

# THE LAKE POWELL MONITORING AND RESEARCH PROGRAM

## FIVE-YEAR STRATEGIC PLAN

DRAFT

### INTRODUCTION

#### Goals and Objectives

The goal of this strategic plan is to establish a framework to develop and implement appropriate monitoring and research programs related to dam operations and their effects on various resources in Lake Powell. This plan will develop priorities and strategies for accomplishing this goal and determine appropriate responsibilities and assignments. An objective of this plan is to clearly articulate the relationship between the GCMRC monitoring program and other ongoing monitoring and research efforts by other agencies.

#### Background

The Grand Canyon Protection Act, Glen Canyon Environmental Impact Statement (EIS), and the resulting Record of Decision (ROD) specify the need to assure protection and enhancement of resources in the Glen Canyon National Recreation Area and the Grand Canyon National Park as related to operations of Glen Canyon Dam.

The stakeholder groups within the Adaptive Management Program (AMP) include managers and interested parties from various federal, state, and private organizations. These

groups identify the management objectives and information needs of the AMP. The Grand Canyon Monitoring and Research Center (GCMRC) formulates monitoring and research programs that best address stakeholder objectives and the specified information needs.

In fiscal year 1996, GCMRC lacked clear definition of its authority for continuing AMP-funded research programs in Lake Powell. The Transition Work Group accepted a proposal by GCMRC to conduct a six-month evaluation of Lake Powell long-term water quality data to determine if dam operations under the Record of Decision exhibited any impact on the physical, chemical, and biological resources of Lake Powell. The Transition Work Group reviewed and approved the GCMRC proposal to conduct the evaluation.

A draft of the Lake Powell impact assessment was completed and externally reviewed for validation. The findings were then presented to the AMWG at its first meeting on September 9-10, 1997. This research determined that dam operations specified under the ROD did produce impacts to physical, chemical and biotic resources in Lake Powell.

Based upon GCMRC findings of Lake Powell resource impacts resulting from operations of Glen Canyon Dam, the AMWG agreed to:

1. Continue the current GCMRC monitoring program for the period of October 1997 to October 1998.
2. Conduct additional assessment of existing data relating to Lake Powell and release water quality. This includes analysis of chemical and biological data that were not performed due to time and monetary constraints. A revised assessment will be completed in January 1998.
3. Review with the Technical Work Group, in January 1998, all existing knowledge related to the effects of Glen Canyon Dam operations on the water quality in Lake Powell and downstream releases.

4. Develop, with the Technical Work Group, objectives and information needs for any future Lake Powell water quality monitoring and research programs. This activity would occur in January to March 1998.
5. Develop for the Adaptive Management Work Group and Technical Work Group approval, a proposed monitoring and research plan for any specified future Lake Powell water quality monitoring programs. The draft plan would be produced by June 1, 1998.

Monitoring and research activities of the Center beyond October 1, 1998 (fiscal year 1999) would be based on review and approval of a Lake Powell Water Quality Monitoring and Research Plan. The Plan would be submitted to the Adaptive Management Work Group for approval in June 1998.

### Ongoing Lake Powell Monitoring and Research

In addition to the ongoing GCMRC Lake Powell Water Quality Monitoring Program, several other agencies conduct monitoring and research on a broad range of resource issues. These activities greatly exceed Lake Powell activities currently funded by the AMP (Table 1).

**Table 1.** Ongoing monitoring and research programs on Lake Powell

GCMRC	Effects of dam operations on water quality (Appendix B)
National Park Service	Bacterial water quality watershed studies
Bureau of Reclamation	Colorado Basin selenium studies Selective withdrawal feasibility Colorado R. water quality (salinity)
Utah Division of Wildlife Resources	Sport fishery monitoring, management, and research
USGS/BRD	Native fish research
San Juan Recovery Implementation Program	Endangered fish research
NPS/USGS	Side channel dynamics (proposed)

### **MANAGEMENT OBJECTIVES AND INFORMATION NEEDS**

The development of management objectives and information needs were structured to help guide design of monitoring and research programs for GCMRC for the period FY2000 to FY2004. In the July 1997 meeting of the Adaptive Management Work Group, the AMWG requested the Technical Work Group to proceed with evaluation and revision of Management

Objectives and Information Needs. The revision represents a concerted effort by the stakeholders to capture objectives as desired resource conditions sought by various stakeholders, and information needs as specific monitoring and science information necessary to assure that stakeholders can determine the condition of these resources, and how conditions are affected by management actions.

Because the AMWG had not formally approved a monitoring and research plan for Lake Powell, the objectives and information needs for Lake Powell were specified as separate and distinct from other AMP management objectives and information needs specified for resources below Glen Canyon Dam. These management objectives and information needs for Lake Powell were agreed upon by the TWG management objectives *ad hoc* group and are included in Appendix A.

An exercise to prioritize information needs was conducted by the TWG management objectives *ad hoc* group on April 23, 1998. The information needs for Lake Powell physical (IN 1.1) and biological (IN 1.2) limnology respectively received priority votes of 10 and 5 of the 14 voting members.

### **FIVE YEAR MONITORING AND RESEARCH PROGRAM**

The Lake Powell management objectives and research needs (Appendix A) can be addressed with a monitoring and research program of \$300,000 to \$500,000 per year in the five-year plan, if sufficient support can be provided from outside funding sources. Otherwise, an additional budget support of \$100-\$300,000 may be necessary each year from the AMP.

The following list of monitoring and research projects respond to all Lake Powell management objectives and information needs. A significant effort has been initiated by GCNRA to bring other funding support to the Lake Powell program. Much of that funding would in support studies to better understand impacts of dam operations to Lake Powell resources.

Most of the information needs for the Lake Powell Water Quality Management Objective MO1 (Appendix A) are addressed by the current GCMRC water quality monitoring program for Lake Powell (Appendix B). Information needs for the Lake Powell Aquatic Ecosystem Management Objective MO2 will be addressed by conceptual modeling efforts, future GCMRC research efforts, or monitoring and research conducted by other supporting agencies.

General Monitoring/ Research Area	Specific Monitoring or Research Program	Time Period
I. Water Quality	A. Evaluate impacts of dam operations on changes in temperature regimes in main channel of Lake Powell.	(M) FY99-04
	B. Evaluate impacts of dam operations on lake chemistry, and how chemocline structures set up and change through time. Monitor cations, anions, and nitrate/phosphate ratios.	(M) FY99-04
	C. Evaluate dam operation impacts to primary and secondary productivity including phytoplankton and zooplankton.	(M) FY99-04
	D. Computer simulation model study to model relative effects of dam operations and non-operational factors	(R) FY99-03

General Monitoring/ Research Area	Specific Monitoring or Research Program	Time Period
	E. Integration and validation of all available of all Lake Powell water quality data in GCMRC database management system (DBMS).	(R) FY99-02
	F. Assessment of Impacts of dam operations to physical, chemical and biological resources in lake side channels and embayments.	(R) FY00-03
II. Lake Powell Aquatic Ecosystem Assessments	A. Develop Conceptual Model to simulate interrelationship and impacts of dam operations on physical, chemical and biotic resources and other resources (fish, aquatic vegetation, habitat, etc.).	(R) FY99-02
	B. Synthesis of all historic science and monitoring information relating dam operations to resource change.	(R) FY99-03
	C. Determine linked impacts of changing temperature and chemical regimes due to dam operations on primary and secondary productivity and fish energy cycle.	(R) FY00-02
	D. Determine effects of physical, chemical and biological water quality changes due to dam operations on long-term fish populations.	(R) FY00-02
	E. Determine probable relationship of dam operations, selenium levels and lake primary productivity.	(R) FY01-02
	F. Determine effects of fluctuating lake levels from dam operations on aquatic factors and shoreline vegetation.	(R) FY02-04
	G. Determine effects of water temperature changes due to dam operations on recreation (swimming, sport fishing).	(R) FY02-04

## RESOURCE SUPPORT

The GCMRC Lake Powell program is proposed to be funded in FY2000 at \$325,000. It is assumed this funding level will be maintained through the five-year plan period from FY2000 to FY2004.

The annual costs to support research vessels, equipment, instrumentation, laboratory analysis, supplies, support staff, etc. and conduct the monthly and quarterly water quality monitoring program is approximately \$250,000. The \$75,000 annual remaining funds will be allocated to four areas over the next five years: science and data synthesis, conceptual modeling, aquatic ecosystem impact assessments, and fish impacts of dam operations.

When one adds research and monitoring costs in the above five areas over the five-year program period it is more than \$2,000,000, and only \$375,000 would be available from AMP under current funding proposals ( $\$75,000 \times 5 = \$375,000$ ). The following groups may provide additional funding:

A.	Western Region Biological Resource Division of USGS . . . . .	\$200K
B.	UCBOR Basinwide Water Quality Program (Trueman) . . . . .	\$200K
C.	USBOR Basinwide Selenium Program (Miller) . . . . .	\$150K
D.	UCBOR Selective Withdrawal Program . . . . .	\$300K
E.	Washington Office BOR Western Resource Initiation . . . . .	\$150K
F.	Utah Division of Wildlife and Fish (Gustaveson) Fishing Research . . . .	\$300K
G.	NPS/BRD T&E Fish Studies (Mueller, Gustaveson, Boobar) . . . . .	\$240K
H.	USGS/NPS Clean Water Initiative . . . . .	\$400K
I.	SJRIIP San Juan River Inflow Habitat Evaluation Study . . . . .	\$200K
		<u>\$2,140K</u>

The above outside funding will assist the GCMRC and GCNRA in understanding the impacts of Glen Canyon Dam operations on Lake Powell resources. Concern exists about the need to obtain over half of the required funding for Lake Powell from outside sources to understand dam impacts. It is not possible to delay many of the above projects through a ten year period and use savings to complete the evaluations, since no savings are expected from the current water quality program.

## APPENDIX A

### Lake Powell Management Objectives and Information Needs

Goal: To understand impacts of Dam operations and where possible minimize these impacts, consistent with other resource objectives.

Definition: The Lake Powell program includes natural, biological and cultural resources impacted by operation of Glen Canyon Dam.

The protocol for Lake Powell management objectives and information needs are related to upstream effects only. Downstream effects are included under other specific resource sections.

**MO 1: Lake Powell Water Quality** Prevent unacceptable effects on the water quality (physical, chemical, biological) of Lake Powell due to dam operations and ensure that fully informed AMWG decisions are possible both now and in the future.

#### Physical/Chemical (Limnology)

IN 1.1 Determine the effect of current dam operations on reservoir water quality, including but not limited to the following:

- a. Determine near-dam hydrogen sulfide levels (and other hazardous chemical constituents) within the hypolimnion occurring under current dam operating criteria.
- b. Determine the dynamics of lake stratification and advective flows and their effects on chemical constituents
- c. Determine/quantify the dynamics of major cations, anions, and nitrate/phosphate ratios resulting from dam operations
- d. Determine the effects of dam operations on the physical/chemical dynamics of Lake Powell side channels and embayments
- e. Quantify/model the heat budget for Lake Powell to determine near-term and long-term (monthly/weekly and annual summaries respectively) effects of a selective withdrawal system.
- f. Determine the effect of current dam operations on reservoir levels of selenium.

## **Biological (Limnology)**

IN 1.2 Determine the impacts of dam operations and resulting water quality on primary and secondary productivity of Lake Powell, including:

- a. algae (phytoplankton, periphyton)
- b. macrophytes
- c. zooplankton
- d. macro invertebrates

IN 1.3 Describe and quantify the effects of elevated levels of selenium on the primary productivity of Lake Powell

**MO 2: Lake Powell Aquatic Ecosystem (Fishery)** Protect Lake Powell aquatic ecosystem from unacceptable impacts due to dam operations and subsequent effects, including but not limited to: temperature, reservoir surface elevations, elevated selenium levels, advective flow patterns, predator/prey relationships, and fish movements.

IN 2.1 Determine the effects of water temperature caused by dam operations

IN 2.2 Determine the effects of fluctuations in the reservoir surface elevations caused by dam operations

IN 2.3 Determine the effects of elevated selenium levels caused by dam operations

IN 2.4 Determine the effects of advective flow patterns on Lake Powell aquatic ecosystem caused by dam operations

IN 2.5 Determine the effects of predator/prey relationships caused by dam operations

IN 2.6 Determine the effects of fish movements caused by dam operations

## APPENDIX B

### GCMRC Lake Powell Water Quality Monitoring Program

The current Lake Powell Water Quality Monitoring Program is linked closely with other water quality monitoring programs below Glen Canyon Dam, which addresses other downstream management objectives. The Lake Powell program consists of **monthly surveys of the forebay** above Glen Canyon Dam and **quarterly surveys of the entire reservoir**. The objective of the program is to characterize the chemical and physical parameters of the water in Lake Powell to determine the effects of Glen Canyon Dam operation and separate these effects from other natural processes affecting reservoir water quality. This program is linked to a long-term record of similar measurements collected by the Bureau of Reclamation and Glen Canyon Environmental Studies since 1965 which describes the entire history of Lake Powell since its impoundment by Glen Canyon Dam.

Pending formal approval by the Adaptive Management Work Group, this program represents an ongoing water quality monitoring effort by GCMRC that would remain in place throughout the five-year period of this work plan.

Monitoring activities are designed to meet the stated information needs of Management Objective 1 for Lake Powell Water Quality:

**MO 1: Lake Powell Water Quality** Prevent unacceptable effects on the water quality (physical, chemical, biological) of Lake Powell due to dam operations and ensure that fully informed AMWG decisions are possible both now and in the future.

Field activities include collecting a profile of measurements throughout the water column at each station for temperature, specific conductance (an indirect measure of salinity), pH, dissolved oxygen, turbidity, and oxidation-reduction potential. This profile describes the degree of stratification or mixing and the range of temperature, salinity, and dissolved oxygen concentrations at a particular station. This information is used to describe the behavior and fate of inflow currents, advective and convective mixing processes, and the effect of Glen Canyon Dam withdrawal currents under different operational scenarios. It is also used to characterize the overall quality of the reservoir as well as that of the major strata within the reservoir. For example, monitoring of dissolved oxygen levels in the deepest stratum of the reservoir, or hypolimnion, can be used to predict when significant levels of hydrogen sulfide could occur.

In addition to the profile of physical and chemical characteristics, several samples may be collected at a station for further chemical analysis. Analysis of major cation and anion concentration is performed to quantify the individual components of salinity and to identify the origin of a parcel of water to further understand reservoir hydrodynamics. Analysis of nutrient compounds of phosphorus and nitrogen is also performed to determine the level of primary

productivity that the reservoir can support and describe nutrient levels in reservoir releases or zones of potential release.

Quarterly lake-wide surveys include the major tributary arms of the Colorado, San Juan, and Escalante Rivers. Occasional sampling is done in mid-Navajo Canyon because of its potential for frequent hypolimnetic hypoxia. Other work on Lake Powell side channels and embayments has not been part of past programs but could be included in future work. An assessment of the potential effects of dam operations to the water quality of side channels and embayments should be conducted before establishing a long-term monitoring program. A study by the USGS for this work has been proposed by the GCNRA with external funding.

Heat budget quantification of modeling has been performed to a limited degree by the Upper Colorado Region of the Bureau of Reclamation as part of preliminary studies for selective withdrawal feasibility. The extent of this modeling has been to determine the effects over a two-year period of selective withdrawal. A more elaborate approach to reservoir modeling is needed to determine heat budget effects over a longer period and to help quantify the relative effects of dam operations and those of other hydrodynamic, hydrologic, and climatologic processes. This modeling effort could be very valuable to test the effects of various operational scenarios on short and long-term water quality conditions in Lake Powell.

Biological sampling is performed routinely as a component of the current Lake Powell Water Quality Monitoring Program. Several analyses are performed at the forebay and other selected stations on the reservoir. Chlorophyll concentrations are measured at the reservoir surface to describe the overall levels of primary productivity from photosynthesizing plankton. Discrete samples are taken near the surface for analysis of phytoplankton concentration and community structure. Composite samples are collected by vertical tows through the water column for analysis of zooplankton concentration and community structure. This information is used to describe long-term and seasonal changes in primary and secondary productivity and describe the type and amount of these organisms in Glen Canyon Dam releases. No work is currently being performed on macrophytes, periphytes, or macro-invertebrates. Evaluation of these shallow-water organisms is more appropriately addressed with a side channel and embayment water quality assessment.

No work is currently being performed by GCMRC to determine levels of selenium in reservoir water, sediment, or biota. Work is planned, however, on a Colorado River basin-wide selenium study to be performed by the Upper Colorado Region of the Bureau of Reclamation. It is expected that Lake Powell selenium issues will be addressed in this study and that it will be linked with the existing Lake Powell Water Quality Monitoring Program.

A final component of the Lake Powell Water Quality Monitoring Program is the development of a database management system for water quality information. This project supports the Lake Powell water quality management objective and addresses the GCMRC

objective of establishing a comprehensive information technology program. This system will be directly linked with other hydrologic and water quality databases and will be available by means of direct access and data warehousing products by various means including World Wide Web access. Its development has been ongoing and is being enhanced as other information technology programs progress.

Costs associated with this program include operating and maintenance for the sampling vessel, maintenance and repair of instrumentation and other equipment, analysis of chemical and biological samples, and travel and salary costs for personnel. The vessel from which the majority of sampling is performed is a 31-foot Uniflite Sedan, which has been in use on Lake Powell for water quality sampling and other activities since 1970. The primary instrument for collecting water quality profiles is a Hydrolab H20/Surveyor 3. Chemical analyses of water samples is currently being performed by Reclamation's Water and Soil Laboratory in Denver, CO. Chlorophyll is analyzed by Reclamation's Boulder City water quality lab. A crew of 4-6 people is commonly used for quarterly reservoir surveys, comprising two GCMRC staff limnologists, an employee from Reclamation's Upper Colorado Region, an employee of the Glen Canyon National Recreation Area, and other ancillary personnel as needed.