and INs, such as tracking the mainstem sediment budget, and measuring changes in area, volume and morphology of sand bars and backwaters, will be specifically emphasized. In addition, the PEP reviewers will be asked to review and provide final comments and suggested revisions regarding the current MOs and INs on the basis of the preferred alternative of the final EIS and other information available

about the ecosystem. Where appropriate, additional testing of new technologies and protocols is planned during FY 2000 through FY 2001, including additional multi-beam hydrographic survey applications for bathymetry, and remotely sensed methods for conducting change-detection analyses.

Because most of the management objectives for physical resources relate to sediment-based resources, the focus of long-term monitoring activities is on a robust strategy for tracking fine sediment (sand-sized and finer); their inputs, storage throughout the ecosystem, and export to upper Lake Mead. Coarse sediment (larger than sand-sized) budgeting is also of interest because cobbles and boulders structure the basic geomorphic units of the river ecosystem, its cobble bars and debris-fan/eddy complexes where fine sediment and related resources reside. Time scales over which coarse sediments must be tracked are longer than fine sediments because the residence time of boulders is potentially much longer than for sand. However, results of the 1996 experimental flood (BHBF-Test), showed that additions of boulders to the main channel from tributary debris flows are also quickly transported over short distances when dam releases are rapidly increased above powerplant capacity. Long-term implications for aggradation of pools and runs by immobile boulders on the ecosystem are presently unknown.

To support monitoring activities, and to provide timely estimates about how the system-wide sediment budget evolves over various time scales, ongoing development of predictive, numerical modeling capabilities will also be pursued during design of the long-term monitoring program, beginning in FY 2001. Special emphasis during FY 2000 will be placed on testing and calibration of physically-based flow and sediment transport models recently designed for the Paria and Little Colorado Rivers by the U.S. Geological Survey, Water Resources Division; including both operations and National Research Program personnel. These efforts will continue during FY 2000 under modification of current agreements with USGS.

As part of an effort to better understand the geomorphic history of lower Glen Canyon and Marble Canyon (river miles -15 to 0 [minus fifteen to zero]), synthesis efforts started in FY 1998, will be extended upstream into the most critical reach with respect to sediment resources (Glen Canyon), in FY 2000. This work will be highlighted by additional time series mapping of sandbars to identify changes in sand storage along shorelines and in

the mainstem channel within GIS study sites 1 and 14. This effort will build on the synthesis work presently being conducted in FY 1999 by Utah State University's Department of Geography. Synthesis efforts for geomorphology, sediment-transport and hydrology shall be completed at the end of 2000 for all reaches from the dam to river mile 87.

Current State of Knowledge - Existing information indicates that fine sediment substrates support social and natural resources of the ecosystem, while coarse sediments structure the geomorphology of the physical habitats of the ecosystem located in numerous debris-fan/eddy complexes (DOI, 1995). Sustainability of fine sediment resources depends on long-term steady-state or increasing trends in the sand budget of inputs and storage that balance with net export; conditions that are controlled by both long-term average supply in combination with river geomorphology and flood frequency (DOI, 1995). The degree to which sand can be stored in the ecosystem below the dam also varies by reach depending on flows and channel geomorphology of pools above rapids and spacing and geometry of debris-fan/eddy complexes (Schmidt and Rubin, 1995; Melis, 1997). Generally, the greatest abundance of sand in the system is found downstream of the Little Colorado River, at river mile 61. As sediment inputs decrease upstream toward the location of the dam, the probability for a long-term sediment deficit increases under any given operational regime. From a sediment budget perspective, the reach between Glen Canyon Dam and Lees Ferry (river miles -15 to 0) is therefore the most critical. The second most critical reach occurs between Lees Ferry and the confluence of the Little Colorado River (river mile 61), the reach identified as Marble Canyon.

Recent results of monitoring and research suggest that there is only a limited range of sand-storage potential within the mainstem channel of the Marble Canyon reach (D. Topping, USGS, and T. Randle, Bureau of Reclamation, personal communication). Despite the high potential for occasional large sand inputs from the Paria River (river mile 1), limited storage space in the main channel may therefore limit the residence time of sand introduced into Marble Canyon, a critical reach with respect to sand supply and related resources. While sand storage potential may be somewhat greater in the Glen Canyon reach, sand inputs there are relatively minimal compared to the sand contributions of the Paria River to the Marble Canyon reach.

The underlying assumption of the *Operations of Glen Canyon Dam - Final EIS* (DOI, 1995), was that channel storage and residence time for sand in critical reaches was sufficient to restore terrestrial sand deposits through occasional controlled floods. If the potential for sand storage is relatively small relative to average annual inputs, and the residence time in critical reaches is relatively short under ROD induced hydrology, then monitoring of sand inputs, changes in channel storage and export rates will be of even more importance with respect to ecosystem preservation strategies.

The physical resources program for FY 2000 aims to improve the GCMRC's ability to track sediment budgets in meaningful and efficient ways within the upstream critical reaches. This can best be accomplished through two methods: 1) daily suspended-sediment measurements at the Grand Canyon stream gage, or 2) through high-resolution bed-sediment classification and topographic profiling, obtained through such strategies as side-scan sonar and multi-beam hydrography, as well as testing and implementation of bed grain-size sampling, and bed elevation change detection procedures. To track bed elevation changes that result from tributary inputs of sand, new, more rigorous methods for three-dimensional bathymetry shall be field tested and assessed during FY 2000 for potential implementation in the long-term monitoring program. The alternative approach of collecting additional empirical data on daily streamflow and sediment transport requires re-establishment of protocols previously used by USGS before 1979, but may prove to be more accurate and less intrusive and costly compared with bathymetric field measurements made in critical reaches on perhaps a quarterly basis. One of the objectives of the FY 2000 program will be to determine which of these two approaches is best for determining long-term trends in the fine sediment budget of the ecosystem.

Relationship to Conceptual Model - Preliminary development of the physical sub-model of the conceptual ecosystem model utilized many previously developed modeling and database resources derived from GCES phases I and II, as well as long-term monitoring and research information developed by the U.S. Geological Survey and the Bureau of Reclamation. The current concern of physical scientists about the physical sub-model lies in the knowledge that many dynamic sediment and flow processes of the river occur on time scales of hours to days, while the conceptual model simulates physical changes in the ecosystem on a monthly time step. In addition, GCMRC cooperating physical scientists

concluded after the first modeling workshop that evolution of site-specific river features such as return-current channel habitats, termed backwaters, and recreational camping sand bars could not presently be adequately simulated over monthly time steps, or in the absence of high-resolution channel topography. However, there was agreement that general trends in the conditions of such resources might be extrapolated from annual trends in reach-specific and system-wide sediment budget trends. In other words, that such sediment resources features were more likely to be sustained under conditions of sediment surpluses.

One outcome from the effort to develop the physical sub-model of the conceptual model has been an increased focus on the present ability of scientists and decision makers to track changes in the fine sediment budget - primarily sand. Additional monitoring efforts and research-derived understanding will be needed in the future to track the evolution of fine sediment inputs as they enter and evolve during transport within the ecosystem. In FY 2000, GCMRC plans consultations with the TWG, National Park Service and USGS to determine the scientific and logistical feasibility of reinitiating daily suspended sediment measurements at the Grand Canyon stream gage located near Phantom Ranch. This intensive sampling effort will be the preferred approach to tracking long-term trends in sand supplies within the most critical reaches of the ecosystem, and will be the means of reporting sand exports until a predictive sand-transport model can be developed in the future. Because sediment transport rating curves for the mainstem are not stable, frequent measurement of sand transport, particularly following tributary inputs, is critical.

Presently, efforts to account for exchanges of sand between main channel storage areas (pools) and storage sites on shorelines and within eddies is based on empirical data in the physical sub-model, rather than on process derived rates that can be simulated. A major contribution to the physical resources program has been identification of these types of gaps in process knowledge that limit our current abilities to model sediment dynamics that have been documented to influence ecosystem resources related to sand bars.

Efforts to design a long-term monitoring program during FY 2000 will focus on developing protocols that allow sediment evolution in the channel bottom to be measured, quantified and reported in a timely manner, such as fine sediment volume, grain size and bed coverage. Also, there was agreement and recognition that the current paucity of 3-D channel topography greatly limits the potential for developing accurate predictions for the 2-D

evolution of bar morphologies, such as backwaters and campable sandbar areas, in reaches and at specific sites of critical concern to native fishes. As a result, efforts will be made in FY 2000 to expand coverage of high-resolution channel topography within critical reaches between Glen Canyon Dam and the Grand Canyon streamgage (river mile 88), and in index sites, such as the existing GIS sites below that point that were established by GCES during phase II development. Such mapping coverage will allow for potential 2-D modeling of sandbars in critical reaches.

Main Focus of Resource Concerns - The primary resource of concern in the physical program during FY 2000 will be research and monitoring of sediment and streamflow relationships that occur in the major gaged tributaries, the Paria and Little Colorado Rivers, and bed evolution of coarse and fine sediments in the mainstem channel that result from the Secretary's actions under the ROD. These topics will be related to the overall goal of better quantification of the sediment budget of the main channel between Glen Canyon Dam and the Grand Canyon streamgage, located at river mile 87. The degree that these monitoring and research efforts provide new knowledge about the sediment budget will depend on the magnitude of new sediment inputs from tributaries during FY 2000, and whether or not additional controlled high releases from the dam occur. In addition, the results of research efforts undertaken in FY 1998 and 1999 related to synthesis of historical information, and estimation of ungaged tributary sediment inputs will influence the progress toward integrating information about the physical resources of the ecosystem.

Combining physical-resource synthesis information with new estimates on the inputs of all tributary sediments, information on suspended-load and channel-bed evolution, and shoreline, eddy and main-channel pool sand storage in FY 2000, will be a major step forward in structuring a total sediment budget. Information on shoreline storage potential is critical data when deciding on implementing controlled flood flows (BHBFs) intended to rebuild beaches and conserve sand. The integration process (structuring and design of the sediment budget protocol) will also be a major step in forming better linkages between streamflow and sediment and non-physical resources. In FY 2000, additional synthesis of historical geomorphic data for the Glen Canyon reach will be accomplished by mapping and interpreting historical changes in sand bar characteristics and distributions developed from existing data, such as aerial and oblique photography, survey data, etc.

Information Needs

A broad array of information needs are specified by stakeholders (Appendix A), on the basis of management objectives adopted by the Glen Canyon Dam Adaptive Management Program. As previously stated, most of the management objectives under physical resources are related to preservation of sediment in key settings throughout the main channel, such as maintenance of terrestrial sandbars useful as recreational sites and habitats. Water quality information needs are also considered to be physical in scope, but monitoring and research activities related to water quality in FY 2000 and beyond will be achieved through the Biological Resources program. This change will better facilitate integration between water quality parameters and biological processes, such as temperature and productivity, etc.

A key element of sand storage along the main channel lies in shoreline deposits, such as separation, reattachment and channel-margin bars (INs 1.1-1.5). In FY 2000, emphasis will be placed on how to better monitor changes in shoreline storage of sand within index sites that represent reach-average geomorphic characteristics. Effectiveness of BHBFs in building sandbars at a given stage will depend on the volume of open storage space available along shorelines. This type of information, combined with antecedent sediment conditions of the mainstem channel, will allow scientists and managers to determine optimal duration and magnitude for BHBFs. This effort will also focus on critical upstream reaches. While there is an obvious linkage between terrestrial sand bars and recreational use in the ecosystem, information on campsite areas will be obtained through the socio-cultural program area in FY 2000 and beyond.

Strategic Objectives

In addition, to individual information needs derived from stakeholder management objectives, larger scale monitoring and research objectives will be pursued that relate to physical and other resource areas during FY 2000. The first of these objectives, is capture of additional main channel geometry (topography) up to the top of the pre-dam flood elevation between Glen Canyon Dam and Pipe Creek, located at river mile 88. In this reach, shoreline topography between the elevation of the 5,000 cfs stage and the top of the pre-dam flood zone currently exists within previously established GIS reaches. To achieve additional

channel coverage in the critical reaches of Glen, Marble and eastern Grand Canyons, additional shoreline topography will need to be obtained between existing GIS study sites. The second strategic objective, is to capture channel geometry data below the elevation of the 5,000 cfs stage within existing GIS reaches below Pipe Creek.

Once these main channel topographic data are obtained, they will allow several other strategic objectives to be accomplished in out years. These include, but are not limited to: predictive stage/discharge modeling at all locations where topographic coverage exists, 2-dimensional hydrodynamic sediment and flow modeling of sand bars features in specific geomorphic setting, such as campsites and return-current channel backwaters within debris-fan/eddy complexes, and sand deposits in the mouths of arroyos that drain pre-dam terraces where cultural resources are preserved. While these predictive modeling capabilities will take additional efforts to develop, the basic topographic coverage of the critical upstream reaches and downstream index reaches will greatly advance the GCMRC's ability to develop such models.

In terms of sediment resources, topographic coverage of the main channel supports current and proposed new long-term monitoring technologies intended as change-detection methodologies for:

- 1) Quantifying volume change in subaqueous channel-stored sand within pools and eddies,
- 2) Measuring grain-size evolution of the bed where fine sediment is stored,
- 3) Detecting three-dimensional changes in main channel bed coverage by sand and coarser sediment (bed classification),
- 4) Detecting volume and grain-size distribution changes in deposits of subaerial sand stored along shorelines (terrestrial sand bars), and
- 5) Providing 3-dimensional channel geometry of the mainstem channel needed to accomplish 2-dimensional hydrodynamic flow and sediment modeling of sandbars and related habitats.

Previous research indicates that all of these components are required to accurately evaluate the status of the system's sediment budget. Changes in mainstem channel sand storage may be mostly inferred from daily suspended sediment sampling at the Grand Canyon stream gage, but some additional bed sampling will be required at key locations

throughout critical reaches upstream. Existing channel geometry (reach-averaged hydraulic geometry) combined with the above sediment parameters is required to develop predictive modeling capabilities for the main channel, such as a 1-dimensional sand transport model that might be used to route sand from upstream to downstream reaches and estimate sand export from the ecosystem. In addition, the antecedent status of these combined sediment elements, especially channel-bed grain-size distribution greatly influences the effectiveness and design criteria for controlled high flows from Glen Canyon Dam intended to replenish sediment related resources. These data will greatly support decisions on BHBF duration and magnitudes for optimal sediment and bar-building responses.

Finally, the topographic coverage of the main channel will greatly advance development of an integrated GIS database where all data from individual discipline areas can be geo-referenced in four dimensions; an initial necessity if data sets are to eventually be integrated and their ecosystem linkages interpreted (Wirth et al., 1993; Pucherelli et al., 1995).

FY 2000 PHYSICAL RESOURCES PROGRAM

The FY 2000 program for physical resources at a level of \$700,000, will be divided into six program components, and will be implemented exclusively through modifications of existing FY 1998-99 awards.

Monitoring Main Channel and Tributaries

Monitoring main channel and tributaries will be continued through a modification of the existing USGS interagency agreement (Arizona District, WRD, Hornewer et al.) to achieve basic monitoring of sediment and flow in the mainstem and gaged tributaries meant to support sediment budgeting in critical reaches. Until more specific monitoring protocols are designed and reviewed that will support sediment budgeting, basic protocols for collecting streamflow and sediment data will be continued, including mainstem streamflow unit data at Lees Ferry (sediment only during flood flows from Glen Canyon Dam), above the confluence of the Little Colorado River (seasonally varied suspended-sediment sampling), and Grand Canyon near Phantom Ranch (move toward resumption of daily or weekly sediment sampling). Streamflow and sediment data will also continue to be collected

for the Paria River gage, and the Little Colorado River gage near Cameron. Under this proposed agreement modification, existing sediment and streamflow model results for gaged tributaries will be assessed with respect to daily and quasi-daily suspended-sediment samples at the Grand Canyon gage to measure export of sand associated with dam operations. This additional intensive monitoring will allow USGS researchers to further assess the likelihood that significant fine sediment storage accumulates in the mainstem channel under the ROD operations, as suggested in the final EIS. Export rates from critical reaches in the first 100 miles downstream of Glen Canyon Dam will be compared with measured residence time for fine-sediment inputs in the main channel. Changes in channel-stored sand will be related to the timing and frequency of BHBFs intended to conserve sand and related habitats to determine whether current strategies for BHBF implementation are effective in maintaining sand and related resources.

Design of Long-Term Monitoring Program

Continuation from FY 1998-99, of ongoing design-planning for a long-term monitoring program for physical resources (streamflow and sediment). These activities include continued protocols evaluation external review (PEP - SEDS), paired field testing, review of draft monitoring design, decision-making about capital investments in new technologies and equipment, coordination with the IT program in testing of remote sensing technologies and initial FY 2000 implementation of some alternative monitoring elements identified in the FY 1998-99 phase of the PEP process. A draft outline of the long-term monitoring plan for physical resources will be reviewed by the external SEDS review panel at the August 1999, review workshop. This element of the FY 2000 plan is the highest priority for the physical science program.

Advanced Conceptual Model Development

Modification of existing, or design of alternative physical sub-model to simulate long-term geomorphic changes in main channel geometry of pools, rapids and related features that relate to system-wide storage of fine sediment, and long-term changes in habitat type and availability. Also, funds will be used to develop improved user interface (GUI) for completed USGS flow and sediment-transport models through the current agreement with

Ecometric Research, Inc.

Verification of Paria and Little Colorado River Sediment and Flow Models

Continued testing of sediment load estimates calculated from flow hydrographs in key sand contributing tributaries that input to critical reaches (Paria and Little Colorado Rivers, during Water Year 2000). Refinement and calibration of these two models allows for rapid estimation of sand and silt/clay loads input to the mainstem channel of the ecosystem within days to weeks of extreme tributary flood events that replenish the sediment supplies of critical reaches. Prior to development of such models, sediment loads were not reported until well after the end of each water year. Timely model estimates of sand inputs are useful to scientists and managers that need to make annual decisions on implementation of BHBFs, including details of duration and optimal magnitude. This work will be carried out for an additional year through modification of an existing agreement with USGS (the agency developing the physically based flow and sediment models). Activities will include monitoring of model reach channel geometry and bed grain-size, and will focus on significant sediment input events that occur during the performance period.

Extended Geomorphic and Hydrologic Synthesis

This project will extend synthesis by accomplishing additional historical sandbar mapping and those data to historically measured changes in mainstem channel storage conditions between Glen Canyon Dam and the confluence of the Paria River. This work will build on the FY 1998-99, synthesis results developed through a collaborative effort by Utah State University and the USGS. Under this modification, researchers will move the focus of synthesis project upstream into the most critical reach with respect to sediment supply and effects of dam operations, Glen Canyon. Specific INs that will be addressed through this ongoing project include defining historical and current levels of river stored sediment in system associated with flow regimes; evaluation of Glen Canyon geomorphology and high-terrace erosion, as well as changes in sand bars and backwaters; and define the character of beaches and backwaters in the system after the BHBF-Test. By its very nature, synthesis is designed to address as many information needs as possible. One key element of the historical synthesis is to relate trends in the above channel characteristics to changes in

operations at Glen Canyon Dam, as well as trends in resources in the pre- and post-dam eras.

Change Detection of Debris Fans and Rapids

This work will consist of an ongoing annual assessment of significant changes that may occur to the mainstem channel geomorphology that result from periodic tributary streamfloods and debris flows. This effort will be accomplished through modification of the existing agreement with USGS (WRD, National Research Program, Webb et al.) In the event that a BHBF occurs during FY 2000, additional research on debris-fan reworking and coarse bedload movement may also be carried out through USGS as a modification of the current agreement to assess ungaged tributary inputs and impacts to mainstem channel resources. Changes in debris fans and rapids are known to increase the potential sand storage in main channel pools. Hence, this study also contributes to ongoing USGS research to determine long and short-term residence time for sand inputs in the mainstem.

It is also anticipated that the strategic goals of the physical program area will be partially accomplished, especially those related to reach main channel geometry, through testing and the development of products resulting from the "Remote Sensing Technologies" activities described within the Information Technology Program.

Implementing the FY 2000 Program and Beyond

The strategy for achieving the goals of the FY 2000 plan, through modifications of existing cooperative and interagency agreements, mainly reflects a need for additional time to complete the PEP process in the physical resources area. This vital information is needed before a long-term monitoring plan for sediment and streamflow can be drafted and implemented. Future long-term monitoring of physical resources will be procured competitively once the long-term monitoring plan is drafted. Once the long-term monitoring plan is ready for implementation, monitoring awards will be made with options for annual modifications for up to five-year cycles. During FY 2000, all GCMRC cooperators will continue to work closely with GCMRC staff in obtaining monitoring data that are collected under specific guidelines and standards that are enforced by program management and outlined in the long-term monitoring plan and future RFPs.

In some cases, beginning in FY 2000, the frequency of monitoring of sediment and

flow related resources will be altered from annual measurements to biennial, semiannual, quarterly, monthly, weekly, daily or even hourly time scales depending on protocols used, budget limitation, or how the data are used to support predictive modeling and decision making procedures. For instance, between dam-induced high flow events, sand storage along shorelines has followed predictable patterns, on the basis of repeated measurements over the last decade. As a result, measurement of shoreline storage will be recorded in annual aerial overflights, and perhaps measured in the field on a biennial schedule, or in response to dam-controlled or large, unregulated tributary floods. In the event that a BHBF occurs in spring 1999, several existing physical science agreements may be modified to extend through FY 2000 to ensure that unique monitoring and research information is obtained and reported to stakeholders.

Existing time series on volume-depletion rates for bars between bar rebuilding events up to 45,000 cfs can provide estimates for the status of system-wide shoreline storage conditions in years when only area measurements may be available from aerial photographs. Additional estimates of volume changes in shoreline storage zones may also be made from stereo-photogrammetric analyses, presently being considered under PEP efforts. Alternatively, some volume-change measurements for shoreline storage might be made on weekly to hourly time scales for long-term and test release purposes using oblique, stereo-photogrammetric applications and remote cameras. Issues of monitoring frequency and sampling strategy system-wide will be described in the long-term monitoring plan prepared by the GCMRC. A draft of the Physical Resources Long-Term Monitoring Plan is scheduled to be available by the end of FY 2000.

GCMRC Support of TWG Requests

In FY 2000, the GCMRC anticipates that additional requests for information assessments, similar to the "Alternative BHBF, Load-Following" request made by the TWG in FY 1998, will arise. Such special requests that require significant amounts of staff time, or outside expertise, will require additional funds to complete. Such funds may be used to gather data, conduct analyses, support convening of a group of scientists to provide analysis of a given issue, or to obtain expertise not contained within the GCMRC staff or contractors (including flood-flow experimental design). The GCMRC intends to create a pool of funding

that can be used by staff in support of such unanticipated requests during the course of the fiscal year. Such funds may be carried over from one year to the next, depending on need and availability.

Contribution of the FY 2000 Program to the Strategic Plan

The physical resources program for FY 2000 is linked to stakeholder objectives and information needs; especially where it supports development of the long-term monitoring plan, and specific protocols that support tracking of the ecosystem's fine-sediment budget. As with the other program areas, information gained from proposed monitoring, protocols evaluation and synthesis will support further development of the conceptual model; a process that will foster better integration between resource areas, and understanding of physical and non-physical processes that structure the Colorado River ecosystem. Such information is vital for successful ecosystem decision making based on science; the foundation of adaptive management practices.

FY 2000 Physical Sciences Program/Budget

		Monitoring / Research	
A.	Conceptual Modeling (GUI Interfaces)	\$ -0-	\$20,000
B.	Extended Synthesis (Glen Canyon Reach)	\$ -0-	\$80,000
C.	Mainstem/Tributary Streamflow/Sediment	\$330,000	\$ -0-
D.	Tributary Model Verification (Tracking)	\$10,000	\$ -0-
E.	Protocols Evaluation Review, Field Testing and Capital Investment	\$ -0-	\$250,000
F.	Debris Fans and Rapids Change Detection	<u>\$10,000</u>	<u>\$ -0-</u>
	Subtotal	\$350,000	\$350,000
TOTAL Monitoring & Research:			<u>\$700,000</u>

THE SOCIO-CULTURAL RESOURCES PROGRAM

The socio-cultural resources program incorporates the cultural resource program and the socio-economic program into one resource program area. These resource areas have been combined to provide a more comprehensive treatment of resources that span prehistoric to current times and are meaningful to a broad group of stakeholders. This section describes the FY 2000 activities planned for cultural resources, such as prehistoric and historic archaeological resources and traditional tribal resources; and recreational resources. Economic and hydropower issues are also included in this section.

FY 2000 PROGRAM ACTIVITIES

A. Cultural Resources: Prehistoric and Historic Archaeological Resources, Traditional Tribal Resources

The activities proposed for FY 2000 for the prehistoric and historic archaeological resources and traditional tribal resources address the Management Objectives and Information Needs developed by AMP stakeholders. The Management Objectives are:

1. Conserve *in situ* all the downstream cultural resources and take into account Native American cultural resource concerns in the Colorado River ecosystem.
2. If *in situ* conservation is not possible, design mitigative strategies that integrate the full consideration of the values of all concerned tribes with a scientific approach.
3. Protect and maintain physical access to and use of traditional cultural properties and other cultural resources where such access and use may be impacted by dam operations.
4. Maintain, and integrate all appropriate cultural data recovered from monitoring, remedial and mitigative actions and incorporate these data into evolving research designs and mitigation strategies for understanding human occupation and use of the Colorado River ecosystem.

Information Needs were also developed and prioritized by the AMP stakeholders to assist in meeting the management objectives. The Information Needs are:

- 1.1. Develop data and monitoring systems to assess impacts to cultural sites potentially impacted by the operations of Glen Canyon Dam.
- 1.2. Develop data systems to assess risk of damage and loss from varying flow regimes
- 1.3. Characterize all cultural resource sites as to the specific associated management/research needs, i.e., preservation, stabilization, documentation etc. under differing flow regimes.
- 1.4. Preservation, stabilization and/or documentation of cultural resources as impacted by sediment resources associated with differing flow regimes.
- 1.5. Preservation, stabilization of flood terraces holding cultural resources.
- 1.6. Evaluate flood terrace stability necessary to maintain cultural resources and terraces at pre-dam condition.
- 1.7. Evaluate methodology for correlating recreational site use and cultural resource impacts.
- 2.1. Characterize through scientific study and data development all assumed historical and current values, including scientific values, of resources to tribal nations and to the general public
- 2.2. Develop research designs and costs associated with data recovery.
- 3.1. Characterize historic and current traditional cultural associations of all sites associated with impacts of dam operating criteria.
- 4.1. Develop evolving research designs and/or other methods including synthesis of existing available data and GIS for understanding human occupation and use.

Some of these information needs will be satisfied during portions of this plan while others will continue to be on-going. The FY 2000 activities are organized around these information needs.

Information Need 1.1: Develop data and monitoring systems to assess impacts.

Project #1: Photographic Monitoring of Terraces within the Glen Canyon Reach containing cultural deposits is expected to cost approximately \$35,000. This project will continue existing monitoring of these sites and synthesize the existing data to answer research questions related to the impacts of varying flow stages and operational ramping rates on the terraces and the associated cultural deposits. Study results that suggest mitigative

activities would be referred to the BOR PA program. This project also addresses Information Needs 1.4, 1.5, 1.6 and 2.1

Project #2: Investigation of Isolated Occurrences (IOs) is expected to cost about \$25,000 and extend for about one year. Data currently being synthesized under an existing project will be evaluated and assessed to determine if IO data represent the last remains of site materials, the first exposures of previously unknown buried sites, or artifacts representing individual episodes of use and occupation within the river corridor. Collectively, IOs yield information about past adaptations and how people interacted with their cultural landscapes. Neither IO distribution nor attribute data are being evaluated under existing programs. Based on these assessments, additional investigations may be suggested.

Project #3: Tribal monitoring and assessment projects that assess traditional resources such as ethnobotanical resources where assessments are not included within other complementary programs. Three projects have been submitted to the GCMRC that address evaluation of tribal traditional resources and total about \$125,000. These projects include 1) a project for \$80,000 that includes the participation of three tribal groups to assess and interpret traditional resources relative to dam operations and disseminate information using CD ROM technology; 2) a tribal project of \$25,000 to disseminate tribal ethnobotanical data through workshops for tribal members and other members of the public, and 3) a tribal project for ethnobotanical resource assessments and tribal field training for \$20,000. These projects are currently being revised to address review comments. These projects also address Information Needs 2.1 and 3.1

Project #4: Continued Application of geomorphic hypothesis testing is expected to cost approximately \$35,000 and be conducted for a period of one year. Work linking certain geomorphic process and archaeological site erosion is currently being evaluated and these data will be available in FY 2000. Refinements to the hypothesis, investigation of additional and/or unanswered questions, further field testing, and possible application to other areas will occur under this project.

Project #5: Protocol Assessments is estimated to cost \$15,000. The project costs for protocol assessments and related project evaluations represent the cultural contribution to the overall costs for protocol assessments. This project was initiated in FY 98 and is expected to continue through FY 2000/2001 for the socio-cultural program. While the GCMRC supports

a comprehensive protocol assessment of all cultural activities, the protocol cost estimates do not include costs associated with protocol evaluations related to the BOR PA program.

Project #6: Unanticipated Information Requests are estimated at \$5,000 for FY2000. These requests include impromptu studies and information research at the request of the TWG or AMWG that cannot be accomplished using existing staff resources. If remaining funds exist at the end of FY2000, they will be obligated for FY2001.

Information Need 1.2: Develop data systems to assess risk of damage at critical threshold levels, and loss from varying flow regimes.

Project #1: Investigation of remaining study questions related to the flow and deposition model, or the model application to other locations with cultural resources is expected to cost about \$25,000 and be conducted over a one year period. This information would help to determine inundation frequency as well as critical threshold levels for triggering recommendations for remedial responses. The ongoing mainstem flow and deposition project is testing this model in one area of the river corridor where archaeological resources have been identified and these data will be available in FY 2000. Some research questions may require additional study. Also if the modeling work proves useful in this test area, the model can be applied to other areas and other types of important resources that appear to be at risk. In addition, flow regimes and deposition at various stages can be quantitatively modeled for previously unevaluated resources, such as traditional tribal resource locations.

Information Need 4.1: Develop evolving research designs and or other methods including synthesis for existing available data and GIS for understanding human occupation and use.

Project #1: Continuation of the Development of Tribal Technology and Procedures for Dissemination and Access to GCMRC Data is expected to cost \$35,000 and is a continuation of project efforts that were initiated and approved in FY 99. These efforts include continuing work with Tribal stakeholders to develop technological capabilities, and educational expertise to allow these stakeholders to access and interpret information in a timely cost efficient manner. Project elements include costs associated with working groups that assist the GCMRC, educational/information dissemination, assessment

of technological capabilities, and co-funding opportunities for continued implementation in future years.

Information Need 2.2 : Develop research designs and costs associated with data recovery. This information need is not addressed in this plan. At the present time, issues of data recovery at cultural sites are being designed under the Programmatic Agreement Program under the direction of Reclamation. No activities are planned in this area under the GCMRC cultural program. Information Need 1.7 (Evaluate methodology of correlating recreational site use and cultural resource impacts) is also not addressed in this plan for FY2000 because it received a low priority for scheduling by the TWG and the AMWG as of their July 1998 meeting.

B. Recreational Resources

Management objectives for the recreational resources were developed by AMP stakeholders with the goal to provide quality recreation experiences that do not adversely affect natural or cultural resources within the Colorado River ecosystem. Recreation resources include sport fishing, white water rafting, boating, hiking, sightseeing, photography, and hunting.

The AMP management objectives include:

1. Provide quality recreation experiences consistent with other resource objectives;
2. Maintain flows (under approved operating criteria) and sediment processes that create an adequate quantity, distribution and variety of beaches for camping, as long as such flows are consistent with management of natural recreation and cultural resource values (other natural resource values);
3. Maintain flows (under approved operating criteria) that minimize impacts to navigability by authorized water craft and for boaters, waders, and campers in the riverine corridor;
4. Maintain flows (under approved operating criteria) and habitat suitable for quality cold water fishery opportunities in Glen Canyon;
5. Maintain flows (under approved operating criteria) and habitat suitable for waterfowl sport hunting and wildlife viewing opportunities in Glen Canyon.

The AMP Information Needs are:

- 1.1 Determine criteria and aspects that are important to, or detract from the recreational experience;
- 1.2 Determine the impacts of scientific study on recreational experience
- 1.3 Characterize procedures to mitigate those aspects of flows that detract from quality recreational experiences
- 1.4 Determine angler satisfaction, use and harvest
- 1.5 Determine potential impacts of increased heavy metals on sport fishing.
- 2.1 Determine adequate beach quantity, quality, distribution, character and structure for camping throughout the system;
- 2.2 Evaluate impacts of operating criteria on establishing and maintaining adequate beaches and distribution of other resources, quality, character and structure.
- 2.3 Develop methodology to evaluate distribution, quantity and quality changes in all campable beaches through time.
- 2.4 Develop systems models to predict flow regimes (under approved operating criteria for building and maintaining beaches).
- 3.1 Determine if operating criteria maintains safe and adequate power craft navigability in Glen Canyon and upper Lake Mead;
- 3.2 Evaluate effects of operating criteria on recreation safety.
- 3.3 Determine if operating criteria maintains whitewater raft navigation in Grand Canyon
- 3.4 Define ecosystem and other resource impacts of flow regimes (under approved operating criteria) required to maintain navigation.
- 3.5 Develop methodology to evaluate potential conflicts of day rafting and other resources (e.g., bank degradation, sport fishing, bird watching, etc.)
- 4.1 Determine flow regimes (under approved operating criteria) necessary to maintain fish populations of 100,000 adult Trout (age class II plus);
- 5.1 Define pattern of waterfowl hunting use and satisfaction and other wildlife use and conflicts to other uses.

Information Need 1.1: Determine criteria and aspects that are important to, or detract from the recreational experience.

Project #1: Conduct a Recreational user preferences and attitudes assessment.

This project is ongoing and will be completed early in FY 2000. This project may also address Information Need 1.3.

Project #2: Monitor trout anglers' use and satisfaction through creel survey and cooperative monitoring program with fishing guides and Trout Unlimited. This program will be developed through a proposed cooperative program involving fishing guides, Trout Unlimited, Arizona Game and Fish Department, and GCMRC staff to compile and assess existing data and methodology. The goal is to establish a minimal cost but more robust monitoring of user sport fishing satisfaction in the Lees Ferry Reach. It is projected that approximately \$5,000 in total costs will be allocated to this project. The results of this study may suggest additional work in FY2001 with possible co-funding opportunities with State and Federal entities. This project will also address Information Need 1.4.

Information Need 2.1: Determine adequate beach quantity, quality, distribution, character and structure for camping throughout the system

Project #1: Use past monitoring, research and cooperative studies to develop synthesis of campsite beach changes over 30 years under ROD Dam Operations. This project will be developed through a one year RFP at a cost of \$25,000. This project will be developed with the following objectives: 1) Using aerial photography and FY 99 GCMRC study of beach changes define the changes that have occurred in beaches from the 1950s to present time in Glen Canyon and above and below LCR by area; 2) Using past and current research studies, identify and associate these change factors that are related to dam operations; and 3) Develop predicting methodologies to forecast possible future changes in beaches under ROD dam operations.

Information Need 2.2: Evaluate impacts of operating criteria on establishing and maintaining adequate beaches and distribution of other resources, quality, character and structure.

Project #1: Evaluate effectiveness of new monitoring protocols for Assessing Campsite Changes under Differing Dam Operations. This project was initiated under a physical science RFP in FY 98 and has an FY 99 cost of \$20,000. In FY 2000, protocol assessments will cost \$20,000. Project objectives include a assessment of hydrography, videography and other potential cost effective protocols for monitoring beach changes in Glen and Grand Canyons through time under differing dam operations. This project partially addresses Information Need 2.3 and may be useful in addressing 3.5.

Project #2: Monitor beach changes through cooperative programs with boating guides. Boating guides are the primary contact for boater recreationists using the Colorado River of Grand Canyon. A pilot program has been initiated to monitor qualitative beach changes using photographs taken by boating guides in Grand Canyon at differing flow regimes. Monitoring of the Glen Canyon reach will be initiated using fishing guides This project that is expected to cost about \$5,000.

Information Need 3.1: Determine if operating criteria maintains safe and adequate power craft navigability in Glen Canyon and upper Lake Mead Information is currently being collected and evaluated in a cooperative effort by the National Park Service using accident data. No GCMRC project is currently proposed in this area. As information becomes available future studies may be suggested. This project may also address Information Needs 3.2, 3.3, and 3.4.

Information Need 4.1: Determine flow regimes necessary to maintain fish populations of 100,000 adult Trout (age class II plus)

Investigations into fish fecundity are currently being conducted in the Biological Resources Program area.

Information Need 5.1: Define pattern of waterfowl and other wildlife use and conflicts to other uses Information from on-going projects addressing recreational issues will be assembled to evaluate future projects in this area. However, no projects are proposed in FY 2000.

Information Need 1.2 is not addressed in this plan but will be scheduled in subsequent work plans. Information Need 2.4 is currently being addressed within the Physical Resources Program and in an on-going project modeling deposition at cultural site locations.

C. Economic Market Activities

C. i. Hydropower Supply

Hydropower supply is an integral part of the economy of the region. It is a product of the Glen Canyon Power plant electrical generation that contributes significant power to rural electrical associations, public municipalities, irrigation districts and Federal and State facilities in the Southwestern and Rocky Mountain areas of the United States. Changes in power operations resulting from changes in annual dam operations would affect the power supply and its costs to power users. The stakeholders' goal within this program is to maximize the value of long term power and energy generation within the criteria and operating plans established by the Secretary under Section 1804 of the 1992 GCPA. The AMP management objectives within this program are to determine the impact of changes in dam operations on hydropower outputs and the concomitant power marketing and economics of the region, a concern of those agencies and organizations associated with hydropower production.

The AMP Information Needs for hydropower include:

1. Continue to monitor the amount of revenues collected from the generation of electrical power at the Glen Canyon Power plant;
2. Continue to account for the financial/economic cost of the operational changes at Glen Canyon Dam due to the ROD including rate impacts to Colorado River Storage Project (CRSP) long-term firm electrical customers;
3. Calculate the financial costs of research flows so that these costs can be declared "non-reimbursable" (as defined by Section 1804 of the Grand Canyon Protection Act); and
4. Monitor any difficulties in operating an integrated electrical system, including regulating a load control area.

At the present time, the data needed to measure and evaluate power production is already routinely collected by the BOR and WAPA and no data gathering or activities by GCMRC are proposed in this area.

C. ii. Water Resources

Water resources include all aspects of water quantity and quality. The “Law of the River” directs the operations of Glen Canyon Dam including monthly and annual release patterns and reservoir contents and elevations with the goal of operating Glen Canyon Dam for water supply and water quality consistent with existing law and policy. Although of more recent concern, water quality as it relates to changes over time is of specific concern. High water levels in reservoirs and rivers also normally maximize recreation benefit and values. High water quality can also create additional value in water supplies.

The AMP Management Objectives for water resources are:

1. The Secretary shall Operate Glen Canyon Dam in a manner fully consistent with the Record of Decision and subject to the “Law of the River,” including but not limited to the following: Grand Canyon Protection Act of 1992, the Colorado River Compact, the Upper Colorado River Basin Compact, the Water Treaty of 1944 with Mexico, the decree of the Supreme Court in Arizona vs. California, and the provisions of the Colorado River Storage Project Act of 1956, and the Colorado River Basin Project Act of 1968 that govern allocation, appropriation, development, and exportation of the waters of the Colorado River Basin.
2. Maintain water quality at levels appropriate to support physical, biotic, and human resource needs of various ecosystems downstream of Glen Canyon Dam as mandated by the Grand Canyon Protection Act and incorporated into the Record of Decision.

The AMP Information Needs for water resources are:

1. Annually collect and report Glen Canyon Dam (GCD) flow release information.
2. Monitor water quality, composition and temperature and compare to applicable standards.
3. Quantify current selenium levels in water discharged from Glen Canyon Dam. Determine how selenium concentrations are affected by dam operations.
4. Determine/quantify the dynamics of major cations, anions and nitrate/phosphate ratios resulting from dam operations.
5. Evaluate feasibility of short term or long term changes of water temperature through selective withdrawal.

Several activities are currently being conducted to address these information needs. These include the flow release information collected at GCD by the Bureau of Reclamation; the Bureau of Reclamation selective withdrawal study efforts; and the GCMRC comprehensive water quality program that studies the effects of water quality on downstream resources by monitoring chemical and biological parameters in Lake Powell, the GCD tailwaters, and at downstream locations. The GCMRC water quality program is described elsewhere in this plan.

C. iii. Economic Assessments of Resource Impacts

A comprehensive assessment of market and non-market costs and values was conducted in Phase II of the GCES. That assessment established a baseline analysis of Grand Canyon resource values and it established a cost analysis relating to impacts of alternative dam operating criteria.

However, an effective Cost/Benefit Analysis (CBA) model that can easily accommodate new economic assessments of any alternative operating criteria proposed for the Dam was not developed. A proposed model should accommodate evaluation of all associated market and non-market costs and benefits, including intrinsic and existence values of key resources. The development of a CBA model should be along design parameters that permit eventual incorporation into a more robust decision support system. A synthesis of data should allow the development of the CBA model in the future and no GCMRC activities are proposed in this area for FY 2000.

FY 2000 BUDGET SUMMARY

Cultural Resource Projects:

Photographic Terrace Monitoring.....	\$35,000
Investigation of Isolated Occurrences.....	25,000
Protocol Assessments.....	15,000
Unanticipated Information Requests.....	5,000
Application of Flow/Deposition Model	25,000
Tribal Resource Projects (3)	125,000
Tribal Technologies	35,000
Application of Geomorphic Testing	<u>35,000</u>
Total	\$300,000

Recreational Resource Projects:

Assessing 30-year Campsite Changes	\$25,000
Evaluating Trout Anglers' Satisfaction.....	5,000
Campsite Monitoring Protocols	20,000
Boater Adopt-a-Beach Program.....	<u>5,000</u>
Total	55,000

CONTRIBUTION OF THE FY 2000 PROGRAM TO THE STRATEGIC PLAN

The GCMRC socio-cultural program is linked to the stakeholder objectives and information needs as formulated under the Adaptive Management Program. The information that is generated from these activities provides the necessary data for the long-term management of socio-cultural resources within the river corridor.

THE BIOLOGICAL RESOURCES PROGRAM

The FY 2000 Biological Resources Program will represent extended and competitively awarded contracts, as discussed in the Strategic Plan. The FY 2000 program will include monitoring and research activities associated with water quality; the aquatic food base; humpback chub and other native fish; Lees Ferry trout fishery; wetland and riparian vegetation; riparian avifauna and the endangered species: Southwestern willow flycatcher, the Kanab ambersnail. The program will also include protocol evaluations, staff activities in support of TWG requests (e.g., BHBF resource criteria, State of the Canyon Resources Report, draft BA, etc.), contingency planning for a BHBF, in-house studies, and unsolicited proposals.

FY 2000 PROGRAM ACTIVITIES

Integrated Water Quality Monitoring and Research

[NOTE: This will be modified pending agreement by the TWG with the recommendations of the Lake Powell AD-hoc group.]

WATER QUALITY MONITORING AND RESEARCH FOR LAKE POWELL AND THE COLORADO RIVER IN GRAND CANYON “DRAFT” TO BE REVISED BASED ON THE INFORMATION PROVIDED BY THE TWG AD-HOC LAKE POWELL GROUP

The FY 2000 annual plan contains a proposal by the GCMRC to integrate all water quality monitoring and research being performed by the GCMRC in Lake Powell, the forebay upstream of Glen Canyon Dam, the tailwater from the dam to Lees Ferry, and the Colorado River through Grand Canyon. The proposed integrated water quality monitoring program is designed to address both the MOs and INs for downstream resources as well as those MOs and INs for Lake Powell which the Ad hoc group has determined may have effects on downstream resources. In the past, some of this work (mainstem monitoring at the USGS gages of temperature, conductivity, and turbidity) has been under the Physical Sciences program, other work has been done under the Biological Resources program (forebay and mainstem monitoring of temperature, conductivity, and pH), while other work has been conducted under the Lake Powell program (monitoring of water quality in Lake Powell). This restructuring will ensure that the water quality information is collected

consistently, using comparable methods and instrumentation, and is integrated into a common data management system for accessibility by all interested researchers and other parties.

Program Background

Water quality changes that occur in Lake Powell and are released downstream to the immediate tailwater have been documented by the existing Lake Powell program. It is generally recognized that water quality changes from Lake Powell through Grand Canyon primarily affect biological components of the aquatic ecosystem. For this reason, it is proposed that this integrated water quality program be moved under the direction of the Biological Resources Program.

The physical, chemical, and biological components of water quality in the Colorado River ecosystem define the conditions in which all biological processes in the aquatic ecosystem take place. Temperature and warming patterns in the Colorado River directly affect the life history of the various native and non-native fish species in Grand Canyon and affect microclimate in the riparian zone. Chemical concentrations of nutrient compounds in Glen Canyon Dam releases are a limiting factor in primary productivity in the tailwater below the dam. Hydrodynamic processes and operational patterns affect the physical and chemical water quality of dam releases as well as organic material and biological organisms which are exported to Grand Canyon. Future plans for selective withdrawal will further affect release water quality in a substantial manner.

The integrated water quality program (IWQP) will be designed by GCMRC and coordinated with Reclamation and the Lake Powell MOU group. The scope of work developed by GCMRC will be submitted to external peer review prior to submission to the AMWG/TWG for review and recommended adoption. Once the scope of work has been developed, additional detail will be added to this Annual Plan.

Water Quality Program Administration and Budget

Monitoring and research activities, subject to the recommendations of the TWG Lake Powell Ad-hoc group, will comprise the GCMRC water quality monitoring program for Lake Powell as well as the GCMRC water quality and temperature monitoring program in the tailwater from the dam to Lees Ferry, and the Colorado River through Grand Canyon.

Under the Ad-hoc group proposal, monitoring and research activities in Lake Powell will be supported by Reclamation (e.g., O&M funds or other sources) and are proposed to cost \$250,000. Monitoring and research activities in the mainstem will be supported by GCMRC within the Biological Resources Program budget and are proposed to cost \$50,000 (see IWQP). No additional programming or funds will be allocated unless revisions to the existing program are proposed by the AMWG.

Aquatic Ecosystem Resource Components and Activities

Aquatic ecosystem resources include water quality parameters, the primary and secondary producers (e.g., algae, Gammarus and other invertebrates), secondary consumers (water fowl, fish), and predators (predatory birds) and the habitat (main channel, shoreline). Avifauna are included as a resource in the aquatic ecosystem, although monitoring and research may be conducted out of terrestrial ecosystem budgets.

Management Objectives

Management objectives regarding aquatic resources include MO 1-10 (Appendix A). Within each resource category the information needs that are planned to be addressed in FY 2000 are separated into either monitoring or research information needs.

[NOTE: When the **Integrated Water Quality Program** is recommended to the Secretary for adoption by the AMWG it will be moved here as the first element of the Aquatic Ecosystem.]

Aquatic Food Base

Aquatic primary and secondary productivity (i.e., the aquatic food base) is the primary trophic link and energetic conduit throughout the Colorado River ecosystem. Fluctuations in the aquatic food base are associated with certain environmental stressors that include water temperature, turbidity, and flow fluctuations, to name a few. Understanding the relationships between dam operations and productivity of the aquatic food base is an important step towards understanding the effects of dam operations on higher trophic levels, especially the population dynamics and interactions of native and non-native fish species in the Colorado River ecosystem.

Monitoring and Research Information Need that will be addressed is 1.1., 1.2, and 1.3 - Aquatic food base monitoring activities will focus on community structure, density, distribution and total biomass along the mainstem and tributaries, and making linkages and distinctions between dam operations, Lake Powell input, tributary influences, and inherent variation in the aquatic food base. This data will be collected in a manner compatible with monitoring and research activities on fish and in such a way as to enable distinction between the effects of dam operations and natural variation on the aquatic food base. Research aspects will include developing linkages between water quality, dam operations, Lake Powell input and tributary influences on the aquatic food base in relationship to composition and energetic contribution to the system using stable isotope analysis of fish tissue. It is intended that the existing contract will be extended for at least one year. Total cost for this project is \$234,000.00.

Native Fish

Native fish are an important part of the Colorado River ecosystem because of their trophic role, evolutionary significance, and inherent value for biodiversity. They are of critical importance because some are listed as threatened or endangered under the Endangered Species Act. Native fish found in the Colorado River ecosystem represent a unique assemblage of species ecologically adapted to a fluvial riverine environment characterized by seasonally variable flows, temperature, and sediment loads. With the completion of Glen Canyon Dam, abrupt environmental changes (e.g., altered sediment

transport, flow patterns and thermal characteristics) were imposed on this system. This resulted in abiotic and biotic changes to habitat, channel morphology, predation pressures, parasitism and diseases, food base and trophic linkages. These changes are reflected in the present relative abundance, reproductive success, survivorship, distribution, and movement of native fish.

An overall goal for GCMRC monitoring and research activities is to understand the processes that enable the maintenance and/or enhancement of native fish, especially the endangered humpback chub. Native fish populations depend on appropriate habitat for all life stages and an adequate food base for their continued survival. Both of these elements may change in response to dam operations. Changes in reproduction, recruitment, and growth in response to dam operations can also affect native fish population demographics.

Native fish information needs will be addressed through a combination of monitoring and research activities. Knowledge gained from these scientific efforts, may negate the necessity of addressing some information needs which have been prioritized for subsequent research efforts, and may refine the direction taken for monitoring efforts and management actions. In addition, non-native fishes, in Grand Canyon are thought to pose a threat to the native species with competition for resources, predation, and the introduction of parasites and diseases. The various non-native species have different direct and indirect effects on multiple aquatic resources. Efforts to monitor the abundance of non-native species and their co-occurrence with native species of concern will be initiated.

The following are information needs that address minimal monitoring needs and primary research needs for native fish.

Monitoring Information Needs that will be addressed include:

3/4.1, 3/4.2, 8.1, 8.2, 8.3, 8.4, 9.3, 10.6 - Monitoring for native and non-native fish will occur within critical habitat for native fish in FY 2000 at an estimated cost of \$470,00. The monitoring will be accomplished through extending the existing contract.

Research Information Needs that will be address include: 6.2, 6.3, 10.1 - Project 1. Research project that examines the relationship between mainstem fish and LCR fish populations of HBC.

Effectively monitoring the status of native fish initially requires addressing information needs that are research oriented. In addition, the implementation of several management actions that intend to address Biological Opinion Statements are eminent. These actions primarily address mainstem spawning issues. Research in mainstem spawning and recruitment success of endangered fish relative to the LCR populations will be addressed in FY 2000. Funds allocated for this projects are estimated at \$90,000 with funding for an additional years work at a similar or decreased level.

Lees Ferry Trout

Rainbow trout were first introduced into tributaries of the Colorado River ecosystem in Grand Canyon during the 1920s. Currently, 90% of the rainbow trout in the tailwater are naturally produced, while 10 years ago, most fish were of hatchery origin. Although large trout in excess of 5 pounds were numerous before 1983, these large fish are now rare. Nevertheless, large numbers of reasonably well-conditioned fish are being sustained by a high biomass of amphipods (Gammarus lacustris) and midges (Chironomidae).

Alternative dam operations and the resulting flow regime can directly and indirectly effect trout found in the dam tailwater. Direct effects include stranding of all life stages in isolated pools, dewatering of spawning and rearing habitats, and displacement of individuals from preferred habitats. Indirect effects involve ecosystem processes and lower trophic level interactions that provide the food base for the fish. For example, dam operations historically caused sloughing of algae, desiccated by the fluctuations, and downstream movement of food. During rising water levels, food intake increased for trout. Stranding and dewatering are sources of mortality for adults, juveniles, and larval fish, while displacement may cause increased energy expenditure, reduced food intake, and disruption of reproductive activities. The temporary increase of drift associated with fluctuations may be outweighed by the other effects on fish health. Understanding the processes that enable the maintenance and/or enhancement of the rainbow trout fishery requires managers to be able to accurately predict the aquatic resource's response to ecological changes that are a (direct or indirect) result of GCD operations.

Monitoring Information Needs that will be addressed include: 2.2, 2.3, 2.5 - Monitoring will be accomplished through extending the existing contract for one more year. Aspects of the monitoring program may be changed based on symposia and protocol evaluation (PEP) results. The monitoring budget for trout in the Lees Ferry/Glen Canyon reach is estimated at \$130,000.

Research Information Needs that will be addressed include: 2.4 - Research is needed to address historic data associated with native and non-native interactions and baseline information for fish. GCMRC will initiate an effort to consolidate data and to provide procedures for sharing data among researchers. Funds associated with this effort are estimated at \$30,000.

In FY 2000, GCMRC intends to conduct a symposia that evaluates the scientific understanding of cold tailwater fisheries in the western United States with a focus on creating a base of scientific information that could be used in the development of future management plans for the Lees Ferry trout fishery. The goal of the symposium is to provide a scientific forum to present and discuss the effects of flow regulation and management activities on the Lees Ferry trout fishery. The outcome of this symposium may result in a modification of the specific elements of the monitoring and research activities to be initiated in FY 2000. Funds of \$20,000 for this program were designated in FY1999 and these funds will be carried over into FY2000.

Protocol Evaluation Process (PEP)

Protocol evaluation for monitoring of trout in the Glen Canyon reach will be conducted in FY 2000. The estimated cost for PEP is \$15,000.

Terrestrial Ecosystem Resource Components and Activities

Riparian vegetation prior to the construction of Glen Canyon Dam, was subject to periodic flooding. The destabilizing actions of historic flows resulted in a community that was often re-establishing itself rather than expanding. Since the establishment of Glen Canyon Dam, the hydrograph has become dampened and resulted in more stable riparian communities both with respect to those components associated with the old high water line (120,000 cfs), and those composing the new high water zone (5,000 cfs to 31,000 cfs). Additionally, reduced seasonal fluctuations associated with dam operations has established

and expanded marsh communities that were rare prior to the dam. Terrestrial ecosystem resources include the primary and secondary producers (e.g., marsh and riparian vegetation and terrestrial invertebrates), consumers (avifauna, deer), and higher trophic level predators (predatory birds) and the associated habitat (near shore marsh and low- and upper-elevation riparian communities). Avifauna represent a trophic level that utilizes both aquatic and terrestrial resources, but are included in terrestrial resource monitoring and research.

Management Objectives

Management objectives for terrestrial resources include MOs 11-16. Information needs associated with specific resources are listed and separated into monitoring needs and research needs.

Monitoring and research efforts within the terrestrial ecosystem resources will vary from monitoring with little to no research to synthesis and little monitoring for some resources. This is reflective of the knowledge base associated with each resource.

Riparian Vegetation

Riparian vegetation is recognized as an important resource serving many roles in the Colorado River ecosystem. The riparian vegetation stabilizes banks, provides aquatic and terrestrial faunal habitat, are botanical resources for tribal groups, and has aesthetic and recreational value. Today, three distinct riparian or marsh communities are represented along the mainstem of the Colorado River: the upper riparian zone; the lower riparian zone; and the near shore wetland communities. The preservation or restoration of riparian communities affected by dam operations is a management objective identified by the AMWG. In part, this is because riparian vegetation provides critical habitat for terrestrial invertebrates, that in turn, provide essential food resources for riparian insectivores (insects, amphibians, reptiles, birds and mammals), thereby linking vegetation, productivity and habitat conditions with secondary consumer population dynamics.

Monitoring Information Needs that will be addressed include:

11.3 - Monitoring for vegetation during FY 2000 will take place only in that aerial photography of the river corridor will occur. In anticipation of implementing a long-term monitoring program for vegetation by FY 2002, a synthesis of previous vegetation data

collection efforts will be conducted with the intent of summarizing the previous efforts within the context of the information needs and providing a focus for protocol evaluation regarding vegetation monitoring. Estimated costs for synthesis is \$55,000.

Research Information Needs that will be addressed include: 11.1, 13.1, 13.2 - Project 1. Identification and evaluation of trophic level interactions for terrestrial habitat. Continuing up the foodweb, trophic interactions between habitat conditions and availability, invertebrates and primary consumers (i.e., terrestrial/riparian vertebrates) affect the sustainability of higher level consumers. The river corridor supports high densities of terrestrial/riparian vertebrates. The populations of many of these animals are changing. More than a dozen native vertebrate taxa have been lost, or their status is unknown (e.g., river otter), while several native and non-native species populations have increased (e.g., waterfowl, beaver). Identifying and developing an understanding of trophic level interactions in the terrestrial environment is as important as understanding aquatic food base interactions. Estimated cost for the pilot project is \$30,000.

Protocol Evaluation Process (PEP)

Protocol evaluation for vegetation monitoring will take place in FY 2000 after the synthesis has made sufficient progress to narrow the scope of the review panel. Estimated cost for PEP is \$20,000.

Riparian Avifauna

Terrestrial vertebrates have a significant influence on ecosystem structure and energy flow, and are recognized as a priority resource by the NPS. Fortunately the conspicuous nature of many of these vertebrates, make monitoring them relatively easy. Avifauna are especially conspicuous and are trophically significant secondary consumers. Their presence or absence can be an indicator of the status of habitat structure, food resource production, and predator populations.

Reduced flood frequency and sediment transport in this system has increased aquatic foodbase productivity, established trout populations, and promoted profuse stands of wetland and riparian vegetation. As a result, threatened or endangered Bald Eagle, Peregrine falcon, and Southwestern willow flycatcher (SWWF), other regionally significant

Neotropical migrants, and other breeding bird species populations have increased in the post-dam river corridor.

Nearly 320 species of birds have been observed downstream from GCD in the Colorado River ecosystem since the 1920's. The avian assemblage within the Colorado River ecosystem includes more than 25 obligate and facultative riparian species, and at least 59 species of waterbirds. Little is known of the pre-dam (pre-1963) avian assemblage within the Colorado River ecosystem. However, numerous post-dam riparian Neotropical migrant species nest in and use the lush native and non-native vegetation along the river, and habitat patches vary considerably in size and condition.

Monitoring Information Needs that will be addressed include:

11.2, 11.4, 12.2, 12.4. Monitoring of riparian avifauna will occur by extending the current contract. The focus of monitoring will be on habitat condition, habitat use and nesting success, including distribution and population trends of breeding birds in the river corridor. Costs for breeding bird surveys will be about \$81,000.

Protocol Evaluation Process (PEP)

Protocol evaluation for bird survey monitoring will take place in FY 2000 with an estimated cost of \$15,000.

Endangered Species

The Colorado River ecosystem supports several species that are federally listed as threatened or endangered, including bald eagles, breeding peregrine falcons, Southwestern willow flycatchers and Kanab ambersnail.

Southwestern willow flycatcher

Monitoring Information Needs that will be addressed include:

11.3, 12.1, 12.2, 13.1 - The Southwestern willow flycatcher (SWWF) has been the focus of intensive monitoring in upper Grand Canyon since 1983. Monitoring of SWWF will focus on SWWF habitat condition, habitat use and nesting success, and nesting fidelity, including their distribution and population trends in the river corridor. Monitoring of SWWF will occur on an annual basis. This program is being internalized and the costs will be covered under employee salaries and in-house research. Estimated cost for this is \$20,000.

Kanab ambersnail at Vaseys Paradise

Monitoring Information Needs that will be addressed include:

14.1, 14.2, 14.3, 14.4, 14.5, 14.6 - The Kanab ambersnail (KAS) is a federally endangered snail. A population of this species exists at Vaseys Paradise in Marble Canyon, Arizona. Monitoring of Kanab Ambersnail at Vaseys Paradise will focus on habitat patch composition, area of cover, and condition; population distribution, abundance, age-class/size distribution, population density, and condition (i.e., occurrence of KAS trematode parasite) as it relates to natural variation and to the local stage-discharge relationship.

GCMRC and Reclamation will continue to cooperate in their efforts to provide support for monitoring the establishment of a second population of KAS.

Monitoring for KAS at Vasey's paradise will be completed internally for the next year as a means to make funds available to other biological resource programs. The efficacy of conducting the work internally will be evaluated during the upcoming year.

Protocol Evaluation Process (PEP)

Endangered species monitoring will undergo a PEP in FY 2000 with an estimated cost of \$10,000.

Other GCMRC Biological Resources Program Activities

GCMRC In-house Studies

In addition to the studies described above, GCMRC staff may conduct studies in FY 2000 related to specific stakeholder objectives and information needs. These research studies will primarily be initiated to address gaps in understanding that have not been anticipated two years out in the planning cycle, or which utilize the unique expertise of the GCMRC staff. In addition, these studies may represent synthesis activities where GCMRC staff have unique access to disparate data sets. All GCMRC in-house studies will be reviewed by the TWG and will undergo independent, external peer review prior to initiation.

Support for GCMRC in-house studies will account for less than 10% of the budget of the GCMRC biological resources program and is in keeping with the recommendation of the National Research Council (NRC, 1996) that the majority of research funding go to support external activities. In addition, utilization of GCMRC scientific

expertise to undertake these studies will contribute to effective synthesis and will contribute to the development and refining of conceptual and predictive models of Colorado River ecosystem processes and function.

Protocol Evaluation Process (PEP)

In FY 2000, the GCMRC biological resources program staff propose to initiate protocol evaluation program (PEP) as a means of evaluating and developing the detailed protocols which will comprise the GCMRC long-term monitoring program. This will be done through the use of visiting committees of scientists with relevant expertise in the field of study.

The strategy will be to identify a lead reviewer with relevant expertise in the field of study and work with that reviewer to identify additional reviewers. These reviewers will be provided with the past two to three years of reports from a given project as well as the currently funded proposal to review. They will be invited to meet with the current PI(s) for a series of project briefings. Time permitting, they will accompany the PI(s) on a river trip to evaluate their field methodology and gain familiarity with the ecosystem.

The reviewers will be required to provide a rigorous review of the protocols currently in use and recommendations for changes in protocols, as appropriate. This information would be used to modify, as appropriate, the FY 2001 monitoring program.

The details of this approach can be found in Appendix C. To the extent possible, protocol evaluations will be completed in FY 2000 and FY 2001.

Unsolicited Proposals

For FY 2000, the Biological Resources Program intends to set aside some funds in support of unsolicited proposals. This will allow for flexibility in the program and help ensure that GCMRC can address critical issues in a timely fashion. It will also provide GCMRC the ability to fund a truly outstanding proposal that addresses a key concern which may be overlooked in the research planning process. All unsolicited proposals will be discussed with the TWG and will undergo independent, external peer review prior to funding.

GCMRC Support of TWG Requests

In FY 2000, GCMRC intends to create a pool of money which can be used by GCMRC staff in support of requests for analysis that arise from the TWG during the course of the year. Such funds may be used to gather data, conduct analyses, support the convening of a group of scientists to provide an analysis of a given issue (i.e., the annual BHBF resources evaluation) or to obtain expertise not contained within the GCMRC staff or contractors. Such funds may be carried over from one year to the next, depending upon need and availability.

CONTRIBUTION OF THE FY 2000 PROGRAM TO THE STRATEGIC PLAN

The FY 2000 program is linked to the stakeholder objectives and information needs. The information gained from the proposed synthesis, monitoring, and research activities when combined with the results of the conceptual modeling effort will make significant contributions to understanding the key components and processes that structure the Colorado River ecosystem. This information is critical to the adaptive management process.

FY 2000 BIOLOGICAL SCIENCES PROGRAM BUDGETS

	<u>Monitoring</u>	<u>Research</u>	<u>PEP²</u>
A. Conceptual Modeling.....	\$ -0-	\$70,000	\$ -0-
B. Integrated Water Quality	\$150,000	\$ 75,000	\$75,000
C. Aquatic Food Base	\$194,000	\$40,000	\$ - 0- ³
D. Native Fish.....	\$470,000	\$90,000	\$20,000 ⁴
E. Lees Ferry Trout.....	\$130,000	\$30,000	\$15,000
F. Riparian Vegetation.....	\$55,000	\$30,000	\$20,000
G. Terrestrial Endangered Species..... (SWWF & KAS)	\$-0-	\$ -0-	\$10,000 ⁵
H. Avifauna (Breeding Birds)	\$81,000	\$ -0-	\$15,000
I. In-House Monitoring and Research.....	\$ -0-	\$100,000	\$ -0-
J. Side-scan Sonar Pilot.....	\$ -0-	\$25,000	\$ -0-
K. Unsolicited Proposals.....	\$ -0-	\$100,000	\$ -0-
L. Technical Work Group Requests.....	\$ -0-	\$50,000	\$ -0-
	<u>\$1,080,000</u>	<u>\$610,000</u>	<u>\$155,000</u>
Subtotal.....			\$1,845,000⁶

² Funds for the Protocol Evaluation Program (PEP) should not be viewed as add-ons to the base budget for a given resource area.

³ PEP for the aquatic food base will be conducted in FY 2001 following receipt of FY 1998 & 99 monitoring and research results. This can't be done in FY 2000, because the results of their trophic synthesis won't be available until March 2000.

⁴ The PEP in FY 2000 will focus on monitoring in the LCR and adjacent mainstem areas immediately above and below the mouth of the LCR. A PEP for the mainstem monitoring will be conducted in FY 2001 following the results of the pilot test of side-scan sonar.

⁵ PEP for KAS may be done as part of the KAS panel in FY99 if that is initiated.

⁶ Represents the \$1,500,000 recommended by the AMWG for the Biological Resources Program and an additional \$250,000 from Reclamation (e.g., O&M or other sources) which will be spent on the Lake Powell portion of the integrated water quality monitoring program. This will include water quality monitoring currently conducted by the USGS at their stream gages and paid for from the physical sciences program.

THE INFORMATION TECHNOLOGY PROGRAM

Introduction

The GCMRC Information Technology Program facilitates the adaptive management process of the Colorado River ecosystem by:

1. archiving and delivering scientific data and other information to stakeholders, scientists, and the public,
2. providing technology based solutions to data collection, manipulation, and analysis, and
3. providing support in areas of computers, surveying, and GIS.

The GCMRC has extensive historical data and information collected over many years relating to the condition of resources in the Colorado River ecosystem. This information represents an extremely valuable asset to researchers, managers, and interested stakeholders, but has yet to be developed into an ecologically integrated information system. Its potential for problem solving, improving management guidelines, modeling relationships, or increasing understanding of the various resources and systems under study justifies an aggressive program of information acquisition, management, and subsequent analysis.

The goal of the Information Technology Program (ITP) is to *satisfy the information needs of stakeholders, scientists, and the public relative to the Colorado River ecosystem* in terms of content and delivery. Key to achieving this goal is the development and maintenance of three core information technologies:

1. a data base management system (DBMS) for tabular information and other electronic non-spatial information,
2. a geographic information system (GIS) for electronic spatial information, and
3. a library for hardcopy information. Content of these systems will consist of all information gathered as the result of GCMRC investigations, both past and present, and additional information relating to the Colorado River ecosystem.

The full exploitation of archived data requires sufficient information as to its context including quality, comparability, and temporal and spatial aspects. Therefore, data standards must be developed which preserve the context under which the data was collected and ensures its quality and comparability from year to year, place to place, researcher to

researcher, and discipline to discipline. Future data collection efforts supported by the GCMRC will incorporate strict data standards and protocols that provides consistency in data collection, storage, and delivery from disparate sources.

Delivery of electronic content will be automated where possible using user-friendly World Wide Web browser interfaces. Library content, while not currently deliverable across the Internet, will be cataloged with content titles, authors, and subject descriptions searchable electronically utilizing similar interfaces.

Electronically warehoused data will conform to the National Information Infrastructure (NII), the National Biological Information Infrastructure (NBII), and the National Spatial Data Infrastructure (NSDI). Guidelines and protocols promulgated by these infrastructures will be incorporated into the overall database design and delivery systems whenever possible.

DBMS, GIS, and library operations together form the core information system infrastructure for storing and retrieving information at the GCMRC. Data standards and protocols ensure the quality and compatibility of the information contained within those systems. World Wide Web browsers provide intuitive, consistent interfaces to the information. However, information technology at the GCMRC goes beyond the content and delivery of information. In addition, the ITP also provides:

- Computer support to GCMRC staff
- Survey support to researchers
- Outreach to stakeholders, scientists, and the public
- Development of remote sensing applications

These ancillary services augment the core information infrastructures by providing the support, training, technology transfer, and development necessary to provide a comprehensive ITP.

FY 2000 INFORMATION TECHNOLOGY PROGRAM

Information Flow

The ITP becomes involved with scientific investigations at the point of contract award. At this point, information flows bi-directionally between the researchers and the ITP.

The ITP provides the researcher with relevant background literature, scientific and remotely sensed data, and survey and other spatial data. The researcher identifies to the ITP the type and attributes of tabular, spatial, and sensitive data they are collecting. Quality control and assurance plans are reviewed and approved. Appropriate protocols and standards for data collection and delivery are incorporated into the contract before award. When GCMRC receives a deliverable from a researcher containing data or other information, the ITP reviews it for completeness and conformance to the standards and protocols and incorporates it into the appropriate data system on a provisional basis. The data is quality assured and then made available to stakeholders, researchers, and the public through delivery systems.

Data Base Management System

A comprehensive and versatile DBMS is the first of the three core information technologies being used by the GCMRC. Its purpose is to store and deliver all tabular and other electronic non-spatial information gathered as the result of GCMRC investigations, both past and present. The ITP of the GCMRC is currently charged with inventorying, organizing, archiving, and developing delivery systems for many years worth of environmental data collection activities representing a vast array of disparate data including physical, biological, cultural, socio-economic, and climatic information. Some data resides on mature DBMS systems but much of it is stored on floppy disks or hard disks on personal computers using PC type spreadsheet and database formats. Although the objective of the information technology program is to provide a centralized database management system (DBMS), it is our policy not to duplicate data warehousing already provided by other entities. In these circumstances it is preferable to interrogate the off-site database remotely when possible. However, the GCMRC will act as a clearinghouse of data owned by other entities in the case where remote database interrogation is not possible. The challenge facing the ITP is how to bring together years of disparate historical data collected by multiple entities located in databases across the southwest in an organized fashion and then deliver it transparently to an equally disparate group of stakeholders for decision making and modeling purposes.

Aside from application of information technology to the warehousing of data, but no less important, is the ability of the information users to easily access, query, and obtain data from the information system. A process needs to be established by which the information

user knows how to find and obtain the information he/she is looking for. Therefore, an additional key area of concern is adequate documentation and training in the use of the information system. Successful application of information technology, a well defined process for obtaining data, and thorough documentation and training culminates in an information system that is accessible and easy to use.

Delivery of electronic content will be automated where possible using user-friendly World Wide Web browser interfaces. When possible, a common interface will be developed which will facilitate dissemination of data to all interested parties

The Oracle data base engine has been selected for GCMRC data base development. Oracle is a state-of-the-art data storage and delivery system that can function either as a centralized or distributed data base and incorporates a high degree of information technology integration. Important features of the DBMS are:

- All data will be ecologically integrated meaning that data will be stored in a consistent format relative to time, space, researcher, and discipline. This is essential for comprehensive ecological analysis. Appropriate data standards and protocols will be developed to regulate this feature.
- Spatial data will be geographically integrated. Although the data base will not contain a spatial data analysis engine, the GIS used by the GCMRC will be highly integrated with, and dependent upon, the data base for storing attribute data associated with spatial features. Data contained in the database will; however, be spatially referenced within the data base where appropriate.
- Public data will be freely available. Sensitive data will be protected. User accessibility will be configurable item by item.
- The data base will be searchable over the Internet using browser interfaces. Intuitive browser interfaces will be the primary method used to interrogate the database.

The GCMRC data base was originally scheduled to be implemented by December, 1999. However, due to the resignation of our database coordinator in August of 1998, the completion date for this activity will likely be pushed back to December of 2000. Eleven benchmarks have been established to track the progress of the data base development:

1. Select database software and hardware platform
2. Install software and document the installation procedure
3. Conduct data inventory and acquire example data sets
4. Evaluate existing environmental databases
5. Define data standards for tabular data
6. Identify attributes of data to be included in the data base
7. Design and program data base structure
8. Populate the data base
9. Develop user interfaces
10. Develop Web interfaces
11. Document administrative procedures

Benchmarks 1 and 2 are completed with work in progress on 7. It is anticipated that benchmarks 3 through 6 will be completed in FY 1999 with work being initiated on benchmark 7 depending upon when the Database Coordinator position is filled. Activities in FY2000 will largely consist of accomplishing benchmarks 7 through 11. Once the data base has been designed, populated, and documented, the cost of this effort will drop substantially.

Projected FY2000 DBMS budget: \$150,000

Geographic Information System

A GIS is the second of the three core information technologies being used by GCMRC. Its purpose is to provide spatial analysis capabilities for trend detection to GCMRC staff and stakeholders and to maintain a library of GIS thematic coverages of the study area. The GIS will be tightly integrated with the remote sensing initiative and, in conjunction with image processing software, will be the primary analysis tools of remotely sensed data sets. The GIS is an integral component of the monitoring program and base data development is used to assess the impacts of variable flow rates within the Grand Canyon (B.O.R. Report: R-95-14, Patrick J. Wright, et al.). It is an objective of the GIS program to use geographically referenced base data to develop an integrated ecosystem-based monitoring program (B.O.R. Report: R-93-20, Lee F. Werth, et al.). The GIS is also an important analytical tool for integrating and comparing spatial data that has been collected in the past and data that will be collected in the future. The digital elevation models stored

within the GIS and developed by the Survey Department will enable GCMRC to answer question regarding flow rates, water surface elevation and percent inundation. Questions such as: “what is at?”, “where is it true that?”, “what has changed?”, “which data are related?”, and “what happens if?” along with many other TWG, AMWG, and staff question concerning spatial data, modeling and trend analysis can be answered with a GIS.

GCES had significant accomplishments in GIS system development and establishment of meta-data protocols. GIS activities were concentrated along 17 reaches of the Colorado River identified as GIS Sites 1-17 (Fig. 4.2). Each GIS Site has up to 20 thematic coverages associated with it depicting spatial relationships of physical, biological, and cultural resources. Considerable tabular attribute data exists as part of these data sets. These data sets are known as “base data”. In addition, there exist other GIS data sets, which were constructed as part of past GCES supported investigations and delivered as part of a final product. These data sets are known as “contributor data.” The base and contributor GIS coverages represent a significant effort by GCES that may have broad application for research and monitoring being conducted in the Grand Canyon. Efforts are now underway to catalog, describe and distribute base and contributor data. All coverage tabular attribute data will be linked to the ORACLE data base for easy data storage and retrieval. Presently, the GIS group is working to increase the GIS coverage of the Grand Canyon by using state-of-the-art mapping techniques discussed under the remote sensing and survey operations.

The GIS will be the workhorse behind the analysis of the remotely sensed data; hence, significant investments in hardware and software will be required to support the Remote Sensing Program. The GIS will be the consolidating tool of remotely sensed data to allow for integrating data and assessing impacts (B.O.R. Report: R-95-14). GIS activities in support of the remote sensing activities will be funded out of the remote sensing budget subsequently described.

GIS objectives to be addressed in FY 2000 include:

- development of an internet map server
- development of an ArcView user interface to base data
- in-house and contractor base data development

Grand Canyon Monitoring and Research Center

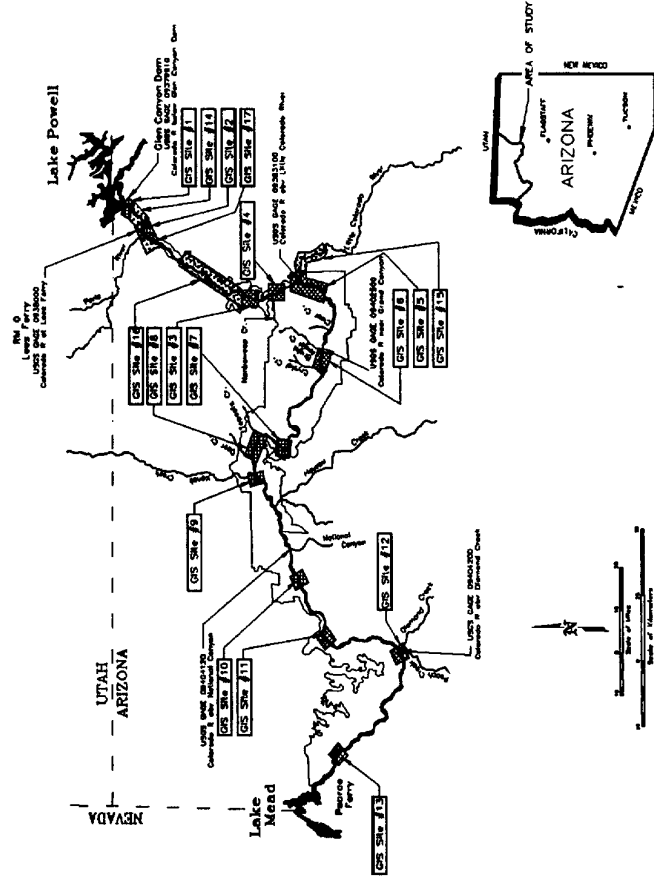
GIS Monitoring Sites

Long-Term Monitoring Sites			
SITE	LOCATION	RIVER MILE	REACH
1	RAVINE CANYON	146.4 to 146.5	2
2	LAKE PERRY	142 to 2	2
3	FRISBURY	42 to 48	2
4	MARSHALL	61 to 68	2
5	LOCH	88 to 72	7
6	CANNONVILLE	88 to 98	8
7	BLICKTAIL	128 to 132	9
8	WATERFALL	128 to 138	11
9	WINDY CREEK	142 to 148	11
10	LAVA FALLS	178 to 182	12
11	GRANT'S PARK	207 to 219	12
12	SHAWNEE CREEK	252 to 258	14
13	CHALMERS FALLS	272 to 278	14

Special Study Sites			
SITE	LOCATION	RIVER MILE	REACH
14	FRISBURY RAPIDS	142 to 142.1	2
15	LOCH	72 to 72.1	7
16	VALLEY'S PALMATE	222 to 222.9	9
17	BARBER	222 to 222.9	9

Legend

- Locations of Geographic Information and Long-Term Monitoring Sites
- Special Study Sites
- Colorado River Corridor
- Grand Canyon National Park
- Tributaries
- State Borders



Graphic Courtesy of Sherry L. Jacobs, Applied Technology Associates, Inc. & Valerie Saylor, Glen Canyon Environmental Studies, BOR

Figure 4.2 GIS Sites 1-17

- development of dynamic links within the GIS for easy field retrieval of existing canyon control
- incorporating all FY 99 contributor base data into the GIS.

The GIS program is committed to the principles and objectives of the NII and NSDI. As such, guidelines and protocols promulgated by these infrastructures will be incorporated into the overall program design and development with specific consideration given to GIS metadata standards. All contributor and in-house data received in FY 2000 will have the appropriate metadata generated and stored within the DBMS.

FY2000 GIS budget: \$10,000

Library Operations

Library operations provide the last of the three core information technologies being used by the GCMRC ITP. Its purpose is to facilitate research by providing a centralized repository for hard copy information such as books, reports, maps, photography, and videos. The scope and purpose of the library should be to collect, archive and deliver those materials that assist the center in its efforts to administer long-term monitoring and research.

Inherent in the administration of plans is the delivery of materials that facilitates monitoring and research activities. Ensuring that these materials, that form the basis for research and monitoring efforts, are available to researchers funded through GCMRC is a primary purpose of the library. Materials utilized in research and monitoring efforts include hard copy documents, photographs, slides, videotapes, and ARC/Info coverages. A loaning policy of these materials will be developed in a manner that is most parsimonious to all researchers, with underlying GCMRC staffing resources determining the ability to deliver and track loaned materials. Delivery of materials also emphasizes technologies that permit remote multi-user access.

Secondary to providing funded researchers access and use of the library's materials is providing non-funded researchers and the general public access to documents unique to GCMRC's holdings. The singularity of a document requires special policy concerning the borrowing of these materials. Because these unique documents are considered part of the public domain, their availability to the public is required. Lending policies concerning these

documents and materials are developed to insure that the loss of these materials is minimized.

Collection of materials for the purpose of research and monitoring efforts are coordinated with program managers and information technology managers. Criteria for the accession of materials include:

- Applicability of materials to specific research efforts and to overall research and management goals; adequacy of the facility and equipment needs of the GCMRC to house materials;
- Ability of the staff to archive and deliver materials;
- Availability of funding for materials (e.g., general reference books, government publications, CD-ROM's, etc.).

Collection also includes the accessioning of documents that are the product of research funded by GCMRC.

Library holdings included the following:

- Hard copies and electronic copy of final funded research reports.
- Reprints of articles resulting from funded research.
- Books resulting from research efforts associated with GCMRC.
- Books and articles related to Grand and Glen Canyon.
- Books and articles related to natural and controlled riverine and environments.
- Photographs and slides developed by GCMRC staff (aerial and field documentation).
- CD-ROM versions of aerial photographs and slides.
- Videotapes (overflights, programs related to Glen and Grand Canyon).
- Maps (topographic, flightline maps, Arc/Info Coverages, Orthophotos).

Archival materials are one of a kind, or hard to replace items (e.g., original aerial photographs, slides, videotapes). Utilizing imaging technology (e.g., CD-ROM's) and electronic media to develop copies of archived materials should always be investigated and promoted so that copies of these materials can be made available to the general collection, and thus reducing the incidence of loss of unique and irreplaceable materials.

The GCES made great strides in the establishment of the library in 1993 when a research librarian was hired to organize and maintain it. However, the librarian resigned in May of 1997 during the transition from GCES to GCMRC and the position was not immediately backfilled. There have been valid concerns about the condition of the library since that time. New holdings were being stacked on shelves, desks, or placed in boxes for safe keeping. There was no formal monitoring of the library or check out process to track the whereabouts of library materials. Fortunately, that situation has since been corrected and great strides have been made in making the library a functional entity within the GCMRC.

A library committee was assembled in October of 1998 and met to decide what actions should be taken to update and maintain the library. Over several months, the committee produced a strategic plan with recommendations for the restoration of the library. The library content and strategic plan was reviewed by two outside consultants who produced written comment and recommendations of their own. Since that time, a student has been hired from Northern Arizona University to oversee the day to day operations of the library and reorganize its content. Library automation software has also been obtained and the library content is being indexed using this software on a time available basis.

Current goals the library seeks to obtain are:

- Establish library policy for material use and checkout
- Catalog library contents using the Dewey Decimal system
- Facilitate the day to day library operations by using automation software
- Provide electronic searching capabilities of library content over the Internet
- Provide more information electronically over the Internet

The Dewey Decimal system was selected based on its overall ease of use and familiarity. Records management requirements will be met through cross-referencing the new system with an approved records management system.

It is anticipated that most of these goals will be achieved in FY99 with the exception of the cataloging of library contents being limited to books and reports. Library activities in FY 2000 will largely consist of library maintenance and cataloging photographs, videos, and maps. Once these goals have been achieved, the library will be able to serve a greater number of constituents in less time with better service at a reduced cost.

Projected FY2000 Library budget: \$12,000

Remote Sensing

Remote sensing is a new initiative at the GCMRC that is intended to address concern over the expeditionary manner in which research has been conducted in the Canyon. The purpose of the initiative is to evaluate remote sensing techniques as a cost-effective means of resource monitoring in the Grand Canyon with the desire to reduce impact and expand monitoring in terms of resource components and geographic extent. A variety of remote terrestrial and underwater data collection techniques will be evaluated including satellite and airborne imagery, global positioning systems, telemetry, hydroacoustics, and sonar. It is anticipated that at least some of the expeditionary resource monitoring activities will be replaced by remotely sensed data collection techniques which will result in reduced costs, less impact, and expanded coverage.

Remote sensing is dependent upon accurate geo-referencing and highly specialized analytical capabilities of the remotely collected data. Therefore, initial investments in geodetic control (surveying), image processing, and GIS capabilities are required. Survey control is required for rectification of collected aerial imagery, development of ortho-photography and bathymetric channel mapping. To allow for the storage and processing of the remotely sensed data the GIS will be used to store the collected data and provide modeling capabilities which are fundamental roles of a GIS (Wetland and Environmental Applications of GIS, Lyon, John G. and McCarthy, Jack, 1995). Although budgets for these activities have been proposed, it has not yet been determined if these activities will be undertaken in-house or by contract.

The remote sensing initiative is being driven by monitoring needs of the biological, cultural, and physical resource programs which are in turn derived from the management

objectives and information needs identified by the AMWG and TWG. Monitoring needs will be (or in the case of the Physical Science Program, have been) reviewed by a protocols evaluation panel (PEP) comprised of resource specialist knowledgeable in remote sensing. The identified monitoring needs, management objectives, information needs, and PEP recommendations will provide direction for the GCMRC remote sensing, GIS, and surveying programs.

Remote sensing currently emphasizes applications in the Physical Science resource areas. This is primarily because the Physical Science program is further along its protocol evaluation process. Biological and cultural resource components will be incorporated into the remote sensing program as they develop. New components of the plan will be presented to the TWG/AMWG for endorsement as they are developed.

In May of 1998, the first remote sensing protocols evaluation panel (PEP) was assembled to evaluate remotely sensed monitoring and research methodology currently used by GCMRC. The panel was tasked with making recommendations for alternative remotely sensed technologies that might better meet program information needs. Their efforts resulted in a 17 page report with recommendations of remotely sensed technologies which may benefit resource monitoring and research in the Canyon (Final Report, GCMRC Remote Sensing Protocols Review Panel, June 15, 1998). Revised management objectives established by the TWG that could benefit from the application of various remotely sensed technologies were also identified in the report. Subsequent to the report, the GCMRC developed a matrix summarizing panel recommendations, applicable management objectives, timelines, and estimated costs. This matrix is now being prioritized based on monitoring needs and feasibility based on the literature. Only the sensors/technologies which show strong potential for resource monitoring in the Grand Canyon environment will be evaluated. Once a suitable sensor has been identified, other sensors of similar characteristics will be eliminated from the evaluation process.

The GCMRC remote sensing initiative will begin in FY 2000 and continue for three years. Remote sensing technologies selected for use in routine resource monitoring will be implemented in FY 2003. However, it is anticipated that some technologies will be evaluated on an accelerated schedule, perhaps as soon as FY 1999, due to pressing needs for technological development in specific monitoring areas or opportunistic circumstances. The

GCMRC intends to continue the annual acquisition of aerial photography until other remotely sensed data sets are identified and implemented into the monitoring program. The total estimated cost of the program is \$1,200,000 over a three-year period and includes:

- the evaluation of airborne terrestrial mapping technology
- establishing control in the canyon
- the literature review and possible evaluation of multi-spectral/hyper-spectral airborne sensors, airborne photographic techniques, and high resolution satellite imagery for resource monitoring
- analysis of existing remotely sensed data sets
- evaluation of image processing techniques and software
- the development of remotely sensed data collection protocols

Selected sensors and mapping techniques will be evaluated over selected representative reaches of the Grand Canyon to reduce costs. The sensors must be able to answer the questions formulated by the revised management objectives. The information gathered will be assessed for accuracy and utility. The results of the assessment will enable the center to answer key questions about the future use and application of the tested images and collection techniques. The images will be evaluated for their ability to be used in the analysis and mapping of the Grand Canyon. It is anticipated that one to five year rotating schedule of data acquisition. However, the frequency and resolution necessary for specific resource monitoring in the Colorado River corridor has yet to be determined.

Remote sensing technologies recommended by the PEP and proposed to be initiated in FY 1999-2000 timeframes are:

- photogrammetric monitoring of terrace stability of archeological sites and sand bar volumes
- stream-bed classification using QTC-view digital processing system
- color infrared aerial photography for determining vegetative changes
- multi-beam hydrographic data collection for bathymetric channel mapping
- HYDICE hyperspectral remote sensing data processing for resource monitoring
- LIDAR remotely sensed terrestrial topographic mapping of the canyon corridor

FY 2000 activities include the following work to be completed by the Survey group in support of remote sensing:

- Complete a high precision Control Network from Glen Canyon dam to Phantom Ranch for spatial-positioning of research sites in the river corridor and geo-referencing topographic, hydrographic, and remotely sensed data such as multispectral, hyperspectral, aerial photography. To date there is continuous control from Glen Canyon dam to the end of GIS area 5. It is necessary that this control be established to achieve the objectives outlined in the Physical Resource Program.
- Ground truthing, geo-referencing, and image rectification of remotely sensed data.
- Hydrographic channel map of all GIS sites and between GIS sites as needs dictate and control is established in support of the Physical Resource Program sediment and flow modeling.
- Continue development of terrestrial ground topography maps. Terrestrial ground mapping in the Canyon is difficult and expensive. Technologies are currently being evaluated for achieving this objective as part of the Remote sensing initiative. The GCMRC will use only the most cost effective method which conforms to National Mapping Standards accuracy. Accurate terrestrial ground topography maps are essential for the sediment and hydrology model development being proposed by the Physical Resource Program.

FY 2000 remote sensing activities also include the purchase of image processing software and hardware and/or consulting services by the GIS group for the purpose of doing image analysis in support of remote sensing. The plan includes the development of a comprehensive topographic/hydrographic map and ortho-photography from the Glen Canyon Dam to Phantom Ranch. The mapping effort is in direct support of the Physical Resource Program desire to provide sediment and river stage modeling capabilities from the Glen Canyon Dam to Phantom Ranch.

The proposed remote sensing plan together with the GIS and Survey plans represent an integrated undertaking by GCMRC which, when completed, will provide the basis for comprehensive resource monitoring in the Colorado River system. Initial costs associated

with the process evaluation and development of the remotely sensed data sets and a GIS database designed to answer the revised management objectives may appear to be high; however, the long term benefit associated with remote sensing may more than offset the initial cost. Remote sensing means: less river trips, less impact, more resource monitoring components and greater geographic area monitored per dollars spent. The GIS will provide a predictive tool for management decisions. Historical data sets can be evaluated to help solve unanswered question. Furthermore, the cost of remotely sensed data has continued to decline over recent years and should continue to decline in the future. New sensors are being developed and data inventories grow. The present high costs of data cannot be expected to continue throughout the long term monitoring program of the Grand Canyon.

FY2000 Remote Sensing budget:

Remote Sensing Evaluation	\$200,000
GIS image processing software, hardware, and consulting	\$90,000
Survey control and bathymetry pilot test results will be used for the for physical science program	<u>\$110,000</u>
Total:	\$400,000

Surveying

The Survey department's mission is to provide survey support for spatial measurement and referencing of scientific data collected in the Colorado River ecosystem by GCMRC programs. This support may be in the form of precise measurement of geographic coordinates of a sample collected in the Canyon or in the generation of topographic maps used for erosion monitoring of terraces adjacent to the Colorado river. The Survey department is also responsible for establishing and maintaining accurate geodetic control in the Canyon that is essential for accurate geo-referencing of remotely sensed data and spatial analysis of resource data using modern image processing and GIS technologies. These technologies are critical to the integration and analysis of the diverse scientific data that have been collected in the Canyon over the past 15 years. Products of the Survey department include precise sample location coordinates, topographic maps, river channel maps and cross sections, digital elevation models, and digital terrain models. This information provides the

basis for spatial analysis of data within the ecosystem using GIS software that in turn provides area and volumetric change detection capabilities of resources.

The Survey department was initiated in 1990 when GCES began the development of the GIS sites (Fig. 4.1). It became necessary to establish topographic control for these sites as well as all other research related mapping in the Grand Canyon. The development of sound topographic and mapping control required good survey control to build these spatial data sets. However, as a result of extremely difficult logistics and access to the river corridor, a reliable geodetic control network had never been established.

BOR remote sensing division contracted Horizon's mapping to establish GIS map coverage's using photogrammetric methods. David Evan's and Associates established GPS control points, and ground control points were traversed and paneled by Banner and Associates.

In 1991 Joseph Mihalko (NPS surveyor) occupied the Banner ground control points for a soil mapping project by the USGS. He found that the control points did not meet their claimed accuracy and precision. As a result, GCES established a survey department to correct all previously established survey control as well as meeting all the research needs of the future.

The Survey department uses a variety of technology to assist in accomplishing its mission in a timely, cost effective manner that utilizes a minimum amount of personnel. These technologies include:

Global Positioning Systems

To include hand-held autonomous units, Static Differential, DGPS, RTK, as well as post- processed solutions.

- Conventional Survey Technology

To include Total Stations, electronic data collectors, Rangefinders, EDM's, etc.

- Hydrographic Technology

To include hydroacoustic and scan sonar, GPS and range/azimuth

positioning, automated hi-speed data collection, seabed classification, and acoustic doppler data.

- Maps and Mapping Products

To include Plannimetric maps, Digital Terrain Models, Area and surface calculations, Volume calculations, change detection, habitat maps, and predictive modeling.

FY2000 objectives the Survey department intends to achieve are:

- Satisfy all RFP requirements. Based on 1998, the survey department will deploy crew and equipment for 4 separate RFP down-river trips for terrestrial and hydrographic data collection. The individual programs funding the research cover the survey costs of these trips.
- Development of a survey database for easy access and a seamless GIS interface.
- Development of archival protocols for GIS/Database interface for control, mapping products, and metadata
- Research and implement any current or developing management objectives in the execution of sound survey practices and procedures

The following FY2000 Survey operations support the remote sensing initiative:

- Complete a high precision Control Network from Glen Canyon Dam to Phantom Ranch for spatial-positioning of research sites in the river corridor and geo-referencing topographic, hydrographic, and remotely sensed data such as multispectral, hyperspectral, aerial photography. To date there is continuous control from Glen Canyon Dam to the end of GIS area 5. It is necessary that this control be established to achieve the objectives outlined in the *Physical Resource Program*.
- Ground truthing, geo-referencing, and image rectification of remotely sensed data.
- Hydrographic channel map of all GIS sites and between GIS sites as needs dictate and control is established in support of the Physical Resource Program sediment

and flow modeling.

- Continue development of terrestrial ground topography maps. Terrestrial ground mapping in the Canyon is difficult and expensive. Technologies are currently being evaluated for achieving this objective as part of the Remote sensing initiative. The GCMRC will use only the most cost effective method which conforms to National Mapping Standards accuracy. Accurate terrestrial ground topography maps are essential for the sediment and hydrology model development being proposed by the *Physical Resource Program*.

Survey support of research activities funded by the GCMRC largely consist of trained GCMRC surveyors, assistants, and professional volunteers accompanying scientists in the field operating total station, GPS, or other sophisticated survey equipment. However, in circumstances where precise survey control or measurement is not needed (i.e. sub-meter), survey support may be limited to providing instruments and training to scientist for the collection of survey data. This allows for more efficient use of the limited GCMRC survey resources.

All survey control points, data, site maps, and other survey related information is documented and archived in the GCMRC survey department. GIS sites are archived using FGDC standards of metadata. All positional survey coordinates are archived in the AZ State Plane Coordinates (Central) system. Control points are photo documented as well as described by river mile, GIS site, etc. All survey control is made available to anyone with a legitimate need for spatial positioning. Survey products are usually submitted to specific research projects funded by GCMRC. Independent survey operations such as control are archived internally and provided to researchers as needed.

The GCMRC survey department tries to minimize all potential impacts to the Grand Canyon river environment. Whenever possible, we try to utilize all existing control/survey monumentation. This includes bolts, X-cuts, nails, and survey monuments. However, in some cases it is necessary to set new points. These points are very carefully selected to be unnoticeable by the average person. We try to select natural features in the rock to use as control points. On occasion, when absolutely necessary, we will scribe a small X on a rock. Extreme care is always taken to avoid any survey operations on or near cultural sites unless that site is specifically being mapped. While mapping cultural sites we are almost always

accompanied by an archaeologist, usually NPS.

Another potential impact on the environment is the deployment of photogrammetry targets as ground control. These targets are laid on known control points for stereo rectification of aerial photography as well as other remote sensing applications. These panels provide a much less intrusive operation on a site than physically doing a ground survey. The panels are usually removed from the site within a month or the next GCMRC river trip.

FY2000 Survey budget: \$16,000

(not including remote sensing initiative support funded under Remote Sensing)

Data Standards and Protocols

The purpose of data standards and protocols is to provide consistency in data collection, delivery, and presentation from disparate sources. Development of data standards and protocols ensures that data contained in the information system is valid data and that the data can be integrated with data collected by at different places at different times by different researchers in different disciplines. Data standards define field descriptors within the database such as definitions, formats, units, significant figures, decimal places, etc. Protocols define standard operating procedures for data collection, entry, and verification, which include quality control and quality assurance procedures, that guarantee the integrity of the warehoused data. A data standards committee will be formed which regulates this activity.

The ITP embraces the principles and objectives of the National Information Infrastructure, the National Biological Information Infrastructure, and the National Spatial Data Infrastructure. Guidelines and protocols promulgated by these infrastructures will be incorporated into the overall database design and delivery systems whenever possible. Implicit in the plan is support of the objective to increase access, sharing, and application of data among public and private cooperators and partners. The program recognizes that guidelines and protocols have not been established for all aspects of biological and spatial data warehousing. When lacking, the plan allows establishment of its own guidelines and protocols that will adhere as closely as possible to the intent and spirit of the infrastructures.

The ITP is committed to making public data freely available to stakeholders, researchers, and the public while at the same time protecting sensitive and confidential data provided by private entities for the purpose of evaluating the Colorado River resources. Cooperation among contributing Tribes, institutions, and state and federal agencies

investigating resources in the canyon concerning timely transmittal of data relating to the GCMRC study area is essential. Scientists will be expected to provide their data to GCMRC after a reasonable period of exclusive use, which is currently being addressed by the TWG working group on data protocols. Concerning some data, such as archaeological-site data which the Indian Tribes define as sensitive, or information on localized endangered species, a level of confidentiality will be necessary.

Data standard and protocol development will commence in FY99 and fall over into FY2000. Data standard and protocol development is primarily a manpower effort and is not anticipated to have budget needs other than already programmed salaries to complete with the exception of perhaps travel and meetings.

FY2000 Data Standards and Protocols budget: \$12,000

System Administration of Computers and Networks

The GCMRC computing environment presently consists of multiple servers, workstations, laptops, printers, and other peripherals. The environment is spread across two separate computer networks, one at the Bank of America building and one at the USGS building. The two networks are linked together by a T1 telecommunications line between the two buildings. Most of the computers are PC types running the Windows NT operating system. In addition, over 30 applications are maintained on most systems. Applications are primarily off-the-shelf products.

Prior to 1997 and the hiring of an Information Technology Program Director, computer systems and networks at the GCMRC were largely maintained contractually with the BOR office in Salt Lake City. The computing environment consisted of several 486 and first generation Pentium class systems which were networked using thin ether net media and a Novell file server. The Bank of America building employee's were networked to the Salt Lake City office and Internet through a 56KB dedicated telecommunications line to SLC.

The USGS building computing environment evolved separately but was heavily influence by the methods and practices of the BOR SLC computer group except that the network infrastructure was provided and maintained by the USGS. The USGS was also delegated limited administration of the networked computing environment that was largely maintained by SLC. The network infrastructure provided by the USGS was 10baseT with T1

access to DOINet and the Internet. Local network support, 10baseT network media, and faster T1 telecommunication line provided for a much more robust networking environment than that at the Bank of America Building.

During the transition GCES to GCMRC, 20, then state-of-the-art, Pentium Pro systems were purchased for both the Bank of America building employees and USGS building employees (10 a piece). A Novell file server was also purchased for the USGS building employees. While this represented a considerable improvement in the GCMRC computing environment, the lack of dedicated local support and unreliable network infrastructure at the Bank of America building contributed to a difficult computing environment. The contracted remote computer support was expensive and often did not lend itself to timely correction of problems encountered in the everyday operation of the environment.

In the summer of 1997, an Information Technology Program Director was hired and, among other things, assumed responsibility for the administration of the GCMRC computing and networking environment. A plan was developed to improve the internal GCMRC computing environment and extend its capabilities to facilitate the AM process.

A primary objective of the plan is to improve overall system performance, reliability and maintenance. The information technology program believes that this can best be achieved by having competent individuals in-house trained in the administration, maintenance, and troubleshooting of the computer system. However, computer administration comes at a high cost in terms of manpower and expertise. A brief analysis of the current GCMRC computer environment has identified that most problems occur at the application-operating system-local area network layer and that few problems occur at the wide area network, or Internet, layer. Internet connectivity infrastructure can be very expensive. Therefore, it makes fiscal sense that Internet connectivity and associated services such as DNS, mail, and news will continue to be administered by entities outside the GCMRC. Most notably the U.S. Geological Survey in the case of the Gemini office and U.S. Bureau of Reclamation in the case of the Bank of America office.

Computer hardware and operating systems at the GCMRC will largely be a combination of state-of-the-art Intel processors running Windows NT. Each workstation will have a core suite of software applications available that will include mainstream off-the-shelf

integrated office products such as a word processor, spreadsheet, graphics, database, browser, etc. Additional software needed for specialized scientific data processing will also be available. To the extent possible, hardware and software will be standardized throughout the GCMRC. The information technology program anticipates standardization will facilitate inter-office exchange of information and reduce the administrative effort of hardware and software support to a level sustainable in-house.

Current goals for systems administration of computers and networks are:

- Remove the Novell servers from the Bank of America and USGS building networks. This will eliminate two, more or less, redundant servers from the GCMRC computing environment reducing cost and administration.
- Combine the two networks into one. This will drastically reduce maintenance and further standardize the environment. This is likely only to occur once the two offices are combined.
- Standardize all software applications and serve from an NT server. This will help reduce computer administration.
- Develop a standard configuration for all workstations. This will help reduce administration and allow user to maintain their personalized computing environment across systems.
- Develop and integrate a World Wide Web publishing environment into our overall computing environment to help make activities and data more accessible to constituents.
- Perform year 2000 check and correct deficiencies.
- Correct DOI EOI management control plan deficiencies.
- Continue to incorporate automation and enhancements capabilities into the overall computing environment as time and products become available.

It is anticipated that most of these activities will be completed in FY99. FY2000 activities will be primarily maintenance of the developed environment with enhancements. FY2000 System administration of computers and networks budget: \$120,000

Total Information Technology Budget for FY2000: \$720,000

Projected FY2000 DBMS budget:	\$150,000
FY2000 GIS budget:	\$ 10,000
Projected FY2000 Library budget:	\$12,000
FY2000 Remote Sensing budget:	\$400,000
FY2000 Survey budget:	\$16,000
FY2000 Data Standards and Protocols budget:	\$12,000
FY2000 System administration of computers and networks budget:	<u>\$120,000</u>
Total Information Technology Budget for FY2000:	\$720,000

CHAPTER 5

PROGRAM ADMINISTRATION AND ORGANIZATIONAL STRUCTURE

The GCMRC organizational structure has been developed in response to GCMRC's mission and roles and responsibilities within the AMP and to ensure successful implementation of the FY 2000 Annual Plan. The GCMRC will be administered by a Chief and four program managers (physical, biological, socio-cultural, and information technologies) to oversee the individual resource areas and an extensive program of data analysis and management, GIS technology and information transfer, surveying and evaluation of remote sensing technologies. Together with the Chief, they will focus on program integration and evaluation of Colorado River ecosystem resource interactions in response to dam operations. One of these program managers will also serve as a deputy to the Chief and as Acting Chief in his/her absence.

In addition to their program management responsibilities, the program managers are also expected to remain subject area experts in their respective fields through the conduct of their own research on the Colorado River ecosystem, and to provide technical assistance in the form of expert analysis, opinion, and advice to the TWG and the AMWG as requested. This will include but is not limited to the annual State of the Canyon Resources Report, evaluation of the BHBF resource criteria, preparing draft biological assessments and other such synthesis and activities which may be requested. The Socio-cultural Program Manager will also function as the Native American coordinator mentioned in the EIS. As appropriate, the program managers will supervise additional technical staff.

The GCMRC will continue to conduct all logistics for its programs internally in FY 2000, with direct coordination with appropriate NPS offices. This approach has proven its cost-effectiveness in FY 1998 and similar cost savings are expected in FY 1999. In addition to cost savings, by running the logistics program in-house, GCMRC is able to ensure compliance with all NPS directives, consolidate and coordinate river trips, and create a level playing field so all researchers have an equal chance at competing for proposals and successfully implementing their projects. All river trip logistics and permitting, air

photography, rescue, etc., is overseen by the logistics coordinator in cooperation with the NPS. In FY 1997 and FY 1998 GCMRC initiated approximately 60 river trips annually. While an effort is being made to reduce the number of trips in FY 1999, GCMRC still expects to initiate between 50 and 60 river trips. Running these many river trips requires a full-time logistics coordinator and a full-time warehouse technician.

All completed proposals, Principal Investigator reports, GCMRC reports, cooperative programs, etc. are subject to independent peer review according to GCMRC's peer-review protocols. Monitoring and research proposals are subjected to independent external peer-review and awards are made competitively based on these reviews. All research proposed by GCMRC program managers and scientists also undergoes an independent external review. Similarly, all PI reports and GCMRC reports are subject to independent external review. Managing GCMRC's peer-review process requires 3 to 6 person months and is the responsibility of the Review Coordinator, currently a member of the Biological Resources Program staff. The Review Coordinator reports directly to the Chief and serves to see that the peer-reviews are overseen by someone one-step removed from the program activities to ensure the objectivity of the review, as specified in the DOI peer-review guidelines. In FY 2000, the Review Coordinator position will be filled by the GCMRC librarian.

A Cultural Resources Task Group operates to facilitate articulation between the Cultural Resource Program and the Programmatic Agreement program. The Task Group consists of the GCMRC Cultural Resources Program Manager, Reclamation's regional Archaeologist, NPS managers, and tribal representatives.

A Biological Opinion Task Group operates to ensure appropriate coordination between GCMRC and the monitoring and research needs of the Bureau and USFWS under various biological opinions. The Task Group consists of the GCMRC Biological Resources Program Manager and appropriate representatives of Reclamation, FWS, AGFD and other AMWG members. All proposed activities are reviewed by the TWG.

The Information Technologies program has personnel with specific responsibility for its Systems Administration, Data Base Management, GIS, Remote Sensing, and surveying activities. These personnel will assure critical timely support to managers and other stakeholders in their interactions with the GCMRC, especially in their requests for information. For example the surveying department is staffed by two full-time surveyors

who provide GCMRC and PIs with high quality, cost-effective, and timely support of their program and activities in the areas of terrestrial and bathymetric surveying, as well as remote sensing. Having in-house capability ensures familiarity with the challenges of surveying in the canyon and promotes reproducible, quality data critical to sound monitoring and research programs.

As called for in the GCDEIS, independent review panels will be utilized to evaluate GCMRC's Annual Plan, review proposals submitted to GCMRC for potential funding, review reports resulting from GCMRC sponsored activities, and provide advice to GCMRC and the AMWG. These panels may include the National Research Council, independent external peer-reviewers and review panels, and the SAB which can provide advice to both the AMWG and GCMRC on the effectiveness of the overall science program. With respect to the SAB, GCMRC proposes to designate a staff person to serve as the Executive Director who can provide leadership to the SAB and serve as the liaison officer to the AMWG and the GCMRC. It is anticipated that the role of Executive Director will require one to three person months annually.

Program Schedule

The tentative schedule for implementation of the FY 2000 annual plan is as follows:

January 12-13, 1999	AMWG review of FY 2000 Annual Plan and recommendations for implementation
February 16-17, 1999	GCMRC Science Symposium
March, 1999	Review of FY 1998 program accomplishments
April, 1999	First Progress Report due on FY 1999 program activities
June, 1999	Develop Overview package for potential researchers and reviewers
July 5, 1999	Second Progress Report due on FY 1999 program activities
July 15, 1999	Release of RFPs
Sept 15, 1999	Receipt of Proposals for FY 2000 program
September 17, 1999	Draft Final Report due on FY 1999 program activities
October, 1999	Develop Logistics Plan for FY 2000 program

October, 1999	Draft FY 2001 Annual Plan and FY 2000 "State of the Colorado River Ecosystem Resources" report for review by TWG/AMWG
October, 1999	Panel Review of FY 2000 Proposals
November, 1999	Notification of Intent to Award FY 2000 Contracts
December, 1999	Award FY 2000 Contracts
December, 1999	Final "State of the Colorado River Ecosystem Resources" report to AMWG.
December 31, 1999	Final Reports on FY 1999 programs with all contract deliverables
January 2000	AMWG approval of FY 2001 Annual Plan and recommendations for implementation

Adaptive Management Program Budget

The FY 2000 budget for the Glen Canyon Dam Adaptive Management Program is \$7,672,000. Of this total, \$1,443,000 is programmed for the management and administration of the AMP and the PA, with the remaining \$6,229,000 programmed for GCMRC and its implementation of the FY 2000 Annual Plan.

Following are the proposed budget allocations for the FY 2000 AMP and the GCMRC FY 2000 Annual Plan.

AMP Program and Programmatic Agreement

• Bureau Administration of AMWG	116,000
• Bureau Administration of TWG	80,000
• Bureau Administration of SAB	47,000
• Bureau Administration of AMP:	
A. Program Management	106,000
B. Biological Opinion	71,000
C. Programmatic Agreement	973,000
• Bureau/Native American Support	50,000 ⁷
Subtotal	1,443,000

⁷These funds are obtained by Reclamation from Native Affairs Office appropriated funds.

GCMRC Program and Operating Costs

A. Bureau Support Services.....	123,000
B. Operations, Personnel, Contract Services.....	2,023,000
C. Physical Resources Science	700,000
D. Biological Resources Science	1,500,000
-- Integrated water quality program (IWQP) ⁸	
E. Socio-cultural Resources Science	355,000
F. Information Technologies Program	320,000
G. Remote Monitoring Technology	400,000
H. Independent Review Panels	155,000
I. Logistics.....	653,000
Subtotal	6,229,000
TOTAL	\$7,672,000

⁸ The Integrated Water Quality Program (IWQP) activities, which includes monitoring and research in Lake Powell and the Colorado River ecosystem will be primarily funded out of Reclamation O&M funds, coordinated with Reclamation and the Lake Powell group, and conducted by GCMRC, and/or its contractors. That portion of the IWQP activities conducted in the mainstem of the Colorado River below Glen Canyon Dam will be funded primarily out of GCMRC funds.

<p align="center">TWG Comments on FY2000 Monitoring and Research Plan (Second Draft dated November 20, 1998 & Final Draft dated June 1, 1999)</p>		
<p align="center">GENERAL PLAN RESPONSE TO COMMENTS Dr. Barry D. Gold, Acting Chief</p>		
<p align="center">Comments and/or Action Recommended</p>	<p align="center">GCMRC Response</p>	<p align="center">Final Plan Reference</p>
<p>TWG Meeting Comments 2/23/99; 6/8/99: Delete Chapters 1-3 entirely. Replace with statement, "this is a step down process of the Strategic Plan to implement it." Keep Chapters 4-5. Add responses to comments as an attachment.</p>	<p>Chapters 1-3 deleted. Statement added. Attachments added.</p>	<p>Statement is on pg. 1. Attachments begin on pg. 75</p>
<p>The Hopi Tribe Comments 12/8/98: Re: Conceptual Model Page 19, Lines 498-500: does this mean additional GCMRC staffing positions? Existing staff.</p>	<p>The intent is to develop the expertise within existing staff so GCMRC can continue model development, as appropriate.</p>	<p>Pg. 3.</p>
<p>CREDA Comments 12/1/98: We have submitted comments on the Strategic Plan and see that many would apply here as well. We have supplied some but not all of these comments and would hope that if you see fit to make the changes to the Strategic Plan that, where applicable, those same changes would be made in the Annual Plan and vice versa. The Annual Plan should be a simple step-down from the Strategic Plan and not attempt to break new ground in format, etc. In this regard, we think you should look carefully to be sure the two plans look similar and can be used interchangeably.</p>	<p>Chapters 1-3 have been deleted and Chapters 4-5 have been made consistent with the Strategic Plan.</p>	

PHYSICAL RESOURCES PROGRAM RESPONSE TO COMMENTS

Dr. Ted Melis, Program Manager

Comments and/or Action Recommended	GCMRC Response (additional response in June 1999)	Final Plan Reference
<p>TWG Meeting Comments 2/23/99:</p> <ol style="list-style-type: none"> On page 33, paragraph 1, Ted talks about six components that would be implemented through a mixture of new competitive awards combined with some modifications to existing 98/99 awards for monitoring. It sounds like 5 of the 6 program components are modifications and possibly the 6th is a modification too. Suggestion to change that to clarify that aspect of it if that's the case, if you're going to go with an RFP for one of them. The FY2000 program budget: The total is \$710,000 versus \$760,000. Two programs had an increase; one had a decrease. 	<p>Budget figures are ranges. Total budget is \$700,000.</p> <p>(All of the FY2000 physical science activities will be accomplished through modifications of existing agreements. No new physical RFPs will be released until spring 2000.</p>	<ol style="list-style-type: none"> See text. (Pg. 6) See text. (Pg. 20)
<ol style="list-style-type: none"> EXTEND HISTORICAL GEOMORPHIC SYNTHESIS UP INTO GLEN CANYON <ul style="list-style-type: none"> Focus on specific information needs: Twenty-five INs to be addressed by this project is excessive. Narrow the focus on fewer, specific INs. Focus on impacts of changed operation: Does the 2000 program complete the geomorphic synthesis going on between the Lees Ferry gage and the Grand Canyon gage? 	<p>(All synthesis work on geomorphology, hydrology and sediment-transport for the reach from Glen Canyon Dam to river mile 87 will be completed by the end of 2000.</p> <p>Specific information needs addressed by this project will focus on sand bars, river terraces and reattachment bars, as related to historical changes in river-stored sand associated with closure of Glen Canyon Dam and its operations. Synthesis, by its very nature, is intended to address multiple information needs.)</p> <p>[Yes, basically synthesis would be done unless the results suggest that additional work is needed. This research is to be completed at the end of this 3rd year extension.]</p>	<ol style="list-style-type: none"> Addressed: see new text under section head. (Pg. 17) As above.

<p>II. CONTINUATION OF MONITORING AND RESEARCH OF MAIN CHANNEL FLOW AND SEDIMENT</p> <ol style="list-style-type: none"> Additional work on Topping hypothesis higher priority than at this time (no piggy bank): Suggestion to do a contract modification for a 3rd year to address this sediment storage issue. (Could you mold that 350k into a project which would include the review of this issue on whether there's a "piggy bank" in the way you describe it?) Shouldn't we extend some studies/research into the question if there is value to BHBFs or there is little value to BHBFs (whether or not the EIS had it right or Topping has it right). Under the hypothesis that sediment is stored in the main channel and you can move it with a high enough spike flow 	<p>(The daily suspended-sediment sampling protocol is intended to support USGS research examining mainstem channel sand storage residence times following tributary inputs.)</p> <p>[Additional FY 2000 workplans for research on sand export and sediment budgets during BHBFs and normal ROD operations will be addressed through implementation of daily suspended-sediment sampling at the Grand Canyon gage. These activities will be included in the modified FY 2000 agreement.]</p>	<p>II. Addressed: see new text under section head. (Pg. 15)</p> <ol style="list-style-type: none"> As above. As above.
<p>III. VERIFICATION OF GAGED TRIBUTARY FLOW AND SEDIMENT MODELS (PARIA AND LCR)</p> <ol style="list-style-type: none"> Do these funds include post-flood assessment on model results in the case of a sediment input (flood during the performance period)? 	<p>(Yes, in the event of a significant sediment input, USGS will report on the performance of the sediment/flow model.)</p>	<p>III. Addressed: see new text under section head. (Pg. 17)</p> <ol style="list-style-type: none"> As above.
<p>IV. ADVANCED DEVELOPMENT OF CONCEPTUAL PHYSICAL SUBMODEL</p> <ol style="list-style-type: none"> In the biological area specifically related to native fish, is Barb going to have additional piece of funds going to a 3rd year contract to Ecometric research? 	<p>[Yes, the biological resources program for conceptual modeling is \$20,000.]</p>	<p>IV. No Revision made to text. (Pg. 16)</p>
<p>V. MONITORING OF DEBRIS FANS AND RAPIDS</p> <ol style="list-style-type: none"> This is not in the MOs and INs which drive the budget, but could be funded anyway. It can be added to the MOs and INs, but that would lose a year. It would be a good project to further the "sand storage piggy bank" hypothesis. 	<p>(This effort will move ahead under a modification of the USGS agreement with Webb et al., and will support both geomorphic framework conceptual modeling and research on mainstem sand-storage residence time.)</p>	<p>V. Addressed: see new text under section head. (Pg. 18)</p> <ol style="list-style-type: none"> As above.
<p>VI. COMPLETION OF PROTOCOLS EVALUATION AND INITIAL DEVELOPMENT OF LONG-TERM MONITORING PLAN</p> <ol style="list-style-type: none"> What INs will be answered? Specific Goals: (1) The information needs that are attached to this program are not well defined. (2) They need to be clearly defined, not a laundry list. 	<p>(The PEP is an external review process (see PEP prospectus).)</p> <p>The objective of the PEP - SEDS is to design an effective monitoring program will provide needed information on changes in downstream resources relative to ROD operations. The PEP is asked to evaluate the monitoring program against the MOs & INs)</p>	<p>VI. Addressed: see new text under section head. (Pgs. 7, 16, 18)</p> <ol style="list-style-type: none"> As above.

<p>The Hopi Tribe Comments 12/8/98:</p> <p>Page 20, Line 518: change "caused" to "attributed."</p> <p>Page 20, Lines 522-524: "...preserving downstream resources under law." Return to original language.</p> <p>Page 23, Lines 597-598: "...Glen Canyon Adaptive Management Group." What is this? Return to old language.</p> <p>Page 24, Line 628: "competitively procured...USGS scientists" How can these be competitively procured if using USGS scientists and no others?</p> <p>Page 24, Line 635: "...synthesis work presently being conducted...by Utah State University's Department of Geography" Is this work being competitively let or is it going to USU?</p> <p>Page 33, Lines 902-903: "Monitoring of Main Channel and Tributaries will be continued through a modification of existing USGS interagency agreement..." Is this what you are referring to on Page 24, Line 628 as a competitive bid?</p> <p>Page 34, Lines 934-936: "This work will be carried out...through modification of an existing agreement with USGS..." Or is this the one that is competitively bid among USGS?</p> <p>Page 34, Line 945: "This work will be achieved through a modification of the existing cooperative agreement." With USU?</p>	<p>Re: Line 518: Suggested change was not incorporated into final plan. Re: Line 524: The text in question was deleted from the final plan.</p>	Pg. 5-6
<p>Page 23, Lines 597-598: "...Glen Canyon Adaptive Management Group." What is this? Return to old language.</p>	<p>Text was deleted from final.</p>	Pg. 7
<p>Page 24, Line 628: "competitively procured...USGS scientists" How can these be competitively procured if using USGS scientists and no others?</p>	<p>Text was revised to reflect modifications as means of procurement.</p>	Pg. 15
<p>Page 24, Line 635: "...synthesis work presently being conducted...by Utah State University's Department of Geography" Is this work being competitively let or is it going to USU?</p>	<p>Text was revised to reflect modifications as means of procurement.</p>	Pgs.15 & 17
<p>Page 33, Lines 902-903: "Monitoring of Main Channel and Tributaries will be continued through a modification of existing USGS interagency agreement..." Is this what you are referring to on Page 24, Line 628 as a competitive bid?</p>	<p>Re: Lines 902-03: Text was revised to reflect modifications as means of procurement. Re: Line 628:</p>	Pgs. 15 &16
<p>Page 34, Lines 934-936: "This work will be carried out...through modification of an existing agreement with USGS..." Or is this the one that is competitively bid among USGS?</p>	<p>Text was revised to reflect modifications as means of procurement.</p>	Pg. 15
<p>Page 34, Line 945: "This work will be achieved through a modification of the existing cooperative agreement." With USU?</p>	<p>Text was revised to reflect modifications as means of procurement.</p>	Pgs. 15, 17-18
<p>Page 34, Lines 951: "...perceived level of need..." By whose perception, TWG, AMWG or GCMRC?</p>	<p>Text was revised to reflect the TWG desire for work to proceed.</p>	Pg. 18-20
<p>Page 34, Line 953: "...additional research..." Isn't this supposed to be covered by the contingency planning?</p>	<p>Yes, it is described in the 1999 BHBF Plan.</p>	Pg. 19
<p>Page 35, Line 964: "...competitive solicitations..." I didn't see much competitive solicitation in this plan.</p>	<p>Text now states all work to be through modified agreements.</p>	Pg. 20
<p>Glen Canyon National Recreation Area Comments 12/17/98:</p> <p>Comment #5, line 505-1037: The physical resources program; it was unclear in this section how the MO/IN related to the research/monitoring proposed. There was probably more background material than necessary since it wasn't until line 895 that the proposed program was actually specified.</p>	<p>(This entire section has been re-written since the November 1998, draft with these comments taken into consideration. Hopefully, the program elements are more clearly linked with the MO/IN list for physical resources monitoring and research than in the initial draft.)</p>	<p>General Comments: 1. See revised text in final plan. Pgs. 8, 13, and 5-20 overall</p>
<p>CREDA Comments 12/1/98:</p> <p>Lines 509-784. This section is cumbersome and wordy. We suggest simplifying the section along the lines used under Water Resources at Line 1266. Lines 895-1022 is the essence of the program and what should be in the FY2000 Plan.</p> <p>Line 524. What does the changed language mean? What law is being referred to?</p>	<p>Lines 509-784: The comments were taken into consideration during the final plan revisions.</p> <p>Line 524: This text has been deleted from the final plan.</p>	Pg. 6

Line 550.	Please explain the reason for this change.	Line 550: Reference to elements of long-term monitoring that support the AMP.	Pg. 7
Line 598.	What or who is this Group?	Line 598: Intended to mean AMWG.	Pg. 7
Line 656.	Although you state the critical importance of this reach, you fail to explain how monitoring at the Grand Canyon gage 90-100 miles downstream (Line 679) will effect accurate assessment of the effects of dam operations on that reach's sediment resources. Why should we support daily sediment measurements 100 miles below the critical reach if it cannot help us understand storage, movement, etc.? Conversely, if we support this gage work, can we be assured you will not need to do additional work in the upstream "critical" reaches later because you lack daily sediment data?	Line 656: Fine-sediment budgeting has been a major emphasis for the physical science program. Exports versus inputs of sand from tributaries will be assessed on the basis of data collected at the Grand Canyon gage during FY 2000. The text has been revised to better reflect this goal.	Pg. 15-16
Line 998.	What Long-Term Plan is this? Are you referring to the Long-Term Strategic Plan due for adoption in January 1999?	Line 998: The long-term monitoring plan for physical resources. Text has been revised to make this clearer.	Pg. 16
Line 1005.	Additional funds are not necessarily the only solution. Reprioritization of existing funds may be needed if additional funds are not available.	Line 1005: This can be achieved, but only with longer-term plans and lead times for support requests from the TWG.	Pg. 19-20

SOCIO-CULTURAL RESOURCES PROGRAM RESPONSE TO COMMENTS

Ruth Lambert, Program Manager

Comments and/or Action Recommended	GCMRC Response	Final Plan Reference
<p>TWG Meeting Comments 2/23/99:</p> <ol style="list-style-type: none"> Isolated Occurrences Concerns with quality of existing IO data base, difficulties in development of relevant models, and project methodologies. 	<p>The GCMRC contractor has identified data problems, but the report has not been finalized. Project methodology will be developed based, in part, on final report data and recommendations. Data quality and model development will be important factors in formulating project methods.</p>	<p>Project specifics will be formulated when the RFP is developed following the completion of the data synthesis project. As such, project specifics and methodology are discussed within this plan.</p> <p>The project is included within the program because it was supported by the TWG.</p>

<p>2. Protocol Assessment</p> <p>a. GCMRC protocol assessments should include cultural activities conducted within GCMRC and the PA programs.</p> <p>b. Concerns were expressed on funding sources for PA program activities that could be included in a combined protocol assessment of cultural activities.</p> <p>c. BOR should consult w/PA signatories. There is a protocol to approach the PA parties about activities that could affect their program. It's important to have them endorse the protocol evaluation so that it would be most effective.</p>	<p>Cultural resource protocol assessments should include all cultural resource activities in the GCMRC and BOR/PA program. This is the most effective way to evaluate the entire group of activities.</p> <p>The outcome of the protocol assessment will be a recommendation to the BOR/PA program. It is advisory. Implementation of the recommendations is the decision of that program.</p> <p>Consultation procedures exist within the PA program and those procedures will be followed to encourage participation in the protocol assessments of that program.</p> <p>Funding sources for the combined protocol assessments remain under discussion. The GCMRC proposed funding relates to GCMRC project assessments as the acceptance of BOR/PA protocol assessments has not been determined. Further, the scale of the BOR/PA protocol assessments are potentially greater than the GCMRC's.</p>	<p>See Socio-cultural Resource Program, Information Need 1.1, Project 5: Protocol Assessments, page 36, 37.</p>
<p>3. Unanticipated Requests</p> <p>Carryover funds are generally not allowed. There is a need to amend the language, although there is agreement with the concept. The language is not accurate.</p>	<p>The funding amount is an estimate. The language can be changed to conform to the process.</p>	<p>Project # 6; Page 37. Language change to funds will be obligated.</p>
<p>4. Information Needs</p> <p>Information needs do not link with proposed projects. Need to make language clearer.</p>	<p>Information needs were clarified and reformatted to clearly link with proposed projects.</p>	<p>See reformatted text and heading throughout the program de</p>
<p>5. Geomorphic Project</p> <p>Rather than apply the result of the on-going project to other resource areas, allow funds to be directed to investigate unanswered questions from the study.</p>	<p>This objective is appropriate and it has been included in the project description.</p>	<p>Language additions made in project objectives. See page 34.</p>

<p>6. Unsolicited proposals from tribes Request for additional information from the Contracting Officer in SLC relative to confidentiality of unsolicited proposals and disclosure of project information while projects are under discussion. Based on information obtained, incorporate appropriate detail in future plans.</p>	<p>GCMRC will obtain information from the CO concerning unsolicited proposals.</p>	<p>Language not included in this plan, however, future plans will incorporate allowable information.</p>
<p>7. Development of Tribal Technology and Procedures for Dissemination and Access to GCMRC Data Approval of the project and a request to the GCMRC to investigate external sources of funding for future years.</p>	<p>GCMRC will investigate external funding sources for future years.</p>	<p>Language not included in this plan, however, future plans will identify external funding, if available. See project description on Page 40</p>
<p>8. Monitor Anglers a. Need to examine protocols (i.e., assessment of the current methodology) of the creel survey program and make some recommendations for change if necessary. b. Include the economics aspects of trout fishery to give us an idea of how much people actually spend related to recreational fisheries. c. Proposed work should reflect prioritization of Information Needs developed by the TWG and approved by the AMWG. How were Information Needs and projects selected?</p>	<p>The proposed project would assemble existing data and conduct a review of current methods of data collection and data gaps. Because the funding amount is small, this project would probably constitute initial efforts in this area. Proposed projects are based on two criteria. First, all of these projects were approved by the TWG and the AMWG for implementation in FY 99. Due to work loads and other factors, these projects were not implemented in FY 99 but were postponed until FY 2000. They were resubmitted for review and recommended implementation. Because these projects were previously approved, they were assumed to be important to the Stakeholders. The second criteria was the prioritized Information Needs by the TWG and AMWG. Using the prioritization process, the projects that are recommended for implementation relate to Information Needs ranked #1, #2 and #3.</p>	<p>Appendix B, resource category – Recreation. Refer to rankings WITHIN resource area and the “X” vote counts: IN 2.1 = 10 IN 1.1 = 9 IN 2.2 = 8</p>

<p>9. Campsite Monitoring and Synthesis of Campsite Beach Changes Concerns that this project will link with the physical monitoring activities and that project evaluate the effectiveness of new monitoring protocols for assessing camp sites, changes under differing operations.</p>	<p>This project integrates physical and recreational components to quantitatively assess changes to specific beaches and to evaluate protocol used in beach assessments.</p>	<p>This project is part of a larger project that is included within the Physical Resources program area. Incorporation within that program area will ensure integration between programs. See page 41.</p>
<p>10. Adopt-A-Beach a. How will qualitative information be used? Will future work plans be subjected to external review to assess the utility of the project product? b. Will the Glen Canyon Reach be included?</p>	<p>Qualitative data collected by the boating guides is useful in targeting areas for additional investigation, using other means including quantitative assessments. A FY 2000 scope of work is currently being prepared and locations in the Glen Canyon Reach can be included in this work. This project will be included in future protocol assessments.</p>	<p>See page 36</p>
<p>The Hopi Tribe Comments 12/8/98: Page 39, Line 1099: Project#3: "Protocol Assessments is estimated to cost \$15,000." Have we been involved in this? Arizona Game and Fish Department Comments, 12/7/98: Line 1187- Project 2: Monitor trout angler's use and satisfaction through creel census and cooperative monitoring program with fishing guides and Trout Unlimited. Is this going on the street or is this a cooperative agreement with the participants already selected? Should a PEP be done on the creel survey work that is ongoing? Also, should be called a survey rather than a census. A creel census implies complete sampling of the angling population, while a creel survey sub-samples anglers. Line 1335: Budget summary indicates project to evaluate boater satisfaction for \$ 5,000. Could not find anything in the narrative addressing this. CREDA Comments 12/1/98:</p>	<p>Language clarification is included in the 6/1/99 draft of the Socio-cultural resources portion of the plan. Project will be developed as a cooperative agreement that includes a protocol assessment. Creel census has been changed to creel survey. Language clarified to indicate Boater Adopt-a-Beach program.</p>	<p>See page 40 See page 45</p>
<p>Lines 1207, 1211, 1215: We suggest deleting "differing" and replacing with ROD or preferred alternative.</p>	<p>"Differing" is used in this context to refer to flows that can occur under the ROD within the AMP.</p>	<p>P. 28.</p>

BIOLOGICAL RESOURCES PROGRAM RESPONSE TO COMMENTS

Dr. Barbara Ralston, Acting Program Manager

Comments and/or Action Recommended	GCMRC Response	Final Plan Reference
<p>TWG Meeting Comments 2/23/99:</p> <p>Separate integrated water quality program to allow accounting: Funding comes from two integrated water quality lists: AMP and O&M. Display that so TWG can track the whole program.</p>	<p>The proposed IWQP has been given to the TWG for review and forwarded to the AMWG. In the plan we have separated out O&M costs from elements to be funded from the AMP program.</p>	<p>GCMRC Integrated Water Quality Program, Final Draft June 24, 1999.</p>
<ul style="list-style-type: none"> • Need to address/resolve "inadequate baseline" issue from symposium: The SWCA report indicates an insufficient baseline for native fish exists. Some data synthesis is required in order to have the protocols evaluations panel effective. We need to get a baseline for native fish, you got to have Owen Gorman's population estimates and Richard Valdez's population estimates not conflict with each other because they use different sampling techniques. The protocols evaluation panel needs to convene to determine what are the monitoring efforts that you should be monitoring for. • The TWG tasked GCMRC to look at the native fish baseline, get the right people together, study it, and work out a plan to address that issue. 	<p>GCMRC disagrees. Baseline data exists and 2000 PIT tags have been analyzed, with 3000 more to be analyzed. That will reduce the uncertainty that exists regarding baseline data. This analysis will also tell us something about population trends. Part of the co-occurrence (of natives and non-natives) is being addressed in a literature review similar to SWCA. However, it will include more non-native fish historical data in relationship to native fish. Fish capture data in relationship to native fish histories to obtain the most information on non-native fish interactions.</p> <p>Protocol review is scheduled to take place in FY2001. The timing of this is constrained by funding available for PEP. It also coincides with PEP for Aquatic Foodbase, in order to develop complementary monitoring programs that can be instituted simultaneously.</p> <p>A group was convened in March. The group agreed to work together to develop a database that will incorporate data and that can be viewed as a shared database, pending the development and adoption of data sharing policies. This group will meet again this fall to discuss its progress.</p>	<p>This analysis is being completed as a part of the conceptual model contract (Walters and Korman). The analysis is relevant to their modeling effort.</p> <p>A description of the PEP is provided as Appendix C to the Annual Plan. The protocol reviews that will take place in FY2000 are listed in the biology section of the FY2000 plan (pp 33-46).</p>

<p>•Terrestrial vs. native fish funding: The aquatic system is very directly affected by dam operations. The terrestrial system less directly affected and given our state-of-knowledge and given our state of critical resources with threatened and endangered aquatic species, that leans very heavily toward the focus on aquatic systems. Budget priorities can be rearranged and put all the terrestrial program on hold, if GCMRC decides that maybe we need to make an evaluation of that. A statement was made at the (Feb. 1999) science symposium that the level of funding for the native fish monitoring was inadequate.</p>	<p>•Funds for monitoring in the terrestrial ecosystem were shifted to address needs in the aquatic ecosystem. Funds were reallocated by internalizing KAS and SWWF monitoring, based on staff capabilities. Additionally, vegetation will not be monitored in the next year except by flying aerial photographs. This reallocation is considered as a temporary fix to resources needs, until long term monitoring in the aquatic ecosystem begins. Monitoring dollars in the aquatic system either stayed the same or were increased. Research emphasis in the aquatic ecosystem is concentrating on the aquatic foodbase, by shifting funds between native fish and the aquatic foodbase.</p> <p>Owen Gorman's comments were regarding total funds for native fish, not just monitoring. Historic funding of this program was between \$750,000 to \$1,000,000/year</p>	<p>The final plan shows several contracts being extended and others either internalized or reformulated as small research and synthesis projects. Total funds in native fish have increased to \$560,000. The aquatic foodbase funding has increased to \$234,000, and the trout program has funding increased to \$130,000 (p.46)</p>
<p>•Fisheries database consolidation effort a high priority: Suggestion that there might be better ways to spend the money and based on information from Rich Valdez. One of those ideas might be a literature review consolidation of data associated with non-natives, and this might include life history information as well as catch occurrence records.</p> <p>•On non-native fish research, literature review data consolidation regarding non-native fish life histories, suggestion that GCMRC make a fishery's database consolidation effort first, before you can address this, otherwise it may not get done. To result in another SWCA report that provides good literature review, provides summary life history forms, but doesn't provide a consolidated database. A consolidated database has got to be top priority for that task.</p>	<p>Part of the reason that we haven't gotten a consolidation effort underway and we struggle with it is the data that has been collected in Phase I and Phase II. We don't own all of the data so this may be one where it would be nice to do this through an RFP process but we're probably going to have to go out and pull all the research together.</p> <p>As stated above, a group of aquatic researchers got together in March. GCMRC is spearheading the effort to consolidate data that was collected during GCES Phases I and II. \$30,000 were allocated for this project.</p>	<p>The funds are included in the FY2000 budget in the trout fishery.</p>

<p>•Need to increase native fish funding, including PEP: I propose we add funding to the native fish work to accelerate the protocol evaluations panel and begin baseline monitoring provided that GCMRC can do that reasonably, gathering the information needed before convening the PEP.</p>	<p>Funds were increased in the Native Fish program. Acceleration of the PEP may take place if information are made available and it makes sense. Acceleration in this sense would mean Fall 2000 (FY2001) as there are not funds available for a PEP in FY2000</p>	<p>FY2000 plan, pp 36-38</p>
<p>• Let GCMRC look at fishery ecosystem and form plan to address--if more money is required, use \$100,000 from unsolicited proposals:</p> <p>Pilot project to remove exotics in native fish reaches: Suggestion about a proposal relative to a pilot project to remove exotic fish in critical reaches. There is \$90,000 under native fishes as a research initiative.</p>	<p>In house and unsolicited funds could be used to augment fishery research.</p>	<p>FY 2000 plan P46.</p>
<p></p>	<p>The research initiative relates to information directly affecting plans for 2nd HBC populations and steady-flow experiments. The project is a genetic project to determine relationships of HBC aggregates. Determining this relationship will help predict the success of either of these plans. An exotic fish removal program requires an understanding of exotic/native interactions which is currently poorly known. The \$30,000 in the trout program was to be allocated to this issue. The first step in this was to develop a consolidated database. These monies may be allocated at a time in FY2000 to move toward an exotic fish control plan. We suggested that an unsolicited proposal could be funded regarding exotic fish removal.</p>	<p>FY2000 plan pp 43-45</p>

<p>Glen Canyon National Recreation Area Comments 12/17/98:</p> <p>Line 1474, integrated water quality monitoring and research; the program lacked sufficient specificity to allow the reader to understand what the program would evaluate and how it would be implemented. Specifically, the following program components should be specified.</p> <p>The specific MO/Ins to be addressed during FY-2000 along with any other issues, such as, conceptual modeling, TCD etc. Further the research, monitoring and PEP components need to be discussed.</p> <p>The proposed method(s) of obtaining the information identified above, RFP, in-house monitoring/research, IA/CA with an agency or university etc. Also, if in-house monitoring is advocated, a rationale and justification needs to be included.</p> <p>The GCMRC staff requirements including technician assistance and overhead (FTE and grade) for implementing the described program.</p> <p>A budget and a budget process to support the program and indicate how the BOR O&M funds would be effectively used.</p>	<p>A proposed Integrated Water Quality Plan has been submitted to the AMWG for approval. This plan provides a detailed chapter regarding the INs and MOs that the plan directly and indirectly addresses.</p> <p>The plan addresses the TCD issue in that WQ will be included as an element of a monitoring and research plan for the TCD that is beyond the baseline monitoring plan. TCD is funded separately from AMP funds.</p> <p>The budget divides O&M and AMP costs including hydrologists' costs. Elements of the IWQP are currently contracted out (sample processing, identification).</p> <p>The backlog of biological samples does exist. A contract for identification is being developed and the samples will be shipped with identification completed by the end of the year Dec., 1999.</p>	<p>IWQP draft final June 25, 1999.</p> <p>No specific reference is available.</p> <p>The FY2000 AP.</p> <p>Final FY2000 AP p. 37.</p> <p>Final FY2000 p 37.</p>
<p>• Line 1816 - 1819; eight INs relate to a single proposed monitoring project. However, the project description was so broad and the funds so limited, that it seems to make the effort infeasible. Will the RFP for this project actually request the investigator to design a program to specifically answer all eight INs? If so, it seems likely that the investigator won't be able to accomplish all the work and it will be left up to him to decide which IN's he felt he could address.</p>	<p>The backlog of biological samples does exist. A contract for identification is being developed and the samples will be shipped with identification completed by the end of the year Dec., 1999.</p> <p>Originally this RFP was to be an extended contract. The RFP did request the P.I. to design a program that addressed these INs. The proposal included both research and monitoring elements. In the future these elements will likely be presented as separate RFPs. In fact, these have been separated into individual RFPs for the FY2000 plan.</p> <p>The three INs were combined as there is overlap in these INs associated with habitat. Subsequent discussion of this research avenue resulted in this being deleted from the work plan for FY2000.</p>	<p>No specific reference is available.</p> <p>The FY2000 AP.</p> <p>Final FY2000 AP p. 37.</p> <p>Final FY2000 p 37.</p>
<p>• Line 1820-1822; here three very specific INs relate to a single research project. Will three different RFPs be issued to address the specified INs? If a single RFP goes out for this research project the same situation as described in 7 above applies.</p>	<p>The three INs were combined as there is overlap in these INs associated with habitat. Subsequent discussion of this research avenue resulted in this being deleted from the work plan for FY2000.</p>	<p>No specific reference is available.</p> <p>The FY2000 AP.</p> <p>Final FY2000 AP p. 37.</p> <p>Final FY2000 p 37.</p>
<p>• 9. Line 1823-1824; same scenario as in 8 above.</p>	<p>The response is the same as above, except that this is being pursued as an RFP in 2000.</p>	<p>No specific reference is available.</p> <p>The FY2000 AP.</p> <p>Final FY2000 AP p. 37.</p> <p>Final FY2000 p 37.</p>

<p>•The result of the scenarios described in 7, 8, and 9 above is that it allows the investigator to select the priority rather than GCMRC. Given that insufficient dollars are available to cover all the specified INs adequately and the range of interests of those that might submit proposals is broad, it seems likely that a potential investigator could develop a superior scientific proposal that addressed only one of the specified INs. Given this, I would like to see all specified GCMRC projects much more narrowly focused to a specific IN.</p>	<p>The work plans for FY2000 were narrowed. INs do have overlap and, although it seems that multiple INs are being requested of the P.I.s, this is not necessarily the case.</p>	<p>Appendix A.</p>
<p>Line 2023 - 2029; the riparian avifauna project is funded at such a low level that it may be impossible to contract. On the other hand, it would seem that SWWF and KAS monitoring could be handled as in-house projects (this seemed to be accepted by GCMRC). If SWWF and KAS were accomplished in-house why would \$60K be needed. Given this rationale, I suggest that the avian project be increased to \$50K, and SWWF and KAS be reduced to \$40K The Hopi Tribe Comments 12/8/98:</p>	<p>The funds were redirected. And avifaunal work was recommended for funding at \$81,000 as an extended contract for FY2000.</p>	<p>Final FY 2000 plan p. 41.</p>
<p>Page 56, Line 1591: "\$250,00." Is this contained in an overall GCMRC budget? Or is it covered by an external BOR budget?</p>	<p>The \$250,000 was used as a place holder until a firm number was provided for the Integrated water quality monitoring program.</p>	<p>FY2000 Final plan, IWQP final draft 6/25/99</p>
<p>Page 57, Line 1633: Vague description of monitoring.</p>	<p>The description was changed to include the specific INs that the monitoring addresses.</p>	<p>FY2000 final plan, p. 49.</p>
<p>Page 65, Line 1878: What are the basic parameters of trout monitoring?</p>	<p>Monitoring consists of relative abundance, catch per unit effort, length, weight ratios, and examination of fish for parasites, stomach samples and determination of recapture/first capture data.</p>	<p>Arizona Game & Fish Department Contract.</p>
<p>Page 67, Lines 1936-1941: Is the aerial photography a part of the synthesis cost?</p>	<p>Aerial photography is not part of synthesis costs, it is part of remote technology's budgeted costs for overflights.</p>	<p>FY2000 Final plan.</p>
<p>Page 71, Lines 2053-2054: "...budget for monitoring endangered species...estimated at \$60,000." SWWF & KAS?</p>	<p>This number came from the \$47,000 cost for KAS and the estimated \$20,000 for SWWF. SWWF requires 6 trips over the course of three months. These have been internalized and money reallocated to other biological resource areas.</p>	<p>FY2000 Final plan.</p>

<p>Arizona Game and Fish Department Comments 12/7/98:</p> <p>Line 1381: The intention for the monitoring plan is to combine projects and develop aquatic and terrestrial monitoring programs. You don't say how you are going to accomplish this. Does this mean you will issue one RFP for the aquatic work and one for the terrestrial work? Line 1464 says that the Biological Resources Program will be awarded through a competitive process, but no mention is made of how many contracts will be issued. As I understand it, the intention is that by issuing one contract for all of the aquatic program work integration across resources will be enhanced. For example, the aquatic food base would be better integrated with the fish resources. However, I do not see that issuing one contract would ensure this integration as it is likely that whomever got the "monster" contract would subcontract out specific components of the work. It would then be up to the contractor to ensure integration rather than the Center. Costs of administering the program would also increase (overhead and or indirect costs would increase). Clearly the integration needs to take place. Specifically, to understand the trout fishery we need to have strong linkages between the fish community and the food base. Presently benthos data are not being collected in the Lees Ferry reach (only at Lees Ferry, not upstream). We need to examine food base and trout where each occur. Don't see how this is being addressed in the Annual Plan.</p> <p>Line 1632: Aquatic food base (AFB) monitoring. What is total biomass? Density? Surely we won't be measuring total biomass. Will work be done canyon wide as in the past, or will efforts be focused in the tailwater? Narrative suggests canyon-wide, but until a PEP is completed for both trout and AFB, don't know that a decision can be made.</p>	<p>The policy regarding monitoring and research is that projects are awarded competitively. Contracts are issued through cooperative agreements for the most part. The decision to issue encompassing terrestrial and aquatic monitoring contracts has not been decided. The comments merit further consideration.</p> <p>The state of monitoring of aquatic foodbase does emphasize downstream resources. The need for monitoring in the Lees Ferry reach is recognized and a solution to this data gap needs to be found.</p>	<p>The concept of combining activities into aquatic and terrestrial monitoring programs was removed from the final FY2000 plan.</p>
<p>Line 1783: Efforts to monitor the abundance of non-native species and their co-occurrence with native species of concern will be initiated". Statement implies that this has not been done. Monitoring sampling is indiscriminant with regard to species collected. Monitoring program should monitor the entire fish community, as it has in the past.</p>	<p>The AFB measures biomass, composition and habitat requirements. Biomass is based on a subsample of an algal or benthic constituent. It represents an estimate of productivity/m². Work is done on a canyon-wide scale. A PEP will be done as soon as is possible in order to ensure that large data gaps do not occur.</p>	<p>FY2000 plan p. 36.</p>
<p>Line 1818: "Designated critical habitat" is a legal term. Defined for razorback sucker; don't think it has been done for HBC, or if it has it is the entire Grand Canyon ecosystem. Be careful here with "designated critical habitat" term.</p>	<p>The current monitoring program does count exotic species as has been done in the past. What was meant by this statement was to initiate work on past data collection and conduct analysis that would allow an exotic removal program to be formulated.</p> <p>The term designated has been deleted so as not to lend to any confusion.</p>	<p>More clarification on this is provided in the first 2 pages of this document addressing biological resources comments.</p> <p>P. 37.</p>

<p>The native fish contractor did assist in monitoring at the LCR both last year and this year. It may be a different level of work in relationship to previous years, but monitoring in the spring in the LCR did occur. The PEP would involve a panel that reviews data and methodologies and provides potential alternative protocols. More information regarding PEP is available in Appendix C. The PEP will not pay for this monitoring effort.</p>	<p>Appendix C PEP</p>
<p>The text has been revised to address timing relative to the PEP as well as budget issues.</p>	<p>P. 39.</p>
<p>The comments were considered and those monies were allocated to HBC population genetics work that is relevant to both the proposed TCD and the steady flows experiment.</p>	<p>FY2000 plan, p. 37.</p>
<p>We estimate PEPs based on numbers of potential panel members and if field trips to a monitoring locality are feasible. PEP panel member numbers may vary if remote sensing applications are a component of the current monitoring program (e.g., vegetation uses aerial photography and GIS).</p>	<p>FY2000 plan, p. 46.</p>
<p>We reduced the amount of money allocated to this project. We feel it is still worth investigating. We would have the experts come down to collect the data and see if it is applicable.</p>	<p>Revised figure FY2000 plan, p. 46</p>

Line 1833: PEP in LCR monitoring. LCR monitoring was not funded last year as part of native fish program; \$20,000 is insufficient to do the standard 40 days of monitoring that we have been doing along with a PEP. Does the PEP include the monitoring work? Is the monitoring work going to be a separate contract or included with the native fish work?

Line 1877: "Long-term monitoring for trout will be implemented in FY2000." The trout PEP is also scheduled for FY2000. Shouldn't implementing a monitoring program be deferred until the PEP is completed? Also, don't see any attempt to link aquatic food base and trout; although I assume that PEP will be conducted on both resources and may indicate different approaches for one or both programs to ensure that linkage, at least in the Lees Ferry reach. I'm also concerned that the budget may be inadequate to do the required work. We expended about \$125,000 to do the monitoring and associated data synthesis this past year. Cutting that to \$80,000 may be difficult.

Line 1882: "A research project that examines FMS and rainbow trout interactions in the mainstream will be developed. Estimated costs for this project is \$80,000." I think this project may be premature; we are working with Scott Rogers, one of our employees who worked the Ferry (food base and trout) for five years on a graduate student program now with University of Arizona. His thesis work will focus on the Lees Ferry flannelmouth sucker community and will answer some of the questions (FMS IN 3, 9). This project sounds like it is meant to address questions of native non-native interactions. I don't think the Lees Ferry is the best place to conduct studies of that nature (there are few natives present other than large adult flannelmouth sucker). Other native non-native interactions are likely of more importance to understand (chub and fathead minnow or red shiner), and may be best addressed with lab work rather than field work. In addition, mining of existing data may help address some of the native non-native concerns.

Line 1893: PEP costs seem highly variable. Can you explain why PEP for one program costs \$20,000 and for another it is \$15,000?

Line 2117: Budget page indicates a side scan sonar pilot for \$50,000. Where is the narrative on this? I think this is jumping the gun a bit; could be done in the Lees Ferry reach for considerably less. There are serious shortcomings of using a system like this (it can't distinguish a trout from a chub; likely can't enumerate small fish occupying nearshore habitat). Before you devote this kind of money to this program I suggest an evaluation by trained and experienced hydro-acoustics experts as part of the PEP.

<p>CREDA Comments 12/1/98:</p> <p>Line 261, footnote 11 and Line 1589. We will need to see the backup for these numbers. How much of the GCMRC staff costs (2FTE - \$148,000) has been moved to USBR funding? On the surface it appears that you have only split the \$325,000 that has been shown for water quality monitoring in the line item, not the total package of \$473,000.</p> <p>Lines 376 and 1466. The statement is made that all monitoring programs will be done through RFPs. Does this include water quality monitoring? If so, what is the function of the two FTEs at GCMRC? Are there other areas of the program where this same issue could be raised (Ex. Physical resources, biological resources)?</p> <p>Dam operations historically caused sloughing of algae and downstream movement of food. It is common knowledge that during rising water levels, food intake increased for trout. The section is not complete unless it describes this historic pattern.</p>	<p>The proposed integrated water quality program's budget divides these salaries into O&M and AMP funds.</p> <p>At this time the water quality program is conducted by GCMRC staff and work is also contracted out for sample analysis. The two staff members associated with the IWQP will be committed to other projects within the IWQP including data management, analysis and model development/integration.</p> <p>We added this to the annual plan.</p>	<p>Integrated Water Quality Program Final Draft 6/24/99.</p> <p>IWQP final draft 6/24/99.</p> <p>p. 38</p>
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	reports since GCES Phase I will be prepared and distributed separately. We are currently doing all we can with the AMWG/TWG website. It will be restructured as time becomes available.	
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