DRAFT

U.S. Geological Survey – Biological Resources Discipline
Southwest Biological Science Center
Grand Canyon Monitoring and Research Center

STRATEGIC SCIENCE PLAN

FISCAL YEARS 2005-2009

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USGS-BRD SBSC GCMRC
2005 – 2009 STRATEGIC SCIENCE PLAN

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NEED AND PURPOSE

The Glen Canyon Dam Adaptive Management Program (GCD AMP) has extensive requirements for research, development, and monitoring activities in the Colorado River Ecosystem (CRE) over the next 10 years. The Grand Canyon Monitoring and Research Center (GCMRC), the GCD AMP science provider, will accommodate these science needs through more effective planning, science implementation, and outreach efforts. However, to accomplish its mission, issues must be resolved relating to expanded program information needs in the face of declining science budgets.

This Strategic Science Plan is developed to evaluate the issues, opportunities and concerns faced by GCMRC, and establish both science and science management strategies that can be helpful in deriving solutions. The strategies, if implemented effectively, will ensure that management information needs will be met.

THE SCIENCE SETTING

GCMRC is a science center of the Department of the Interior, U.S. Geological Survey-Biological Resources Discipline, a premier government science agency. USGS provides science support to GCMRC in meeting its responsibilities to the Glen Canyon Dam Adaptive Management Program (GCD AMP).

The GCD AMP is managed by the Adaptive Management Work Group, a Federal Advisory Committee that is comprised of 25 stakeholders, many of whom have management responsibilities for resources in the Colorado River Ecosystem (CRE). The AMWG is responsible for providing overall guidance to the GCD AMP and articulating critical research, development and monitoring information needs for which GCMRC develops scientific understanding.

Science development is accomplished within an adaptive management paradigm, wherein new science information is continually cycled into application by managers, and outcomes are monitored for effectiveness. This adaptive management process requires highly focused applied science projects, which address specified management information needs.

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GCMRC will have an aggressive science program for the FY 2005-2009 period. It will include Core Monitoring and Long Term Experimental programs combined with shorter-term research and development projects. These programs will be designed to incorporate more integrated interdisciplinary science approaches with current discipline and multidiscipline procedures.

Information needs of AMWG as specified in the GCD AMP Strategic Plan will be addressed fully by the above program direction. To strengthen the results of these inquires, especially as relates to integrated resource impacts of management activities, selected information needs will be addressed through science questions that invoke interdisciplinary assessments, rather than single discipline assessments. This strategy is established for the following science questions:

- How does the CRE and Lake Powell respond to drought?
- How will recent changes in water temperature effect distribution and trophic interactions of native and exotic fishes?
- How will HBC and RBT respond to varied flows, temperatures, and populations?
- How do CRE biotic resources such as HBC and RBT respond to changes in water quality?
- What are the food base requirements for HBC and RBT?
- What comprehensive cultural resource strategy is most appropriate for FY 2005-2009?
- How can flow impacted cultural resource loss be best mitigated in FY 2005-2009?
- How are sediment fines routed and stored through the CRE under differing flow regimes?
- What flow regime strategies best maintain fines and enhance and maintain beaches and cultural resources?
- How are riparian and spring communities and habitat affected by flow regimes?

- What are the physical and biotic relationships of flows and terrestrial vegetation?

- How does the occurrence and state of marsh and backwater communities associated with different flow regimes effect fish reproduction and survival?

- How is the encroachment of native and non-native vegetation on to recreation sites related to flow regimes?

- How are current human uses of the CRE impacted by flow regimes and how do these current uses impact other components of the CRE?

GCMRC SCIENCE MANAGEMENT STRATEGIES TO SUPPORT RESEARCH, DEVELOPMENT, AND MONITORING PROGRAMS

GCMRC science management strategies address science management needs to answer the above questions. Management strategies are accomplished by focusing on the following issues, opportunities, and concerns of stakeholders.

- Limited effectiveness in the adaptive management process.

- Ineffective specification and prioritization of stakeholder needs.

- Insufficient program integration.

- Need for more effective science program implementation including synthesis of knowledge.

- Limited incorporation of agency development activities in CRE.

- Need for focused knowledge exchange.

- Need for greater support in funding, staffing and administrative requirements of the GCMRC.

- Need to resolve budget short falls.

Limited Effectiveness in the Adaptive Management Process

To secure its vision as the premier science provider to the GCD AMP over the next 5 years and have increased effectiveness in the adaptive management process, GCMRC will: establish a strong science presence with AMWG and TWG, provide

ongoing science knowledge assessments, and obtain timely AMWG prioritized information needs.

Need to Create Greater Effectiveness in Program Integration

Past reviews of GCMRC have criticized the lack of integration in research designs, data collection, and resource impact assessments. A strategy will be pursued over the period FY 2005-2009 for GCMRC to work with the Science Advisors to develop and incorporate effective integrated ecosystem assessment procedures in GCMRC programs.

A Need for More Effective Science Programs and Knowledge Assessments

Key strategies need to be pursued to improve the GCD AMP science process as follows:

- At two year intervals, a priority listing an updated status of science knowledge assessment from AMWG, a priority listing of managers information needs from AMWG, and a 2 year science program and budget is needed from GCMRC.

All science plans will reflect new science integration approaches, and the science program will address all AMWG information needs and the above critical science questions.

- GCMRC will implement a 2 year test science program in FY 2005/2006 in collaboration with TWG and AMWG, and an operational "Two Year Comprehensive Science Work Plan" in FY 2007/2008. The GCMRC strategy for the period FY 2005-2009 is to move completely to 2 year science program and budget cycles by FY 2007.

Need to Focus Knowledge Exchange on Stakeholders Information Needs

GCMRC has excellent capabilities in information gathering, management and dissemination. The 5 year strategy is to focus these capabilities on transmission of knowledge to managers/stakeholders to accelerate management application of knowledge over the next five years.

Need to Include Management Development Activities in CRE

As the GCD AMP matures, managers are becoming more directly involved in development activities and knowledge application. Our strategy is to collaborate with AMWG to incorporate these activities in GCD AMP, to accelerate learning in the adaptive management process.

Need for Improved Mechanisms for Funding, Staffing, and Administrative Support

GCMRC does not currently have either the appropriate staffing or budget to respond to all specified information needs of the Adaptive Management Work Group. To resolve these inequities, GCMRC will review all assigned internal and external GCMRC programs by FY2007, for efficiency and effectiveness. The Center will create improved administrative management approaches, including expanded cooperative programs with AMWG management agencies, and outsourcing and changes in science procedures to create greater effectiveness and efficiency. It will also evaluate all staffing needs for appropriate balance of federal and contracted staff support, and utilize information prioritization, revised science procedures, improved data collection technology, expanded science collaboration and 2 year planning and budget cycles to mitigate possible budget shortfalls.

USGS GCMRC STRATEGIC SCIENCE PLAN
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INTRODUCTION

Organizations require strategic plans so that all employees can articulate corporate visions, missions, and goals. For the U.S. Geological Survey, Grand Canyon Monitoring and Research Center, a Strategic Science Plan is critical to explicitly support the mission and goals of managers with the highest quality science capability.

The last approved Strategic Science Plan for the Grand Canyon Monitoring and Research Center (GCMRC) expired in Fiscal Year (FY) 2002, after being implemented in FY 1998. A draft revision extending to FY 2004 was never formally adopted and implemented by GCMRC. During the time period from 1997-2004, GCMRC went through several dramatic changes, including transfer from the Bureau of Reclamation to the USGS, appointment of several Chiefs (Center Directors), and most recently, a reorganization. These changes necessitate immediate development and implementation of a new GCMRC Strategic Science Plan to guide research, development, monitoring and adaptive management in the Grand Canyon over the next five years.

Strategic Science Plans should be visionary, conceptual, directional, and short. Earlier GCMRC Strategic Science Plans were more operational in design and quite lengthy. The new Strategic Science Plan will cover the interval from FY05-FY09. It is intended to be a living document that will be assessed annually to ensure that we are on track to achieve our goals. In short, the Strategic Science Plan is the means by which GCMRC will constantly recreate itself to achieve extraordinary purpose and relevance.

It is comprised of two primary sections: a science strategy and a science management strategy. The science strategy is utilized to specify critical science questions that will respond to the information needs of managers. The science management strategy is necessary to assure that the science approaches utilized are both efficient and effective in meeting management needs.

GCMRC STRATEGIC SCIENCE PLAN FOUNDATION

This plan is founded on two unwavering principles. The **first** is a commitment to ensuring the conduct, interpretation and delivery of high quality science. High quality science is defined as monitoring, research, development, and adaptive management programs that are rigorous, repeatable, and subject to the highest standards of data collection, analysis, interpretation, and peer review. GCMRC values objective, non-advocacy science that is based on combinations of developing testable hypotheses, rigorous collection of data, state-of-the-art analysis, anonymous peer review of findings, and timely delivery of results to our stakeholders and the general public.

GCMRC advocates only one thing: high quality science. We do not advocate for positions, protection of resources, or a particular mission beyond our own, or that of the USGS as a whole.

The **second** principle is relevance and responsiveness to the needs of our stakeholders. GCMRC research and monitoring activities will be evaluated against the goals, management objectives, and information needs contained in the current AMP Strategic Plan and its subsequent revisions. To perform within this second principle, GCMRC will program its science in research, development, and monitoring projects and studies in support of the Glen Canyon adaptive management Program (GCD AMP). These applications of science will often require specific input and support from managers. Examples are areas where scientists feel they have adequate knowledge of expected outcomes, but wish to monitor closely expected changes and impacts to resources. We will strive to meet the needs of our stakeholders in all of our research and reporting activities, including areas of development.

Who are our stakeholders? Our primary stakeholders are the 25 members of the AMWG. Because of the additional need for USGS to meet societal needs, our broader list of stakeholders includes the public. Failure to meet the needs of our stakeholders will result in failure to achieve our mission.

Vision

Every organization needs a vision to pursue excellence. While GCMRC has made significant accomplishments toward achieving the vision outlined below, we recognize that there is room for improvement. Simply stated, our vision is:

> *To be the undisputed leader in providing relevant, valuable, accurate, and timely information on the effects of Glen Canyon Dam operations on the natural and cultural resources in the Grand Canyon.*

During the five year implementation period for this Strategic Science Plan, GCMRC will develop well-integrated research, development, and monitoring programs with state-of-the-art information on the effects of Glen Canyon Dam operations on natural and cultural resources in the Colorado River Ecosystem (CRE). Our research, development, and monitoring activities will be conducted using the most appropriate mix of skills, including partnership programs with our federal, tribal and state agency management partners, work conducted by GCMRC scientists and staff, work accomplished with cooperators, and work accomplished through contracts with individuals and organizations external to GCD AMP.

Interdisciplinary approaches will be significantly increased over the five year period. Results, databases, and geospatial information will be published and disseminated in real time through our web site, scientific journals, AMWG public relations programs and other USGS products. We will regularly produce a State of the Colorado River

Ecosystem (SCORE) report that is used by resource managers as the undisputed source of relevant information on the topic.

The GCMRC vision is one of excellence in science. The vision will be achieved when our science is aligned with the needs of our stakeholders, especially agency managers who come to us as the acknowledged experts on the Colorado River Ecosystem.

Mission and Role

Our mission has remained virtually unchanged since the first Strategic Plan was written for GCMRC cooperatively with our stakeholders.

> *To provide credible, objective scientific information to the Glen Canyon Dam Adaptive Management Program on the effects of operating Glen Canyon Dam on the downstream resources of the Colorado River ecosystem, utilizing an ecosystem science approach.*

GCMRC's key roles and responsibilities are comprehensive, but remain focused on critical issues of our stakeholders. GCMRC will:

1. Advocate quality, objective science and the use of that science in the adaptive management decision process.

2. Provide scientific information for priority resources of concern identified in the "Operation of Glen Canyon Dam Final Environmental Impact Statement."

3. Support the Secretary' designee and the Adaptive Management Work Group in a technical advisory role.

4. Develop research designs and proposals for implementing, by GCMRC and/or its contractors, monitoring, research and development activities in support of information needs identified by the Adaptive Management Work Group.

5. Coordinate ongoing reviews of the monitoring and research program with independent review panels.

6. Coordinate, prepare and distribute technical reports and documentation for review as final products.

7. Prepare and forward technical management recommendations and annual reports, as specified in Section 1804 of the Grand Canyon Protection Act to the Technical Work Group.

8. Manage all data collected as part of the Adaptive Management Program. Serve as a repository (source of information) for others (stakeholders, students, public, etc.) in various formats (paper, electronic, etc.) about the effects of operating Glen Canyon Dam on the downstream resources of the Colorado River Ecosystem and the Adaptive Management Program.
9. Administer research proposals through a competitive contract process, as appropriate.

10. Manage GCMRC finances and personnel efficiently and effectively.

ADAPTIVE MANAGEMENT WORK GROUP PROGRAM GUIDANCE

GCMRC does not operate in a vacuum, but instead is directly linked to the GCD AMP program by the Adaptive Management Work Group (AMWG), which clarifies science needs, and its parent organization USGS, which provides critical science support. GCMRCs most critical role is to provide the highest quality science information to its stakeholders, the Adaptive Management Work Group (AMWG).

In responding to its primary charge, GCMRC will align its Strategic Science Plan and programs to the goals, objectives, and information needs in the GCD AMP Strategic Plan, developed by the Adaptive Management Work Group (AMWG). The GCD AMP Strategic Plan is the keystone document upon which GCMRC will measure our success and relevance in terms of accomplishing our vision and mission.

The GCD AMP Strategic Plan contains goals, management objectives, and information needs that guide the entire Glen Canyon Dam Adaptive Management Program. It is not the intent of this plan to list each of these again here. The reader is instead referred to the AMP plan. However, the research, development and monitoring programs of the GCMRC will be driven by these elements. And, the relevance of our research and monitoring outputs will be measured by their contribution to these goals and needs.

PARENT ORGANIZATION SUPPORT

GCMRC resides in the U. S. Geological Survey (USGS) of the U.S. Department of the Interior (DOI). The Mission of the DOI is to protect and provide access to our Nation's natural and cultural heritage and honors our trust responsibilities to Indian Tribes and our commitments to island communities. The DOI has established five Departmental goals that encompass the major responsibilities of the Department. These goals provide a framework for the strategic plans of DOI's bureaus and GCMRC.

1. Protect the Environment and Preserve Our Nation's Natural and Cultural Resources.

2. Provide Recreation for America.

3. Manage Natural Resources for a Healthy Environment and Strong Economy.

4. Provide Science for a Changing World.

5. Meet Our Trust Responsibilities to Indian Tribes and Our Commitments to Island Communities.

The U.S. Geological Survey (USGS), established in 1879, is the Nations leading natural science and information agency. As the primary science bureau for the U.S. Department of the Interior, the USGS plays a key role in research and monitoring activities on public lands and beyond. As a part of the USGS, GCMRC will direct our program in adherence to the vision, mission, strategic direction, and goals outlined by the Bureau.

The vision of the USGS – *The USGS is a world leader in the natural sciences through our scientific excellence and responsiveness to society's needs.*

The mission of the USGS – *The USGS serves the Nation by providing reliable scientific information to:*

- *describe and understand the Earth;*
- *minimize loss of life and property from natural disasters;*
- *manage water, biological, energy and mineral resources; and*
- *enhance and protect our quality of life.*

ASSESSING GCMRC CAPABILITIES AS A CENTER OF SCIENCE

Development of a Strategic Science Plan gives an organization the opportunity for self-examination with respect to its strengths, especially as regards achieving the vision, mission and goals contained therein. Questions that need to be asked include the following:

- What are the science needs that we currently have the capacity to support well?

- What are the areas that we need to develop to have capacity in the future?

- What are the opportunities and critical needs in the future?

GCMRC is serious about resolving issues that affect achievement of the goals identified in our Strategic Plan. Because these issues tend to be tactical or operational in

nature, they are recognized, but not addressed in this plan. Rather, they will be dealt with by management of the Center through internal reviews, supervision, and accountability.

GCMRC has significant capabilities in research, development and monitoring, and has opportunities for improvement as follows:

Dedicated staff. One of GCMRC's overarching assets is a highly dedicated and experienced staff, committed to science excellence in the Grand Canyon. This experience staff is the primary strength of GCMRC, even though it is currently understaffed in key areas.

A well defined mandate and science focus permits the Center to pursue long term programs of science using integrated interdisciplinary approaches as well as single discipline approaches.

State-of-art equipment and logistic programs create the ability for GCMRC staff to react quickly to special research needs.

Premier programs such as sediment research and monitoring have demonstrated the capability of Center scientists to produce high quality data that can be used to improve resource conditions in the CRE.

Along with the above strengths are opportunities for improvement as follows:

Contracting and permitting require more efficient and effective program planning by AMWG, TWG and GCMRC.

Work load and effective staffing requires improved planning to insure program effectiveness.

Science program integration and ecosystem science approaches must be evaluated and expanded for implementation in all program areas.

Productivity, peer review and outreach need evaluation for more efficient timely outputs.

Worker morale and productivity must be enhanced by maintaining a high quality work environment.

The above capabilities will contribute to critical science and science management strategies in the following sections. Some of science and management strategies can be pursued in a short time interval, and be completed in one to two years. However, several strategies will require multiple years to incorporate effectively.

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GCMRC has since 1998 significantly increased scientific understanding of resource impacts associated with differing regulated flow regimes from Glen Canyon Dam. In collaboration with AMWG and TWG, it has invoked adaptive management processes to use this knowledge to enhance some resources and also mitigate, as possible, continued impacts to other resources.

In spite of the continued efforts of AMWG, GCMRC and TWG, resource impacts continue, and some resources, such as Humpback chub and fine sediment appear to be at extremely precarious levels in the system. These heightened resource concerns have prompted AMWG, GCMRC and TWG to launch extensive science and management planning efforts in fiscal years 2004-2006 to create improved science and management strategies to further improve Colorado River resources of concern.

GCMRC, in its contributions to the above direction, will commit new and improved science and science management strategies to assure that information required by AMWG is accurate, current, and the most robust that can be made available.

To accomplish this effort GCMRC has reviewed all information needs specified in the AMWG Strategic Plan as well as reports on prioritization of these needs from the 2004 AMWG workshop and the GCMRC Core Monitoring Plan. When one condenses all of this information to a key set of critical subjects of concern to AMWG, the following list emerges:

- Fish and Aquatic: aquatic food base, native fish, non-native rainbow trout.
- Cultural Resources: register eligible historic properties, tribal concerns.
- Threatened and endangered species: Humpback chub, Kanab ambersnail, Southwest willow flycatcher.
- Sediment: substrate, beaches, sediment storage.
- Vegetation: terrestrial wildlife, non-native species.
- Water: hydrology, springs, riparian habitat, water temperature, water quality, flow dynamics, TCD.
- Hydropower: power capacity, energy generation.
- Recreation: quality of recreation experience, recreational boating, fishing.

- Adaptive management process, ecosystem management, integrated research.

Placing the set of priority information needs from the 2004 AMWG workshop into a question format, permits the researcher to address integrated resource impacts of the CRE while at the same time addressing all of the individual discipline resource information needs specified by AMWG.

The following set of science questions, if answered, should significantly advance the understanding of integrated resource impacts of differing managed flow regimes, as well as other resource issues identified by AMWG. And, because science approaches that evaluate individual disciplines (hydrology, fish ecology) or resources (sand, sediment, rainbow trout) have not provided appropriate answers to more complex ecosystem questions, the Center will also pursue these questions in a more integrated interdisciplinary science paradigm.

To accomplish all of its programs, the Center expects to employ a mix of disciplinary (single discipline efforts), multidisciplinary (combination additive process with different disciplines) and interdisciplinary (integrated disciplinary approach) efforts. However, the interdisciplinary approach, which synthesizes the perspective of the individual disciplines and integrates during all phases of the approach to a question or problem, will have increased application over the next five years.

Integrated Interdisciplinary River Science

GCMRC recognizes the importance of integrated interdisciplinary science as an effective way to study and understand ecosystem complexity. Eugene Odum, the "father of modern ecology," noted that as far as ecosystems are concerned, "the whole is greater than the sum of its parts," and as such, reductionist scientific methods alone cannot adequately explain living systems. Few would argue that one of the traits of an ecosystem is incredible complexity; a bewildering array of interconnections between all the individual components that make the whole.

River science is by its very nature fundamentally interdisciplinary. Answering the most critical freshwater problems of our times requires integrating socio-cultural and biophysical concepts and methods. Flow, dissolved and suspended materials, and living resources within the river channel all interact. As emphasized in a recent internal USGS (2004) white paper, river science today transcends conventional disciplinary boundaries because "*the hydrologic cycle, in concert with human activities and geological, biological, chemical, and climatic processes, controls most of the commonly recognized features of rivers, such as river form, seasonal variations in flow, chemical quality, and the type of living resources in rivers.*"

GCMRC is poised to meet this challenge and provide pioneering work and leadership in the arena of integrative river science. GCMRC is already well along the path to integrative research in many areas. An integrative river science approach will

support AMWG's broad concerns on how to best manage and sustain competing goods and services of rivers to benefit both humans, and the natural ecosystems to which humans belong. This means that single resources (and their research programs) are not studied in isolation from other resources or from the socio-cultural context. Further, truly integrative river science should aim to both understand and ultimately predict how rivers respond to human activities and outside forces such as climate variability. Human activities include, for example, flow regulation, water extractions, land use alterations, and recreational use. Understanding will come from the developed integrated Core Monitoring Program and Long Term Experimental Program. Predication comes from a synthesis of findings in a quantitative framework.

TRANSITIONING TO INTEGRATED INTERDISCIPLINARY SCIENCE

Several steps are necessary to transition to more integrated interdisciplinary science approaches. First, the Center's Strategic Science Plan is the foundation from which all monitoring and research strategies should be derived. The purpose of this plan is to use stakeholders' information needs to formulate the critical research questions of this time. The phrase "of this time" is used because priority areas will change over time (e.g., due to droughts, endangered species status) and the science plan must be adaptive like management.

Second, all members of interdisciplinary research teams (e.g., physical, biological, cultural) should *together* develop a conceptual model that illustrates the information needed to answer each highly prioritized question. Some of this information will be core monitoring and some will be research. Such models are critical to identifying knowledge gaps and scientific directions. Some of the high priority questions may be answerable using the theories and methods from single disciplines, but justification to do the work must be made in the context of the entire strategic plan. For CRE programs, the vast majority of the high priority questions will require input from multiple disciplines.

Third, the science information needs of stakeholders should be identified along with interdisciplinary teams that will gather the data; this should result in a list of core measurements and/or research tasks along with a timetable for each priority question. The challenge is to determine which "keystone" components of the almost infinite number of measurable physical, chemical and biological parameters in a river system should be studied to most comprehensively evaluate the interrelationships among them in a river system that are critical to answering the priority questions in the science plan.

Fourth, leaders should be identified for priority research questions. That person does not represent his/her area (physical, biological, cultural resources) but is responsible for making sure all the information that is needed to answer the critical question is gathered and the timeline adhered to. This person will also be responsible for the

collation, analysis, and interpretation of the data which must result in a written report to AMWG and development of management guidelines.

SPECIFYING GCD AMP CRITICAL SCIENCE QUESTIONS

GCMRC, AMWG and TWG have over the past seven years brought focus to the most critical science issues facing the GCD AMP. Further, the AMWG has maintained a continued effort at articulating specific information needs that can be used in formulating more comprehensive science questions. Because of these efforts, the following science questions, identified and posed by GCMRC, will also address the critical information needs of the stakeholders.

GCMRC proposes the following more holistic science questions be engaged over this strategic plan period. Greater specificity on each is provided in this section.

Question: How does the CRE and Lake Powell respond to drought and climate stressors?

Need/Rationale: Historically Lake Powell has acted to minimize the seasonal and longer-term climatic variability that occurs in the physical and chemical characteristics of the Colorado River. As a result of water being released from well below the surface of the reservoir, the water leaving Lake Powell has been relatively stable with respect to temperature and nutrient concentrations. However, as the current drought continues and the water level in Lake Powell drops, these relatively stable conditions have and will continue to change. As the water level drops and the thermocline in the lake approaches the depth of withdrawal, water temperatures leaving the dam are increasing and water quality parameters are changing.

Increased water temperatures and the possible associated decrease in nutrient concentrations could impact the CRE food base, the movement of warm water fish upstream, and the magnitude of disease and parasites. Changes associated with the current drought can be used to help predict the changes that may be expected with a temperature control device and other future long-term droughts. There is a need to be able to understand the downstream effects of the recent drought, possible long-term climatic change, and climatic variability.

Science Approach: Direct effects of the drought and climatic variability on the hydrology upstream of Lake Powell are currently monitored by agencies outside of the GCMRC. The Bureau of Reclamation monitors the climatic conditions throughout the Colorado River Basin, and the USGS monitors the streamflow of the major tributaries near to where they enter Lake Powell. GCMRC will encourage these agencies to conduct water-quality sampling (at least water temperature, conductivity, and nutrient concentrations) at the streamflow monitoring sites on these tributaries.

The direct effects of climatic variability, including the present drought, on the physical and chemical conditions in Lake Powell, including the forebay, can be evaluated using GCMRC's monthly sampling of the forebay and quarterly sampling throughout the lake. To determine if the climatic effects and the effects of varying water level on Lake Powell are properly understood, the BOR CE-QUAL-W2 model should be used to simulate the recent drought and the output from the model should be compared with the recent data collected in the lake.

Changes in water temperature that occurs as water moves down the canyon is measured at various locations; however, changes in nutrient concentrations are not presently included in the program. The BOR is in the process of developing a sub program in the dynamic model (CE-QUAL-W2) to simulate the changes in water quality as the water flows downstream. GCMRC will collaborate on this model development.

Changes in the hydrology, water temperatures, and nutrient concentrations downstream of the dam will significantly impact the Colorado River ecosystem. This information can be used to predict changes that may occur with the implementation of the temperature control device and what could occur in future long-term droughts. These changes include, but are not limited to, changes in metabolism throughout the river, changes in rainbow trout and humpback chub recruitment, changes in the food base, etc. To examine all of the impacts of the drought requires input from all of the disciplines within the GCMRC and will foster interdisciplinary collaboration. Specific monitoring needs for these other key questions are discussed elsewhere.

Question: How will recent changes in water temperature affect distribution and trophic interactions of native and exotic fishes?
Question: How will HBC and RBT respond to varied flows, temperatures, and population?
Question: How do CRE biotic resources such as HBC and RT respond to changes in water quality?

Need/Rationale: This issue is of immediate relevance in two respects. First, the proposed development of the Temperature Control Device at Glen Canyon Dam is moving forward to the implementation phase. Second, dropping water levels during 2004 put the Lake Powell metalimnion at the depth of GCD penstocks, and river water now warms in response.

Approach: Temperature monitoring and prompt reporting of results are essential in this year and the next several years of low lake levels. So, too, are the distribution and numerical responses of key biological resources such as the humpback chub, its prey resources, competitors and predators as well as rainbow trout. Special attention will be directed to effects on rainbow trout below the dam, the ongoing removal of exotics above and below the LCR, and recruitment success of HBC at the LCR. Other concerns include the upstream migration of brown trout from the Bright Angel region, plus similar responses of coolwater fishes (e.g., walleye) and warmwater fishes (e.g., striped bass,

smallmouth bass, common carp, and channel catfish) advancing from the lower river reaches and Lake Mead. These prospects call for a much more aggressive pursuit of modeling approaches that incorporate the recent responses as a calibration process.

Question: What are the food base requirements for HBC and RBT?

Need/Rationale: Critical to stabilizing the HBC population in the canyon is a clear ecosystem level understanding of the effects of the food base on the HBC and RBT population. Because there is substantial diet overlap between these two species and they are both of concern to multiple groups, we must determine what their primary food resources are and how dam operations influence those resources.

Approach: The historic focus of the food base research has been on biomass and standing stocks (algae, invertebrates). However, their huge variability over space and time made it impossible to make inferences on the status and trends of the food base. Therefore, the recommended approach is to begin:

- A stable isotope analysis that would identify the energetic base (allochthonous, autochothonous) in this system and serve to guide core monitoring for the food base program. Isotopic signatures of the HBC and RBT combined with food gut analyses can tell us if the primary basal resource that supports these fish is algae or detritus and how this varies from Lees Ferry to the LCR. Note, the purpose here is *not* to develop a predictive model between food levels and fish but to use this tool to determine what aspect of the food base the fish rely on so that long term monitoring of those aspects can be begun quickly.

- Collecting water and suspended sediment samples at multiple points along the river for analysis of chlorophyll and nutrients: carbon (DOC and POC), nitrogen (DIN, DON), and phosphate phosphorus. This serves the dual purpose of providing a water quality monitoring baseline for pre TCD deployment, and should allow for the future development of a carbon budget, which ultimately is necessary for and determining if food limitation is an issue.

Question: What comprehensive cultural resource strategy is most appropriate for FY 2005-2009?
Question: How can flow impacted cultural site resource loss be best mitigated in FY 2005-2009?

Need/Rationale: Progress in the cultural program has been hampered over the years due to agency politics and differences in interpretation over agency roles and authorities. Until these issues are resolved, a science strategy cannot be successfully implemented. There are three major material deficiencies within the cultural resources program, as it currently stands, that prevent forward progress in the program:

- Lack of an acceptable Historic Preservation Plan that lays out an unambiguous process whereby the Bureau of Reclamation can fulfill its Section 106 responsibilities.

- Lack of a comprehensive Park Service management plan to fulfill the NPS mandate for long-term protection and management of cultural resources within Grand Canyon National Park.

- Lack of sufficient integration and information exchange between the PA program and the AMP, which would allow information from the current interim monitoring and remedial action program to be systematically applied towards a long-term program that would benefit threatened historic properties within the Canyon, as required by both GCPA and the current PA.

Approach: In order to make significant progress in the cultural arena during the next five years, current deficiencies within the existing program must be rectified, as follows:

The agencies responsible for managing the cultural resources in the CRE must clearly define and acknowledge their respective roles for accomplishing the established aims of the GCPA and the PA within the AMP. For example, the National Park Service recognizes its obligations under Section 110 of the National Historic Preservation Act to develop a plan for the "identification, evaluation, and nomination" of historic properties within the areas of its responsibility. The Bureau of Reclamation recognizes and acknowledges its responsibilities under Section 106 of the National Historic Preservation Act to evaluate the impacts of its undertakings on historic properties within the area of potential effects from dam operations and to define a process whereby it can mitigate its adverse effects to meet the requirements of NHPA. The USGS has a clearly defined and well-established role within the Adaptive Management Program to provide credible, independent, objective scientific information on the effects of dam operations (and related activities authorized by GCPA) and to oversight the acquisition, storage and analysis of data resulting from monitoring and research activities. Currently, in spite of the recognition by the other agencies that GCMRC has a clearly defined role in the AMP, its authority to analyze and integrate information on cultural resources and to evaluate the impacts of the various federal agencies' programs on these resources remains in dispute. Furthermore, the National Park Service continues to monitor National Register historic properties under the Monitoring and Remedial Action Plan of the 1994 Programmatic Agreement, but there has been no adequate attempt as yet to evaluate the utility of the resulting information or use the information gained from this monitoring to develop a more robust program that could prove beneficial to the long-term protection of monitored sites and other threatened properties in the Grand Canyon. Given its established role as the lead science provider to the AMP, and the designated repository for data derived from AMP activities, it seems reasonable for GCMRC to play a leading role in the

coordination, planning and implementation of remedies to address these current deficiencies in the cultural program through the development and application of scientifically credible approaches to future monitoring, data recovery, and data management.

Before science can be successfully applied, however, the future role of science in the cultural program must be clearly defined. Therefore, it is critical that a plan for *managing* cultural resources and associated activities within the program be in place prior to *treating* cultural resources of the Colorado River in Grand Canyon National Park. As the lead agency for Section 106 compliance related to dam operations, it is essential that the Bureau of Reclamation fully develop and implement a Historic Preservation Plan (as called for under the current Programmatic Agreement) as soon as possible, rather than continuing to operate in an *ad hoc* fashion under the Monitoring and Remedial Action Plan of the 1994 Programmatic Agreement. For serious progress to occur in the cultural arena, the Historic Preservation Plan must be completed without further delay. The Historic Preservation Plan needs to clearly specify the role that GCMRC will play to meet program objectives that are fully consistent with its established role within the AMP, including: 1) providing independent, credible, objective, peer-reviewed scientific information related to the effects of dam operations on cultural resources in the CRE; 2) developing and over-sighting a long-term monitoring program for cultural resources in the CRE to document and track the effects of dam operations and the effectiveness of mitigation efforts; 3) establishing scientifically-credible standards and research objectives for data recovery at cultural sites in the CRE; and 4) managing the data that results from these and other directly-related research and monitoring activities within the CRE.

It is also imperative that the National Park Service clearly and realistically define its long-term objectives for managing and maintaining the integrity of register-eligible historic properties within the CRE. These objectives must explicitly recognize and address the reality that erosional processes and visitor impacts will continue to occur as long as the Park is managed primarily as a "natural park" with wilderness-like recreational objectives. The establishment of these management objectives is necessary in order to have a credible basis for evaluating whether AMP activities, including flow regimes, are meeting the stated objectives of GCPA for the protection, mitigation of adverse effects to, and preservation of cultural resources.

In order to meet GCPA *and* National Historic Preservation Act mandates to monitor and mitigate impacts of dam-operations on historic properties, the GCMRC must define and implement (through established cooperative agreements, competitively bid RFPs, and other means) scientifically-credible approaches for monitoring status and trends in resource condition, as well as fulfilling AMP objectives for implementing well-conceived (scientifically defensible) mitigation strategies within the CRE. The selected approaches and strategies need to be compatible with the objectives defined by the NPS for long-term management of its resources; they also need to meet high professional standards and produce high-quality information. GCMRC will work collaboratively with the land managers and other AMP stakeholders to ensure that cultural resources are

monitored and treated with the same (or higher) level of scientific-credibility and sensitivity as other threatened resources in the CRE.

GCMRC needs to ensure that all program activities involving cultural resource monitoring, research, and mitigation efforts are subject to the same level of independent peer review that other GCMRC resource program activities currently undergo.

Through supporting this strategy, the AMP will finally have a truly credible program in place for monitoring and mitigating the impacts of dam-operations on historic properties of high risk, as mandated by NHPA, as well as meeting the GCPA mandate for researching and monitoring the effects of sediment loss, vegetation change, experimental flows, and mitigation activities on cultural resources in the CRE, as is currently being done for other resources in the CRE.

Question: How are sediment fines routed and stored through the CRE under differing flow regimes?
Question: What flow regime strategies best maintain fines in the system and enhance and maintain beach areas?

Need/Rationale: The post-dam change in river regime has severely reduced fine sediment input to the river (~93% reduction)**.** Effects of this include: 1) reduced turbidity, with implications for fish survival; 2) decrease in bed cover by fine sediments, particularly in Glen Canyon reach and above LCR; and 3) erosion of beach sands at and above level of normal fluctuating flows.

Approach: It is necessary to continue research and monitoring of fine sediment transport and storage and develop management strategies. Sediment transport and sand inventories have been a priority for research and monitoring for a number of years. The system is reasonably well understood based upon: 1) long-term monitoring of the geographic distribution of deposits using a variety of techniques; 2) monitoring of suspended sediment concentration along the mainstem and in tributaries; 3) studies of the effects of experimental flows; and 4) theoretical modeling and laboratory experiments

An adaptive management strategy of short-duration beach-building flows following sediment input from the Paria River has been initiated but to date not implemented due to lack of sufficient sediment input. Contingent beach-building flows should continue to have a high priority.

- Study of possible long-term sediment augmentation should be conducted including assessment of beneficial effects from increased turbidity and increased sand supply for bed and beach rebuilding. In addition, potential negative effects should be assessed, including effects at source sites, pollutants, and costs relative to benefits. This might be implemented in a staged fashion, with initial assessment within a two-year period and an in-depth study based upon initial findings.

- Research is needed in both fine sediment modeling and sediment augmentation.

- Development of a predictive fine sediment model will continue, perhaps at a reduced level after 2 years. Model development should result in a computer program that can be queried for such issues as: 1) Long-term effects of Glen Canyon Dam; 2) effects of tributary floods on sand volumes and sediment availability for beach building flows; 3) estimated size and areal coverage of bed sediment (sand and gravel); and 4) effects of possible future sediment augmentation. This program should be able to distinguish between effects within different reaches of the river, such as above Lees Ferry, within Marble Canyon, the open reach below the Little Colorado River, etc. The program should be targeted for completion by 2006 and no later than 2008. A continuing budget item should be included for validation of the model with new sediment data.

Monitoring of the fine sediment budget will need to be continued and further developed with regard to new technologies and implementation procedures, but possibly at a reduced level of effort and frequency. Possibilities for more efficient sediment monitoring will be evaluated as follows:

- Fewer monitoring sites for measuring sand volumes and/or less frequent resurveying.

- Less frequent collection of physical samples of suspended sediment, with greater reliance on automated turbidity measurements.

- Less frequent routine collection of images and topography from overflights.

- Development of a sampling and sand inventory survey protocol that is partially event-triggered, such as after major tributary floods (e.g. floods with >5 to 10 year recurrence interval), with less frequent resurveys or samples during normal dam release periods.

However, the number of sediment concentration measurement sites will not be reduced. A provision will be included in either the core monitoring or research budgets to permit sediment sampling and sand inventory surveying after experimental flows.

Question: How are Riparian and Spring Communities and Habitats Effected by Flow Regimes?

Question: What are the physical and biotic relationships of flows and terrestrial vegetation?

Question: How does the occurrence and state of marsh and backwater

communities associated with different flow regimes effect fish reproduction and survival?

Question: How is the encroachment of native and non-native vegetation on to recreation sites related to flow regimes?

Need/Rationale: The Management Goal states: "protect or improve riparian and spring communities within CRE, including T&E species and their critical habitat." Several research and monitoring emphasis are important for the next five years, including:

- Investigations as to how the occurrence and state of marsh and backwater communities formed under differing flow regimes effect fish reproduction and survival. The question requires an integration of aquatic resources research and terrestrial habitat. It could include addressing the importance of terrestrial (allochthonous) inputs to food base in some backwaters.

- Monitor the status of seeps, springs, and related communities, including Kanab ambersnail habitat and their association with differing flow regimes.

- Evaluate remote sensing technology to track the encroachment of non-native and native vegetation onto recreation sites under alternative flow regimes. This is a combination of research and monitoring to determine how to interpret remotely-sensed information.

Approach: There are important elements of the terrestrial vegetation program that need to be continued and integrated with other critical needs. Some ground measurements will need to be continued at a much lower frequency. Core monitoring and research as currently specified are sufficient to aid in the understanding of how, under differing flow regimes, the terrestrial ecosystem may affect aquatic resources of the CRE, the state and condition of the KAS and its habitat, and the affect of vegetation encroachment on campsites, and the subsequent influence on recreational experience.

GCMRC SCIENCE MANAGEMENT STRATEGIES TO SUPPORT RESEARCH, DEVELOPMENT, AND MONITORING PROGRAMS

The comprehensive mission and role of GCMRC within the GCD AMP as outlined in the above science strategy, set against the summary of its capabilities, surfaces several issues, opportunities and concerns that require new science management strategies for the Center. GCMRC assumes a dynamic GCD AMP setting, in which continued interaction of managers and scientists is necessary, including modification in program strategies as needs arise. The following issues, opportunities and concerns, if successfully addressed with proposed science and science management strategies over the

next five years, will greatly improve the effectiveness of GCMRC in meeting its mission and goals to AMWG and the GCD AMP:

- Need for improved GCMRC effectiveness in the Adaptive Management Process.

- Need for greater effectiveness in ecosystem science integration.

- Need to implement more effective research, development and monitoring programs.

- A need to effectively incorporate in the GCD AMP all existing and planned development programs being pursued in the CRE.

- Need for more effective and efficient knowledge exchange.

- Need for improved planning and commitment on general and specific funding, personnel and administrative support needs of the Center.

These general issues, opportunities and concerns are the basis for the following science management strategies for the Center over the next five years.

Need for Improved GCMRC effectiveness in the Adaptive Management Process

GCMRC intends to realize its vision as a premier science center, meeting the critical information needs of the GCD AMP. To accomplish its vision, it will maintain strong working relationships with AMWG and TWG to assure that it is held in the highest professional regard, and its science is both requested and accepted without qualification. The following management strategies will be implemented to gain this desired condition.

Create a strong, consistent science presence with AMWG and TWG, to clearly articulate knowledge critical to resource and management needs, and future planning requirements.

- The GCMRC Chief, or designee, will provide a status report at all AMWG formal meetings that will highlight requested and/or new GCMRC findings, and overview program needs and new recommendations. Similar science presentations will be prepared for quarterly TWG meetings.

- The Chief, Program Managers, and/or staff, as appropriate, will provide requested and/or relevant science information to AMWG and TWG (i.e., budget, program planning), developed by GCMRC, Science Advisors, and/or other science organizations under GCMRC guidance.

Include as part of annual programs, status of science documentation and/or applied science information, to specifically address changing management needs.

- At two year intervals GCMRC will host a science conference with published proceedings, to document current knowledge of the Center and information related specifically to management needs.

- At five year intervals GCMRC will publish the SCORE report as the acknowledged current science compendium for the CRE.

- Annually produce management summaries and guidelines for new published science and technical reports.

Obtain AMWG approval for planning documents that respond to immediate future (2 year) and longer (5 and 10 year) science management needs. These will also provide recommendations on associated AMWG and TWG programming.

- GCMRC will develop cooperatively with AMWG and TWG in FY 2005, 2006 and 2008 several key short and long term planning documents specified in a later section.

- Develop any necessary annual planning updates in 5 year strategic and 10 year Monitoring Plans.

Develop annual GCMRC resource requirement updates, including funding and staffing capabilities for changing AMWG needs.

- GCMRC will inform AMWG of staffing and resource requirements of newly assigned projects or programs that are additions to approved programs.

Need to Create Greater Effectiveness in Program Integration

GCMRC research and monitoring programs within the GCD AMP are designed to provide greater understanding of all resources in the Grand Canyon that are impacted by changing flow regimes. Determining hydrology impacts on individual elements of each resource, i.e., annual reproduction levels of humpback chub, is difficult in and of itself. However, due to integrated linked impacts of literally scores of sub-elements of each resource, the complexity of comprehensive science investigation becomes unwieldy.

Often one must understand these system linkages to properly evaluate cause and effect and advise managers of corrective courses of action. Past science reviews of the Center have proposed that an effort be undertaken to move to a new strategy of science inquiry, wherein flow effects on Colorado River Ecosystems are the basis for evaluation, rather than effects on individual resources.

GCMRC proposes a strategy to have the GCD AMP Science Advisors evaluate in 2005/2006 most appropriate opportunities for invoking integrated ecosystem science approaches into GCMRC's current science paradigm and invoke greater interdisciplinary approaches in FY 2007-2008 science programs. It is proposed that ecosystem science approaches will become more dominant in all program areas over the next five years. A charge will be given to the Science Advisors in October 2004 to complete the following task by December 2005.

- Evaluate opportunities for increased use of integrated ecosystem science paradigms within GCMRC research, development and monitoring programs. The assessment must evaluate effects on several criteria, the most important being improvements in information required by managers on canyon resources, and costs for implementing new ecosystem strategies.

The new GCMRC approach to program integration developed with assistance of the Science Advisors will incorporate methods for improved ecosystem sampling, data collection and data management procedures as well as new ecosystem designs for hypothesis testing. Also, it will include improved approaches for deriving ecosystem impact assessments instead of single resource assessments.

Need to Implement More Effective Research, Development, and Monitoring Programs

To ensure effective and efficient GCMRC research and monitoring programs requires implementation of the following three complex primary strategies, each of which require a series of sub-strategies:

- Gain continued effective knowledge of changing short and long-term needs of managers and stakeholders (AMWG).

- Develop integrated 5 year strategic and 2 year operational research, development and monitoring science plans, including specified resource requirements.

- Implement 2 year research, development and monitoring programs with effective outreach and education components for stakeholders.

Gaining effective knowledge of stakeholders changing needs will be accomplished through several strategies. In the past, several significant steps have been taken by GCMRC, AMWG and TWG to continually monitor stakeholders' needs as follows:

- 1995: Assessment of stakeholder issues, opportunities and concerns in the EIS process.

- 1998: During establishment of first GCMRC strategic plan, a detailed evaluation of stakeholder objectives and needs was developed with the Transition Work Group, prior to formation of the AMWG.

- 2000: A review and sequencing of stakeholder needs was accomplished cooperatively by the TWG and GCMRC.

- 2004: An AMWG workshop was developed to evaluate overall stakeholder need priorities in the GCD AMP. A review of stakeholder needs was conducted by GCMRC in development of the Core Monitoring Plan.

In these continuing efforts by GCMRC and AMWG to define stakeholder needs, key word descriptors of nine general areas of focus listed above in the science strategies section have been consistent across the decade. The nine areas are: threatened Fish, Cultural Resources, threatened and endangered species, sediment, vegetation, water, hydropower, recreation, and adaptive management process.

As noted in the above science strategies these general areas of research, development and monitoring, as stepped down in objectives and information needs, have been and continue to be prescribed by AMWG as the primary focus areas of GCMRC science efforts. However, increasing program complexity in each of these areas, with expanded information need assignments to GCMRC, are causing significant difficulties for sustained program accomplishment. Strategies as follows must be developed collaboratively by AMWG and GCMRC to resolve impacts of program expansion.

- A GCMRC biannual conference of science accomplishments (2006, 2008) and SCORE reports every fifth year will capture the status-of-knowledge and permit better definition of unresolved science needs.

- AMWG should develop a priority program needs list every two years, which will become the basis for GCMRC's 2 year operation plan.

Designing efficient and effective long term and short term science plans are paramount for specifying planning strategies. GCMRC strategies follow:

- Four science plans will be developed by GCMRC in collaboration with AMWG in FY 2005 and 2006; the Strategic Science Plan, Long Term Experimental Plan, Humpback Chub Comprehensive Plan, and Core Monitoring Plan.

- In FY 2005 AMWG/TWG will capture all development projects of management groups and stakeholders, and GCMRC will assist AMWG in preparing criteria and procedures to bring those projects fully into the GCD

AMP program. In FY 2005, GCMRC will finalize a test 2 year science plan (FY2006/2007).

- In FY 2006 GCMRC will develop procedures for the first "Two Year Comprehensive Science Work Plan" that contains all GCD AMP science programs i.e., all research, development and monitoring activities and all resource requirements.

Implementing science and management in the Comprehensive Science Plan for FY 2007/2008. This effort will require approval for the following sub-strategies by AMWG and GCMRC for FY 2005/2006.

- In FY 2005 AMWG approval of the following GCMRC Plans are necessary: Core Monitoring Plan (10 years) and Strategic Plan (5 years). Also, in FY 2005 the AMWG Ad Hoc committees draft HBC and draft LTEP plans must be approved by AMWG.

- In FYs 2005/2006 AMWG must approve a process to develop a "Two Year Comprehensive Science Work Plan" for FY 2007/2008, including all criteria and protocol for program and budget approvals.

- In FY 2006 AMWG must approve the following final GCMRC Collaborative Science Plans: "Long Term Experimental Plan" (LTEP) and "Two Year (FY 2007, 2008) Comprehensive Science Work Plan." AMWG must also approve revisions to the LTEP and CMP that directly address HBC research and development, and monitoring needs approved in the AMWG Ad Hoc draft HBC Plan.

- In FY 2005/2006 GCMRC will commission the Science Advisors to assist in development of a science integration strategy and strategy for effective status-of-knowledge assessments to support science implementation. AMWG's LTEP and HBC Ad Hoc Committees will develop reports of required actions by GCMRC, and GCMRC will develop the science basis for the Long Term Experimental Plan and incorporate HBC specified needs in both the LTEP and CMP.

- In FY 2007 GCMRC must implement the first GCMRC "Two Year Comprehensive Science Work Plan."

Need to Focus Knowledge Exchange on Stakeholder Information Needs

GCMRC has excellent capabilities in information gathering, management and dissemination. Our effort will become more focused to maximize effectiveness and impact.

GCMRC will continue strategies in 2005-2007 that streamline its knowledge dissemination to its primary stakeholders, the Adaptive Management Work Group**.**

- AMWG and TWG management information needs and priorities will be clearly identified for each science program activity.

- GCMRC planning (i.e., strategic, operational, study) documents will include a management summary statement that focuses on key management information sought, its relationship to information needs, and expected utility of results.

- Specific knowledge assessments will be developed (i.e., Conference proceedings, SCORE Report) with the intent of documenting both what we know and what we need to know to meet management needs.

- All research, development and monitoring reports will have a developed "Management Implications Section" that explicitly ties the science outcome to a management need.

- The GCMRC web site will create a separate page for ecosystem impact assessments that will be devoted to displaying annually updates to the status-of-knowledge as related to specified management needs.

- GCMRC has a commitment to the greater science community to continue publication of referred journal articles, USGS technical science reports and contributions to published proceedings. These outputs will continue to subscribe to the highest science standards.

Need to Include Management Development Activities in CRE

The GCD AMP program continues to change as more knowledge is gained. In this transition, managers are becoming more directly involved in development activities and application. Programmed effectively, these actions can result in accelerated learning in the adaptive management process. However, currently much of these activities are not captured in GCMRC's information development programs.

Scientists and managers must implement greater collaboration and cooperation to assure that both management action and learning advances together. In adaptive management programs, the requirements of research information can diminish as programs mature/advance. In this transition, more science efforts are devoted to monitoring and cooperative development programs with managers. In this process, management begins to implement more approaches that have been validated by science. This process is occurring in the GCD AMP, but protocols do not capture developed knowledge.

GCMRC research and monitoring programs will respond to increased development activities of managers by collaborating with AMWG and TWG on protocols and procedures for information retrieval. AMWG/TWG will document all development activities. GCMRC and AMWG will develop protocols for incorporating into GCD AMP all appropriate data from management directed development and short term monitoring programs.

Need for Improved Mechanisms for Funding, Staffing, and Administrative Support

GCMRC replaced the Glen Canyon Environmental Studies (GCES) program. During its existence, GCES was managed by the Upper Colorado Region BOR, and had variable staffing and annual budgets in the 1990's that exceeded $10 million dollars. Established in 1997, GCMRC was initially managed by the Assistant Secretary of Interior, and is now managed by the USGS Southwest Biological Science Center. It has had variable staffing and level to declining budgets of $ 6-$8 million dollars.

The status of the GCD AMP and the AMWG, a Secretary appointed Federal Advisory Committee, have been somewhat maintained over the tenure of GCMRC. However, GCMRC's position in DOI as a science center has been diminished, at least as regards position in DOI hierarchy.

GCMRC does not have either the appropriate staffing or budget to respond to the current specified information needs of the Adaptive Management Work Group. To resolve this incongruence will require that specific science management strategies be developed and followed by GCMRC in cooperation with AMWG over the next 5 years. Many have been introduced in the above sections. If effective, GCMRC feels the needs will be met by a much more efficient GCD AMP and GCMRC.

The following strategies in administrative management, staffing and funding are critical to attaining appropriate resolve.

Administrative Management Strategies will involve management review of all GCMRC programs by the Chief, program managers and staff by March 2006, as follows:

- Contrast all existing planned requirements of GCMRC from AMWG against its existing capabilities.
- Examine combinations of new proposed science and science management strategies that will improve effectiveness and efficiencies.
- Evaluate the effects (cost and benefits) of moving some GCMRC programs into cooperative agreements with other agencies. Also, evaluate benefits of incorporating more ecosystem science approaches. An overall program review to be completed by March 2006 will assist the Center in its efforts to develop a "Two Year Comprehensive Science Work Plan" for the FY 2007/2008 program years. However, it will not assist in resolving critical resource issues facing the Center in FY 2005.

In 2005, the Center will review several of its programs for cooperative programming with other agencies, outsourcing, to create greater overall program effectiveness. Some GCMRC programs could potentially realize improved coordination and effectiveness by working more closely with other science programs in other agencies. Such decisions and /or actions would not remove the current program or its requirements from the GCD AMP, but simply transfer its management oversight to another government entity. Also, some programs and or functions will be reviewed to determine if outsourcing will result in greater overall benefit to GCMRC and AMP. The Chief, program managers, and staff will first need to evaluate any impacts of change to overall program effectiveness before final recommendations are made to AMWG.

The intensive planning and design requirements for GCMRC in 2005/2006 will require GCMRC to access some specialists through short term contracts to insure timely accomplishments. For example fisheries and aquatic food base efforts in both native and non-native fishes require significant activities in FY 2005 to respond to program planning and operation needs.

New staffing strategies are needed for FY 2005 and the period FY 2006-2009. Selected immediate adjustments are necessary in staffing to accommodate intensive planning and assessment needs. A longer-term strategy is needed to accommodate potential program changes currently being evaluated in the new planning direction.

In FY 2005 the Center strategy is to utilize Science Advisors, external science organizations, and potential staff additions to provide critical needs in planning, reviews and program operations. Staffing support will be evaluated in the area of fisheries, aquatic ecology, and information technology.

Parallel to GCMRC's development of its FY 2007/2008 programs, the Center will develop a new staffing strategy. That strategy will strive to design future GCMRC science programs around a core of permanent program managers and scientists, with specialty science and support needs obtained through contracts, term appointments and cooperative agreements. The strategy is intended to provide greater operations effectiveness. It will be reflected in the FY 2007/2008 2 Year Comprehensive Science Plan.

GCMRC program funding problems, both in planning and project allocations, are having a highly negative impact on Center staff and programs. Several strategies are necessary to gain short and long-term improvements as follows:

- AMWG's Budget Ad Hoc Committee should host collaborative workshops with GCMRC in FY 2005 and 2006 to refine 2 year program and budget planning strategies, procedures, protocols etc. This would permit maximum understanding and efficiency in the budget process and permit opportunities for enhancing the GCD AMP budget.

- Cooperative fast track planning by TWG, GCMRC and AMWG is necessary for the FY 2006 programs and budget allocations, by focusing on only unresolved issues and programs, primarily in the area of research and development.

- GCMRC, TWG and AMWG will work collaboratively to develop a "Two Year Comprehensive Science Work Plan" and approved funding allocation for FY 2007/2008.

ACRONYMS

AMP - Adaptive Management Program (synonymous with the GCDAMP)

AMWG – Adaptive Management Work Group

CRE – Colorado River Ecosystem

GCD AMP – Glen Canyon Dam Management Program (synonymous with AMP)

GCMRC – Grand Canyon Monitoring and Research Center

IESP – Integrated Ecosystem Science Program

SCORE Report – State of the Colorado River Ecosystem Report

TWG – Technical Work Group (of the Adaptive Management Work Group)

USGS – United States Geological Survey