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RECLAMATION
Managing Water in the West

Prepared in cooperation with the Glen Canyon Dam Adaptive Management Program

Glen Canyon Dam Adaptive Management Program Biennial Budget and Work Plan—Fiscal Years 2010-11

Prepared by
Bureau of Reclamation
Upper Colorado Regional Office
and
U.S. Geological Survey
Grand Canyon Monitoring and Research Center

Planning Document

U.S. Department of the Interior
U.S. Geological Survey

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Bureau of Reclamation
Upper Colorado Regional Office
Salt Lake City, Utah

and

U.S. Geological Survey
Southwest Biological Science Center
Grand Canyon Monitoring and Research Center
Flagstaff, Arizona

Approved by the Secretary of the Interior on
August 13, 2009

U.S. Department of the Interior
U.S. Geological Survey

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Preface

This document was prepared by the Bureau of Reclamation's Upper Colorado Regional Office and the U.S. Geological Survey's Grand Canyon Monitoring and Research Center (GCMRC) in cooperation with members of the Glen Canyon Dam Adaptive Management Program's Adaptive Management Work Group (AMWG) and Technical Work Group. On August 13, 2009, the AMWG met and recommended that the Secretary of the Interior adopt the work plan, budget and hydrograph presented in the following pages with two amendments:

- The AMWG recommends to the Secretary of the Interior that Reclamation report on the status of the TCD and Sediment Augmentation projects to the TWG. The TWG will make a recommendation to the AMWG for consideration at the spring 2010 AMWG meeting.
- AMWG recommends that the Secretary of the Interior conduct meaningful consultation with the participating tribal stakeholders regarding the non-native fish control (i.e., mechanical removal efforts) portion of the 2010-2011 budget and work plan including an examination and evaluation of different locations for carrying out the mechanical removal and a compelling presentation of the scientific data. AMWG further recommends that the results of the consultation be reported to the AMWG.

On November 16, 2009, the Secretary of the Interior accepted the AMWG's recommendation including the two amendments and adopted the Fiscal Year (FY) 2010-11 work plan, budget and hydrograph (as amended). Prior to implementation of the work plan, there will be an evaluation of the need for additional compliance with existing laws and government-to-government consultation with Native American tribes with traditional ties to the Grand Canyon. Appropriate actions to fulfill necessary compliance obligations will be taken by the responsible action agency.

The majority of the funding used to implement this work plan comes from power revenues. This funding is annually adjusted to reflect inflation using the consumer price index (CPI). This budget assumed a 0 percent CPI for FY 2010. However, the actual CPI for FY 2009 was reported at -1.3 percent. Reclamation and GCMRC will adjust the budget presented here to account for this change; these adjustments will be documented in an addendum available later in the fiscal year.

U.S. Geological Survey
Grand Canyon Monitoring and Research Center
November 18, 2009

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Chapter 1. Bureau of Reclamation, Upper Colorado Region Biennial Budget and Work Plan—Fiscal Years 2010–11

Introduction

The Glen Canyon Dam Adaptive Management Program (GCDAMP) is a science-based process for continually improving management practices related to the operation of Glen Canyon Dam (GCD) by emphasizing learning through monitoring, research, and experimentation. The Bureau of Reclamation's (Reclamation) Upper Colorado Region (BRUC) is responsible for administering funds for the GCDAMP and providing those funds for monitoring, research, and stakeholder involvement. The majority of program funding is derived from hydropower revenues; however, supplemental funding is provided by various Department of the Interior (DOI) agencies that receive appropriations. These agencies include Reclamation, the U.S. Geological Survey (USGS), the National Park Service (NPS), the U.S. Fish and Wildlife Service (USFWS), and the Bureau of Indian Affairs (BIA).

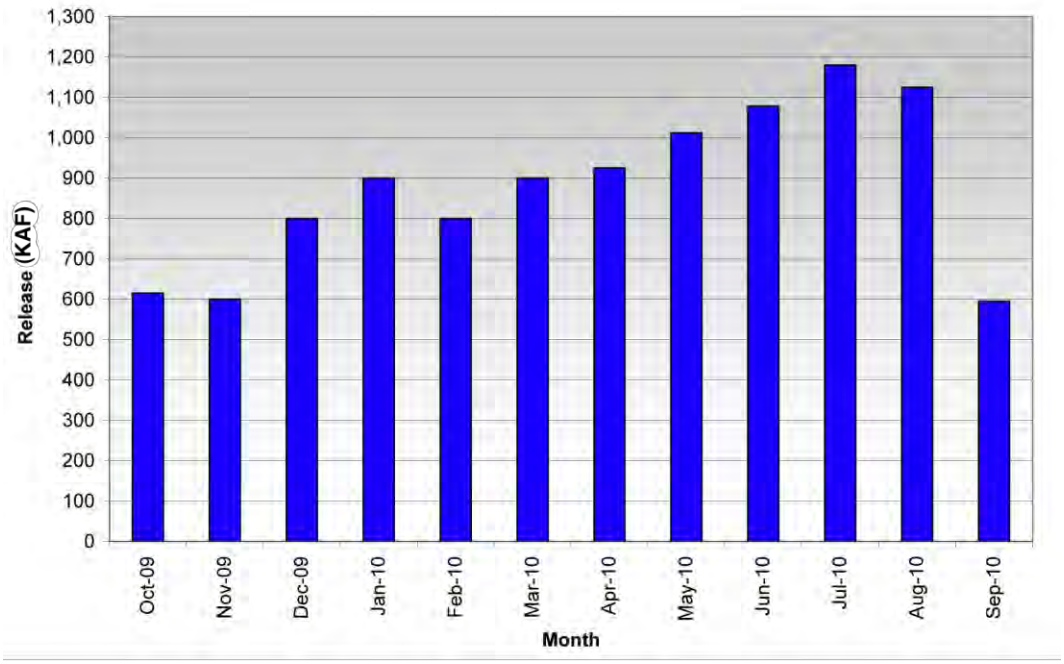
The budget and work plan for fiscal years (FY) 2010–11 was developed on the basis of previous budgets and work plans, the Grand Canyon Monitoring and Research Center (GCMRC) Strategic Plan, and the GCMRC Monitoring and Research Plan—all of which have been approved by the Adaptive Management Work Group (AMWG). In FY2010–11, additional consideration was given to meeting the commitments outlined in the conservation measures sections of two biological opinions issued by the USFWS: (1) the *2007 Biological Opinion for the Proposed Adoption of Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* (known as the shortage criteria biological opinion) and (2) the *2008 Final Biological Opinion for the Operation of Glen Canyon Dam*.

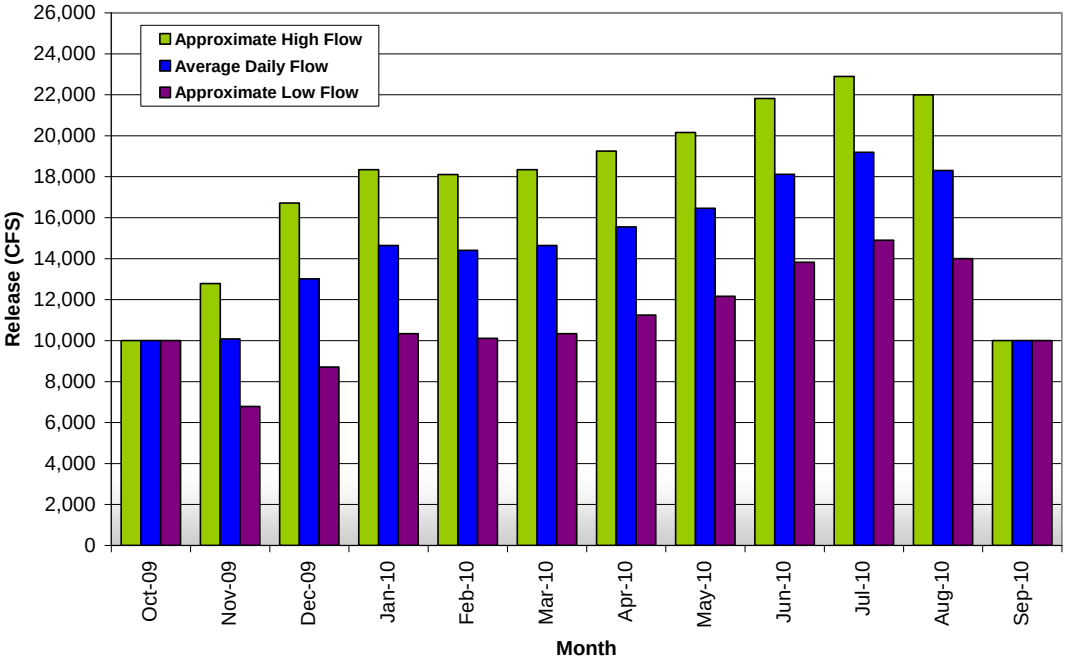
The process used to arrive at the FY2010–11 budget and work plan was adopted by the AMWG in 2004. In summary, the Budget Ad Hoc Group (BAHG) of the Technical Work Group (TWG), with input from the Cultural Resources Ad Hoc Group (CRAHG), worked with the BRUC and the GCMRC to develop a proposal for the TWG. The TWG then reviews the proposed budget and work plan and develops a recommendation to the AMWG (this document).

The projected hydrograph for Lake Powell release (fig. 1) for water year (WY) 2010 is based on forecasted inflows to Lake Powell and GCD releases determined by the 1996 Record of Decision on the operation of Glen Canyon Dam, the 2007 Record of Decision on interim guidelines for coordinated operation of Lake Mead and Lake Powell, and the 2008 Finding of No Significant Impact on the environmental assessment of experimental releases for the period 2008–12. It also observes commitments made in the 2007 and 2008 biological opinions. The projected hydrograph is based on best estimates available from Reclamation's 24-month study released in June 2008; however, the forecast is subject to change as further data becomes available.

This document consists of two chapters: chapter 1, the BRUC budget and work plan, and chapter 2, the GCMRC budget and work plan. A comprehensive budget spreadsheet is provided in Appendix E.

Figure 1. (Top) Proposed water year (WY) 2010 Lake Powell monthly release volumes (kaf) under most probable conditions; (Bottom) Proposed WY 2010 Lake Powell high, average daily, and low releases (cfs) under most probable conditions. Source: Upper Colorado Region, Bureau of Reclamation, June 3, 2009 (subject to revision).





A.1. Personnel Costs

General Project Description

This project represents Reclamation staff costs to perform the daily activities required to support the AMWG. The work includes completing assignments resulting from AMWG meetings, consulting with stakeholders on a variety of GCDAMP issues relating to the operation of GCD, disseminating pertinent information to the AMWG, preparing and tracking budget expenses, and updating Reclamation's Web page. Reclamation also responds to regular requests from the General Services Administration (GSA) to complete Federal Advisory Committee Act (FACA) reports and incorporate meeting and member information into the FACA database. Reclamation is now required to complete all stakeholder travel, activities that range from preparing travel authorizations to completing travel vouchers. Additionally, Upper Colorado Region staff must provide documentation related to litigation involving the Department of the Interior's operation of Glen Canyon Dam to various solicitors; these efforts often require many hours of work not programmed into the fiscal year budget(s).

Project Goals and Objectives

The primary goal is to perform all work associated with the AMWG in a timely and efficient manner, while using the funds available as prudently as possible. Secondary goals include increasing each stakeholder's awareness of significant budget and legislative issues related to the GCDAMP, improving working relationships with the AMWG members/alternates, finding constructive ways to resolve differences, and addressing individual concerns in an open and accepting forum of discussion.

Expected Results

Personnel costs will not exceed what has been proposed in the budget unless Federal employee salaries are increased above the consumer price index (CPI). Reclamation staff will provide budget information to the AMWG on a regular basis. Completed work products will be of high quality and promptly distributed to AMWG members/alternates and interested parties. Budget reports will be presented in a format conducive to AMWG needs.

Budget

FY2010 = $176,747 FY2011 = $182,049

Reclamation Project A.1. Personnel Costs—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	116,375	119,866	123,223	132,892	132,892	136,879
Subtotal	116,375	119,866	123,223	132,892	132,892	136,879
DOI Customer burden (33% for FY09 and FY10)	40,043	34,762	35,735	43,855	43,855	45,170
Project total	159,418	154,628	158,958	176,747	176,747	182,049
Total outsourced (%)						

A.2. AMWG Member Travel Reimbursement

General Project Description

This project covers the costs to reimburse AMWG members or alternates to attend regularly scheduled AMWG meetings.

Project Goals and Objectives

Reimbursing AMWG members or alternates for travel expenses is done to encourage their attendance at all meetings. Many members live outside of Phoenix, Ariz., where meetings are often held. As a result, many members must incur travel costs. Having Reclamation provide reimbursement to AMWG members or alternates for air travel or mileage for the use of private vehicles, as well as other related travel costs such as hotel, per diem, and rental car increases opportunities for members to participate in a variety of AMWG assignments. Because Reclamation can purchase airline tickets at the Federal Government rate, there are additional cost savings to the program.

Expected Results

The GCDAMP benefits from having all AMWG members participating in regularly scheduled meetings. As a collective body, they address and resolve concerns associated with the operation of GCD and make recommendations to the Secretary of the Interior for continued science efforts performed below the GCD.

Budget

FY2010 = $17,467 FY2011 = $17,991

Reclamation Project A.2. AMWG Travel Reimbursement—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	15,725	16,197	16,651	17,467	17,467	17,991
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	15,725	16,197	16,651	17,467	17,467	17,991
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	15,725	16,197	16,651	17,467	17,467	17,991
Total outsourced (%)	—	—	—	—	—	—

A.3. Reclamation Travel

General Project Description

This project supports travel expenses Reclamation staff incur to attend AMWG and ad hoc group meetings. In order to work on AMWG/ad hoc assignments, the meetings are often held in Phoenix, Ariz. As such, Reclamation staff must make additional trips throughout the year in completion of those assignments.

Project Goals and Objectives

The primary goal is for Reclamation staff to be able to travel to meetings and participate in completing AMWG/TWG assignments. By doing so, the program benefits from greater interaction among its members as well as continued improvement and commitment to operating GCD in the best manner possible and obtaining the results from science being conducted in the study area.

Expected Results

Reclamation staff will be involved with AMWG/TWG members in completing work assignments and resolving issues that affect the GCDAMP. They will develop better working relationships with all involved and work toward consensus on a variety of sensitive issues.

Budget

FY2010 = $14,178 FY2011 = $14,873

Reclamation Project A.3. Reclamation Travel—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	13,000	13,390	13,765	14,439	14,439	14,873
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	13,000	13,390	13,765	14,178	14,178	14,873
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	13,000	13,390	13,765	14,178	14,178	14,873
Total outsourced (%)	—	—	—	—	—	—

A.4. Facilitation Contract

General Project Description

This project supports a facilitator who is under contract to Reclamation to provide facilitations services for AMWG meetings. This person may also assist AMWG ad hoc groups in completing assignments.

Project Goals and Objectives

The facilitator's primary responsibility is to keep the AMWG meetings organized and help the members reach consensus on important issues. The facilitator creates a setting that allows all members and the public to express their views.

Expected Results

The facilitator will create an atmosphere in which the members and other participants at AMWG meetings feel comfortable expressing their individual viewpoints. The facilitator will help bring the AMWG members to consensus on pertinent issues affecting the GCDAMP when possible.

Budget

FY2010 = $26,959 FY2011 = $27,768

Reclamation Project A.4. Facilitation Contract—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	25,000	25,000	25,700	26,959	26,959	27,768
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	25,000	25,000	25,700	26,959	26,959	27,768
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	25,000	25,000	25,700	26,959	26,959	27,768
Total outsourced (%)	—	—	—	—	—	—

A.5. Public Outreach

General Project Description

This project covers the expenses for Reclamation staff and the Public Outreach Ad Hoc Group (POAHG) to develop materials for the GCDAMP public outreach efforts.

Project Goals and Objectives

Reclamation public affairs staff and the POAHG will work jointly in developing materials to inform and educate the public on the goals and administration of the GCDAMP. They will keep other GCDAMP members advised of progress and expenditures.

Expected Results

Products will include fact sheets, Web site information, tribal outreach materials, video B-roll, special events, conference participation, and other pertinent means of advising the public and program members on the achievements of the GCDAMP. The POAHG will maintain accurate records of payments made against the contracts and will keep Reclamation staff informed of discrepancies or concerns.

Budget

FY2010 = $ 55,536 FY2011 = $57,202

Reclamation Project A.5. Public Outreach—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training				2,000	2,000	2,000
Operations/supplies	—	—	—	—	2,500	2,500
Reclamation salaries	50,000	51,500	41,040	38,846	36,346	38,509
Subtotal	50,000	51,500	41,040	40,846	40,846	43,009
DOI Customer burden (33% for FY09 and FY10)			11,902	13,684	13,684	14,193
Project total	50,000	51,500	52,942	55,536	55,536	57,202
Total outsourced (%)	—	—	—	—	—	—

A.6. Other

General Project Description

This project represents some of the other "miscellaneous" expenses incurred in operation of the AMWG, including the following expenses:

- Overnight mailings of AMWG meeting packets
- Copying of reports
- Purchasing meeting materials (cassette tapes, markers, paper, software upgrades for GCDAMP Web site posting, etc.)
- Purchasing equipment (audio recording/transcribing machines)

In addition to the expenses noted above, training courses are often required for staff to keep current on environmental issues, FACA changes, computer technology improvements, etc. Also included in this category are monetary awards given to Reclamation staff who have contributed significantly to the success of the GCDAMP.

Project Goals and Objectives

The primary goal is to limit spending on "other" items as much as possible. By doing so, more money can be applied to science and research.

Expected Results

Other expenses will be kept to a minimum in an effort to reduce the administrative portion of the GCDAMP budget.

Budget

FY2010 = $7,969 FY2011 = $8,208

Reclamation Project A.6. Other—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	5,000	5,390	5,597	5,969	5,969	6,208
Operations/supplies	2,175	2,000	2,000	2,000	2,000	2,000
Reclamation salaries	—	—	—	—	—	—
Subtotal	7,175	7,390	7,597	7,969	7,969	8,208
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	7,175	7,390	7,597	7,969	7,969	8,208
Total outsourced (%)	—	—	—	—	—	—

B.1. Personnel Costs

General Project Description

This project represents Reclamation staff costs to perform the daily activities required to support the TWG, a subgroup of the AMWG. The work includes completing assignments resulting from TWG meetings, consulting with stakeholders on a variety of GCDAMP issues relating to the operation of GCD, disseminating pertinent information to TWG members, preparing and tracking budget expenses, and updating the Web pages Reclamation maintains for the program. Reclamation also completes all stakeholder travel activities, which range from preparing travel authorizations to completing travel vouchers.

Project Goals and Objectives

This project represents Reclamation staff costs to perform the daily activities required to support the TWG. The work includes completing assignments resulting from AMWG or TWG meetings, consulting with stakeholders on a variety of GCDAMP issues relating to the operation of GCD, disseminating pertinent information to TWG members, preparing and tracking budget expenses, and updating the Web pages Reclamation maintains for the program.

Expected Results

Personnel costs will not exceed what has been proposed in the budget unless Federal employee salaries are increased above the CPI. Reclamation staff will provide budget information to the TWG on a regular basis. Completed work products will be promptly distributed to TWG members/alternates and interested parties.

Budget

FY2010 = $86,195 FY2011 = $88,780

Reclamation Project B.1. Personnel Costs—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	53,178	54,773	56,306	64,808	64,808	66,752
Subtotal	53,178	54,773	56,306	64,808	64,808	66,752
DOI Customer burden (33% for FY09 and FY10)	19,669	15,884	16,329	21,387	21,387	22,028
Project total	72,847	70,657	72,635	86,195	86,195	88,780
Total outsourced (%)	—	—	—	—	—	—

B.2. TWG Member Travel Reimbursement

General Project Description

This project provides funds to reimburse TWG members or alternates for expenses incurred to attend regularly scheduled TWG meetings.

Project Goals and Objectives

Reimbursing TWG members or alternates for travel expenses is done to encourage their attendance at all meetings. Many members live outside of Phoenix, Ariz., where meetings are often held. As a result, many members must incur travel costs. Having Reclamation provide reimbursement to TWG members or alternates for air travel or mileage for the use of private vehicles, as well as other related travel costs such as hotel, per diem, and rental car increases opportunities for members to participate in a variety of TWG assignments. Because Reclamation can purchase airline tickets at the Federal Government rate, there are additional cost savings to the program.

Expected Results

The GCDAMP will benefit from having all the TWG members participate in regularly scheduled meetings. As a collective body, TWG members address and resolve concerns associated with the operation of GCD and make recommendations to the AMWG for continued research.

Budget

FY2010 = $23,952 FY2011 = $24,670

Reclamation Project B.2. TWG Member Travel Reimbursement—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	20,836	22,211	22,833	23,952	23,952	24,670
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	20,836	22,211	22,833	23,952	23,952	24,670
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	20,836	22,211	22,833	23,952	23,952	24,670
Total outsourced (%)	—	—	—	—	—	—

B.3. Reclamation Travel

General Project Description

This project covers travel expenses that Reclamation staff will incur to prepare for and attend TWG meetings and ad hoc group meetings resulting from AMWG/TWG assignments. Meetings needed to advance AMWG/TWG efforts are often held in Phoenix, Ariz., because it is centrally located to those entities/States represented on the AMWG/TWG. As a result, Reclamation staff who are not located in Phoenix are required to make additional trips throughout the year in completion of AMWG/TWG assignments.

Project Goals and Objectives

The primary goal is for Reclamation staff to be able to travel to meetings and participate in completing AMWG/TWG assignments. By doing so, the program benefits from greater interaction among its members as well as continued improvement and commitment to operating GCD in the best manner possible and for obtaining the necessary results from science being conducted in the study area.

Expected Results

Reclamation staff will continue to be involved in meeting with AMWG/TWG members to complete work assignments and resolve issues that affect the operation of GCD. They will develop better working relationships with all involved and work toward consensus on a variety of GCDAMP issues.

Budget

FY2010 = $17,658 FY2011 = $18,188

Reclamation Project B.3. Reclamation Travel—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	15,898	16,375	16,834	17,658	17,658	18,188
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	15,898	16,375	16,834	17,658	17,658	18,188
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	15,898	16,375	16,834	17,658	17,658	18,188
Total outsourced (%)	—	—	—	—	—	—

B.4. TWG Chair Reimbursement

General Project Description

This project supports a person who is under contract to Reclamation to serve as the chairperson for TWG meetings. This person may also assist AMWG/TWG ad hoc groups in completing assignments.

Project Goals and Objectives

The chairperson's primary responsibility is to conduct regularly scheduled TWG meetings. The chairperson also participates in ad hoc group assignments and works closely with Reclamation and GCMRC staff in setting meeting agendas. The chairperson follows up on TWG and ad hoc group assignments and ensures that information is shared with the members and alternates in a timely manner.

Expected Results

The chairperson creates an atmosphere in which the members and other participants at TWG meetings feel comfortable expressing their individual viewpoints. The chairperson will bring the TWG members to consensus on sensitive issues with the ultimate goal of making recommendations to the AMWG that incorporate the best scientific information available to the GCDAMP. The chairperson will follow up on action items and make assignments as necessary to accomplish TWG objectives.

Budget

FY2010 = $24,625 FY2011 = $25,363

Reclamation Project B.4. TWG Chair Reimbursement—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	22,171	22,836	23,474	24,625	24,625	25,363
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	22,171	22,836	23,474	24,625	24,625	25,363
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	22,171	22,836	23,474	24,625	24,625	25,363
Total outsourced (%)	—	—	—	—	—	—

B.5. Other

General Project Description

This project represents some of the other "miscellaneous" expenses incurred in support of the TWG, including the following expenses:

- Overnight mailings of TWG meeting packets
- Copying of reports
- Purchasing meeting materials (cassette tapes, markers, paper, etc.)
- Purchasing equipment (audio recording/transcribing machines)

Project Goals and Objectives

The primary goal is to limit spending on "other" items as much as possible. By doing so, more money can be spent on science and research.

Expected Results

Other expenses will be kept to a minimum in an effort to keep within the GCDAMP budget.

Budget

FY2010 = $2,277 FY2011 = $2,345

Reclamation Project B.5. Other—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	2,050	2,112	2,171	2,277	2,277	2,345
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	2,050	2,112	2,171	2,277	2,277	2,345
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	2,050	2,112	2,171	2,277	2,277	2,345
Total outsourced (%)	—	—	—	—	—	—

C.1. Compliance Documents

General Project Description

This project covers the costs for preparing documents for GCDAMP-proposed actions required to comply with the Endangered Species Act (ESA), National Environmental Policy Act (NEPA), and National Historic Preservation Act (NHPA). In FY2010–11 these funds will be carried forward for anticipated use in 2012, unless the Secretary of the Interior agrees to a recommendation for a large-scale experiment.

Project Goals and Objectives

Reclamation staff will keep informed on changes to the ESA, NEPA, and NHPA and will consult with AMWG stakeholders to ensure appropriate compliance is undertaken for actions taken in support of the GCDAMP.

Expected Results

Reclamation staff will be involved in all compliance issues related to the GCDAMP, using travel expenses to meet with the GCDAMP stakeholders to resolve any differences.

Budget

FY2010 = $50,000 FY2011 = $51,500

Reclamation Project C.1. Compliance Documents—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	22,450	263,622	210,080	37,594	37,594	38,722
Subtotal			60,923	37,594	37,594	38,722
DOI Customer burden (33% for FY09 and FY10)				12,406	12,406	12,778
Project total	22,450	263,622	271,003	50,000	50,000	51,500
Total outsourced (%)	—	—	—	—	—	—

C.2. Administrative Support for NPS Permitting

General Project Description

This project provides funding to support the Grand Canyon National Park permitting of research and monitoring projects conducted under the GCDAMP. Grand Canyon National Park employs a permitting specialist and staff who review all proposals for projects to be completed in the park under the auspices of the GCDAMP. The program provides these funds to offset the park's administrative burden in providing these services.

Project Goals and Objectives

The primary goal is to ensure that projects conducted under the GCDAMP are reviewed and permitted by the NPS.

Expected Results

Projects conducted under the GCDAMP will receive permits from the NPS in a timely manner.

Budget

FY2010 = $118,852 FY2011 = $122,417

Reclamation Project C.2. Administrative Support for NPS Permitting—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	100,000	110,000	113,300	118,852	118,852	122,417
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	100,000	110,000	113,300	118,852	118,852	122,417
Total outsourced (%)	—	—	—	—	—	—

C.3. Contract Administration

General Project Description

This project covers the expenses for Reclamation staff to prepare and monitor contracts associated with the GCDAMP. Specifically, these contracts are for AMWG facilitation, TWG chairperson reimbursement, Tribal participation, and programmatic agreement (PA) work.

Project Goals and Objectives

Reclamation contract specialists will accurately apply funds spent on individual contracts to ensure costs do not exceed contract limits. They will keep other Reclamation staff informed as to those charges so accurate reporting can be made to both AMWG and TWG members.

Expected Results

Contract specialists will ensure that individual contractors are fulfilling the requirements of their contracts. They will maintain accurate records of payments made against the contracts and will keep Reclamation staff informed of discrepancies or concerns. Work will be completed on time and within the limits of the contract.

Budget

FY2010 = $39,953 FY2011 = $41,152

Reclamation Project C.3. Contract Administration—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	24,394	32,413	25,830	30,040	30,040	30,941
Subtotal	24,394	32,413	25,830	30,040	30,040	30,941
DOI Customer burden (33% for FY09 and FY10)			7,491	9,913	9,913	10,211
Project total	24,394	32,413	33,321	39,953	39,953	41,152
Total outsourced (%)	—	—	—	—	—	—

C.4. Experimental Carryover Funds

General Project Description

This budget item reserves funds for conducting experiments under the GCDAMP. Given previous experience, the estimated cost of large-scale experiment, or high-flow experiment (HFE), is approximately $1.5 million. This amount will be reserved over the course of several years to minimize the budgetary impacts of conducting a large-scale experiment on any individual annual budget.

Project Goals and Objectives

See above.

Expected Results

The funds will be available to conduct a large-scale experiment when conditions are appropriate.

Budget

FY2010 = $500,000 FY2011 = $515,000

Reclamation Project C.4. Experimental Carryover Funds—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	424,675	500,000	500,000	500,000	500,000	515,000
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	424,675	500,000	500,000	500,000	500,000	515,000
Total outsourced (%)	—	—	—	—	—	—

C.5. Integrated Tribal Resources Monitoring

General Project Description

This budget item provides funds to identify traditional cultural properties (TCPs) and implement Native American monitoring protocols that were developed in FY2007 and recommended by the TWG as part of efforts to develop a core-monitoring program.

In addition, the five GCDAMP Tribes (Hopi Tribe, Hualapai Tribe, Kaibab-Paiute Tribe, Pueblo of Zuni, Navajo Nation) will work with Reclamation and the NPS to implement monitoring of historic properties in Glen and Grand Canyons. This will be accomplished by adding an additional 3 days to the annual GCDAMP monitoring trips.

Project Goals and Objectives

The primary goal of this activity is to evaluate the effects of dam operations and other actions under the authority of the Secretary of the Interior on resources of value to Native American Tribes. A secondary goal is to conduct condition monitoring of historic properties to assist Reclamation in compliance with Section 106 of the National Historic Preservation Act.

Expected Results

Annual reports will be prepared detailing activities, findings, and monitoring data that result from implementing core-monitoring protocols for historic properties. Condition monitoring data will be provided to Reclamation to assist in prioritization of historic properties for treatment in subsequent years. In addition, monitoring data will be used to update NPS databases.

Budget

FY2010 = $142,884 (Power revenues)
FY2011 = $147,171 (Power revenues)

FY2010 = $75,000 (Appropriated fund)
FY2011 = $75,000 (Appropriated fund)

Reclamation Project C.5. Integrated Tribal Resources Monitoring—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal (power revenues)	125,000	132,500	136,210	142,884	142,884	147,171
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Appropriated Funds	—	—	—	—	75,000	75,000
Project total	125,000	132,500	136,210	142,884	217,884	222,171
Total outsourced (%)	—	—	—	—	—	—

C.6. Nonnative Fish Suppression Contingency Fund

General Project Description

This budget item establishes a nonnative fish suppression contingency fund to ensure that funds are available for the control of nonnative fish should the need arise. Efforts to control nonnative fish, particularly warmwater species that reproduce rapidly, may be required to protect native fish populations more expeditiously than can be accommodated by the standard biennial budget process. The 2008 Final Biological Opinion for the Operation of Glen Canyon Dam expressed concern about the threats posed to native fish by nonnative fish species and called for planning to address the potential threat. This fund will be incrementally increased with future carryover dollars when available. A plan of action for nonnative fish control is being developed by the GCMRC and will be used to determine when and how these funds will be used after the plan has been recommended by AMWG and accepted by the Secretary of the Interior.

Project Goals and Objectives

The goal of this budget item is to ensure that funds are available for nonnative fish control, particularly the control of rapidly reproducing warmwater species that can become problematic at time scales unsuitable for addressing with the standard biennial GCDAMP process.

Expected Results

Funds will be available for nonnative fish control efforts as a contingency for addressing rapidly developing populations of problematic species.

Budget

FY2010 = $48,483 FY2011 = $49,937

Reclamation Project C.6. Non-native Fish Suppression Contingency Fund—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	—	—	—	48,483	48,483	49,937
DOI Customer burden (33% for FY09 and FY10)	—	—	—	—	—	—
Project total	—	—	—	48,483	48,483	49,937
Total outsourced (%)	—	—	—	—	—	—

D.1. Programmatic Agreement: Reclamation Administrative Costs

General Project Description

This project funds the salary and travel expenses of the PA program administrator and indirect costs of PA program administration. Reclamation's regional archeologist administers the PA program and tribal contracts. The project integrates the PA and Tribal consultation into the larger GCDAMP.

Project Goals and Objectives

- Management of five tribal sole source contracts from appropriated funds for participation in the GCDAMP and management of five tribal sole source contracts from power revenues to implement Native American monitoring protocols.
- Management of the treatment plan contract (second and third option year) for data recovery of at-risk historic properties.
- Chair one PA meeting and attend TWG and AMWG meetings.

Expected Results

The administration of the Glen and Grand Canyon treatment plans is the primary outcome of this project, which also ensures accountability for the ten tribal contracts and appropriate use of both appropriated dollars and power revenues.

Budget

FY2010 = $60,164 FY2011 = $61,969

Reclamation Project D.1. Programmatic Agreement: Reclamation Administrative Costs—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	3,000	3,000	3,000
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	54,107	71,892	57,354	42,236	42,236	43,593
Subtotal	54,107	71,892	57,354	45,236	45,236	46,593
DOI Customer burden (33% for FY09 and FY10)	—	—	—	14,928	14,928	15,376
Project total	54,107	71,892	57,354	60,164	60,164	61,969
Total outsourced (%)	—	—	—	—	—	—

D.2. Canyon Treatment Plan and Implementation

General Project Description

In consultation with Grand Canyon National Park, the Arizona State Historic Preservation Office (SHPO), and the remainder of the PA signatories, Reclamation completed a scope-of-work for the development of a treatment plan for the cultural resources of Grand Canyon. A request for proposal based on this scope-of-work was issued in FY2008 and the contract was awarded to Utah State University. Four sites were targeted for data recovery in FY2008 and five to six sites will be excavated in subsequent years.

Project Goals and Objectives

- Implementation of a treatment plan memorandum of agreement (MOA) through consultation with SHPO, NPS, Tribes, and other stakeholders.
- Government-to-government consultation with Tribal councils based upon the treatment plan recommendations.
- Fieldwork was initiated in winter of 2008. Five to six sites will be selected in subsequent years.
- Collaboration with NPS archeologists in carrying out field activities.

Expected Results

This effort will result in the prioritization, based on significance, of all affected Glen and Grand Canyon properties and implementation of an MOA for treatment of adverse effects. Detailed and comprehensive reports on consultant activities, results, and recommendations will be produced. Evaluation and implementation of mitigative measures or total data recovery, following the Secretary of the Interior Standards and Guidelines for Historic Preservation and guidance of the Advisory Council on Historic Preservation, will be completed.

Budget

FY2010 = $500,000 FY2011 = $500,000

Reclamation Project D.2. Canyon Treatment Plan and Implementation—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal			300,000	500,000	500,000	500,000
DOI Customer burden (33% for FY09 and FY10)						
Project total			300,000	500,000	500,000	500,000
Total outsourced (%)	—	—	—	100%	100%	100%

E. Tribal Participation in the GCDAMP: Sole-Source Reimbursable Contracts with Tribes

General Project Description

As a result of this project, participation in GCDAMP meetings, resource monitoring, and government-to-government consultation will be accomplished in concert with the five GCDAMP Tribes (Hopi Tribe, Hualapai Tribe, Kaibab Paiute Tribe, Pueblo of Zuni, Navajo Nation) and five DOI agencies (U.S. Geological Survey, National Park Service, Reclamation, U.S. Fish and Wildlife Service, and Bureau of Indian Affairs), with Reclamation serving as lead agency.

Project Goals and Objectives

The purpose of the continued funding of tribal contracts is to ensure tribal viewpoints are integrated into continuing GCDAMP dialogs, votes, and in the final recommendations made to the Secretary of the Interior.

Expected Results

The most important product is the incorporation of tribal perspectives into the recommendations forwarded to the Secretary. In addition, the Tribes prepare annual reports on activities funded under the contracts. Continued funding of government-to-government consultation through the agreements ensures enhanced communication and understanding of the GCDAMP issues and concerns.

Budget

FY2010 = $475,000 FY2011 = $475,000 (appropriated funds)

Reclamation Project E. Tribal Participation in the GCDAMP: Sole-Source Reimbursable Contracts with Tribes—Funding History

Activity	2006	2007	2008	2009	2010	2011
Outside Reclamation science/labor	—	—	—	—	—	—
Logistics field support	—	—	—	—	—	—
Project-related travel/training	—	—	—	—	—	—
Operations/supplies	—	—	—	—	—	—
Reclamation salaries	—	—	—	—	—	—
Subtotal	477,375	475,000	475,000	475,000	475,000	475,000
DOI Customer burden (33% for FY09 and FY10)						
Project total	477,375	475,000	475,000	475,000	475,000	475,000
Total outsourced (%)	100%	100%	100%	100%	100%	100%

Chapter 2. U.S. Geological Survey, Southwest Biological Science Center, Grand Canyon Monitoring and Research Center Biennial Budget and Work Plan—Fiscal Years 2010–11

Introduction

The Glen Canyon Dam Adaptive Management Program (GCDAMP) is a science-based process for continually improving management practices related to the operation of Glen Canyon Dam (GCD) that emphasizes learning through monitoring, research, and experimentation. The U.S. Geological Survey's (USGS) Grand Canyon Monitoring and Research Center (GCMRC) is responsible for the scientific monitoring and research of the GCDAMP. GCMRC staff worked cooperatively with GCDAMP participants and the Bureau of Reclamation (Reclamation) to develop this document, the *Glen Canyon Dam Adaptive Management Program Biennial Budget and Work Plan—Fiscal Years 2010–11* (hereafter BWP).

Purpose

This BWP describes the core-monitoring, long-term experimental, research and development, and related activities by project that will be implemented in fiscal years (FY) 2010–11 to address priority goals, questions, and information needs specified by the GCDAMP. This document also provides budget information for each project.

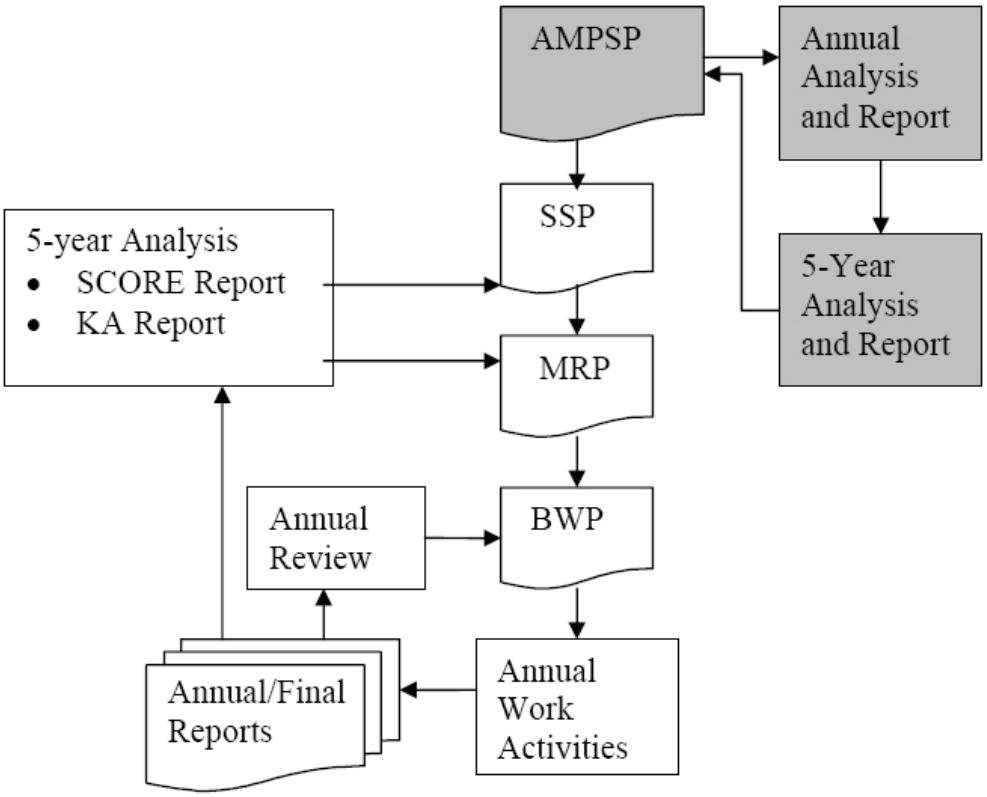
Overview of the GCMRC Strategic Science Plan and Monitoring and Research Plan

This BWP is designed to implement and be consistent with the GCMRC SSP Strategic Science Plan (SSP) and Monitoring and Research Plan (MRP). The primary elements of the MRP and SSP addressed by this BWP include

- employing the adaptive environmental assessment and management approach to resources management that was developed by Holling (1978) and Walters (1986), and articulated in the Adaptive Management Program Strategic Plan (AMPSP);
- using GCDAMP priority questions and associated strategic science questions (SSQs) to provide the primary (but not exclusive) basis for designing the science program (appendix A);
- implementing an interdisciplinary, integrated river science approach to better understand the factors contributing to native fish population status and trends, and updating key elements of the Grand Canyon Ecosystem Model (GCEM) to assist in long-term experimental planning such as future high-flow experiments (HFE); and
- working collaboratively with managers and stakeholders to better integrate the use of scientific information (fig. 2) into the GCDAMP process.

In FY2011, the GCMRC will update the 2005 Knowledge Assessment and *State of the Colorado River Ecosystem in Grand Canyon* (SCORE) report for managers and stakeholders for planning management actions and the next phase of research and experimentation.

Figure 2. Diagram outlining the collaborative science planning and implementation process. The Glen Canyon Dam Adaptive Management Program and the U.S. Department of the Interior have lead responsibility for the shaded boxes. The USGS Grand Canyon Monitoring and Research Center has lead responsibility for the boxes that are not shaded.



Overview of Biennial Work Plan and Budget

In April 2009, the Adaptive Management Work Group (AMWG), the Federal Advisory Committee that facilitates the GCDAMP, recommended approval of amendments to the SSP and MRP—the documents that are the basis of this BWP—that reflect the requirements of two biological opinions prepared by the U.S. Fish and Wildlife Service (USFWS). As a result, projects presented in this work plan incorporate requirements of the *2007 Final Biological Opinion for the Proposed Adoption of Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* (known as biological opinion for shortage criteria) and the *2008 Final Biological Opinion for the Operation of Glen Canyon Dam*.

Additionally, GCMRC staff members discussed FY2010–11 budget priorities with the Budget Ad Hoc Work Group (BAHG), the Technical Work Group (TWG), and the AMWG. The results of those discussions were considered in the development of this BWP.

This BWP assumes that the FY2010 hydrograph will consist of modified low fluctuating flow (MLFF) operations, including experimental steady flows in October 2009/10 and September 2010–11. The BWP

does not address a potential high flow experiment (HFE) in FY2010 or FY2011. Currently, an HFE has not been authorized by the Secretary of the Interior for FY2010–11.In FY2011, the GCMRC will develop a science plan for future high-flow experimentation based on the results of a synthesis of the scientific findings for HFEs conducted in 1996, 2004, and 2008 that will be completed in FY2010.

This BWP includes several new and expanded projects as well as the continued implementation of a number of ongoing projects included in the approved *Glen Canyon Adaptive Management Program Budget and Work Plan—Fiscal Year 2009*. Funding for ongoing projects was adjusted to reflect cost of living increases, increased salary costs, logistical support, past performance, etc.

To achieve a balanced budget, a number of ongoing projects had to be scaled back to accommodate new and expanded efforts and non-discretionary cost increases for continuing projects. These adjustments are noted in the attached spreadsheet. Major changes in this BWP compared to the 2009 budget and work plan include the following changes by goal:

Goal 2. Native Fish

- Establish fish monitoring activities in the mainstem and Little Colorado River (LCR) as core-monitoring projects beginning in FY2011 (BIO 2.M1.11). The scope and budget for these monitoring efforts will be determined by data analyses that will be conducted in FY2010 pursuant to the recommendations of the protocol evaluation panel (PEP) review that occurred in May 2009.
- Establish a new project in FY2010 to provide science support for implementation of the *Nonnative Fishes Management Plan* (BIO 2.R17.10) that will be completed in FY2010.
- Continue to provide GCMRC biology staff support to work with the Senior Scientist (Carl Walters) to develop more robust ecosystem models (PLAN 12.P1.10).
- Redirect funding from the Nonnative Control Pilot Testing Project (BIO 2.R6.09) to the Mainstem Fish Monitoring Project (BIO 2.M4.10) in FY2010 to improve the ability of scientists to detect changes in the abundance or the distribution of nonnative fish.
- Implement mainstem nonnative fish control in FY2010 and FY2011 as an experimental activity, including an evaluation of potential alternative approaches for controlling rainbow trout near the confluence of the mainstem and LCR.

Goal 4. Rainbow Trout

- Establish Lees Ferry Rainbow Trout Monitoring Project as a core-monitoring project beginning in FY2010 (BIO 4.M2.10). The scope and budget for the rainbow trout monitoring effort considered the recommendations of the May 2009 PEP review.

Goal 6. Riparian/Springs

- Establish Vegetation Mapping Project and Vegetation Transects Project as core-monitoring projects beginning in FY2010 (BIO 6.M1.10 and BIO 6.M2.11, respectively).
- Conduct vegetation transects (BIO 2.M2.11) every other year beginning in FY2011.

Goal 8. Sediment

- Suspend channel and sandbar mapping in FY2010 and focus on analysis and reporting of data collected in FY2009 and earlier. Beginning in FY2011, channel mapping will occur annually and measurements at Northern Arizona University (NAU) sandbar study sites will occur every other year.

Goal 9. Recreation

- Suspend sandbar and campsite mapping fieldwork in FY2010 (REC 9.R1.10) and focus on analysis and reporting of previously collected data. A PEP review will be conducted in early FY2011 to determine the scope and direction of future monitoring.
- Establish the Campsite Area Monitoring Project (REC 9.R1.11) as a core-monitoring project beginning in FY2011.
- Include staff support for maintenance, updating, and analysis of the information in the GIS campsite atlas (REC 9.R3.10).
- Discontinue the project to compile and analyze existing safety data (REC 9.R4.09) in FY2010.

Goal 11. Cultural

- Reduce the scope and budget of the Cultural Research and Development Towards Core-monitoring Project (CUL 11.R1.10) to eliminate National Park Service (NPS) funding, and reduce survey and cooperator support in FY2010 and FY2011. Implementation of this project assumes NPS permitting and close integration with NPS-funded Colorado River Monitoring Plan (CRMP) monitoring efforts. A final PEP review is proposed for FY2012 to determine the long-term monitoring program.

Goal 12. DASA

- Establish a new initiative (DASA 12.D9.10) to coordinate and manage various image acquisition, processing, and change-detection efforts, including the vegetation mapping, legacy data conversion, channel change, and sandbar and campable area mapping/change detection. Funding for this new initiative comes from existing projects (Integrated Image Analysis and Change Detection Project; DASA 12.D9.10), the Vegetation Mapping Project (BIO 6.M1.10), and the Incorporate and Analyze Campsite Data in the GIS Atlas Project (REC 9.R3.10).
- Establish a new initiative to synthesize the results of the 1996, 2004, and 2008 HFE using a portion of the Experimental Carryover Funds.
- Fully implement a new initiative (Biometrics and General Analysis Project; DASA 12.D8.10–11) to provide study design and statistical support for GCMRC science projects.

Finally, the FY2010 budget assumed a 0 percent increase in funding based on the consumer price index (CPI) and a 3 percent CPI increase from FY2010 to FY2011.

The proposed budget addresses all of the conservation measures included in the 2007 and 2008 USFWS biological opinions that are within the purview of the GCMRC (see appendix C for a summary of the conservation measures). Addressing conservation measures was accomplished, in part, with additional appropriations from Reclamation. Projects that address a conservation measure are identified with the code BOCM in the comment column of the budget table (appendix E).

Table 1 summarizes core-monitoring, research and development, and experimental activities presented in this BWP to address GCDAMP goals 1–11. These three types of activities are briefly explained below, including a current progress update and anticipated progress in FY2010–11:

1. **Core-monitoring activities** are consistent, long-term repeated measurements using scientifically accepted protocols to measure status and trends of key resources. Core-monitoring activities are those that have been pilot tested for one to several years, have undergone a PEP and independent peer review, and have been approved by the GCDAMP for core-monitoring status.

A summary of projects that will be proposed as core-monitoring projects in FY2010–11 are shown in table 2.

2. **Research and development activities** are aimed at (1) addressing specific hypotheses or information needs related to a priority GCDAMP resource(s) and (2) developing and testing new technologies or monitoring procedures.

The majority of research and development activities presented in this BWP are aimed at developing long-term core-monitoring protocols associated with GCDAMP goals 1–11 (excluding goal 3). Another major research project includes the Nearshore Ecology/Fall Steady Flows Project (BIO 2.R15.10–11).

3. **Experimental activities** are flow and nonflow treatments and management actions designed to improve conditions of target resources while allowing for an understanding of the relationship between actions and the target resources. In FY2010, the analysis and reporting of the results of the March 2008 HFE will be completed. Other experimental activities planned for FY2010–11 are (1) the evaluation of experimental steady flows to be released from GCD in September and October, beginning 2008 and continuing through 2012, and (2) experimental mainstem nonnative fish removal.

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Table 1. Summary of core-monitoring, research and development, and experimental activities presented in the in the fiscal year (FY) 2010 and 2011 biennial work plan for the Grand Canyon Monitoring and Research Center (GCMRC). Activities address Glen Canyon Dam Adaptive Management Program (GCDAMP) goals 1–12 and related science questions and information needs. Priority and related strategic science questions are paraphrased from the GCMRC Strategic Science Plan (appendix A). Information needs are paraphrased from the GCDAMP Strategic Plan. Abbreviations are as follows: SSQ = strategic science question, CMIN = core-monitoring information need, RIN = research information need, SA = GCDAMP Science Advisors summary questions, ADWG = Adaptive Management Work Group, and TWG = Technical Work Group.

GCDAMP goal	Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)	Core-monitoring activities	Experimental activities	Research and development activities
1. Food base	AMWG Priority: 1, 3, and 5 *SSQ 1-5. What are the important pathways, and the rate of flux among them, that link lower trophic levels with fish and how will they link to dam operations?* *SSQ 1-6. Are trends in the abundance of fish populations, or indicators from fish such as growth, condition, and body composition (for example, lipids), correlated with patterns in invertebrate flux?* *SSQ 5-2. How is invertebrate flux affected by water quality (for example, temperature, nutrient concentrations, turbidity) and dam operations?*	FY 2011: Conduct protocol evaluation panel (PEP) and implement core monitoring	FY2008-12: Fall steady flows study (in combination with nearshore ecology study)	FY2006–10: Determine carbon budget to understand how energy is exchanged among organisms in the Colorado River; develop monitoring techniques and metrics for key organisms
2. Humpback chub (HBC) and other native fish (A.)	AMWG Priority: 1, 3, and 5 *SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year (YoY) and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?* *SSQ 1-2. Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile HBC to the adult population?* *SSQ 1-4. Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.* CMIN 2.1.2 Determine and track abundance and distribution of all size classes of HBC in the Little Colorado River (LCR) *SSQ 5-6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance?* SA 1. What are the most limiting factors to successful HBC adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?	FY 2010: use data to assess PEP recommendations FY 2011: implement core monitoring for rainbow trout (RBT), humpback chub (HBC), and other Grand Canyon fish FY2010-11: Mainstem monitoring of fish community per PEP	FY2008-12: Fall steady flows study (in combination with nearshore ecology study)	FY2006 and ongoing: Stock assessment FY2007–11: Statistical review of existing HBC monitoring protocols and habitat data FY2007–11: Evaluate protocols for warmwater and coldwater nonnative fish monitoring, removal, and control; effects on native fish FY2007–10: Monitor status and trends of HBC in LCR and mainstem using existing protocols FY2010-11: Develop bioenergetic model for aquatic ecosystem FY2008-12: Nearshore ecology study (in combination with fall steady flows study) FY2010–11: Develop alternative, noninvasive HBC monitoring gear to reduce stress on fish (for example, remote passive integrated transponder (PIT) tag reading, and sonic tags)

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GCDAMP goal	Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)	Core-monitoring activities	Experimental activities	Research and development activities
	SSQ 1-7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained? *SSQ 1-8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?*			
3. Extirpated species	Not an identified AMWG priority			FY 10–11: GCMRC will participate in the TWG Species of Concern Ad hoc Work Group and in the Lake Mead razorback sucker assessment
4. Rainbow trout (RBT)	AMWG Priority: 3 *SSQ 3-6: What Glen Canyon Dam operations (ramping rates, daily flow range, etc.) maximize trout fishing opportunities and catchability?* CMIN 4.1.2 Determine annual proportional stock density of rainbow trout in the Lees Ferry reach. CMIN 4.1.4 Determine annual standard condition (Kn) and relative weight of rainbow trout in the Lees Ferry reach.	FY2010–11: Monitor status and trends of Lees Ferry RBT population	FY2010–11: Monitor redds and larval production in response to fall steady flows	FY2010–12: Assess natal origins of RBT
6. Springs /riparian	AMWG Priority: 4 *SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?* *SSQ 4-2. How important are backwaters and vegetated shoreline habitats to the overall*	FY2010–11: Monitoring using vegetation mapping (area cover, distribution) and		FY2010–11: Terrestrial monitoring (deferred) FY2010–11: Vegetation synthesis project

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GCDAMP goal	Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)	Core-monitoring activities	Experimental activities	Research and development activities
	growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs? CMIN 6.1.1., 6.6.1., 6.2.1., 6.5.1. Determine and track the abundance, composition, distribution, and area of terrestrial native and nonnative vegetation species in the CRE.	vegetation transects (diversity, richness, community composition, nonnative/native ratios)		
7. Quality-of-water	AMWG Priority: 1, 3, and 5 *SSQ 3-5. How is invertebrate flux affected by water quality (for example, temperature, nutrient concentrations, turbidity) and dam operations?* *SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE)?* *SSQ 5-3. To what extent do temperature and fluctuations in flow limit spawning and incubation success for native fish?* CMIN 7.2.1. Determine the seasonal and yearly trends in turbidity, conductivity, DO, and pH, (decide below whether selenium is important) changes in the mainstem throughout the Colorado River ecosystem?	FY2010–11: Lake Powell monitoring using existing protocols, investigating new protocols, and conducting PEP FY2007–11: Downstream integrated quality-of-water (IQW) monitoring (including suspended-sediment flux)		FY2007–11: Advanced development of downstream flow, temperature, and suspended-sediment models FY10–11: Synthesis of existing chemical and biological data Evaluation of revised monitoring program Continued development and verification of CE-QUAL-W2 model
8. Sediment (fine and coarse sediment)	AMWG Priority: 1,2,3, and 4 *SSQ 4-1. Is there a "Flow-Only" operation (that is, a strategy for dam releases, including managing tributary inputs with (beach/habitat-building flows (BHBFs), without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?*	FY2007–11: Implementation of "SedTrend" monitoring to detect long-term trends in sand storage by reach-scale topographic measurements. Continue monitoring of long-term		FY2007–11: Map change in sandbars and nearshore habitat resulting from 2004 and 2008 high-flow experiments (HFE).

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GCDAMP goal	Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)	Core-monitoring activities	Experimental activities	Research and development activities
		sandbar study sites.		
9. Recreation (A	AMWG Priority: 3 and 4 *SSQ 3-9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?* CMIN 9.3.1. Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons.	FY10: Analyze and synthesize campsite area monitoring data from 1998-2009. FY11: conduct campsite PEP and implement long-term core-monitoring program	FY10: Incorporate campsite monitoring data into HFE synthesis	FY10: Evaluate 2002–09 remote-sensing data as alternative tool for measuring systemwide campsite area change in advance of FY20II PEP
9. Recreation (B)	AMWG Priority: 3 *SSQ 3-7. How do dam-controlled flows affect visitors' recreational experiences, and what is/are the optimal flows for maintaining a high-quality recreational experience in the CRE?* *SSQ 3-8. What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes?* *SSQ 3-12. How do varying flows positively or negatively affect group encounter rates, campsite competition, and other social parameters that are known to be important variables of visitor experience?*			FY10–11: Continue to expand campsite atlas database. Apply atlas data in conjunction with 2002, 2005, and 2009 remote-sensing data to analyze effects of vegetation encroachment on campsite area and recreation quality through time

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GCDAMP goal	Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)	Core-monitoring activities	Experimental activities	Research and development activities
10. Hydropower	AMWG Priority: 3 *SSQ 3-3. What are annual hydropower replacement costs of the modified low fluctuating flow (MLFF) since 1996?* *SSQ 3-4. What are the projected hydropower costs associated with the various alternative flow regimes being discussed for future experimental science (as defined in the next phase of experimental design)?* CMIN 10.1.1. Determine and track the marketable capacity and energy produced through dam operations in relation to the various release scenarios (daily fluctuation limit, upramp and downramp limits, maximum flow limit of 25,000 cfs minimum flow limit of 5,000 cfs).	FY10-11: Serve Western Area Power Administration data on hydropower generation and replacement costs		
11. Cultural	AMWG Priority:2, 3, and 4 *SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites in the CRE, and if so, how?* *SSQ 2-4. How effective are various treatments (for example, check dams, vegetation management, etc.) in slowing rates of erosion at archaeological sites over the long term?* *SSQ 2-7.Are dam-controlled flows affecting TCPs and other tribally-valued resource in the CRE, and if so, in what respects are they being affected, and are those effects considered positive or negative by the tribes who value these resources?* CMIN 11.1.1 Determine the condition and integrity of prehistoric and historic sites in the Colorado River ecosystem through tracking rates of erosion, visitor impacts, and other relevant variables. CMIN 11:2.1 Determine the condition and integrity of TCPs in the Colorado River ecosystem.			FY10: Complete Phase I reporting of cultural monitoring research and development project and implement Phase II (pilot monitoring program) FY11–12: Continue pilot monitoring

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GCDAMP goal	Priority science questions and information needs (questions from Strategic Science Plan and Monitoring and Research Plan in italics)	Core-monitoring activities	Experimental activities	Research and development activities
12. High-quality monitoring, research, and Adaptive Management Program (A.) Data acquisition, storage, and analysis (DASA) (B.) Control network (C.) Logistics (D.) IT support (E.) Interdisciplinary reporting activities	AMWG Priority: 1,2, 3, 4, and 5	Remote-sensing acquisition, processing, and analysis for change detection GIS and database support of all tabular and spatial data to provide storage, archiving, and Web access General support in GIS, database, and biometrics	FY10: Complete LSSF Synthesis F10: Complete HFE Synthesis FY11: HFE Science Plan	Ongoing: Control network and survey support Ongoing: Logistics support for GCMRC filed activities FY11: Knowledge Assessment and *State of the Colorado Ecosystem in Grand Canyon* report updates FY10–11: Refine and develop new GIS and image processing techniques to increase accuracy and precision of derived products for change detection Continued development of new GIS and database automation Develop new archiving system for long-term availability, migration to future media, and, where possible, operating system and application independence Legacy conversion of analog images (especially overflight imagery) and reports to digital formats DASA biometrician will conduct focused research in areas such as model development and analytical techniques to further the science capabilities of the GCMRC

Table 2. Schedule for protocol evaluation panel (PEP) reviews and development of final core-monitoring plans in fiscal years (FY) 2010–11.

Project	Task	FY2010	FY2011
Aquatic Food Base Monitoring (BIO 1.M1.11), Water-Quality Monitoring of Lake Powell and the Glen Canyon Dam Tailwater (BIO 7.R1.10–11), and Core Monitoring of Downstream Integrated Quality of Water Quality (below Glen Canyon Dam) (PHY 7.M1.10–11)	Final PEP Core-monitoring Plan		X X
Monitoring Mainstem Fish (BIO 2.M4.10–11) and Monitoring Lees Ferry Fish (BIO 4.M2.10–11)	Core-monitoring Plan	X	
Vegetation Mapping (BIO 6.M1.10 and Vegetation Transects (BIO 6.M2.11)	Core-monitoring Plan	X	
Campsite Area Monitoring (REC 9.R1.10–11)	Final PEP Core-monitoring Plan	X	X X

This BWP includes a variety of projects and activities associated with GCDAMP goal 12 (that is, the maintenance of a high-quality monitoring, research, and adaptive management program). In general, these activities support the production of high-quality science, including the management and administration of the GCMRC science program and logistical support for field activities. Specifically, efforts in support of GCDAMP goal 12 are listed below.

1. Data acquisition, storage, and analysis (DASA), including
   - conducting the next quadrennial aerial overflight to acquire remote-sensing data of the entire Colorado River ecosystem (CRE) in May 2013
   - maintaining, updating, and enhancing the Oracle database
   - converting analogue data (report and imagery) to digital format
   - providing geographic information system (GIS) support to science projects
   - supporting the GCMRC library
2. Logistical support for field activities/river trips and survey operations
3. Compilation, synopsis, and synthesis of the data and results of the studies carried out in conjunction with the experimental flows of 2000 (low steady summer flows; LSSF)
4. The services of a senior ecosystem scientist to better understand the factors contributing to native fish population status and trends and updating key elements of the Grand Canyon Ecosystem Model (GCEM) to assist in long-term experimental planning such as future HFEs
5. Various administrative support services for the GCMRC and its cooperative science programs

6. GCMRC program planning and management support (including support for the GCDAMP)

7. Independent peer review, PEPs, and Science Advisor support

8. Information technology (IT) support provided by the Southwest Biological Science Center (SBSC)

9. A comprehensive revision and publication of the Knowledge assessment and SCORE and in FY2011 to include new information and findings since the documents were published in 2005

FY2010–11 Funding Sources

A summary of anticipated GCMRC support in FY2010 and FY2011 by funding source is provided in tables 3 and 4, respectively and summarized below.

- Lake Powell water-quality monitoring ($275,502 in FY2010 and $286,342 in FY2011)—Power revenue funding received under a separate interagency agreement from Reclamation to monitor water quality in Lake Powell.
- GCDAMP power revenue carry forward funding ($1,244,064 in FY2010)—Funding from the GCMRC FY2009 GCDAMP budget that was deferred for use in FY2010.
- Nearshore fish ecology ($16,184 in FY2010 and $556,911 in FY 2011)—Appropriated funds received from Reclamation under a separate agreement to conduct research on the nearshore ecosystem.
- GCDAMP power revenues ($7,967,420 in FY2010 and $8,206,442 in FY2011)—GCDAMP power revenues are capped by Congress and adjusted annually based on the CPI. For the purposes of this budget, the CPI is estimated at 0 percent in FY2010 and 3 percent in FY2011. The budget will be adjusted in fall 2010 to reflect the actual CPI for FY2010.
- Experimental funds—$258,674 in FY2010 and $484,251 in FY2011
- Nonnative Fish Contingency Fund—$96,966 in FY2010 and $0 in FY2011
- USGS appropriations (approximately $1,000,000 annually)—These funds are used to provide a reduced USGS overhead rate for the GCDAMP. Overhead rates vary annually. With the approximately $1,000,000 in support appropriations, the GCMRC is able to maintain the Department of Interior (DOI) customer rate of 15 percent plus facilities for the GCDAMP agreement. In FY2010–11, the DOI customer rate is estimated to be 21percent.

Table 3. Total anticipated funding to support the U.S. Geological Survey's Grand Canyon Monitoring and Research Center (GCMRC) in fiscal year (FY) 2010 .

Funding source	Agreement title	Type of funds	Estimated FY2009 carry forward funds	FY2010 Funds	Gross funding total	Percent of FY2010 GCMRC budget	Notes
Bureau of Reclamation (Reclamation)	Lake Powell water quality	Power revenues not under cap	$0	$275,502	$275,502	2.53%	
Reclamation	Nearshore fish ecology	Appropriated funds	$536,641	$16,184	$552,825	5.10%	FY2010 funding received in FY2009
Reclamation	Glen Canyon Dam Adaptive Mgmt Program	Power revenues under cap (GCDAMP)	$641,097	$7,967,420	$8,608,517	79.27%	
Reclamation	Glen Canyon Dam Adaptive Management Program	High-flow experiment modification for FY2008–FY2009	$ 66,326	$0	$66,326	0.61%	
Reclamation	Glen Canyon Dam Adaptive Management Program	Experimental Funds held by Reclamation	$0	$258,674	$258,674	2.39%	Supplement FY2010 project funding
Reclamation	Glen Canyon Dam Adaptive Management Program	Non-native Fish Suppression Contingency Funds held by Reclamation	$0	$96,966	$96,966	0.90%	Supplement FY2010 project funding
Subtotal of funding received from Reclamation:			$1,244,064	$8,614,746	$9,858,810		
USGS Headquarters	Cost-share burden assistance	USGS appropriated funds for cost-share use for GCMRC annual work plan	$0	$1,000,000	$1,000,000	9.20%	
Total of estimated funding to be received for FY2010:			$1,244,064	$9,614,746	$10,858,810	100.00%	

Table 4. Total anticipated funding to support the U.S. Geological Survey's Grand Canyon Monitoring and Research Center (GCMRC) in fiscal year (FY) 2011.

Funding source	Agreement title	Type of funds	Estimated FY2010 carry forward funds	FY2011 Funds	Gross funding total	Percent of FY2011 GCMRC budget	Notes
Bureau of Reclamation (Reclamation)	Lake Powell water quality	Power revenues not under cap	$0	$286,342	$286,342	2.72%	
Reclamation	Nearshore fish ecology	Appropriated funds	$0	$556,911	$556,911	5.28%	
Reclamation	Glen Canyon Dam Adaptive Mgmt Program	Power revenues under cap (GCDAMP)	$0	$8,206,442	$8,206,442	77.90%	
Reclamation	Glen Canyon Dam Adaptive Management Program	Experimental Funds held by Reclamation	$0	$484,251	$484,251	4.60%	Supplement FY2011 project funding
Subtotal of funding received from Reclamation:			$0	$9,533,946	$9,533,946		
USGS Headquarters	Cost-share burden assistance	USGS appropriated funds for cost-share use for GCMRC annual work plan	$0	$1,000,000	$1,000,000	9.50%	
Total of estimated funding to be received for FY2011:			$0	$1,000,000	$10,533,946	100.00%	

Figure 3 summarizes the GCMRC's FY2009, FY2010, and FY2011 budgets by GCDAMP goal. A breakout of the projects included as part of goal 12 is summarized in figure 4. The budget for each project in the work plan is included in the project descriptions and summarized for the entire budget in the separate budget attachment.

Figure 3. Bar chart showing a comparison of Grand Canyon Monitoring and Research Center (GCMRC) fiscal year (FY) 2009 approved budget and FY2010 and FY2011 preliminary budget by Glen Canyon Dam Adaptive Management Program (GCDAMP) goal.

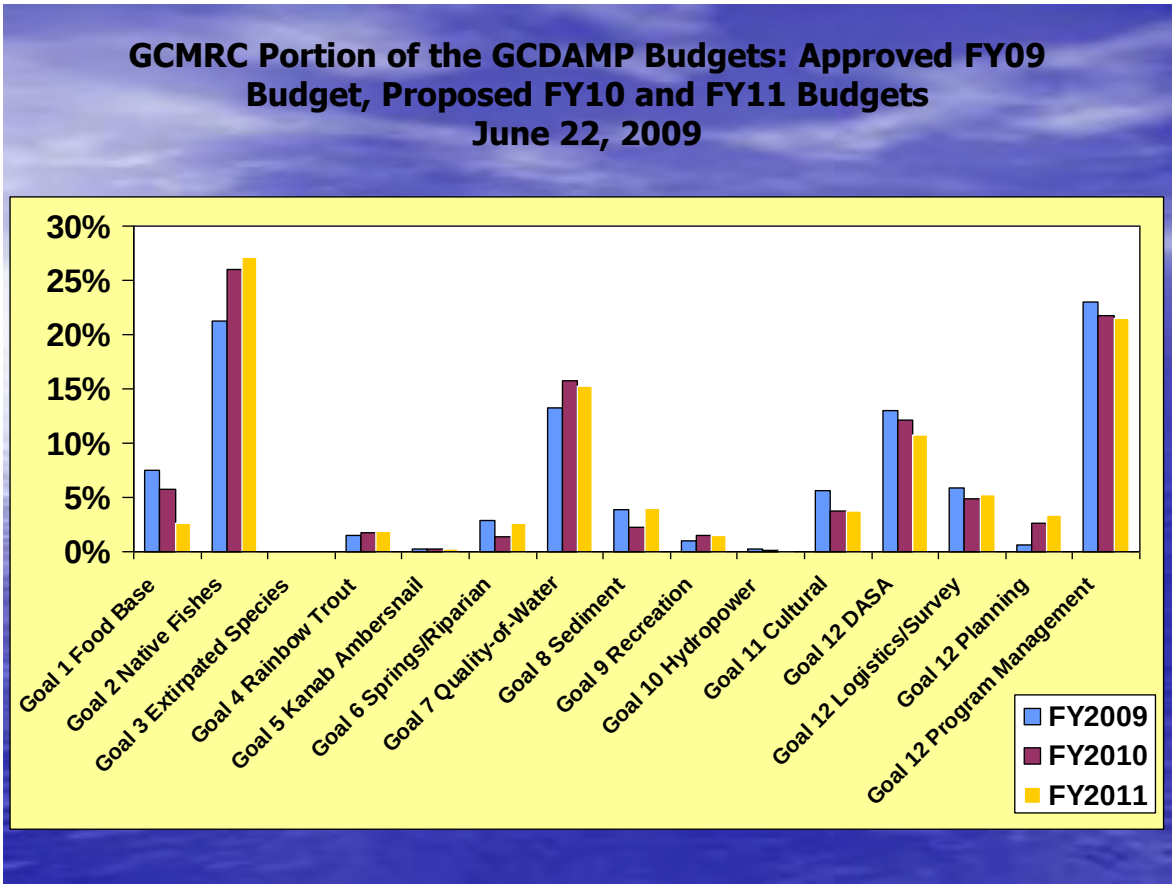
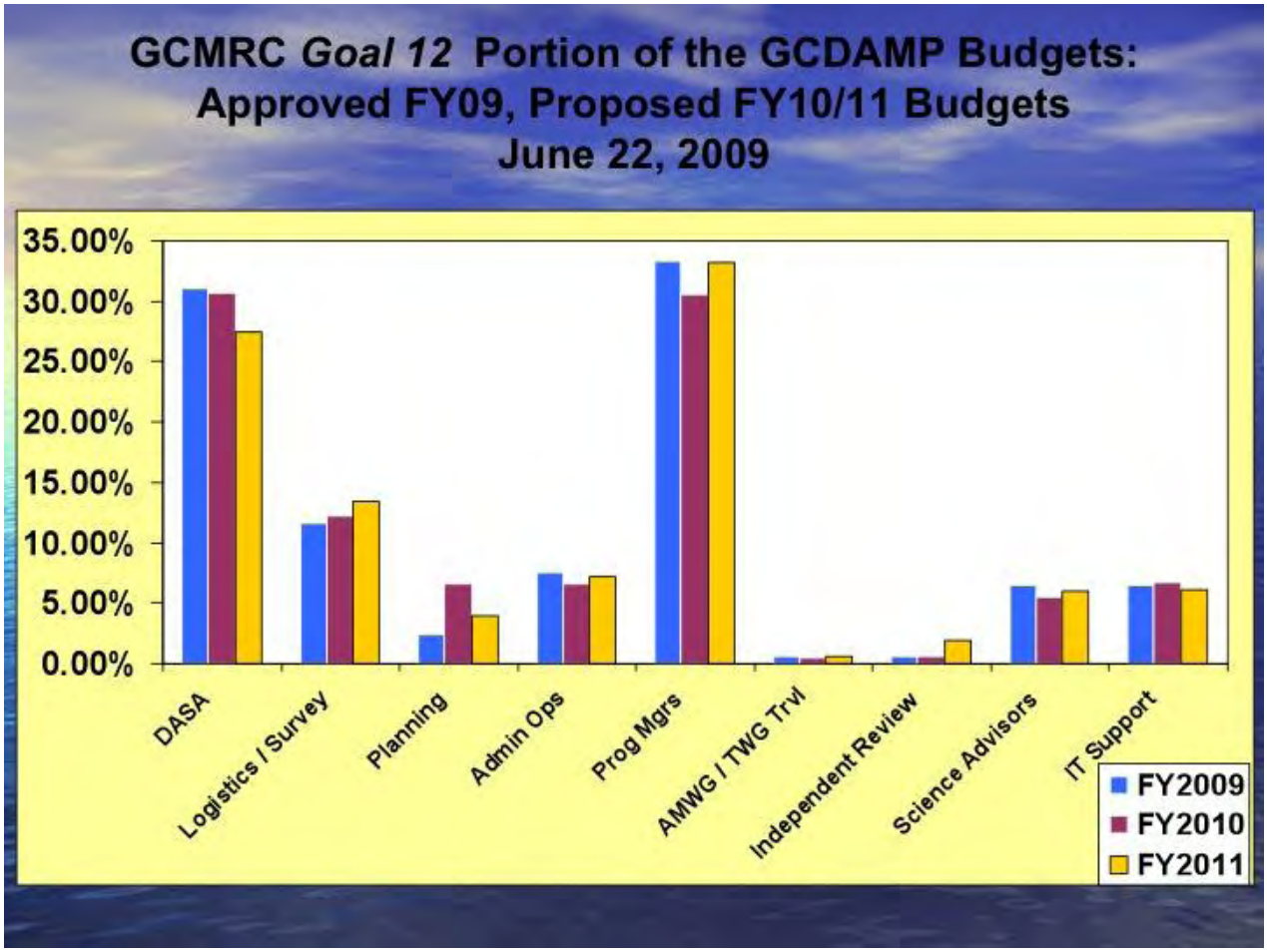


Figure 4. Bar chart comparing the Grand Canyon Monitoring and Research Center (GCMRC) fiscal year (FY) FY2009 approved budget and FY2010–11 preliminary budgets for Glen Canyon Dam Adaptive Management Program (GCDAMP) efforts by project for goal 12.



Annual Reporting

An annual report for projects included in this BWP will be completed by December 15, 2010 and 2011. The reports will summarize the work accomplished, project shortfalls, and recommendations for additional studies or project modifications. The GCMRC will host a meeting in mid-January 2011and 2012 for GCDAMP stakeholders to review the annual reports and discuss their implications for the next BWP.

Project Descriptions

Detailed descriptions of each project included in the FY2010–11 BWP are provided in the following section. Activities are presented based on the GCDAMP goal they are designed to address. Activities included in the BWP will be carried out in an integrated, interdisciplinary fashion. Integration efforts are described as an element of each project description.

Since its inception, the GCDAMP has attempted to ensure appropriate science program continuity and balance across all goals adopted by the program. The current focus of the GCDAMP is on SSQs associated with high-priority AMWG information needs and on meeting the conservation measures included in the 2007 and 2008 USFWS biological opinions. Other GCDAMP goals will still be pursued but with less intensity until priority issues of concern are resolved and monies can be reprogrammed or obtained through alternative sources. This BWP, with the exception of GCDAMP goal 3 (restore extirpated species), includes at least one activity to address each GCDAMP goal.

GCDAMP Goal 1—Protect or improve the aquatic food base so that it will support viable populations of desired species at higher trophic levels

BIO 1.R1.10—Aquatic Food Base

BIO 1.R4.10—Impacts of Flows on the Aquatic Food Base

BIO 1.M1.11—Aquatic Food Base Monitoring

Start Date

September 2005

End Date

September 2010 (BIO 1.R1.10 and BIO 1.R4.10, with BIO 1.M1.11 ongoing)

Principal Investigators

Theodore Kennedy, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; Robert Hall, University of Wyoming; Emma Rosi-Marshall, Loyola University; and Colden Baxter, Idaho State University

Geographic Scope

Glen Canyon Dam to Diamond Creek, Ariz., about river mile (RM) 225

Project Goals

The overall goal of this project is to determine the role that food plays in the distribution, condition, and abundance of fish throughout the system. Quantifying the density and production of basal resources (that is, algae, terrestrial leaf litter, etc.) and invertebrates will determine the amount of energy that is available to support fish production. The trophic basis of production calculations, where the types and amounts of different food items eaten by invertebrates and fish are quantified, will determine the relative contribution of basal resources, invertebrates, and other food items to fish production. The results of this work will establish the degree to which native fish are limited by food resources, by either low production at the base of the food web or via shunting of energy to nonnative animals such as New Zealand mudsnails or rainbow trout (RBT). This information, in turn, provides guidance to managers considering various management options.

The specific objectives addressed by this project include,

- determining the important energy sources and pathways that support fish, especially native species and trout;
- quantifying the abundance of basal resources using a carbon budget framework to determine potential available energy for higher trophic levels;

- identifying composition and quantity of drifting organic matter and invertebrates;
- incorporating knowledge into bioenergetics model and trophic basis of production calculations; and
- developing core-monitoring strategies for the aquatic food base in the Colorado River from Glen Canyon Dam to Diamond Creek.

Specific goals for FY2010 include,

- completing the processing and analysis of all backlogged samples (for example, fish diet samples, invertebrate biomass samples, etc.) and data;
- producing a final report and peer-reviewed publications that summarize project findings and provide protocols for long-term monitoring of the aquatic food base; and
- collecting data monthly at Lees Ferry and Diamond Creek with less accessible sites sampled once per year, to ensure continuity as this project transitions from research to monitoring.

Specific goals for FY2011 include,

- implementing fully long-term monitoring protocols at Lees Ferry and Diamond Creek as well as monitoring protocols at less accessible sites;
- convening a protocol evaluation panel (PEP); and
- producing a core-monitoring report based on the recommendations of the PEP.

Need for Project

After habitat, food is the resource that most often limits the distribution or abundance of animal populations (Krebs, 1994). With the changes in the Colorado River that have accompanied the installation of Glen Canyon Dam has come some dramatic changes in the species and productivity of primary and secondary producers found below the dam, especially between the dam and the Paria River near Lees Ferry. The clear, relatively cold tailwaters now have increased levels of primary productivity in the form of algae and diatoms, which in turn support a short list of invertebrate species. Both of these resources, primary and secondary producers, are consumed by the vertebrates of the Colorado River, including RBT in the Lees Ferry sport fishery and native and nonnative fish downstream of Lees Ferry in Marble and Grand Canyons. Project BIO1.R1.10, using an ecosystem context, will determine if food might be limiting the distribution or abundance of native and nonnative fish. Project BIO1.R4.10 complements these efforts by evaluating if dam operations impact rates of invertebrate drift, which is an important component of available food resources; the project has also provided funds to purchase equipment that continuously measures algae production.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-5. What are the important pathways, and the rate of flux among them, that link lower trophic levels with fish and how will they link to dam operations?

SSQ 1-6. Are trends in the abundance of fish populations, or indicators from fish such as growth, condition, and body composition (for example, lipids), correlated with patterns in invertebrate flux?

SSQ 3-5. How is invertebrate flux affected by water quality (for example, temperature, nutrient concentrations, turbidity) and dam operations?

Information Needs Addressed

RIN 1.1. What are the fundamental trophic interactions in the aquatic ecosystem?

RIN 1.4. What is the current carbon budget for the Colorado River ecosystem?

CMIN 1.1.1. Determine and track the composition and biomass of primary producers below Glen Canyon Dam in conjunction with measurements of flow, nutrients, water temperature, and light regime.

CMIN 1.2.1. Determine and track the composition and biomass of benthic invertebrates below Glen Canyon Dam in conjunction with measurements of flow, nutrients, water temperature, and light regime.

CMIN 1.5.1. Determine and track the composition and biomass of drift in the Colorado River in conjunction with measurements of flow, nutrients, water temperature, and light regime.

Methods and Tasks

Monthly sampling at Lees Ferry and Diamond Creek will continue in FY2010 and FY2011. In each year, probably in early summer, one river trip will be launched to collect samples at each of the four less accessible sites (Marble Canyon, about RM 30; below the Little Colorado River (LCR) confluence, about RM 61; Randy's Rock, about RM 126; and below Havasu Creek, about RM 163). Three of these less accessible sites support known aggregations of humpback chub.

Specifically, primary production is being measured continuously at Lees Ferry and at Diamond Creek. Primary production data collected during September and October 2008–12 will be compared with the months before and after this period to determine whether steady flows affect rates of in-stream primary production. Organic and invertebrate drift is also measured monthly at Lees Ferry and Diamond Creek. To determine whether steady flows affect drift rates, data collected in September and October 2008–12 will be compared data collected during months before and after this period. In addition to regular monitoring efforts, the food base project began intensive study of backwaters on an April 2008 river trip as part of the 2008 high-flow experiment (HFE). Data collected in backwaters includes primary and invertebrate production and dye-tracer studies to determine water residence time. Because data collection in backwaters began in April 2008, data on biological parameters from previous years is not available to compare with 2008 fall steady flows data. However, water residence time will only be affected by the morphology of backwaters and the flow regime but not season. Thus, it is possible to determine if steady flows affect water residence time in backwaters by comparing data collected during other flow regimes (that is, April and June 2008 and January 2009). The food base project is planning a river trip in September 2009 to collect additional samples and water residence time measurements during the steady flow experiment.

Quantify Basal Resources Using a Carbon Budget Framework (RIN 1.4, CMIN 1.1.1)

Primary production and ecosystem respiration will be quantified using whole-stream metabolism calculations. Diel changes in dissolved oxygen concentration, a byproduct of algal photosynthesis, will be used to determine rates of algae production for mile-long reaches of the river. Nighttime sags in dissolved oxygen concentration will be used to determine ecosystem respiration, a measure of basal resource (both leaf litter and algae) consumption. If the quantity of carbon consumed during respiration exceeds the quantity of carbon produced by algal photosynthesis, this finding indicates allochthonous inputs may be an important basal resource fueling the aquatic food web. Data are being collected monthly at Glen Canyon and Diamond Creek and once per year along the river corridor.

Allochthonous Inputs

Allochthonous inputs originate from riparian vegetation, tributaries, and Lake Powell. Allochthonous inputs from riparian vegetation have been quantified (U.S . Geological Survey, unpub. data, 2008). ISCO automated water samplers (only at Paria River and LCR) will be used to collect samples of particulate organic matter during flooding events. During flood events, Paria River coarse organic matter will be sampled using large plankton nets. Water samples and plankton nets will be used to quantify the concentration of dissolved nutrients, dissolved organic matter, and plankton coming from Lake Powell. Samples will be collected monthly.

Standing Stocks

The standing stock of algae and organic matter will be quantified using a Hess sampler, a modified suction sampler, or by scraping algae off rocks (method depends on habitat type). These data will provide a measure of basal resource availability within each reach. Collections will occur quarterly at Glen Canyon and Diamond Creek and once per year at downstream locations.

Transported Organic Matter and Invertebrates

The amount of organic matter and invertebrates transported into and out of each reach will determine the extent to which downstream reaches are linked to upstream processes. Depth integrated water samples will be used to quantify transported organic matter and invertebrates.

Determine Important Trophic Pathways Linking Basal Resources with Fish (RIN 1.1)

Stable isotope and diet analysis of invertebrates and fish were conducted during the first 3 years of this project. These samples will be used to determine trophic pathways. No additional samples will be collected in FY2010–11.

Determine Flux along Trophic Pathways (CMIN 1.2.1)

Invertebrate density, production, and growth measurements were made through sampling all benthic habitats (that is, cobble bars, cliff faces, boulders, talus slopes, sandy bottom, etc.) to quantify density of invertebrates. Habitat specific density estimates will be made using shoreline and bed classification data from the Physical Science and Modeling Program. Growth measurements were made for the most common invertebrates (for example, New Zealand mudsnails, *Gammarus*, chironomids, and simuliids) in controlled chambers. Production of invertebrates will be calculated using density estimates coupled with growth measurements. During FY2010–11, invertebrate density will be quantified quarterly at Glen Canyon and Diamond Creek and once per year at downstream locations.

Fish density and production estimates were made during the first 3 years of the project. No such sampling will occur in FY2010–11. Density estimates for small-bodied and juvenile fish have been determined quarterly using the multi-pass depletion method. Density estimates for larger bodied fish have been derived using existing fisheries monitoring data. Production estimates will be attempted using existing fisheries data and literature values.

Bioenergetics modeling and trophic basis of production calculations will be made in FY2010–11. Invertebrate and fish production data will be coupled with diet information (derived from both gut content and stable isotope analysis) to determine the relative contribution of basal resources to invertebrate and fish production.

Organic and invertebrate drift concentrations will be measured monthly at Lees Ferry and Diamond Creek and once per year at the LCR confluence. Samples will be collected across a range of discharge rates to determine the effect that dam operations have on drifting food resources. Continuous

measurements of whole-stream metabolism are being conducted at Lees Ferry to determine the effect that dam operations have on algae production and ecosystem respiration. YSI 6600 sondes are deployed continuously at RM -8 and RM 0 to measure dissolved oxygen concentrations, which are used in metabolism calculations. Estimates of algae production at Diamond Creek are also being made using a YSI 6920 sonde that is continuously deployed there. These instruments are recalibrated once per month when the collection of drift samples is undertaken.

Links/Relationships to Other Projects

Physical Sciences

Four of the food base six study reaches are fine grained integrated sediment transport (FIST) and integrated water-quality (IWQ) monitoring sites. Bathymetry, bed classification, sediment transport, and water-quality data will be used to determine how the physical environment affects the standing mass, distribution, and production of basal resources and invertebrates. The Physical Science and Modeling Program will be relied upon for its infrastructure and capabilities to estimate inputs of organic matter from the Paria River during base flow and flood events. Finally, the temperature model that is being developed by the Physical Science and Modeling Program will be a valuable tool for estimating systemwide growth rates of algae and invertebrates because temperature is an important determinant of algae and invertebrate growth rates.

Fisheries

Ongoing fisheries monitoring data on the distribution and relative density of common native and nonnative fish will be used to determine rates of energy flow to fish in the system. Where possible, existing fisheries monitoring efforts will be relied on to obtain the fish stomachs and tissue samples required for gut content and stable isotope analysis, respectively.

Terrestrial Resources

Ongoing vegetation mapping efforts have been used to estimate rates of allochthonous inputs to the mainstem Colorado River.

Logistics

Monthly sampling at will be conducted at Lees Ferry and Diamond Creek, and one river trip will be launched annually to sample less accessible sites.

Products/Reports

Publications

At least six publications in peer-reviewed journals will be produced as a result of these projects. Tentative subjects for these publications include,

- measuring air-water gas exchange and whole-system metabolism in a large, regulated river (proof-of-concept paper);
- assessing the seasonal and spatial variation in organic matter inputs to the Colorado River, Grand Canyon (synthesis paper of metabolism, allochthonous inputs, lake inputs, tributary inputs, etc.);
- determining spatial variation of secondary production of invertebrates in the Colorado River;
- analyzing the spatial variation in the relative importance of basal resources to invertebrate and fish production in the Colorado River;

- linking whole-river carbon flows with food webs in the Colorado River; and
- determining impacts of New Zealand mudsnails on invertebrate and fish production in the Colorado River.

Reports

An number of reports will be produced as the result of these projects, including the following items:

- Brief trip reports are completed and submitted to Grand Canyon National Park shortly after each trip to comply with permitting requirements.
- Multiple manuscripts using the data from this effort are being prepared for peer-reviewed outlets.
- Annual progress report will be submitted by December 31 of each year.
- A final report summarizing findings from the March 2008 HFE will be submitted by December 31, 2009.
- A core-monitoring report will be produced by September 2011.
- A draft final report summarizing major results and recommendations will be submitted by May 2010.

Budget

FY2010

BIO 1.R1.10	
Aquatic Food Base (FY2005–10)	
	Fiscal Year 2010
GCMRC personnel costs (21% burden)	185,122
GCMRC project-related travel/training (21% burden)	5,000
GCMRC operations/supplies (21% burden)	5,000
GCMRC equipment purchase/replacement (21% burden)	1,000
GCDAMP logistical support (21% burden)	30,000
Outside GCMRC and contract science labor (21% and/or other burden rate)	0
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator's burden)	219,000
Project Subtotal	**$ 445,122**
DOI customer burden (combined 6.09%, 21% and/or other rates)	60,823
Project Total (Gross)	**$ 505,945**
Percent outsourced (outside of GCMRC; includes 50% of logistics)	52.6%

BIO 1.R4.10	
Impacts of Various Flow Regimes on the Aquatic Food Base (FY2008–10)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	11,260
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	5,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	40,000
Project Subtotal	**$ 52,260**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	5,851
Project Total (Gross)	**$62,111**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	68.4%

FY2011

BIO 1.M1.11	
Aquatic Food Base Monitoring (FY2011–Ongoing)	
	Fiscal Year 2011
GCMRC personnel costs (21% burden)	164,200
GCMRC project-related travel/training (21% burden)	3,000
GCMRC operations/supplies (21% burden)	5,000
GCMRC equipment purchase/replacement (21% burden)	5,000
GCDAMP logistical support (21% burden)	30,000
Outside GCMRC and contract science labor (21% and/or other burden rate)	0
Cooperative/interagency agreements (6.09% GCMRC burden plus cooperator’s burden)	0
Project Subtotal	**$ 207,200**
DOI customer burden (combined 6.09%, 21% and/or other rates)	43,512
Project Total (Gross)	**$ 250,712**
Percent outsourced (outside of GCMRC; includes 50% of logistics)	7.2%

GCDAMP Goal 2—Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.

BIO 2.R1.10—Little Colorado River Humpback Chub Monitoring Lower 13.6 km (Population Estimates)

BIO 2.R2.10—Little Colorado River Humpback Chub Monitoring Lower 1,200 m

BIO 2.M1.11—Little Colorado River Humpback Chub Monitoring

Start Date

2000

End Date

Ongoing

Principal Investigators

D.R. Van Haverbeke (FY2010–11) and W. Persons (FY2010), Arizona Game and Fish Department

Geographic Scope

Little Colorado River

Project Goals

This project seeks to continue monitoring of humpback chub (HBC) in their primary spawning tributary area in Grand Canyon, the Little Colorado River (LCR), using three monitoring efforts in FY2010. If a review of the data confirms the recommendation of the 2009 Protocol Evaluation Panel (PEP) for Grand Canyon Fishes, then one modified effort will be mounted in FY2011 with the goal of implementing an ongoing core monitoring of HBC in the LCR.

The specific objectives that are addressed by this project include

- providing an annual assessment of the HBC population in the LCR by collecting the mark-recapture data that supports an annual closed population estimate of HBC in the lower 13.6 km of the LCR;
- collecting and reporting biological data including length-frequency data, community composition, sexual condition, characteristics of native fish (gender, ripeness, tuberculate, etc.), frequency of external parasites (primarily *Lernaea cyprinacea*), and predation frequency;

- collecting and reporting biological data, including length-frequency data and catch rates for nonnative fish in the lower 13.6 km of the LCR;
- collecting other pertinent information related to physical parameters of the LCR, especially temperature and turbidity; and
- determining the critical physical and biotic factors that may be limiting to, or supportive of, the HBC and other native fish populations in Grand Canyon so as to develop strategies that reduce, eliminate, or control limiting factors.

Need for Project

The endangered status of HBC makes the species a resource of concern for the GCDAMP and natural resource managers. The data collected as a result of this project has been essential to modeling the Grand Canyon population of HBC (Coggins and Walters, 2009). Monitoring of the Grand Canyon HBC population, which feeds modeling efforts, is critical to meeting the important, ongoing need for status and trends information for this endangered fish. Because, most humpback chub in Grand Canyon are found either in or near the LCR (Paukert and others, 2006), monitoring in the LCR is an efficient way to gather data on the population.

Since 2000, this project has included an annual spring and fall mark-recapture effort and annual monitoring in the lower 1,200 m of the LCR during the spring. The 2009 PEP noted that the spring sampling of HBC in the LCR is one of the most important fish monitoring projects that the GCMRC and its cooperators conduct on behalf of the GCDAMP and recommended that it be maintained in the future. While the PEP recognized that much good HBC information had been generated by the fall monitoring effort and monitoring the lower 1,200 m during the spring, the PEP did not identify these projects were not critical to a core-monitoring effort. The PEP did observe, however, that these two projects might have other benefits, including occasional increased tagging efforts, in the future. The PEP did recommend that elements of monitoring conducted in the lower 1,200 m of the LCR—such as sampling protocol, gear types, and analysis—were suitable for continuation.

The established program of three LCR monitoring trips will be continued in FY2010 to allow sufficient time to determine the ramifications of possible PEP recommended changes on monitoring results and modeling. The evaluation of proposed changes will be conducted early in FY2010, and a meeting of the cooperating agencies and interested GCDAMP parties will be convened to discuss the results. This meeting will be used to identify the specific monitoring techniques, gears, and analyses to be incorporated into monitoring efforts for FY2011 and beyond. However, if the evaluation process to be conducted in FY2010 does not support the recommendations of the PEP, then one or more efforts described in FY2010 will be maintained in FY2011.

Strategic Science Questions

Primary SSQ addressed:

> **SSQ 1-1.** To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year (YoY) and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

Additional science question addressed by these projects:

> **SSQ 1-2.** Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile HBC to the adult population?

GCDAMP Science Advisors (SAs) have summarized the SSQs with the following question (the projects outlined here specifically address this question, especially their evaluation of annual spawning success):

> **SA 1.** What are the most limiting factors to successful HBC adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

Information Needs Addressed

Primary information needs addressed:

> **CMIN 2.1.2.** Determine and track recruitment (identify life stage), abundance, and distribution of HBC in the LCR.

Methods and Tasks

Annual Spring (March and April) Humpback Chub Abundance Assessments in the Lower 13.6 km of the Little Colorado River (FY 2010)

In the spring, two mark-recapture trips (10 days) are conducted annually in the lower 13.6 km of the LCR to estimate the abundance of HBC (>100 mm total length). This program has been ongoing since 2000 and produces annual closed population assessments of HBC abundance. These efforts rely on multiple-event mark-recapture analysis of passive integrated transponder (PIT) tag data to produce abundance estimates using closed population models. Additionally, this sampling effort provides data for populating the Age-Structured Mark-Recapture (ASMR) stock assessment model (open population model) and measures of relative abundance of the spawning and resident populations of HBC in the lower 13.6 km of the LCR.

During each LCR trip, three camps are established: Salt Canyon, Coyote Canyon, and Boulders Camps. Unbaited hoop nets (0.5–0.6 m diameter, 1.0-m length, 6-mm mesh, single 10-cm throat) are set from shorelines to capture and PIT tag HBC as part of a mark-recapture program. Each camp is responsible for fishing hoop nets throughout an approximately 5-km reach from 0 to 13.57 km. Sixty hoop nets spaced 80 to 150 m apart will be fished throughout this reach. Each hoop net will be positioned in habitat suspected of yielding good catches of HBC. Nets will be repositioned as needed. On average, each hoop net will be checked once every 24 hours. Each reach will be broken down into three sub-reaches and nets will be fished for three net checks (3 days) in each sub-reach. In addition to fishing hoop nets as detailed above, personnel will be responsible for the following tasks, including:

- measuring and recording the fork and total lengths, sex, sexual condition, and sexual characteristics for all captured native fish (except speckled dace);
- measuring and recording the total length, sex, and sexual condition of all other captured fish;
- recording the stomach contents of all captured large-bodied nonnative fish (except common carp);
- implanting PIT tags in all HBC ≥100 mm total length and all other native fish ≥150 mm total length and fin clipping tagged fish recaptured on the same marking effort (In order to reduce PIT tagging, but still obtain needed population information, bluehead suckers will only be tagged during the April trip.); and
- recording the location, shoreline habitat, hydraulic unit, and set and pull time, and map locations for each hoop net set.

Personnel at Boulders Camp make daily measurements of turbidity with the Hach 2100 turbidimeter and water temperature.

Annual Fall (September and October) Humpback Chub Abundance Assessments in the Lower 13.6 km of the Little Colorado River (FY2010)

The fall sampling primarily provides an estimate of the abundance of subadult fish rearing in the LCR. These data support the ASMR model to assess HBC population numbers. Two trips into the LCR are conducted to collect the data used to construct these estimates in the fall (September and October). Findings from the fall trip are compared to the spring-abundance estimates. Sampling is predominantly conducted using hoop nets evenly distributed throughout the lower 13.6 km of the LCR. Other types of sampling gear are not used in the LCR because they have been shown to be less efficient at capturing HBC >150 mm total length in the LCR.

Mainstem Hopi-Salt Site

At the conclusion of the October LCR effort, two people from the LCR crew will proceed down the mainstem by boat to the Hopi-Salt site (~RM 63.5). Thirty hoop nets are deployed along standardized sites within this reach. Each net is fished for 3 nights and checked daily.

Annual Spring Relative Humpback Chub Abundance Assessment in the Lower 1,200 m of the Little Colorado River (FY2010)

This program was established by the Arizona Game and Fish Department (AZGFD) in 1987 and has operated continuously through 2004, except from 2000 to 2001 (Arizona Game and Fish Department, unpub. data, 2008). The program produces annual assessments of the relative abundance (that is, catch-per-unit effort) of all size classes of HBC, flannelmouth suckers, bluehead suckers, speckled dace, and a host of nonnative fish in the lower 1,200 m of the LCR. Data are collected during a 30- to 40-day period in spring (April and May) using hoop nets set in standardized locations throughout the reach. In general, this effort has produced the longest and most consistent relative abundance data set available to infer trends for the population of HBC in the LCR. Results provide an independent comparison to the mark-recapture assessments. The statistical power of this portion of the monitoring program has not yet been assessed, but statistically significant differences in relative abundance are apparent in current data.

Annual Spring Humpback Chub Monitoring in the Lower 13.6 km of the Little Colorado River (FY2011)

Analysis of all of the historical data of HBC monitoring generated by the three projects listed above will be conducted in FY2010. The three cooperating agencies (USGS, USFWS, and AZGFD) will provide their data and participate in the analysis process. In particular, the analysis process will focus on the how closed population efforts and the ASMR population estimate performs using only spring catch data. If a spring monitoring effort, using one or more of the sampling approaches described above, can be used and still provide useful HBC population information as well as information on other native and nonnative fish species, then a single monitoring effort will be employed in FY2011. For planning purposes, it is assumed that the spring sampling, the first project described above, would be the basis for the FY2011 project, subject to modification with additional analysis. Specific sampling methods, gears, and analyses are to be determined when the cooperators meet; a meeting is planned for late 2009. This project will be led by USFWS, with support from AZGFD.

Links/Relationships to Other Projects

Improvement of the status of the HBC will be necessary for the species to be considered for downlisting or delisting. The GCDAMP can contribute to an improved status for HBC, thereby decreasing the amount of effort required of the GCDAMP stakeholders on behalf of this species. The most recent iteration of the recovery goals for the HBC (initiated in 2007) required a minimum of 2,100 adults in Grand Canyon, a steady or increasing trend in the population, and control of environmental threats, among other requirements. One element of HBC conservation in Grand Canyon

could be a Glen Canyon Dam flow-release regimen that supports this species. These flows can be expected to impact many elements of the canyon resources, including sediment, cultural resources, and recreation. Therefore, releases that benefit one resource like the HBC must also be consistent with conservation of other resources. Conservation of LCR resources, especially water, and protection from catastrophic events is important not only to protecting the spawning HBC population in the LCR but also to protect other organisms found there.

The HBC monitoring conducted in the LCR has been fundamental to increasing understanding of the life history of Grand Canyon HBC. Stone and Gorman (2006) found that young life stages of HBC rely heavily on shallow, nearshore habitats by day to avoid predation and cannibalism. This is one piece of evidence that has led GCMRC, USFWS, and AZGFD researchers to be interested in the fate of young HBC in shallow, nearshore habitats of the mainstem Colorado River. The interest in expanding knowledge of HBC in the nearshore mainstem habitats to support conservation of this species has contributed to the development of the nearshore ecology/fall steady flows project described below.

Logistics

FY2010

Lower 13.6 km: Two spring mark-recapture trips, two fall mark-recapture trips, helicopter support
Lower 1,200 m: One spring trip, helicopter support

FY2011

Lower 13.6 km: Two spring mark-recapture trips, helicopter support

Products/Reports

- The USFWS will deliver two trip reports annually within 60 days of completion of the fieldwork, including data collected, to the GCMRC. The trip reports will be summarized and analyzed in a final report delivered to the GCMRC in January of the following year. These reports address the lower 15-km monitoring and the monitoring above Chute Falls (see project description for BIO 2.M3.10–11).
- The AZGFD will deliver one annual report on the results of their monitoring of the lower 1,200 m of the LCR to the GCMRC. The data collected in these monitoring efforts support the stock assessment project described below. These data also contribute to the HBC core-monitoring report. Annual reporting due will be provided by December 15 of each year.
- A core-monitoring report, summarizing core-monitoring efforts, 2009 PEP recommendations, and results of analyses recommended by the 2009 PEP, will be completed in FY2011.

Budget

FY2010

BIO 2.R1.10	
LCR HBC Monitoring Lower 13.6km (Population Estimates) (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	20,000
GCDAMP Logistical Support (21% Burden)	52,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	347,455
Project Subtotal	**$ 419,455**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	36,280
Project Total (Gross)	**$455,735**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	89.0%

BIO 2.R2.10	
LCR HBC Monitoring Lower 1,200m (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	8,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	45,000
Project Subtotal	**$ 53,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	4,421
Project Total (Gross)	**$ 57,421**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	92.5%

FY2011

BIO 2.M1.11	
LCR HBC Monitoring (FY2011—Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	12,000
GCDAMP Logistical Support (21% Burden)	28,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	245,475
Project Subtotal	**$ 285,475**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	23,349
Project Total (Gross)	**$ 308,824**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	84.0%

BIO 2.M3.10–11—Humpback Chub Translocation and Monitoring Above Chute Falls

Start Date

2003

End Date

Ongoing

Principal Investigator

D.R. Van Haverbeke, U.S. Fish and Wildlife Service

Geographic Scope

The Little Colorado River (LCR) above Chute Falls

Project Goals

The goals of this project in FY2010–11 include,

- determining the critical physical and biotic factors that may be limiting to or supportive of humpback chub (HBC) and other native fish populations in Grand Canyon, so as to identify strategies to reduce, eliminate, or control limiting factors;
- identifying the habitat characteristics that are most important to all life stages of HBC, so as to identify methods that maintain, and possibly replicate, suitable habitats; and
- reducing predation risk to HBC from nonnative species that may ascend the LCR from the mainstem Colorado River.

Specific objectives of the projects include,

- translocating small HBC from near the confluence with the Colorado River to above Chute Falls and
- obtaining population estimates for HBC ≥100 mm and ≥200 mm above Chute Falls.

Need for Project

Translocating HBC above Chute Falls, a series of waterfalls approximately 16 km upstream on the LCR above the confluence with the Colorado River, has been conducted since 2003. Despite evidence that fish do move above Chute Falls on their own, the potential exists for genetic drift, or a change in the genetic makeup of the population when compared to the main HBC population farther downstream on the LCR, owing to the "founder effect," a situation managers wish to avoid. Genetic drift was considered in the *Draft Humpback Chub Genetics Management Plan* (U.S. Fish and Wildlife Service, unpub. data, 2008). The recommended approach to avoiding founder effect above Chute Falls is to (1) provide for an influx of fish to span a generation (long-lived fish); (2) establish a reasonable approximation of a natural population; and (3) select fish of normal size, age distribution, and gene flow from donor source.

Translocating HBC above Chute Falls has now been conducted five times between 2003 and 2009. Because the LCR above Chute Falls contains fewer nonnative fish than the lower portion of the LCR, translocation efforts above Chute Falls allow managers to assess the degree of impact to HBC imposed

by interactions with nonnatives. With the documentation of a limited amount of reproduction in the LCR above Chute Falls, the translocation of HBC also is helping to support population growth and increase the demographic range for the species by nearly 5 km. Managers have been able to document the movement of HBC from below Chute Falls to above the barrier, providing new information about the movement capabilities of HBC and the potential for the population to expand with limited human interference. Monitoring of HBC above Chute Falls is important for evaluating the effectiveness of translocating HBC.

A review of monitoring data for HBC above Chute Falls during a 2009 Protocol Evaluation Panel (PEP) for Grand Canyon Fishes concluded that if the translocation is continued, then monitoring of the translocation should continue. The need for additional translocations and the timing of those efforts should be compared to recommendations made in the *Final Humpback Chub Genetics Management Plan*, which is being prepared by the USFWS, when it is available.

Translocation is a management action designed to help conserve HBC. Because this project includes translocation, external funding for the management action should be developed.

Strategic Science Questions

The Glen Canyon Dam Adaptive Management Program Science Advisors have summarized strategic science questions related to HBC with the following question, which this project specifically addresses, especially annual spawning success):

> **SA 1.** What are the most limiting factors to successful HBC adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

Information Needs Addressed

Primary information need addressed:

> **CMIN 2.1.2** Determine and track recruitment (identify life stage), abundance, and distribution of HBC in the LCR.

Methods and Tasks

Two separate trips are conducted in the summer above Chute Falls in the LCR to monitor translocated fish and potential offspring. These trips occur during late May or early June when the LCR discharge is at base flow to provide an annual abundance estimate of HBC within this region. In addition to the annual population estimate, these data can be incorporated into open population models for HBC being developed by the Grand Canyon Monitoring and Research Center (GCMRC). Moreover, because these fish continue to be implanted with PIT tags (Biomark, Inc.), it is likely that some individuals will eventually be recaptured in the lower LCR corridor and mainstem Colorado River, which would help to improve understanding of HBC migration patterns.

A camp has been established on Navajo lands 16.2 km above the LCR and Colorado River confluence, which is used to house project staff. The camp has an established helicopter pad and offers protection from most floods.

As part of a mark-recapture program to estimate the abundance of individuals ≥100 mm, project staff will be responsible for fishing baited hoop nets (0.5–0.6-m diameter, 1.0-m length, 6-mm mesh, single 10-cm throat) in the LCR corridor above Chute Falls (13.6 km), which is the upstream extent of the current downstream LCR monitoring. Approximately 50 hoop nets will be fished throughout this upper reach from 13.6 to 18.0 km, with an average spacing between nets of approximately 100 to 150 m. Hoop nets will be positioned in favorable habitats for good catches of HBC. Nets will be

repositioned as needed. On average, each hoop net will be checked once every 24 hours. Each net will be baited near its cod end by attaching a nylon mesh bag (30- by 30-cm, 6-mm mesh) containing AquaMax™ Grower 600 for Carnivorous Species (Purina Mills Inc., Brentwood, Mo.). All captured HBC will be examined for colored elastomer tags and PIT tags. Individuals not previously PIT tagged, but of sufficient size to be tagged without injury, will be held overnight offshore in an aerated tank or in the LCR in a secured holding pen to allow time for digestion of any consumed bait, and thereafter tagged and released.

The overall reach will be broken down into two subreaches and each subreach fished for 3 days. The upper reach designation will be from 18.0 to 15.0 km (at an undesignated point below Blue Spring to the first travertine dam above Chute Falls). Currently, 18 km is the highest point in which HBC have been located above Chute Falls. The lower subreach will extend from 15.0 to 13.6 km (from the first dam above Chute Falls to Lower Atomizer Falls, where lower LCR monitoring begins). In addition to fishing baited hoop nets and PIT-tagging HBC as detailed above, staff will be responsible for

- measuring and recording the fork and total lengths, gender, spawning condition, and sexual characteristics for all captured native fish (except speckled dace);
- measuring and recording the total length, gender, and spawning condition of all other captured fish;
- recording the stomach contents of all captured large-bodied nonnative fish, except common carp;
- recording the location, shoreline habitat, hydraulic unit, set and pull time, and map locations for each hoop net set; and
- measuring daily turbidity (using the Hach 2100 turbidimeter), water temperature, and CO_2 (using titration).

Links/Relationships to Other Projects

Projects such as this one that investigate potential strategies for expanding the Grand Canyon HBC population support the basinwide goal of conserving HBC with the long-term goal of downlisting and delisting the species from the Federal endangered species list. The experiences gained, and successes realized, in this project have been fundamental to supporting additional translocation efforts. Further translocations and monitoring are expected to provide important techniques and life-history information to inform additional translocations to other tributaries, currently expected to be Shinumo Creek, and perhaps Havasu and Bright Angel Creeks.

Logistics

Both the translocation trip and the monitoring trip for this effort require helicopter support. Translocation is anticipated in the summer with follow-up monitoring in the fall.

Products/Reports

The USFWS will deliver two trip reports annually, including data collected, to the GCMRC by December of each year. The trip reports will be summarized and analyzed in a final report delivered to the GCMRC in January of the following year. These reports address HBC monitoring in the lower 13.6 km of the LCR and incorporate the translocation and the monitoring above Chute Falls.

Budget

FY2010

BIO 2.M3.10	
HBC Translocation and Monitoring Above Chute Falls (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	55,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	72,244
Project Subtotal	**$ 127,244**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	15,950
Project Total (Gross)	**$ 143,194**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	78.9%

FY2011

BIO 2.M3.11	
HBC Translocation and Monitoring Above Chute Falls (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	55,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	74,412
Project Subtotal	**$ 129,412**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	16,082
Project Total (Gross)	**$ 145,494**
Percent Outsourced (Outside of GCMRC; includes 50% of	78.8%

Logistics)	

BIO 2.M4.10–11—Monitoring Mainstem Fish

Start Date

2010

End Date

Ongoing

Principal Investigators

A.S. Makinster, Arizona Game and Fish Department; D.R. Van Haverbeke, U.S. Fish and Wildlife Service; and M.E. Andersen and K.D. Hilwig, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

The mainstem Colorado River in Grand Canyon between Lees Ferry and upper Lake Mead

Project Goals

This project is intended to increase knowledge of native and nonnative fish in the Colorado River mainstem. It is also intended to be responsive to the recommendations of the 2009 Protocol Evaluation Panel (PEP) for Grand Canyon Fishes. The project seeks to advance the following goals:

- Monitor the documented humpback chub (HBC) aggregations in the mainstem Colorado River
- Continue to monitor native and nonnative fish in the mainstem Colorado River
- Provide presence/absence and distribution information on Colorado River native and nonnative fish
- Implement an effort consisting of three monitoring trips that are responsive to advances in data analysis, sampling design, and gear selection (A flexible approach that builds on prior knowledge is needed to develop monitoring of the Colorado River fish population that is responsive to continuing changes in dam operations, climate, local meteorology, species population sizes, and management actions. Primary emphasis is on broad sampling, with a secondary emphasis on developing high statistical confidence in species-specific trends. If this monitoring suggests changes in either native or nonnative populations, then future monitoring can be directed at gathering more data on a specific species or location.)
- Provide annual monitoring and timely reporting that allows for annual review of specific sampling design, gear, and data analyses (The cooperating agencies will meet formally at least once a year with interested Grand Canyon Adaptive Management Program (GCDAMP) members to review and potentially modify sampling design, gear, and data analyses. The three lead cooperators— Arizona Game and Fish Department (AZGFD), U.S. Fish and Wildlife Service (USFWS), and Grand Canyon Monitoring and Research Center (GCMRC)—will assume responsibility, with other cooperators as assigned, for data reporting and analysis.

Annual review of monitoring efforts may suggest that the modification of objectives and efforts is needed, which may include, but is not limited to the following changes:

- Sampling at known humpback chub aggregations may be increased. Managers and scientists may investigate population expansions, especially in support of range-wide recovery goals (U.S. Fish and Wildlife Service, 2008).
- Sampling may be increased for nonnative species. Managers and scientists may concentrate efforts to reduce threats from nonnatives.

Tasks to address the goals described above will be phased in over the FY2010–11 period, and are to be included in analysis of existing fish-capture data recommended by the 2009 PEP.

Need for Project

Native fish populations in Grand Canyon are key resources of concern influencing decisions on both the operation of Glen Canyon Dam and nonflow actions. To inform these decisions, it is imperative that accurate and timely information on the status of fish populations, particularly the endangered HBC, be available to managers. A suite of adaptive experimental management actions are being contemplated to better understand the mechanisms controlling the population dynamics of native fish and to identify policies that are consistent with the attainment of management goals. The assessments generated from this project provide a baseline from which to assess the effects of implemented experimental actions. This information is therefore crucial to (1) inform the program as to attainment of identified goals, (2) provide baseline status and trend information to be used as a backdrop to further understand mechanisms controlling native fish population dynamics, and (3) evaluate the efficacy of particular management policies in attaining program goals. The results of this project are potentially useful in assessing changes to the Federal Endangered Species Act listing status of HBC in Grand Canyon.

Nonnative fish are among the greatest threats to native fish in western North American rivers (Miller, 1961; Minckley and Deacon, 1991; Tyus and Saunders, 2000; Coggins, 2008). Nonnative fish may threaten native fish by direct predation, by competing for available food and other resources, and by habitat modification (Minckley, 1991; Hawkins and Nesler, 1991). Nonnative fish were introduced into Grand Canyon not later than early in the 20th century (Woodbury, 1959; Valdez and Ryel, 1995). While native fish survived these initial introductions at least long enough to be described by early researchers, other system stressors, especially the modification of natural flows as a result of dam installation, appear to have increased the threats to native fish from nonnative fish (Minckley, 1991; Clarkson and Childs, 2000).

The GCDAMP has recognized nonnative fish as a threat that needs to be addressed, proceeding with implementation of a nonnative fish control experiment around the Little Colorado River (LCR) inflow reach from 2003 to 2006. The 2003 to 2006 control project was most successful at removing rainbow trout (RBT). This work plan builds on that effort. As the Colorado River mainstem becomes warmer because of climate effects (Seager and others, 2007), the potential for an increased threat from warmwater adapted nonnative fish increases (Eaton and Scheller, 1996; Chu and others, 2005; Rahel and Olden, 2008). There is an immediate need to begin investigating which species pose the greatest threats to natives in Grand Canyon, to understand how those species might be better monitored and controlled, and to test control approaches for efficacy.

In response to identified GCDAMP goals, the 2009 PEP for Grand Canyon Fishes concluded that it is important to conduct mainstem fish monitoring with a variety of sampling designs and gear types. The experts involved with the PEP determined that fine resolution of confidence in species-specific mark-recapture population estimates could only be accomplished with large amounts of personnel time, sampling gear and equipment, and funding that is not currently available. Further, the PEP determined that even if more resources could be employed, fine-scale data collection every year was not warranted and could cause harm to native fish. Therefore, the PEP recommended a broad approach to use multiple gear types at various times of the year and over a broad geographic range to give scientists and managers the most useful data on an annual basis.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

SSQ 1-2. Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile humpback chub to the adult population?

Additional SSQs addressed:

SSQ 1-4. Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.

SSQ 1-8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

SSQ 5-6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance?

The GCDAMP Science Advisors articulated the following summary science questions to addressed by this project:

SA 1. What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on young of year and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

SA 2. What are the most probably positive and negative impacts of warming the Colorado River on humpback chub adults and juveniles?

Information Needs Addressed

Primary information needs addressed:

CMIN 2.1.2. Determine and track recruitment of all life stages, abundance, and distribution of HBC in the Colorado River.

CMIN 2.4.1. Determine and track the abundance and distribution of nonnative predatory fish species in the Colorado River.

CMIN 2.6.1. Determine and track the abundance and distribution of flannelmouth sucker, bluehead sucker, and speckled dace populations in the Colorado River ecosystem.

RIN 2.4.2. Determine if suppression of nonnative predators and competitors increases native fish populations.

RIN 2.4.3. To what degree, which species, and where in the system are exotic fish a detriment to the existence of native fish through predation or competition?

RIN 2.4.4. What are the target population levels, body size, and age structure for nonnative fish in the Colorado River ecosystem that limit their levels to those commensurate with the viability of native fish populations?

Methods and Tasks

The methods described below are intended to be consistent with the 2009 PEP for Grand Canyon Fishes and will be compared to the PEP final report to ensure consistency when that document is available. Annual review may indicate alternative methods are required, especially if expanding HBC populations or expanding nonnative fish populations are indicated by the data from this and other trips collected in these and previous years. This approach is intended to sample species and habitats as broadly as possible in order to give managers and scientists diverse information on which to direct this and other projects in future years. If the analyses conducted by GCMRC, USFWS, and AZGFD in 2009 and 2010 indicate that the methods described herein and the recommendations of the 2009 PEP are not warranted, then alternative approaches to monitoring will be developed and implemented.

Mainstem Spring Electrofishing

Electrofishing will be conducted at stratified random sites not in immediate proximity to campers. Mainstem fish monitoring, including the monitoring below Diamond Creek, has used boat-operated electrofishing to provide a general assessment of the status and trends of native and nonnative fish in the Colorado River between Lees Ferry and Lake Mead since 2001. The electrofishing gear is not without its limitations—in particular, it is not effective at sampling deep-water habitats or when conditions are turbid. However, electrofishing remains the most important tool for providing an overall assessment of the mainstem fish community, and its use will be retained in FY2010–11. Data from these trips supports annual analyses of species catch-rate data and also support the update of the Age-Structured Mark-Recapture (ASMR) model for HBC, if this species is captured.

Mainstem Fall Humpback Chub Monitoring

Three known aggregations of HBC (Valdez and Ryel, 1995) are sampled with a variety of nets by this project. Additional sites selected by a stratified random selection will also be sampled. The primary HBC aggregations that will be sampled include 30 Mile, below the LCR, and Inner Granite Gorge. This project will also sample at and below the mouth of Shinumo Creek, a tributary to the Colorado River, to investigate whether HBC translocated to this tributary have moved into mainstem habitats. Gear types may include but are not limited to the following: hoop nets, trammel nets (water temperature below 20 deg. C), and seines (backwaters). Gear selection is dependent on habitats sampled.

This project makes use of trammel nets when water temperatures are below 20 degree C to limit stress on captured fish. Trammell net sets are 2 hours or less. Because working trammel nets requires use of motor boats, this monitoring will emphasize use of trammel nets in locations determined in advance of the trip, but other gear types may be deployed as time and opportunity is available. Sampling in the LCR reach is not conducted in areas where the nearshore ecology project is working. Data from this monitoring may support the update of the ASMR model for HBC.

Mainstem Fall Monitoring

This project will conduct multi-gear monitoring at potential nonnative aggregations, especially near HBC aggregations, and also stratified random sites. Primary HBC aggregations to sample are 30 Mile, Below LCR, and Inner Granite Gorge. Gear types may include, but not be limited to: hoop nets, backpack electroshockers, seines, and angling. Gear selection is dependent on habitats sampled. This trip is conducted in October so that an assessment of species presence/absence and distribution,

especially warm water nonnatives, is conducted when dam release temperatures are typically at their warmest for the year.

The primary site selection for this trip will be conducted using a stratified random design. As additional information is gathered regarding nonnative species, this trip may also be focused on areas where nonnative concentrations may be found. When not sampling at potential nonnative aggregations alternative locations are sampled using a stratified random approach. Data from these trips supports annual analyses of species catch rate data and may also support the update of the ASMR model for HBC.

Links/Relationships to Other Projects

Understanding the factors influencing the dynamics of the Grand Canyon native fish populations, especially the endangered HBC, is important to evaluating the effects of management and conservation activities, especially GCD operations. To determine these factors, a combination of large scale manipulations (for example, experimental removal of nonnative fish or long-term implementation of contrasting flow regimes) and smaller scale process oriented research (for example, assessment of juvenile fish growth rates under various temperature regimes or availability of particular food items) will likely prove most efficient in determining the key mechanisms regulating native fish populations. In each of these endeavors, it is critical that baseline trends in population abundance and recruitment be known. Only with this knowledge is it possible to assess the population level effects of large-scale manipulations. Although it is informative to assess the effects of experimental management on processes thought to be important, like growth or survival at particular life stages, this is not enough to determine the efficacy of particular management actions. Linkages between these processes and ultimate recruitment to populations must be established. Again, these linkages can only be made if baseline trends in population abundance and recruitment are available.

Logistics

The logistical needs for the project are as follows:

- Mainstem Spring Electrofishing Monitoring—2 trips, February and March, motorized; AZGFD (FY2010–11)
- Mainstem Fall Humpback Chub Monitoring—1 trip, September, motorized; GCMRC (FY2010); USFWS (FY2011)
- Mainstem Fall Fish Monitoring—1 trip, October, float; GCMRC (FY2011)

Products/Reports

- Annual reporting on the catch rates, species encountered, size class distributions, and locations of captures for the mainstem spring electrofishing will be the responsibility of AZGFD in FY2010 and FY2011.
- Annual reporting on the catch rates, species encountered, size class distributions, and locations of captures for the fall HBC monitoring will be the responsibility of GCMRC in FY2010 and USFWS in FY2011.
- Annual reporting on the catch rates, species encountered, size class distributions, and locations of captures for the fall mainstem fish monitoring will be the responsibility of GCMRC in FY2011.
- All fish data will be submitted to GCMRC for inclusion in the fish database. These data are used for other projects, especially the stock assessment project and to support nonnative fish monitoring.

Budget

FY 2010

BIO 2.M4.10	
Monitoring Mainstem Fish (FY2010–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	59,662
GCMRC Project Related Travel / Training (21% Burden)	10,000
GCMRC Operations / Supplies / Publishing (21% Burden)	10,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	30,000
GCDAMP Logistical Support (21% Burden)	150,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	300,000
Project Subtotal	**$ 559,662**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	72,799
Project Total (Gross)	**$ 632,461**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	67.0%

FY 2011

BIO 2.M4.11	
Monitoring Mainstem Fish (FY2010–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	43,804
GCMRC Project Related Travel / Training (21% Burden)	10,000
GCMRC Operations / Supplies / Publishing (21% Burden)	10,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	30,000
GCDAMP Logistical Support (21% Burden)	150,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	475,000
Project Subtotal	**$ 718,804**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	80,126

Project Total (Gross)	**$ 798,930**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	76.5%

BIO 2.R7.10–11—Stock Assessment of Grand Canyon Native Fish

Start Date

2007

End Date

Ongoing

Principal Investigators

Fisheries Biologist, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, and C.J. Walters, University of British Columbia

Geographic Scope

Colorado and Little Colorado Rivers in Glen, Marble, and Grand Canyons

Project Goals

This project will provide annual updates of size composition and capture rates of humpback chub (HBC) and other Grand Canyon fish to the Glen Canyon Dam Adaptive Management Program (GCDAMP) and other managers. Reporting will include retrospective time series to allow for comparison with previous years' data. The assembled HBC data from the Grand Canyon fish monitoring projects will be incorporated into updates of the Age-Structured Mark-Recapture (ASMR) model every 3 years (the next ASMR update will be published in 2012).

This project will lead the analyses of existing fish capture information recommended by the 2009 Protocol Evaluation Panel (PEP) for Grand Canyon Fishes. The goal of these analyses is to evaluate whether the fish monitoring project changes recommended by the PEP, especially to reduce some efforts and increase others, are consistent with the available data.

This project will seek to develop and implement methods for making the HBC database available electronically. Data serving must be done in a manner consistent with USGS Fundamental Science Practices.

Need for Project

Native fish populations in Grand Canyon are key resources of concern influencing decisions on both the operation of Glen Canyon Dam and other non-flow actions. To inform these decisions, it is imperative that accurate and timely information on the status of native fish populations, particularly the endangered HBC, be available to managers.

Several adaptive experimental management actions are being contemplated to better understand the mechanisms controlling the population dynamics of native fish and to identify policies that are consistent with management goals. The stock assessments generated from this project will support assessment of implemented experimental actions. This information is therefore crucial to

- inform the program as to attainment of identified goals,
- provide baseline status and trend information to be used as a backdrop to understand the mechanisms controlling native fish population dynamics, and

- evaluate the efficacy of particular management policies in attaining program goals. Finally, results from this project are potentially useful in assessing changes to Federal Endangered Species Act listing status of HBC in the Colorado River.

Strategic Science Questions

Primary SSQ addressed:

> **SSQ 1-1.** To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of YoY and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

Additional SSQ addressed:

> **SSQ 1-8.** How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

The Adaptive Management Program Science Advisors have articulated the following science question, which is partially addressed by this project:

> **SA 1.** What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

Information Needs

> **RIN 2.2.8.** What combination of dam release patterns and nonnative fish control facilitates successful spawning and recruitment of humpback chub in the Colorado River ecosystem?

> **RIN 2.4.2.** Determine if suppression of nonnative predators and competitors increases native fish populations.

Methods and Tasks

To provide HBC status and trend information, the Grand Canyon Monitoring and Research Center (GCMRC) mark-recapture database will be annually updated with the most recent data collected during routine monitoring efforts. Following this update, the HBC mark-recapture database will be reanalyzed using (where appropriate) both open and closed mark-recapture-based abundance estimators to provide the most current information on HBC status and trends. In particular, the ASMR models (Coggins and others, 2006a and 2006b; Coggins, 2007; Coggins and Walters, 2009) will be used to determine trends in HBC abundance and recruitment over multiyear time scales. Over annual time scales, this project will assemble and deliver summaries of annual catch rate and size-class composition of HBC and other species from the Little Colorado River (LCR) and mainstem to the GCDAMP and managers. It will also deliver other species metrics, likely to include results of closed population estimates and juvenile abundance from the LCR.

This project was reviewed by the 2009 PEP for Grand Canyon Fishes. The panel recommended that because of the inherent variability in the ASMR (for example, estimates of growth and mortality rates limit its ability to detect fine scale changes), preparing annual updates of the model was an inefficient use of personnel time, especially for the long-lived HBC. The PEP also observed that the ASMR has only limited sensitivity to detect small annual population changes, and that it requires tremendous personnel and computer resources to generate. Based on these observations, the PEP recommended that the ASMR be updated every 3 to 5 years. Because the GCMRC is planning to prepare the next *State of the Colorado River Ecosystem in Grand Canyon* (SCORE) report in FY2011, the GCMRC

will accelerate this recommendation for the next iteration and include an update of ASMR in the FY2011 SCORE report. In the future, the GCMRC intends the next iteration of the ASMR following the FY2011 update will be scheduled for FY2014, consistent with the PEP recommendation. Updates will include not only estimates of HBC abundance and recruitment from ASMR, but also summaries of annual catch-rate and size composition estimates from LCR hoop net sampling, summaries of annual catch-rate and size composition estimates from mainstem Colorado River hoop and trammel net sampling, and closed population abundance estimates of HBC adults and rearing juveniles in the LCR as these data are available. Finally, the applicability of similar techniques to those described above will be evaluated to assess stocks of flannelmouth sucker and bluehead sucker.

The GCMRC fisheries biologist will work with agency and cooperative personnel to evaluate the utility of the remote passive integrated transponder (PIT) tag antenna project to provide information useful in determining movement rates of HBC into and out of the LCR, empirical capture probability estimates of LCR hoop het sampling, and PIT tag recapture information for inclusion in ASMR.

The 2009 PEP for Grand Canyon Fishes made a series of recommendations that direct shifting monitoring efforts to decrease efforts in the LCR and increase efforts in the mainstem of the Colorado River, subject to an analysis of the existing data to see if their recommendations are consistent with the data. The GCMRC fisheries biologist working on this project will be responsible for assembling and/or conducting the analyses necessary to evaluate the recommendations. AZGFD and USFWS personnel to support this effort will also conduct data analyses of individual projects. If the recommendations are found to be warranted, the shift to different monitoring will be initiated in FY2011; these projects are described elsewhere in Goal 2 of this work plan. If the data analyses are not found to support the recommendations, projects will revert to the work plans described for FY2010. The full analysis of all the data will not be required in FY2011, so there will be some shifting of the fisheries biologist time to other projects.

Links/Relationships to Other Projects

The status and trend of the Grand Canyon HBC population are two of the key metrics utilized in GCDAMP to evaluate the success of the GCDAMP and actions undertaken under the sponsorship of the GCDAMP. Therefore, annually updating the HBC catch rates and size-class composition and updating ASMR model runs every 3 years is related to many other GCDAMP work plan elements, especially experimental actions such as the March 2008 High Flow Experiment (described in a separate science plan) or removal of nonnative fish. The annual HBC population status will be important to projects studying biotic and abiotic aspects of the system—including the aquatic food base, riparian vegetation mapping, and nearshore ecology projects—because changes in the parameters measured by these projects can be compared to trends in the HBC population to search for relevant correlations.

Logistics

There are no logistical needs for this project.

Products/Reports

- This project will be the lead for retrospective analysis of the fish catch rate data, especially for HBC. The analyses will also be supported by AZGFD and USFWS personnel as part of the reporting for their respective projects. Under this project GCMRC will convene an annual fish meeting to review these analyses and see if the 2009 PEP recommendations are consistent with project changes in FY2011.
- The next scheduled update of the ASMR model will be in FY2011 to coincide with the next SCORE report, with the next update to occur in FY2014.

- Annual reports of the status and trends of HBC will be delivered to the GCDAMP committees by December 15 of each year. These updates will include summaries of annual catch-rate and size composition estimates from LCR hoop net sampling, summaries of annual catch-rate and size composition estimates from mainstem Colorado River hoop and trammel net sampling, and closed population abundance estimates of HBC adults and rearing juveniles in the LCR as these data are available.
- This project will pursue making the HBC data base information available electronically. This will be done in a manner consistent with USGS Fundamental Science Practices.

Budget

FY2010

BIO 2.R7.10	
Stock Assessment of Grand Canyon Native Fish (FY2007–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	86,634
GCMRC Project Related Travel / Training (21% Burden)	3,000
GCMRC Operations / Supplies / Publishing (21% Burden)	2,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 91,634**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	19,243
Project Total (Gross)	**$ 110,877**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

BIO 2.R7.11	
Stock Assessment of Grand Canyon Native Fish (FY2007–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	80,765
GCMRC Project Related Travel / Training (21% Burden)	3,000
GCMRC Operations / Supplies / Publishing (21% Burden)	2,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0

GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 85,765**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	18,011
Project Total (Gross)	**$ 103,776**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

BIO 2.R13.10–11—Remote PIT Tag Reading

Start Date

October 2006

End Date

Ongoing

Principal Investigator

W. Persons, Arizona Game and Fish Department

Geographic Scope

Little Colorado River

Project Goals

This project is planned for FY2010–11 and seeks to advance the following goals:

- Determine and refine the most appropriate method(s) for estimating the population size of humpback chub (HBC) and other Grand Canyon fish, including sampling design and development of remote monitoring methods
- Determine movement patterns of fish in Grand Canyon using the Little Colorado River LCR

This project will test monitoring methods that do not require repeated handling of fish, capture of evasive species, or additional field sampling trips. Remote antennae can read the passive integrated transponder (PIT) tags as tagged fish pass the station. PIT tags are already implanted in a large proportion of the adult population of HBC in Grand Canyon. Because some PIT-tag antennae were installed in the LCR in FY2009, this project also seeks to provide operation and maintenance to the equipment already in place.

Need for Project

A limited number of HBC and other native fish are present in the modern day Colorado River in Grand Canyon. Nonnative fish species are also present and are important to study because of the known predatory and competitive threats they pose to native fish. Scientists and managers wish to know the spatial and temporal movement patterns of these species and the effectiveness of sampling gears in sampling populations. Obtaining population information in the least intrusive manner(s) possible, especially when sampling the endangered HBC, is also desirable. Remote PIT-tag antennae have been shown in other rivers and stream, which have generally been smaller than the LCR, to be very effective at continuous monitoring, alleviating the need for additional field sampling trips and multiple fish handling events.

The 2009 Protocol Evaluation Panel (PEP) for Grand Canyon Fishes reviewed the initial implementation of this project and recommended that it be continued and expanded. This project description is designed to be consistent with the panel's recommendations.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

Information Needs Addressed

CMIN 2.1.2. Determine and track recruitment (identify life stage), abundance and distribution of HBC in the LCR.

RIN 2.2.2. Determine if a population dynamics model can effectively predict response of native fish under different flow regimes and environmental conditions.

Methods and Tasks

In FY2009, personnel from Grand Canyon Monitoring and Research Center (GCMRC), Arizona Game and Fish Department (AZGFD), and the USGS Columbia River Research Lab experimented with the use of remote antennae to read PIT tags. The equipment installed generally performed as anticipated; although, some improvements will be sought, especially detection distance and equipment stability in high flows. PIT-tag antennae are initially evaluated with passing tags over the antennae, which is followed by assessing whether the antennae are reading and recording deployed tags. The study area will focus, at least initially, on the LCR because of the smaller width of this river and because HBC spawn in and are concentrated there. Progressively more sophisticated equipment and more extensive deployments have been tested over time. This incremental approach has allowed for efficient use of funds, specific evaluation of equipment and methods, and consultation with Tribes that must permit the deployment.

In FY2010, additional arrays will be deployed in the LCR to increase coverage of the width of the river, increasing the probability of captures. Personnel from USGS and AZGFD will cooperate to expand the coverage and detection capabilities beyond those already observed. USGS Columbia River Research Lab personnel will be consulted as necessary to expand detection distance. Personnel from USGS will assist with data analysis.

Together with AZGFD, the GCMRC will seek to identify an appropriate graduate student to work on this project, both as the primary person for maintenance and for data analysis. The USGS Cooperative Unit Leader from Colorado State University has indicated initial interest in serving as the major advisor for this person, and thereby would also contribute to data analysis.

Remote data telemetry will be attempted in FY2010. This will allow biologists to remotely download the data from the remote PIT-tag detector and determine operational status and maintenance needs instead of visiting the site regularly throughout the year.

Links/Relationships to Other Projects

If the PIT-tag readers continue to be successful, more ‘recapture’ data on individual tagged native and nonnative fish are expected. Currently about one-half of the fish captured have been HBC, with other natives and common carp making up the remainder. These data will be important for support of the annual catch-rate indexes and multiyear model updates. More information on life history, specifically movement into and out of the LCR, is anticipated, which informs managers working to conserve and protect HBC.

Logistics

Trips that require large equipment transport will require helicopters into and out of the LCR. In FY2010, 3 days of helicopter transport are budgeted. The goal of the FY2010 trips will be to bring in all of the large equipment that might be anticipated, especially the large antenna. The logistics budget for FY2010 also includes costs for boat transport of personnel. Emergency operations and maintenance may be supported by helicopter, if boat and hiking trips are not practical. Two trips for two people are

expected to conduct servicing and downloading trips. Based on work done in FY2009, it is anticipated that it will take a crew of five people about 5 days to install the second antenna array.

In FY2011, it is anticipated that only smaller repair components will be needed and that two helicopter trips will be necessary to accomplish this effort. Personnel will schedule appropriate servicing and downloading trips using a combination of hiking and boat travel, ideally in combination with other science trips, but this project includes logistics costs to support the minor additional demands of small crews in the LCR to service the PIT antennae.

Products/Reports

Annual reporting on the installation operation of the equipment and collected data will be delivered to the GCMRC by December of each year. These data are to be discussed in at least one annual meeting by the fish cooperators, managers, and interested Glen Canyon Dam Adaptive Management Program committee members.

AZGFD and GCMRC will pursue the identification of an appropriate graduate student and institution to support cooperative additional data analysis. A graduate student would be expected to provide a thesis and one or more peer reviewed reports analyzing the data collected by this project. The emphasis of possible graduate research may include detailed descriptions of the movement patterns of HBC in to and out of the LCR.

Budget

FY2010

BIO 2.R13.10	
Remote PIT Tag Reading (FY2007–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	5,579
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	45,000
GCDAMP Logistical Support (21% Burden)	15,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	130,000
Project Subtotal	**$ 195,579**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	21,689
Project Total (Gross)	**$ 217,268**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	70.3%

FY2011

BIO 2.R13.11	
Remote PIT Tag Reading (FY2007–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	5,904
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	45,000
GCDAMP Logistical Support (21% Burden)	15,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	136,500
Project Subtotal	**$ 202,404**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	22,153
Project Total (Gross)	**$ 224,557**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	71.2%

BIO 2.R15.10–11—Nearshore Ecology / Fall Steady Flows

Start Date

2008

End Date

September 2012

Principal Investigators

William E. Pine, III, University of Florida; M.D. Yard and L.G. Coggins, Jr., U.S. Geological Survey, Grand Canyon Monitoring and Research Center; and C.J. Walters, University of British Columbia

Geographic Scope

The mainstem Colorado River in Grand Canyon below the mouth of the Little Colorado River

Project Goals

The primary goal of the nearshore ecology study is to relate river flow variables and ecological attributes of nearshore habitats to better understand the relative importance of the biotic and abiotic attributes of these habitats to juvenile (< 200mm total length) native and nonnative fish

The objectives that are addressed by this project are as follows:

- Develop sampling approaches and analytical methods to use for determining abundance, density, or occurrence of native and nonnative fish among different nearshore habitat types
- Assess past and current data and integrate data across multiple sources and disciplines to determine small-bodied and juvenile fish nearshore habitat selection at local, geomorphic, and landscape scales
- Evaluate past habitat classification schemes and associated data collection efforts, using both habitat information associated with the fisheries database and Data Acquisition, Storage and Analysis (DASA) Program GIS habitat classification methods
- Develop methods for measuring and estimating small-bodied and juvenile fish vital rates (growth and survival) among different nearshore habitat types and during steady versus fluctuating flow operations
- Determine the key factors (abiotic and biotic) influencing nearshore habitat selection among small-bodied and juvenile fish
- Determine the effect(s) of fluctuating and steady flow releases have on nearshore habitat selection, movement, growth, and survival of native and nonnative fish
- Design and implement a multiyear (FY2009–12) experimental plan (process oriented) to determine the effect(s) of fluctuating and steady flow releases (September–October) on nearshore habitat selection, movement, growth, and survival of native and nonnative fish
- Develop a contingency plan for releases above peak powerplant capacity that details how these releases will affect the proposed research and a research plan for assessing the potential impacts of these releases on nearshore habitat selection among small-bodied and juvenile fish

The goal of this project is to provide information for developing future models with the capability to predict small-bodied and juvenile fish composition, distribution, and abundance in relation to changes

in management actions (for example, flows, temperatures, and nonnative fish interactions) and nearshore habitat availability.

Need for Project

The mainstem Colorado River life-history requirements of HBC are not well understood. The habitat selection of HBC, and how those habitats may or may not be affected by human activities such as dam operations, are of particular interest to the Glen Canyon Dam Adaptive Management Program (GCDAMP) and managers. To help meet these information needs, this project is intended to identify juvenile native fish habitat requirements, and how habitat selection, preference, and availability affect native fish vital rates such as growth and survival. Findings from this project are intended to provide information on native fish habitat requirements and guide future GCDAMP recommendations for the Department of the Interior to consider as management or experimental actions.

Strategic Science Questions

Primary SSQs addressed:

SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year (YoY) and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

SSQ 1-7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?

SSQ 3-2. To what extent could predation impacts by nonnative fish be mitigated by higher turbidities or dam-controlled high-flow releases?

SSQ 4-2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possibly mortality of young humpback chub) associated with high flows?

SSQ 5-4. What is the relative importance of increased water temperature, shoreline stability, and food availability on the survival and growth of YoY and juvenile native fish?

SSQ 5-6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance?

Information Needs Addressed

RIN 2.1.3 What is the relationship between size of HBC and mortality in the LCR and the mainstem? What are the sources of mortality (that is, predation, cannibalism, other) in the LCR and the mainstem?

RIN 2.1.4 What habitats enhance recruitment of native fish in the LCR and mainstem? What are the physical and biological characteristics of those habitats?

RIN 2.4.3 To what degree, which species, and where in the system are exotic fish a detriment to the existence of native fish through predation or competition?

RIN 4.2.6 To what extent are RBT below the Paria River predators of native fish, primarily HBC? At what size do they become predators of native fish, especially HBC, that is, how do the trophic interactions between RBT and native fish change with size of fish?

RIN 2.4.4 What are the target population levels, body size and age structure for nonnative fish in the Colorado River ecosystem that limit their levels to those commensurate with the viability of native fish populations?

RIN 12.9.1 What is the impact on downstream resources of short-term increases to maximum flow, daily fluctuations, and downramp limits?

RIN 2.6.6 How is the rate of mortality for flannelmouth sucker, bluehead sucker, and speckled dace in the Colorado River ecosystem related to individual body size? What are the sources of mortality for flannelmouth sucker, bluehead sucker, and speckled dace in the Colorado River ecosystem?

RIN 4.2.5 To what extent is there overlap in the Colorado River ecosystem below the Paria River of RBT habitat and native fish habitat?

RIN 7.4.1 What is the desired range of seasonal and annual flow dynamics associated with powerplant operations, BHBFs, and habitat maintenance flows, or other flows that meet GCDAMP goals and objectives?

EIN 2.1.1 How does the abundance and distribution of all size classes of HBC in the LCR and mainstem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 2.1.2 How does the year class strength of HBC (51–150 mm) in the LCR and mainstem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 2.4.1 How does the abundance and distribution of nonnative predatory fish species and their impacts on native fish species in the Colorado River ecosystem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 2.6.1 How does the abundance, distribution, recruitment and mortality of flannelmouth sucker, bluehead sucker and speckled dace populations in the Colorado River ecosystem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

SIN 8.5.4 What is the role of turbidity and how can it be managed to achieve biological objectives?

Methods and Tasks

The potential effects of fall steady flows on biological resources are being investigated with three Grand Canyon Monitoring and Research Center (GCMRC) projects: aquatic food base (goal 1), rainbow trout monitoring (goal 4), and nearshore ecology (goal 2). Descriptions of the first two projects are found under the goal they are intended to address elsewhere in this work plan.

This nearshore ecology study is to incorporate findings from ongoing studies and to develop new sampling and analytical approaches that examine the effects of the March 2008 high-flow experiment

on nearshore habitats and address the effects of modified low fluctuating flows (MLFF), including September–October steady flows, on juvenile HBC and other native fish.

In terms of methods, this project will investigate sampling methods to estimate fish habitat use, growth, and survival. Estimation of juvenile abundance, survival rate, growth rate, and habitat use is fundamental to resolving uncertainties in the conceptual model and the two key research questions outlined and identified above. Sampling trips are proposed in late July and late August to characterize abundance, habitat use, growth, and survival rate of juvenile fish over the summer under MLFF operations. These trips would be followed by sampling trips in early September and late October to characterize juvenile fish responses during the MLFF-fall steady experimental flow transition and steady flow period. Differences in abundance in each habitat type, between sampling trips would be used to estimate habitat specific, reach-wide survival rates across flow events.

Two basic sampling approaches are proposed for estimating these characteristics, including (1) reach-wide abundance estimation and (2) robust-design mark-recapture at replicate sites.

In terms of site selection, the expectation is to use existing data and models from the GCMRC Physical Science and Modeling Program to quantify habitat availability over the study reach that contains the robust-design mark-recapture sites, habitat availability within the sites, and how habitat changes with flow. The existing GCMRC shoreline GIS database and other surveys can be used to stratify habitat into classes such as talus slopes, open sandbars, vegetated sandbars, cobble bars, and backwaters. The working hypothesis is that unstable habitat types will be used only minimally during the summer unsteady flow period, but that use of these habitats will increase during the fall steady period when flows are stabilized. If this difference in habitat use is ecologically important, the prediction would be an increase in growth and survival of fish during the fall steady flow period relative to the summer.

Any mark-recapture approach to estimating abundance and density depends on recapturing sufficient numbers of marked individuals to draw inferences on the parameters of interest. Closed population models generally have fewer parameters (and assumptions) than open models and are thus better able to estimate parameters of interest (capture probability and abundance) when recaptures are low. The closure assumption will be evaluated in our mark-recapture experiments using methods similar to Korman and others (2009). Additionally, recaptures of fish marked on previous trips will provide useful information on growth and movement (for example, movement into backwaters during periods of steady flow) between sampling trips and associated flow conditions. The Nearshore Ecology Project pilot sampling data from 2008 should provide some information on closure and also provide information on capture probability that is necessary to fully assess how violation of the closure assumption biases abundance estimates. This project will evaluate occupancy models (MacKenzie and others, 2006) and sonic tags to support habitat-use assessment. This project will use otoliths (inner ear bones) from humpback chub and other natives to investigate habitat use and origin of fish. Otoliths may also prove useful for determining growth and survival rates of humpback chub and other fish.

These methods are discussed in greater detail in the project proposal submitted to the GCMRC by Pine and others. These methods require repeated sampling at multiple mainstem locations below the mouth of the Little Colorado River. Repeated sampling is needed to develop statistical confidence in abundance estimation, which in turn is needed to draw conclusions about habitat use. Repeated sampling will require use of motorboats and electroshocking equipment, including generators.

Links/Relationships to Other Projects

This project uses habitat information developed largely by the Physical Science and Modeling Program and the Data Acquisition, Storage, and Analysis (DASA) Program. The results of this project will help evaluate responses of small-size classes of fish to various dam release flows and will provide some of the information needed to assess the status and trends of humpback chub in the mainstem Colorado River.

Logistics

This project will require four trips, one each in July, August, September, and October for 3 years, FY2009–11, subject to permit approval. All four trips are to be motor supported. The first three are scheduled to launch in the motor season, but the October trip will require authority from Grand Canyon National Park to use motors during the non-motor season. Sampling in October supports investigation of the possible effects of steady flows on fish habitat use and so authority to conduct the trip will be requested.

Products/Reports

Annual reports of project results will be delivered in December of each year. A final, synthetic report will be delivered by September 2012.

Budget

FY2010

BIO 2.R15.10	
Nearshore Ecology / Fall Steady Flows (FY2008–12)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	67,544
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	100,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	330,000
Project Subtotal	**$ 497,544**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	55,281
Project Total (Gross)	**$ 552,825**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	76.4%

FY2011

BIO 2.R15.11	
Nearshore Ecology / Fall Steady Flows (FY2008–12)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	70,921
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0

GCDAMP Logistical Support (21% Burden)	100,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	330,000
Project Subtotal	**$ 500,921**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	55,990
Project Total (Gross)	**$ 556,911**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	75.9%

BIO 2.R16.10–11—Mainstem Nonnative Fish Control

Start Date

2003

End Date

Ongoing

Principal Investigators

A.S. Makinster and B. Persons, Arizona Game and Fish Department; M.E. Andersen, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

The mainstem Colorado River in the Little Colorado River inflow reach (river miles 56–68)

Project Goals

The project has the following goals:

- Calculate the abundance of rainbow trout (RBT) in the Little Colorado River inflow reach
- Reduce the abundance of RBT in the Little Colorado River inflow reach
- Reduce the abundance of other nonnative fish in the Little Colorado River inflow reach
- Evaluate methods and means other than mechanical removal of reducing the abundance of RBT in the Little Colorado River inflow reach of the Colorado River

The electrofishing methods employed for this project are most effective at capturing salmonids, including RBT and brown trout. Previous electrofishing efforts also captured small numbers of common carp, red shiners, fathead minnows, bullhead species, channel catfish, and green sunfish. Hoop netting, also used by this project, is most effective at capturing small-bodied fish, both native and nonnative. Previous efforts using hop nets have captured small-bodied nonnatives such as red shiner and fathead minnow. All nonnative species captured as a result of this project will be removed.

Need for Project

Nonnative fish are among the greatest threats to native fishes in western North American rivers (Miller, 1961; Minckley and Deacon, 1991; Tyus and Saunders, 2000). Nonnative fish may threaten native fish by direct predation, by competing for available food and other resources, and by habitat modification (Minckley, 1991; Hawkins and Nesler, 1991). Nonnative fish were introduced into Grand Canyon not later than early in the 20th century (Woodbury, 1959; Valdez and Ryel, 1995). While native fish survived these initial introductions at least long enough to be described by early researchers, other system stressors, especially the modification of natural flows as a result of dam installation, appear to have increased the threats to native fish from nonnative fish (Minckley, 1991; Clarkson and Childs, 2000). It is the consensus of Glen Canyon Dam Adaptive Management Program (GCDAMP) committees that RBT and other nonnatives are one factor limiting to humpback chub (HBC), especially young HBC that are washed into the mainstem in their first year or two of life. As a result, the committees seek to continue mechanical removal of nonnative species as a means of benefiting native fish.

RBT have been implicated as a threat to native fish in habitats where RBT have been introduced, including the confluence of the Colorado and Little Colorado Rivers (hereafter confluence) in Grand Canyon. The confluence is important not only because most of the Grand Canyon population of HBC are found there, but also because the HBC conduct most of their spawning in the LCR (Paukert and others, 2006). RBT are thought to both prey on and compete with HBC. These assumptions have been supported by the findings of Coggins (2008) and Yard and others (in prep.). The nonnative fish removal project sanctioned by the GCDAMP from 2003 to 2006 was intended to be a 4-year study, which as to be followed by 4 years without removal efforts. The nonnative fish removal project demonstrated that the numbers of RBT, brown trout, and other nonnatives could be mechanically controlled in a limited reach of river. The findings of Yard and others (in prep.) indicate that although RBT have only limited ability to successfully prey on HBC, if their numbers in the confluence get to be as large as they were at the beginning of this decade, then RBT can have a measureable, negative impact on HBC.

Given the potential threat of nonnative fish to native ones, continued control of RBT and other nonnative fish found in the confluence area was a recommendation of a 2007 Scientific Workshop held in Flagstaff, Ariz. (Grand Canyon Monitoring and Research Center, 2008). The workshop recommendations led the U.S. Fish and Wildlife Service to define control of the RBT as a conservation measure in their *2008 Final Biological Opinion for the Operation of Glen Canyon Dam* (U.S. Department of the Interior, 2008).

This continuing project seeks to address the need to document the status and trend of the confluence RBT population, to reduce the threats on nonnative species to HBC and other native fish, and to implement a conservation measure from the 2008 biological opinion. Because the Grand Canyon HBC population can be negatively affected by predation by other nonnative fish, especially brown trout, other nonnative fish captured by this project will also be removed.

While mechanical removal efforts in the LCR inflow reach have been demonstrated to be effective in reducing the numbers of RBT and other nonnative fish, there are long-standing concerns by Native American stakeholder about conducting this effort in this culturally sensitive reach. Additionally, mechanical removal efforts in this portion of the river are both financially and logistically demanding. As such, an additional activity to be conducted in 2010 will be to scope and plan for alternatives to mechanical control in this reach. Possible alternatives include mechanically removing RBT upstream of the confluence in sections of Marble Canyon, using discrete high or low flows targeted to limit recruitment of nonnative fish, increasing turbidity through augmentation, and other strategies. Scoping and planning meetings will be held during 2010 to include GCDAMP stakeholders, relevant Federal and State agencies, and other interested parties. It is anticipated that future actions associated with this planning process would require compliance activities as dictated by the National Environmental Policy Act, the Endangered Species Act, and the Fish and Wildlife Coordination Act.

Strategic Science Questions

Primary SSQ addressed:

> **SSQ 1-2.** Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile humpback chub to the adult population?

Additional SSQs addressed:

> **SSQ 1-4.** Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.

SSQ 1-8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

SSQ 5-6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance?

The GCDAMP SAs have articulated the following summary science questions that are addressed by this project:

SA 1. What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on young of year and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

Information Needs Addressed

Primary information needs addressed:

RIN 2.4.2. Determine if suppression of nonnative predators and competitors increases native fish populations.

RIN 2.4.3. To what degree, which species, and where in the system are exotic fish a detriment to the existence of native fish through predation or competition?

RIN 2.4.4. What are the target population levels, body size, and age structure for nonnative fish in the Colorado River ecosystem that limit their levels to those commensurate with the viability of native fish populations?

Methods and Tasks

This project will launch one or two annual trips to count and control RBT and other nonnative fish in the LCR inflow reach, which will be accomplished with four to six passes of the reach (approximately river miles (RM) 56 to 68) using nighttime boat-mounted electrofishing. All nonnative fish species captured will be removed and humanely euthanized. The Hualapai Tribe has agreed to receive the fish remains for use as agricultural fertilizer. This approach will allow for an estimation of the RBT population in this reach of the Colorado River. The anticipated timing of this project is during May and June.

Because the electrofishing work is conducted after dark, this trip will also allow for the daytime use of hoop nets along shorelines of the study reach to monitor small-bodied fish. Previous experience with this method suggests that such efforts will capture young HBC, contributing additional data to help monitor and assess HBC in conjunction with the primary effort of counting and removing RBT. Limited numbers of other nonnative fish species, including red shiners and fathead minnows, have been captured with this hoop net method during previous efforts. All nonnative fish captured with hoop nets will be humanely euthanized.

The necessity of conducting a second annual trip will be determined based on observed catch rate and preliminary abundance of RBT observed during the initial trip. If results from the first trip suggest a second annual trip is unnecessary, funding for the second trip will be deposited in the GCDAMP nonnative contingency fund. A public outreach program to describe this project to interested members of the public will be initiated through the GCDAMP Public Outreach Ad-Hoc Group.

Links/Relationships to Other Projects

An important corollary to this project will be continuing monitoring in the Little Colorado River inflow reach (RM 56to 68) to evaluate the fish community. Other projects in this work plan describe the mainstem monitoring efforts that will be employed to conduct fish community monitoring (BIO 2.M4.10-11), including both natives and nonnatives. Because the species that is intended to benefit from this removal project is HBC, ongoing HBC monitoring in the Little Colorado River (BIO 2.R1.10, BIO 2.R2.10, and BIO 2.M1.11) will also be important to maintain to assess the impacts of this mechanical removal project.

Logistics

One or two boat-mounted electrofishing trips will be deployed in both 2010 and 2011 to remove nonnative fish in the Little Colorado River inflow reach. The timing of these trips will most likely occur in May and June of each year. A camp will be established near RM 61 for processing captured fish; fish will be captured, euthanized, and ground in accordance with protocols established in previous years (2003–2006, 2009).

Products/Reports

Annual report will be delivered to the GCMRC by October 1 of each year. Annual oral reporting on removal results to be reported to the Technical Work Group in January of each year.

Budget

BIO 2.R16.10	
Mainstem Nonnative Fish Control (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	20,000
GCMRC Project Related Travel / Training (21% Burden)	1,554
GCMRC Operations / Supplies / Publishing (21% Burden)	2,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	31,768
GCDAMP Logistical Support (21% Burden)	125,013
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	92,000
Project Subtotal	**$ 272,335**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	43,473
Project Total (Gross)	**$ 315,808**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	56.7%

NOTE: Total project amount for FY2010 is $315,808 of which $68,842 is BOR reimbursable agreement # 06-AA-40-2439, $96,466 from BOR Nonnative Contingency Fund, and $150,000 from BOR Experimental Fund, all from power revenues under cap.

FY2011

BIO 2.R16.11	
Mainstem Nonnative Fish Control (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	7,806
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	36,496
GCDAMP Logistical Support (21% Burden)	123,600
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	100,000
Project Subtotal	**$ 267,902**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	41,349
Project Total (Gross)	**$ 309,251**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	60.4%

NOTE: Total project amount for FY2011 is $309,251, all of which is funded from BOR Experimental Fund from power revenues under cap.

BIO 2.R17.10–11—Nonnative Control Plan Science Support

Start Date

October 2009

End Date

Ongoing

Principal Investigator

K.D. Hilwig, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Colorado River ecosystem in Grand Canyon

Project Goals

This project supports efforts to monitor nonnative fish in Grand Canyon and to recommend appropriate control methods, if monitoring results indicate control is necessary. The project implements the analysis functions of the plan to control nonnative fish species to be completed by the Grand Canyon Monitoring and Research Center (GCMRC) in FY2009. This project will produce a risk assessment to be developed by the GCMRC in FY2010 in conjunction with other efforts, especially the fall mainstem monitoring with multiple gear types. Capture information provided by all fish-sampling and monitoring projects (Lees Ferry, Little Colorado River (LCR) Colorado River) will be used to assess the presence or absence of nonnative species at various locations and the potential need for nonnative control efforts.

Specific project goals for this project in FY2010 are the following:

- An assessment of the relative risks to native fish from nonnative species in Grand Canyon
- An assessment of habitat use by nonnatives (occupancy model or other appropriate model)
- A report summarizing the known sources of nonnative fish found in Grand Canyon

Need for Project

Nonnative fish are among the greatest threats to native fishes in western North American rivers (Miller, 1961; Minckley and Deacon, 1991; Tyus and Saunders, 2000; Coggins, 2008). Nonnative fish may threaten native fish by direct predation, by competing for available food and other resources, and by habitat modification (Minckley, 1991; Hawkins and Nesler, 1991). Nonnative fish were introduced into Grand Canyon not later than early in the 20th century (Woodbury, 1959; Valdez and Ryel, 1995). While native fish survived these initial introductions at least long enough to be described by early researchers, other system stressors, especially the modification of natural flows as a result of dam installation, appear to have increased the threats to native fish from nonnative fish (Minckley, 1991; Clarkson and Childs, 2000).

Recognizing the threat posed to native fish by nonnative species, the Glen Canyon Dam Adaptive Management Program (GCDAMP) implemented a nonnative fish control experiment near the LCR inflow reach from 2003 to 2006. The 2003 to 2006 control project was most successful at removing rainbow trout (RBT). This work plan builds on that effort. As the Colorado River mainstem becomes warmer because of climate effects (Seager and others, 2007), the potential for an increased threat from warm water-adapted nonnative fish increases (Eaton and Scheller, 1996; Chu and others, 2005; Rahel

and Olden, 2008). There is an immediate need to begin investigating which species pose the greatest threats to natives in Grand Canyon, so as to understand how those species might be better monitored and controlled and to test control approaches for efficacy.

Strategic Science Questions

Primary SSQs addressed:

SSQ 1-4. Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.

SSQ 5-6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance?

Information Needs Addressed

Primary information needs addressed:

CMIN 2.4.1. Determine and track the abundance and distribution of nonnative predatory fish species in the Colorado River.

RIN 2.4.1. What are the most effective strategies and control methods to limit nonnative fish predation and competition on native fish?

RIN 2.4.3. To what degree, which species, and where in the system are exotic fish a detriment to the existence of native fish through predation or competition?

Methods and Tasks

The GCMRC has prepared a draft nonnative species control plan that responds to reviews by the GCDAMP Science Advisors. It will be delivered to the GCDAMP committees in FY2009. Monitoring of nonnative species will be conducted with other fish projects described elsewhere in this work plan. Those projects will use different gear types to sample different species and different habitat types.

In FY2010, this project will implement some of the higher priority research recommendations of the plan control plan including the following,

- developing a bioenergetics, or ecosystem modelling, approach to identify nonnative species that pose the greatest threat;
- improving monitoring methods through implementation of occupancy modeling to track changes in abundance and distribution of nonnative fish;
- identifying the sources of juvenile and adult nonnative fish into the mainstem such as tributary inflows, dam passage, and stocking; and
- implementing isotope and larval drift studies to identify spawning areas and natal origins of nonnative fish.

This project is also responsible for conducting an annual nonnative fish workshop with agency fish cooperators, managers, and other nonnative fish experts.

In FY2010, the nonnative biologist will participate in a larger ecosystem modeling effort to ensure that nonnative fish elements are incorporated in the model. The results of the ecosystem model will be used

to inform the bioenergetics model mentioned above, which should inform nonnative sampling and monitoring efforts in FY2011 and future years.

In 2011, in addition to continuing to assemble and present all nonnative catch data received from other projects, this project will compare the risk assessment model results to the catch data for that year. Results from the risk assessment, occupancy model, and source report will be used to inform projects conducting field work at Lees Ferry, the LCR, and the Colorado River regarding species and locations to target to maximize catches of nonnative fish. The nonnative control plan will also be utilized as a source of available and potential gear types to provide additional recommendations to field projects with a nonnative fish-sampling component.

Links/Relationships to Other Projects

One management approach that has been proposed to support HBC and other native fish in Grand Canyon is the installation of a temperature control device (TCD) on Glen Canyon Dam so that water of various temperatures, especially warmer water from the reservoir's epilimnion (the upper layer of water), may be preferentially released. A potential concern with this approach is that warmer mainstem temperatures may also favor warmwater nonnatives, increasing the risk from these species to natives. In FY2010, the project biologist will evaluate this possible threat in the context of bioenergetical modeling and how threats may be addressed. Temperature modeling information and actual temperature data will also be used to develop and validate the bioenergetic risk assessment.

This project links to several ongoing projects. Nonnative fish are, or are proposed to be, sampled as part of the Monitoring Mainstem Fish Project (BIO 2.M4.10–11), the Little Colorado River Humpback Chub Monitoring Project (BIO 2.M1.10), the Aquatic Food Base Project (BIO 1.R1.10), the Nearshore Ecology/Fall Steady Flows Project (BIO 2.R15.10–11), and the Monitoring Lees Ferry Fish Project (BIO 4.M2.10–11). These projects gather information on nonnative species captured in Grand Canyon, including the relative abundance of these species, their size distribution, and their role in the food web; this information contributes to the parameters needed for bioenergetic modeling. Data produced by the projects noted above will support this project to assess potential changes in nonnative fish populations and assist in the bioenergetic risk assessment.

Logistics

There are no logistics requirements for this project.

Products/Reports

This project will compile the data/reports produced by other projects for nonnative fish into a summary (project reports are due by December 15 of each year). Nonnative fish data and reports will be discussed at an annual nonnative control meeting of the fish cooperators to develop specific monitoring strategies and to determine gear types to be used in the following year. In addition to the annual reporting summary, this project will deliver three reports in FY2010: (1) a risk assessment, (2) habitat-use model, and (3) a nonnative sources report.

Budget

FY2010

BIO 2.R17.10	
Nonnative Control Plan Science Support (FY2010–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	62,511
GCMRC Project Related Travel / Training (21% Burden)	2,000
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 64,511**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	13,547
Project Total (Gross)	**$ 78,058**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

BIO 2.R17.11	
Nonnative Control Plan Science Support (FY2010–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	111,545
GCMRC Project Related Travel / Training (21% Burden)	3,000
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 114,545**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	24,054
Project Total (Gross)	**$ 138,599**

Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

BIO 2.R18.10–11—Natal Origins of Rainbow Trout in Grand Canyon

Start Date

2010

End Date

2011

Principal Investigator

M.E. Andersen, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Mainstem Colorado River between Glen Canyon Dam and Tanner Rapid (river miles (RM) -15 to 68)

Project Goals

This project will investigate where rainbow trout (RBT) reproduce in the Colorado River between Glen Canyon Dam and Tanner Rapid. This project seeks to combine results from available literature and currently collected data to develop a report describing the evidence for where RBT are reproducing, or their location of natal origin.

Need for Project

Although RBT are sought after as a sport species above Lees Ferry (RM 0), and propagation of that sport fishery is a Glen Canyon Dam Adaptive Management Program (GCDAMP) goal, RBT that proceed downstream have increasing potential for harm to native fish, especially in the Little Colorado River reach (RM 61–68). Although available literature from the Grand Canyon Monitoring and Research Center (GCMRC), Arizona Game and Fish Department (AZGFD), and Ecometric, Inc. indicate that the majority of RBT are spawned above Lees Ferry, this has not been definitively determined. When conditions are favorable, it is known that RBT may spawn below Lees Ferry. For example, when the mainstem is running high, RBT can spawn in Nankoweap Creek, though favorable conditions there have not existed for years. If the primary spawning ground of RBT in Grand Canyon can be established more conclusively, then this will allow for more informed management of the population.

Strategic Science Questions

Primary SSQ addressed:

> **SSQ 1-3.** Do RBT emigrate from Glen to Marble and eastern Grand Canyons, and, if so, during what life stages? To what extent do Glen Canyon emigrants support the population in Marble and eastern Grand Canyon?
>
> **SSQ 1-4.** Can long-term decreases in abundance of RBT in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will re-colonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action?

Information Needs Addressed

Primary information needs addressed:

> **RIN 2.4.1.** What are the most effective strategies and control methods to limit nonnative fish predation and competition on native fish?
>
> **RIN 2.4.5.** What are the sources (natal stream) of nonnative predators and competitors?
>
> **RIN 2.4.6.** What are the population dynamics of those nonnative fish that are the major predators and competitors of native fish?

Methods and Tasks

This project will use both peer-reviewed and grey literature and the results of ongoing studies to investigate the natal origins of RBT in Glen, Marble, and Grand Canyons. Studies and publications on this population have been produced by GCMRC, AZGFD, Ecometric, Inc., U.S. Fish and Wildlife Service, Arizona State University, and others over the years, so a bibliography will be assembled and used as a basis for a manuscript on the subject of the natal origins of RBT.

Current GCDAMP projects are being conducted that are expected to yield new information that relates to the natal origins of RBT. These projects are listed in the next section, but, briefly, the field projects will be monitoring all life stages of RBT in the vicinity of Lees Ferry, particularly if mechanical removal is conducted in this reach. The Nearshore Ecology/Fall Steady Flows Project (BIO.R15.10–11) will be investigating the use of otoliths as a source of isotopes that may allow for specific identification of the source of fish. If this method proves successful, it will be applied to RBT specimens.

Links/Relationships to Other Projects

A series of GCDAMP projects are expected to provide new information to support investigation of the natal origin of rainbow trout, including

- Monitoring Mainstem Fish Project (BIO 2.M4.10–11)
- Nearshore Ecology/Fall Steady Flows Project (BIO 2.R15.10–11)
- Mainstem Nonnative Fish Control Project (BIO 2.R16.10–11)
- Monitoring Lees Ferry Fish Project (BIO 4.M2.10–11)

Logistics

No logistics are required for this project.

Products/Reports

Annual oral reporting on removal results to be reported to the Technical Work Group in January of each year. A manuscript on this topic will be developed not later than September 1, 2011.

Budget

FY 2010: $0
FY 2011: $0

GCDAMP Goal 4. Maintain a naturally reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.

BIO 4.M2.10–11—Monitoring Lees Ferry Fish

Start Date

2010

End Date

Ongoing

Principal Investigator

A.S. Makinster, Arizona Game and Fish Department

Geographic Scope

Colorado River from Glen Canyon Dam (GCD) to Lees Ferry

Project Goals

The goals of this project are as follows:

- Monitor the rainbow trout (RBT) recreational fishery between Glen Canyon Dam and the Paria River
- Monitor for presence or absence of other nonnative fish in this reach
- Monitor RBT redds and early life stages to support assessment of experimental flow releases from Glen Canyon Dam

Operation of Glen Canyon Dam affects the ecology of RBT and the aquatic food base in the Lees Ferry reach (McKinney and others, 1999, 2001). The Lees Ferry recreational fishery was recognized as a resource of concern in the *Operation of Glen Canyon Dam Final Environmental Impact Statement* (U.S. Department of the Interior (DOI), 1995), which concluded: "Glen Canyon Dam Adaptive Management Program (GCDAMP) goals for the trout fishery are to provide a recreational resource while maintaining and conserving native fish in Grand Canyon." The management objective of the GCDAMP is to maintain a blue ribbon trout fishery that produces a healthy, self-sustaining population of at least 100,000 age-2 RBT that achieve 18 inches in length by age-3 with a mean annual relative weight of at least 0.90.

This project is designed to monitor the status and population of the Lees Ferry fishery in response to management actions and to determine how abundance, reproduction, survival, and growth are influenced by operations of GCD, including fall steady flows. Trend analysis using indices of abundance can be used to compare operational changes at GCD to determine whether these changes are having population-level effects on the fishery.

This project was reviewed by the 2009 Protocol Evaluation Panel (PEP) for Grand Canyon Fishes. The panel recommended that it was not cost effective or necessary to conduct multiple population monitoring and assessment trips each year to assess the Lees Ferry RBT fishery. Rather, the panel recommended a single electrofishing trip at randomized sites each year to physically observe the adult population and perhaps to tag fish, if tagging was desired for more data collection. Analysis of this long-term data set will be completed in FY2009 to determine impacts of the recommended reduction in effort and the ability to meet management objectives.

The 2009 PEP for Grand Canyon Fishes also recognized the importance of sampling, and potentially removing, other nonnative fish in the Lees Ferry reach. The relative ease of conducting boat operations for this reach and the potential risk to other species downstream from nonnatives that might enter or expand in the Glen Canyon/Lees Ferry reach, suggests that at least one monitoring trip be conducted annually focused not on the recreational RBT fishery but on other nonnative species. Known aggregations of common carp should be sampled and could be considered for mechanical removal actions.

The 2009 PEP for Grand Canyon Fishes did not recommend maintaining the monitoring of early life stages of RBT that has been conducted for 5 of the last 7 years. However, this monitoring technique may be useful for studying the response of the fishery to experimental dam releases, and it should be maintained through FY2012 in response to the fall steady flow regime.

Need for Project

The Arizona Game and Fish Department (AZGFD) has managed the Lees Ferry recreational fishery since 1964. Lees Ferry serves as a popular destination fishery for international and national anglers. As such, it provides significant contributions to the Marble Canyon business community. The fishery is regulated by biotic and abiotic mechanisms that may in turn be affected by the operations of GCD. The monitoring of basic fish population elements, including abundance and distribution of native and nonnative fish, provides the information necessary to assess the status of these resources and inform the GCDAMP.

Strategic Science Questions

Primary SSQ addressed:

> **SSQ 3-6.** What GCD operations (ramping rates, daily flow range, etc.) maximize trout fishing opportunities and catchability?

This project also seeks to develop information to inform the following SSQ:

> **SSQ 1-3.** Do rainbow trout immigrate from Glen to Marble and eastern Grand Canyons, and, if so, during what life stages? To what extent do Glen Canyon immigrants support the population in Marble and eastern Grand Canyon?

Information Needs Addressed

Information needs are the basis for developing and implementing the long-term strategic and annual monitoring and research programs. Identified below are the current information needs pertinent to the monitoring plan for the Lees Ferry Glen Canyon trout fishery.

Primary information needs addressed:

> **CMIN 4.1.1.** Determine annual population estimates for age 2+ rainbow trout in the Lees Ferry reach

CMIN 4.1.2. Determine annual proportional stock density of rainbow trout in the Lees Ferry reach.

CMIN 4.1.4. Determine annual growth rate, standard condition (Kn), and relative weight of rainbow trout in the Lees Ferry reach.

There are a number of RINs that are partially addressed by this project, or which depend, in part, on the results of this project. The primary RIN addressed is the following:

RIN 4.1.1. What is the target proportional stock density (that is, tradeoff between numbers and size) for rainbow trout in the Lees Ferry reach?

Data collected from this monitoring project provide the basis which managers make decisions.

Methods and Tasks

Summary of annual monitoring/sampling:

- Two annual standardized random sampling surveys
- Two annual early life history trips (one or both may extend below Paria River)
- One annual nonnative survey (may extend below Paria River)
- Creel surveys are supported by AZGFD

RBT are sampled using electrofishing to estimate biological parameters and to assess the status and trends of the fishery. The sampling design, methods, and analyses provide sufficient information on the relative abundance, size, and condition of the fish community in the Lees Ferry reach of the Colorado River. The purpose of this sampling design is to have a monitoring tool with the temporal "power" to detect population trends without biases in site selection as well as a means to precisely estimate status of the RBT population (Urquhart and other, 1998). Electrofishing provides information on size composition, relative abundance (catch per minute as an index of population size), condition (length-weight relationships), and disease. Equipment costs are captured in BIO 2.M4.10–11. Samples are collected annually for whirling disease examination. Electrofishing before FY2010 occurred three times per year with sampling effort stratified over 27 random and 9 fixed sites. Present sampling design can detect a 6 to 10 percent linear change in abundance over a 5-year period. Work is currently underway to assess the statistical power of intra- and interannual comparisons.

Present methods for assessing abundance using catch-rate indices may or may not be adequate for addressing management objectives and targets. If managers require a population estimate, further work is needed. The project will likely suggest some alternative methods to assess the abundance objective rather than "annual population estimates" as stated in CMIN 4.1 or attempt to clarify the CMIN. The stock-assessment model developed for the fishery will be updated and revised as needed.

Over the last 7 years a contractor, Ecometric, Inc., has been conducting surveys of RBT redds and early life stages of RBT in the Lees Ferry reach. These studies have been useful, especially in the analysis of dam operation impact to RBT. Similar studies may not be incorporated into long-term monitoring, but in light of the continued experimental operations of GCD through FY2012, the work is to be maintained for FY2010–11. In FY2010–11, the AZGFD will work cooperatively with Ecometric, Inc. to transfer the techniques and data analysis for this project from the contractor to the agency, anticipating that AZGFD will be completely responsible for the conduct of any early life stage monitoring that may be necessary in FY2012 and beyond.

Consistent with the recommendations of the 2009 PEP for Grand Canyon Fishes, this project will seek to expand efforts to monitor nonnative fish other than RBT and will also attempt sampling to see if movement of RBT or other species downstream of the Paria River can be successful. Surveys of RBT

and other nonnative fish below the Paria River will be combined with other field efforts of this project to compare distributions of these species above and below the mouth of the Paria River and, thereby, provide data such as catch rates, presence/absence, and distribution to help support multiyear analysis of movement of nonnatives downstream. Specific reaches to study will be determined in the winter FY2009 fish data meetings to be convened between the cooperating fish agencies AZGFD, U.S. Fish and Wildlife Service, the Grand Canyon Monitoring and Research Center (GCMRC), and interested GCDAMP members.

Links/Relationships to Other Projects

Understanding the status of the Lees Ferry RBT population is critical to estimating the risk that this species may pose to native fish further downstream in the Colorado River ecosystem. With the reinitiation of a project to remove RBT from the Little Colorado River reach of the Colorado River, it will be critical to understand the status and trends of Lees Ferry RBT to evaluate the movement and repopulation of RBT that may occur in downstream reaches.

Monitoring Lees Ferry is an important project to conduct to support GCDAMP and managers monitoring the nonnative fish species that may expand in or be introduced into the Lees Ferry reach. Analysis of early life stage data supports analysis of the impact of dam operations on the RBT fishery and other nonnative species in the Lees Ferry reach.

Logistics

This project will field five trips annually as follows:

- Two annual standardized random sampling surveys
- Two annual early life history trips (one or both may extend below Paria River)
- One annual nonnative survey (may extend below Paria River)

All trips are motor supported, launching from and returning to Lees Ferry just upstream of the mouth of the Paria River.

Products/Reports

- Annual reporting of the results of all monitoring efforts will be delivered to the GCMRC by December 15 of each year.
- AZGFD and GCMRC will be working together to develop additional peer-reviewed products documenting the status and trends of the Lees Ferry RBT fishery in FY2010–11.
- AZGFD will be responsible for delivering analysis of the data from this project to fish cooperator meetings in calendar year 2009 and beyond.

Budget

FY 2010

BIO 4.M2.10	
Monitoring Lees Ferry Fish (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	4,858
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	15,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	143,000
Project Subtotal	**$ 162,858**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	12,879
Project Total (Gross)	**$ 175,737**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	92.4%

FY 2011

BIO 4.M2.11	
Monitoring Lees Ferry Fish (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	5,100
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	15,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	149,400
Project Subtotal	**$ 169,500**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	13,319

Project Total (Gross)	**$ 182,819**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	92.6%

GCDAMP Goal 5—Maintain or attain viable populations of Kanab ambersnail.

BIO 5.R1.10–11—Monitor Kanab Ambersnail

Start Date

April 2007

End Date

September 2011

Principal Investigator

J.A. Sorensen, Arizona Game and Fish Department

Geographic Scope

Vaseys Paradise, located 31.5 river miles (RM) downstream of Lees Ferry

Project Goals

This project is proposed for FY2010–11. The goals of this project are to determine the extent and kind of vegetation that exists as habitat for the Kanab ambersnail (KAS) and to track the abundance and distribution of KAS at Vaseys Paradise.

Need for Project

Knowing the extent of habitat is needed in the event of a high flow experiment to develop a biological opinion and to determine snail densities. Changes in snail numbers can be associated with changes in vegetation. By monitoring the vegetation at Vaseys Paradise, the snails are indirectly monitored, based on the assumption that if the preferred habitat is present, snails will also be present. Total habitat can be measured using remote methods, but the composition of the habitat may still require on-the-ground sampling. Sampling at Vaseys Paradise can also provide data for Glen Canyon Dam Adaptive Management Program (GCDAMP) goal 6, which refers to the protection and improvement of riparian and spring communities.

The KAS is a federally listed endangered species; however, the legal status is under review by U.S. Fish and Wildlife Service. Conducting this project in FY2010 and FY2011 will allow for consistent surveying during the review period. If it is determined that the KAS will no longer be listed as endangered, the GCDAMP will need to consider if their support for monitoring of the species increases, decreases, or remains the same.

Strategic Science Questions

There are no SSQs that are directly related to the goal of maintaining or attaining viable KAS populations.

Information Needs Addressed

Primary information needs addressed:

CMIN 5.1.1. Determine and track the abundance and distribution of Kanab ambersnail at Vaseys Paradise in the lower zone (below 100,000 cfs) and the upper zone (above 100,000 cfs).

CMIN 5.2.1. Determine and track the size and composition of habitat used by Kanab ambersnail at Vaseys Paradise.

Methods and Tasks

Determine percent cover, diversity, and distribution of vegetation that constitutes KAS habitat. Random samples of habitat document percent cover, plant height of dominant plants, and soil moisture. Survey total habitat and plots using conventional survey methods. The Grand Canyon Monitoring and Research Center (GCMRC) survey department calculates habitat area. Data are analyzed using univariate and multivariate approaches. This project will

- monitor relocated vegetation associated with high-flow experimental conservation measures;
- sample vegetation plots at Vaseys Paradise to determine patch composition and areal extent (fall of each year) and sample for the presence of KAS in plots;
- enter data and conduct quality control on data entry, providing the data to the GCMRC for vegetation analysis; and
- compare previous vegetation composition to previous vegetation/habitat surveys to assess habitat;
- provide abundance estimates of snails; and
- write reports for the GCMRC during the winter of each year.

Links/Relationships to Other Projects

Riparian vegetation, including vegetation at springs, is a critical interface between aquatic and terrestrial environments around the world. There are multiple components that riparian and spring communities either contribute to or influence (for example, food base and available habitat). In the Colorado River ecosystem, the spring vegetation itself serves as a host for invertebrates like KAS, provides breeding and foraging habitat for small mammals and birds, provides cover in the heat of the day, and provides spring water that may be used for ceremonial purposes. Changes in the composition or structure of riparian spring communities, such as the expansion of an exotic species, may alter these interactions. Riparian and spring vegetation regulates nutrient exchange between the land and water, and leaf litter is a terrestrial carbon source that may influence in-stream invertebrate production. The relative importance of terrestrial carbon in the aquatic food web is being addressed in part through the Aquatic Food Base Project (BIO 1.R1.10). The linkage could be further defined through studies that focus on terrestrial productivity and processes.

Logistics

The survey work described for this project requires two scientists to have a full day at Vaseys Paradise in the fall. This work is conducted in conjunction with fall fish monitoring effort (BIO 2.R4.10) led by the GCMRC.

Products/Reports

The AZGFD will produce an annual report for KAS habitat and density estimates by Arizona Game by December 15 of each year.

Budget

FY2010

BIO 5.R1.10	
Monitor Kanab Ambersnail (FY2007–11)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	5,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	17,640
Project Subtotal	**$ 22,640**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	2,124
Project Total (Gross)	**$ 24,764**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	89.0%

FY2011

BIO 5.R1.11	
Monitor Kanab ambersnail (FY2007–11)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	5,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	18,522
Project Subtotal	**$ 23,522**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	2,178
Project Total (Gross)	**$ 25,700**
Percent Outsourced (Outside of GCMRC; includes 50% of	89.4%

Logistics)	

GCDAMP Goal 6—Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.

BIO 6.M1.10—Vegetation Mapping

BIO 6.M2.11—Vegetation Transects

Start Date

September 2009

End Date

Ongoing; FY2010 is the initiation of long-term monitoring for riparian vegetation.

Principal Investigators

Barbara E. Ralston, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, and other cooperators, to be determined

Geographic Scope

The riparian zone, including the old high-water zone (OHWZ; >97,000 cubic feet per second (cfs)), in the Colorado River corridor from Glen Canyon Dam to Lake Mead

Project Goals

The goals of these projects are to determine the areal extent of vegetation classes among the major habitat zones in the Colorado River ecosystem (CRE) (for example, new high-water zone (NHWZ), sand beach community, OHWZ) and how Glen Canyon Dam (GCD) operations affect vegetation cover, richness, and diversity by surface elevation measured at a meaningful time interval, as recommended by the protocol evaluation panel (PEP) (Cooper and others, 2008). The project evaluates vegetation change at both the landscape scale and the community scale over time.

Need for Project

Riparian vegetation expansion since operations at GCD began in 1963 has played a pivotal role in the ecology of the postdam river corridor. The reduction in annual flood volumes has allowed vegetation to expand and more permanently occupy land previously subjected to scouring in most years. The expansion has included marsh habitat occurring throughout the CRE, whereas previously these habitats were restricted to Glen Canyon and the western Grand Canyon (Clover and Jotter, 1944; Turner and Karpiscak, 1980). The plants associated with the expansion include alien species like tamarisk (*Tamarix ramossisma*), camel thorn (*Alhagi maurorum*), and peppergrass (*Lepidium latifolium*), but also native species such as arrowweed (*Pluchea sericea*), seepwillow (*Baccharis emoryi*), and coyote willow (*Salix exigua*). Variable operations at the dam over the years have resulted in an ebb and flow of vegetation expansion, with vegetated area generally increasing over time (Turner and Karpiscak, 1980; Waring, 1995; Ralston and others, 2008). The increase in terrestrial vegetation contributes to aboveground primary productivity, arthropod densities, and associated food resources for terrestrial

and aquatic vertebrates. It is also a source of culturally important plant species and can cause conflicts with recreational activities requiring available camping area. Because riparian vegetation is linked to multiple resources, knowing how vegetation is changing through monitoring (for example, which species are expanding or declining and where) is an important source of data when evaluating dam operations.

Addressing the Adaptive Management Work Group (AMWG) information needs associated with riparian vegetation requires systemwide assessment of vegetation change at the broad scale (NHWZ) and at the local scale (community composition). While knowing the amount of vegetation in the river corridor is useful, it is equally useful to note changes in the species makeup of the vegetation. Riparian systems are highly susceptible to exotic species introductions (Nilsson and Jansson, 1995). Because riparian vegetation contributes to aquatic productivity (Naiman and others, 2005) and serves as a host to terrestrial invertebrates and higher order vertebrates (for example, lizards and birds), assessing the quality of these plants can help explain changes observed in higher order vertebrate abundances, including fish species (Nakano and Murakami, 2001). Changes in riparian vegetation are associated with dam operations (Stevens and others, 1995; Kearsley, 2006), which can affect the propagation of exotic species like tamarisk (Porter, 2002). Monitoring transects at a biologically meaningful frequency to detect changes among herbaceous species, including invasive species, can assess how operations inhibit or encourage invasive species colonization and expansion, which cannot be determined through remote-sensing techniques because the scale is too small for image resolution. Monitoring changes in the composition of vegetation requires on-the-ground sampling. Remotely sensed data can assess changes in overstory wood species that change more slowly.

These two projects, on-the-ground sampling and remote sensing, complement each other. Monitoring of composition change in vegetation is done relatively frequently (for example, occurring at annual and biennial intervals; see Cooper and others, 2008) and records species diversity, richness, and cover at specific stage elevations. The changes in vegetation parameters that this monitoring detects are relevant to perennial and annual herbaceous species like bunch grasses, marsh species, and invasive species that can change at higher frequencies than woody vegetation. Vegetation mapping with remote sensing utilizes digital overflight imagery (using the Data Acquisition, Storage, and Analysis Program (DASA)) to quantify larger scale area changes (for example, expansion of arrowweed patches or extent and type of vegetated shoreline). Landscape-scale change is determined by comparing area changes of vegetation between years (for example, imagery from a FY2005 overflight is compared with imagery from a FY2002 overflight for the purposes of change detection). Analysis of change detection between years can identify patterns of change in woody riparian shrubs that may not be observable over shorter time periods or at the local scale. The two projects complement each other because they provide information about changes in riparian habitat at different ecological scales that affect riparian community constituents like invertebrate biomass and riparian bird abundances.

Glen Canyon Dam Adaptive Management Program goal 6 is directed at the protection or improvement of riparian and spring communities. This goal is based on the recognition that the riparian and spring environments are hosts for some endangered species like the Southwestern willow flycatcher (*Empidonax traillii extimus*). The protection of these species' critical habitats is part of this goal. Riparian plant communities can be viewed at either a single-resource level without ecosystem linkages or at an integrative level where riparian vegetation is linked to aquatic and terrestrial ecosystem processes (for example, when it contributes to secondary production and cover). Riparian plant communities interact with cultural resources associated with recreation (for example, camping sites) and traditional cultural properties (TCPs), affecting aeolian sand transport and possibly archaeological site erosion rates. Understanding how riparian vegetation responds to flows and affects other resources of concern forms the basis for managing critical resources like native fish, archaeological properties, and recreational resources.

Strategic Science Questions

Primary SSQs addressed:

SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?

SSQ 4-2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possible mortality of young humpback chub) associated with high flows?

SSQ 5-7. How do warmer releases affect viability and productivity of native/nonnative vegetation?

Information Needs Addressed

The primary information needs addressed by these projects are CMINs 6.1.1., 6.2.1, 6.5.1, and 6.6.1, which are summarized as the following:

- Determine and track the abundance, composition, distribution, and area of terrestrial native and nonnative vegetation species in the CRE.
- Determine parameters and metrics to be measured, and the information needs that address each element.
- Determine how the abundance, composition, and distribution of the OHWZ, NHWZ, and sand beach community have changed since dam closure (1963), high flows (1984), interim flows (1991), and the implementation of ROD operations (RIN 6.2.1, 6.3.1, 6.4.1, 6.5.1, 6.5.2, 6.5.3).

These information needs will be addressed through the following actions:

- Quadrennial color infrared digital imagery mapping that quantifies (1) area change of dominant overstory species, (2) community composition and possibly changes in understory community composition through ground truthing associated with mapping, and (3) coarse primary productivity estimates for riparian vegetation.
- Vegetation transects conducted at an appropriate frequency correlated with river stage elevations zones. Quantifies cover, richness, and diversity, and community composition at each zone. This work is most informative for herbaceous annuals and perennials, including invasive species. This component may incorporate marsh-monitoring needs of Tribes.

Methods and Tasks

Vegetation Mapping

Community identification in the field will be done using the 50 m² plot data obtained from the vegetation transect monitoring. In these plots, the presence and cover of species will be recorded. Cover scales use a Daubenmire scale. Data are recorded as categorical data, but plant height of the dominant species is also recorded. Samples come from a stratified sample approach within geomorphic reach, and include vegetation sample data from debris fans, sandbars, and channel margins. These data are analyzed using nonmetric multidimensional scaling (McCune and Grace, 2002), per the PEP recommendations (Cooper and others, 2008) to identify the dominant communities along the river corridor. Classification follows the National Vegetation Classification System. Field efforts include

initial vegetation sampling to identify vegetation classes and a subsequent accuracy assessment the year following data acquisition and analysis.

Vegetation classification will use supervised classification routines that are available in an image-processing software package ENVI (ITT, 2005). Training areas will be selected from previously ground-truthed areas. Classes that will likely be used for this effort include tamarisk (*Baccharis/Salix)*, marsh/wetlands, mesquite/acacia, arrowweed, and bare ground (Ralston and others, 2008). User and producer accuracies will be determined and class aggregation may be required to meet national vegetation-mapping standards. The FY2009 overflight data and subsequent overflight data will be compared with previously mapped imagery (for example, FY2005 and FY2002) for vegetation area change-detection purposes.

Quantification of changes in riparian communities will be done using a Geographic Information Systems (GIS) platform (ArcMap; Environmental Systems Research Institute, 2002).

The following tasks in FY2010 are designed to reach the goal for vegetation mapping:

- Determine the capabilities of the FY2009 imagery for vegetation classification
- Identify community types from FY2008–09 field samples
- Use FY2002 and FY2005 vegetation data to compare total vegetation change
- Develop draft report of community change and accuracy assessment based on May 2009 ground-truth data
- Compare revised vegetation map to FY2002 vegetation map (Ralston and others, 2008) to determine area change for vegetation classes. Write draft report (summer 2010)
- Assess accuracy in association with vegetation transects in FY2011

Vegetation Transects

A biannual, canyon-wide, stratified sampling approach tied to hydrologic zones and geomorphic features will be used for the vegetation transect work, following the PEP recommendations (Cooper and others, 2008). Plots will be approximately 50 m^2 in size to ensure characterization of species found within a hydrologic zone. Hydrologic zones that are sampled consist of four zones: 8–20k cfs, 20–31k cfs, 31–45k cfs, and >45k cfs. An additional higher zone specific to the OHWZ is sampled on a less frequent basis (every 4 years). Geomorphic features sampled include debris fans, sandbar eddies, and channel margins. Each of these features can consist of somewhat different riparian species assemblages.

At each sampling point and within each zone a list of species encountered and an assigned cover value is given using a categorical scale of cover. These data are included in the univariate measures (cover, richness, diversity) and in developing community descriptions for vegetation mapping purposes.

Sampling will take place every other year, coinciding with vegetation mapping overflights and accuracy assessments that also occur on a biannual basis. In the event of a HFE, transects will be conducted around the event to supplement monitoring as per the PEP recommendations (Cooper and others, 2008).

Links/Relationships to Other Projects

Riparian vegetation is a critical interface between aquatic and terrestrial environments around the world. In the CRE, the vegetation itself serves as a host for invertebrates, provides breeding and foraging habitat for birds, provides cover in the heat of the day, and may be harvested for cultural purposes. Changes in the composition or structure of riparian vegetation, such as the expansion of an exotic species, may alter these interactions. Riparian vegetation regulates nutrient exchange between

the land and water, and leaf litter is a terrestrial carbon source that may influence in-stream invertebrate production. The relative importance of terrestrial carbon in the aquatic food web is being addressed in part through the food base initiative. The linkage could be further defined through studies that focus on terrestrial productivity and processes. Again, changes in abundance or kind of riparian carbon sources may influence aquatic productivity processes. The 2005 knowledge assessment workshop revealed that there was some certainty about the relationship of marsh community development and flows for the CRE but that this situation certainty decreased as one progressed upslope (Melis and others, 2006). Additionally, the knowledge assessment workshop and the science questions for riparian habitats indicate that an understanding of the integrated role of riparian vegetation with other resources is needed (for example, aquatic or cultural resources). This understanding would come from a combination of monitoring, synthesis, and field research.

Logistics

Logistics require a 4-boat oar trip or a single snout and sport boat trip in May 2011.

Products/Reports

These projects will produce a USGS draft report on vegetation change from 2002 to 2009, update the vegetation base layer for GIS, and develop a core-monitoring report for vegetation monitoring to be delivered by September 2012. A species list by hydrologic zone and geomorphic feature will also be developed for the use of Tribal monitoring.

Budget

FY2010

BIO 6.M1.10	
Vegetation Mapping (FY2010–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	73,197
GCMRC Project Related Travel / Training (21% Burden)	2,000
GCMRC Operations / Supplies / Publishing (21% Burden)	3,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	1,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$79,197**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	16,631
Project Total (Gross)	**$95,828**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

BIO 6.M1.11	
Vegetation Mapping (FY2010–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	81,778
GCMRC Project Related Travel / Training (21% Burden)	2,000
GCMRC Operations / Supplies / Publishing (21% Burden)	3,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	1,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$87,778**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	18,433
Project Total (Gross)	**$ 106,211**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

BIO 6.M2.11	
Vegetation Transects (FY2011–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	35,274
GCMRC Project Related Travel / Training (21% Burden)	3,000
GCMRC Operations / Supplies / Publishing (21% Burden)	5,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	1,000
GCDAMP Logistical Support (21% Burden)	30,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	50,000
Project Subtotal	**$124,274**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	18,643
Project Total (Gross)	**$ 142,917**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	52.3%

BIO 6.R3.10—Vegetation Synthesis

Start Date

October 2006

End Date

September 2010

Principal Investigators

Barbara E. Ralston, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, and other cooperators to be determined

Geographic Scope

The riparian zone, including the old high-water zone (OHWZ; >97,000 cfs), in the Colorado River corridor from Glen Canyon Dam (GCD) to Lake Mead

Project Goals

The goal of this project is to use existing data from previous investigations associated with the riparian zone to characterize temporal and spatial responses of riparian vegetation to GCD operations. Characterization can include compositional changes in species over time and the effects of spatial scale on data interpretation. Results of both aspects have implications for long-term monitoring approaches for riparian vegetation in terms of frequency and sampling location aspects.

Need for Project

A large amount of information exists in the grey literature associated with riparian vegetation for the Colorado River. Several studies were specific research projects associated with the environmental impact statement process for the operation of GCD (Waring and Stevens, 1986; Anderson and Ruffner, 1987; Stevens and Ayers, 1993; Kearsley and Ayers, 1996) or associated with experimental flows from 1996 or 2000 (Kearsley and Ayers, 1999; Stevens and others, 2001; Porter, 2002). The project is intended to use data and results of these studies to construct a more cohesive view of riparian vegetation changes within the Colorado River ecosystem (CRE). A multi-temporal and spatial scale approach could possibly better characterize vegetation dynamics and vegetation change along the river corridor. By establishing a basic depiction of riparian vegetation constituents and identifying variables that affect riparian vegetation dynamics along the CRE, more integrative analyses and hypothesis testing involving aquatic and terrestrial resources are possible.

Strategic Science Questions

Primary SSQs addressed:

> **SSQ 2-1.** Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?
>
> **SSQ 4-2.** How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possible mortality of young humpback chub) associated with high flows?

SSQ 5-7. How do warmer releases affect viability and productivity of native/nonnative vegetation?

Information Needs Addressed

The primary information needs addressed by these projects are CMINs 6.1.1., 6.2.1, 6.5.1, and 6.6.1, which are summarized as the following:

- Determine and track the abundance, composition, distribution, and area of terrestrial native and nonnative vegetation species in the CRE.
- Determine parameters and metrics to be measured, and the information needs that address each element.
- Determine how the abundance, composition, and distribution of the OHWZ, NHWZ, and sand beach community have changed since dam closure (1963), high flows (1984), interim flows (1991), and the implementation of ROD operations (RIN 6.2.1, 6.3.1, 6.4.1, 6.5.1, 6.5.2, 6.5.3).

General Methods/Tasks

Transect data from 2001 to 2005 (Kearsley, 2006) will be reanalyzed to consider tributary effects on richness and diversity and to evaluate scale effects on interpretation of change. Discharge frequency and magnitude from GCD and the tributaries (Paria and Little Colorado Rivers) will be used in the analysis to determine how frequency of disturbance affects richness and diversity downstream.

Large-scale area change detection will use GIS analysis tools (ArcMap; Environmental Systems Research Institute, 2002) to identify area change for vegetation classes or zones of interest between years. Identification of tamarisk in black and white imagery will be conducted using 2002 and 2005 imagery to compare vegetation characteristics. The Data, Acquisition, Storage and Analysis (DASA) Program scanning project intended to orthorectify historical imagery to permit retrospective analysis of vegetation change has been delayed because of funding limitations. As a consequence, smaller areas already orthorectified will be compared to determine the feasibility of retrospective analysis.

This project will compare vegetation patches from the FY2002 vegetation base map (Ralston and others, in press) with previous vegetation maps (Waring, 1995) completed for sections of the river for the years 1965, 1973, 1984, 1990, and 1991 to determine distribution and abundance information at a gross scale (for example, new high-water zone, OHWZ, sand beach, and marsh). Area coverage will be provided for different zones. The project will perform change detection between years to identify change in area and distributional changes for woody exotics (for example, tamarisk) and quantify allochthonous inputs using a combination of field and mapping data to estimate annual inputs.

Links/Relationships to Other Projects

The expansion of vegetation along the river corridor affects multiples resources. The increased shoreline vegetation contributes to aquatic drift and may serve as a supplemental source of carbon for aquatic food webs in addition to in-stream production. The ecology of human behaviors along the river corridor is affected by riparian vegetation. Exotic species that spread by tributary introductions (for example, camel thorn) impact campable area by making some beaches unusable. Available campsite area is dependent on the amount of open sand, availability of trees and shrubs for shade and wind breaks, and accessibility to the river (that is, steepness of bank), among other variables (Kearsley and others, 1994; Kaplinski and others, 2005). In a similar vein, culturally important plants and locations have been monitored under the auspices of the Glen Canyon Dam Adaptive Management Program since the 1990s (Phillips and Jackson, 1996; Austin and others, 1997; Lomaomvaya and others, 2001). How these data have changed over time also needs to be incorporated into a synthesis to provide a holistic view of the riparian community.

Logistics

No logistics are required.

Products/Reports

As a result of this project, reports are anticipated on the following topics:

- Marsh and riparian species richness and diversity patterns with the Colorado River corridor (U.S. Geological Survey, unpub. data, 2008)
- Vegetated area changes and rates of change within the Colorado River corridor since 1965 (The product will use 2002 and 2005 vegetation map information (Pr 6.2) as well as legacy data to document vegetated area change and rates of change among vegetation classes.)
- Quantification of annual allochthonous production of marsh and riparian vegetation to the aquatic system in the Colorado River ecosystem (U.S. Geological Survey, unpub. data, 2008)

Budget

FY2010

BIO 6.R3.10	
Vegetation Synthesis (FY2007–10)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	31,840
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 31,840**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	6,686
Project Total (Gross)	**$ 38,526**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

GCDAMP Goal 7—Establish water temperature, quality, and flow dynamics to achieve the Adaptive Management Program ecosystem goals.

BIO 7.R1.10–11—Water-quality Monitoring of Lake Powell and the Glen Canyon Dam Tailwater

Start Date

1991

End Date

Ongoing

Principal Investigator

William S. Vernieu, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Lake Powell and its major tributary arms, inflow tributaries entering Lake Powell, and the tailwater from Glen Canyon Dam to Lees Ferry

Project Goals

This project seeks to

- maintain a water-quality monitoring program for Lake Powell to predict and track processes in the reservoir that may influence Glen Canyon Dam (GCD) release water quality;
- maintain water-quality monitoring in tailwater to directly evaluate the quality of GCD releases, the effects of GCD operations, and suitability for downstream aquatic resources;
- contribute to ongoing modeling efforts by the Bureau of Reclamation (Reclamation), currently the CE-QUAL-W2 model, to predict future changes in the water quality of Lake Powell and GCD releases by simulating the effects of various proposed and hypothetical climate, experimental, and operational scenarios; and guide future monitoring program revisions;
- compile and publish biological information from the long-term database of Lake Powell water-quality information and provide further interpretation, synthesis, and analysis of this and previously published chemical and physical data;
- implement a revised monitoring program in conjunction with development of the CE-QUAL-W2 model and historical data analysis; and
- conduct a protocol evaluation panel (PEP) review of the monitoring program to ensure scientific credibility and adequate linkages with other downstream resources.

Need for Project

Processes within Lake Powell, climate changes in the upper Colorado River Basin, the structure of GCD, and various aspects of dam operations affect the quality of water released from GCD to the Colorado River in Grand Canyon. Temperature, dissolved oxygen concentrations, nutrient concentrations, biological composition, and other characteristics of GCD releases can have a profound effect on the aquatic ecosystem below the dam.

Since 1999, inflow to Lake Powell has been below average in every year except water years (WY) 2005 and 2008. The 5-year period of below normal inflows in the upper Colorado River Basin from 2000 to 2004 resulted in a drawdown of Lake Powell by more than 140 ft, decreasing total capacity of the reservoir to 38 percent. The increasing influence of Lake Powell surface layers on GCD releases caused warmer release temperatures, decreased release nutrient concentrations, and increased the export of aquatic biota from Lake Powell. The lower level of warm surface layers in relation to withdrawal levels at the penstock resulted in above normal late summer release temperatures from WY2003 to WY2007. Release temperatures of 16°C were recorded in October 2005, representing the warmest releases since 1971. Resuspension of exposed deltaic sediments from reservoir drawdown by WY2005 inflow currents resulted in a plume of hypoxic water that appeared at GCD and began to be incorporated in dam releases in July 2005. As a result, dam releases contained the lowest concentrations of dissolved oxygen on record, only 3.3 milligrams per liter in October 2005. Changes to individual turbine operations at GCD in September and October 2005 were shown to have a significant impact on the reaeration of hypoxic releases.

Differential routing of winter inflow currents can cause longer term changes to the water quality of Lake Powell and eventual dam releases. For the period WY2000–07, with the exception of WY2006, winter underflow density currents moved along the bottom of the reservoir and refreshed oxygen concentrations in the deepest layers of Lake Powell, displacing older hypolimnetic water upward to be entrained in penstock releases. In contrast, from WY1994 to WY1999 and during other periods in Lake Powell's history, winter density currents moved through the reservoir in intermediate layers as an interflow, which caused stagnation and a reduction of dissolved oxygen concentrations in the deepest hypolimnetic water of the reservoir. This interflow pattern again appeared in WY2006. Exceptionally cold winter inflows caused an underflow in January 2007, increasing hypolimnetic density and increasing the likelihood of future interflow conditions, which may cause reductions in hypolimnetic dissolved oxygen in future years. A weak underflow current was observed in early WY2008, but was absent in WY2009.

Since 2007, the western United States has experienced a rapid invasion of the nonnative quagga (*Dreissena rostriformis bugensis*) and zebra mussel (*Dreissena polymorpha*) and has been found in several Colorado River reservoirs above and below Lake Powell. These mussels have the potential to drastically alter reservoir and lake ecosystems and as yet, have not been documented in Lake Powell. Zooplankton and phytoplankton sampling at Lake Powell has been conducted since 1990. The analyses from these samples forms a rich database from which to establish a pre-invasion baseline at Lake Powell and evaluate changes to the ecosystem if these mussels become established at Lake Powell.

The Grand Canyon Monitoring and Research Center (GCMRC) works in cooperation with the Reclamation on the development of the CE-QUAL-W2 model by providing monitoring data to be used for model calibration and verification. This monitoring data consists of information describing the quality of water in GCD releases, Lake Powell, and tributary inflows into Lake Powell. In addition, the GCMRC provides comments on the direction of model development so that a product can be developed that meets the needs of both Reclamation and the Glen Canyon Dam Adaptive Management Program (GCDAMP). A functional model is expected to provide reliable simulations of hydrodynamic processes and water-quality conditions in the reservoir, including validation with historical observations. It is also expected to provide reasonable predictions of these processes and conditions under various projected and hypothetical operational and climatological scenarios. Comparison of

these predictions with monitoring observations may help to verify or refute the sensitivity of the model to various input factors. Beyond simulations of historical and future conditions, many questions may be posed that could be addressed by a well-constructed and calibrated model. It is likely that GCMRC, Reclamation, and other parties will have different priorities and research interests for questions to be addressed by the model. A functional, calibrated model with a common set of input files would provide a common basis from which the research needs of these various entities could be met.

As model development progresses, many components of the water-quality monitoring program and Lake Powell data synthesis can be facilitated with results from the model, such as identifying parameters for which the model is more or less sensitive and restructuring monitoring efforts appropriately. Results can be used to identify the need for more detailed inflow water-quality monitoring, establish and maintain additional meteorological stations at the reservoir, and modify sampling methods and frequency for biological parameters such as chlorophyll and plankton, in order to refine the model's ability to simulate productivity processes in the reservoir.

Strategic Science Questions

While the 2005 knowledge assessment workshop specified many SSQs addressing the effects of water quality on various resources (sediment, food base, fisheries, recreation), no SSQs were proposed that dealt directly with tracking and predicting changes in water quality in Lake Powell or GCD releases. The following questions are the SSQs most closely related to the effects of water quality on key resources:

AMWG Priority 3: What is the best flow regime?

> **SSQ 3-5.** How is invertebrate flux affected by water quality (for example, temperature, nutrient concentrations, turbidity) and dam operations?
>
> **AMWG Priority 5:** What will happen when we test or implement the temperature control device (TCD)? How should it be operated? Are safeguards needed for management?
>
> **SSQ 5-1.** How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?
>
> **SSQ 5-3.** To what extent do temperature and fluctuations in flow limit spawning and incubation success for native fish?

Information Needs Addressed

The following information needs (including synthesis information needs (SINs)) (as updated June 23, 2003) relate directly to water-quality monitoring in Lake Powell and the GCD tailwater.

> **CMIN 7.1.1.** Determine the water temperature dynamics in the mainstem, tributaries (as appropriate, temperature only in mainstem and LCR), backwaters, and near-shore areas throughout the Colorado River ecosystem.
>
> **CMIN 7.2.1.** Determine the seasonal and yearly trends in turbidity, water temperature, conductivity, DO, and pH changes in the main channel throughout the Colorado River ecosystem.
>
> **SIN 7.2.1.** How do the hydrodynamics and stratification of Lake Powell influence the food base or fisheries downstream?
>
> **SIN 7.2.2.** Which water-quality variables influence food base and fisheries in the Colorado River ecosystem?

RIN 7.3.1. Develop simulation models for Lake Powell and the Colorado River to predict water-quality conditions under various operating scenarios, supplant monitoring efforts and elucidate understanding of the effects of dam operations, climate, and basin hydrology on Colorado River water quality.

7.3.1.a. Determine status and trends of chemical and biological components of water quality in Lake Powell as a function of regional hydrologic conditions and their relation to downstream releases.

7.3.1.b. Determine stratification, convective mixing patterns, and behavior of advective currents in Lake Powell and their relation to GCD operations to predict seasonal patterns and trends in downstream releases.

RIN 7.3.3. How do dam operations affect reservoir limnology?

SIN 7.3.1. Measure appropriate water-quality parameters to determine the influence of these parameters on biological resources in the Colorado River ecosystem.

EIN 7.3.1. How does the water quality of releases from GCD change in response to an experiment performed under the ROD, unanticipated event, or other management action?

Other information needs (as updated June 23, 2003) require supporting information from water-quality monitoring in Lake Powell and the GCD tailwater:

RIN 7.1.1. What are the desired ranges of spatial and temporal patterns of water temperatures for the CRE?

RIN 7.1.2. What are the most likely downstream temperature responses to a variety of scenarios involving a TCD on GCD?

RIN 7.1.3. What are the potential ecological effects of increasing mainstem water temperature?

RIN 7.2.1. Which major ions should be measured? Where and how often?

RIN 7.2.2. Which nutrients should be measured? Where and how often?

RIN 7.2.3. Which metals should be measured? Where and how often?

General Methods/Tasks

Lake Powell monitoring is conducted monthly in the GCD forebay and quarterly at 25–30 sites throughout the reservoir. Profiles of physical parameters (temperature, specific conductance, pH, dissolved oxygen, turbidity, redox potential) are collected through the water column at each site in the reservoir. Chemical (major ions and nutrients) and biological samples (chlorophyll and plankton) are collected at selected sites to characterize major strata and advective currents in the reservoir.

GCD tailwater monitoring consists of continuous monitoring (temperature, specific conductance, pH, dissolved oxygen, turbidity) with monthly chemical and biological sample collection. Grand Canyon monitoring consists primarily of collection of temperature and conductance at various locations.

Lake Powell monitoring parameters include temperature, conductance, pH, dissolved oxygen, redox potential, and turbidity. Chemical analyses include determination of major ionic constituents and nutrient compounds of phosphorus and nitrogen. Plankton analyses include enumeration and

identification of species, biomass estimates, and relative abundance calculations. All measurements and laboratory analyses are performed in accordance with standard approved methods.

In FY2009, the Hydrolab H20/Surveyor III multiparameter water-quality monitoring system was lost at Lake Powell. The system has been the primary monitoring instrument for Lake Powell since 1993. A replacement system is proposed and will be in place for the FY2010–11 period and will incorporate state-of-the-art sensors and oceanographic methodologies. With its replacement, the monitoring program will be restructured with input from analysis of historical data and simulation modeling. Part of the restructuring will be the reduction of some of the chemical sampling, higher spatial resolution of in situ monitoring and establishment of meteorological and inflow water-quality monitoring stations.

Reservoir modeling is performed cooperatively between Reclamation and the GCMRC to achieve predictive capabilities, and guide, redirect, or supplant some aspects of monitoring. Current model development has progressed to include calibrations for dissolved oxygen concentration, algal components, and oxygen demand from deltaic resuspension.

Links/Relationships to Other Projects

The quality of dam releases and subsequent in-stream changes can have a profound effect on various aspects of the aquatic ecosystem in Grand Canyon. Temperature affects metabolic rates of various organisms, including bacteria, plants, invertebrates, and vertebrates. It also affects reproductive processes, larval development, and behavior of native and nonnative fish. Nutrient concentrations in dam releases can influence primary productivity processes in the clear water Lees Ferry reach. Dissolved oxygen is essential to maintaining healthy fish and invertebrate populations throughout Grand Canyon. Temperature and dissolved oxygen have the most direct effect on native and nonnative fish populations. Suspended sediment concentrations limit the light available for primary productivity and affect the behavior of various fish. Tracking status and trends of these water-quality parameters represent a direct link with various food base and fishery studies currently underway in Grand Canyon.

Logistics

The current Lake Powell monitoring program provides its own logistic support and does not require support from the GCMRC Logistics program, with the exception of the use of GCRMC vehicles for transportation of personnel and equipment between Flagstaff and Lake Powell. Lake Powell logistics consists of operation, fuel, maintenance, and repair costs for the Uniflite limnology vessel. Food costs and procurement for field monitoring crews are borne by the monitoring crew travel costs.

Products/Reports

- A comprehensive report describing the 43-year history of Lake Powell water-quality monitoring was published in FY2009.
- A compilation of existing biological data, analysis of the existing backlog of biological samples, and a preliminary analysis of the existing data will be performed in FY2010
- An interpretive data synthesis report will be developed in FY2010 to build upon the monitoring data and provide insights into how climatological, meteorological, and hydrodynamic processes, and the operation of GCD, affect inflow routing and stratification in the reservoir and the quality of releases from GCD.
- Periodic reports of water-quality conditions will be posted on the GCMRC Web site.
- Updates on water-quality conditions will be provided to the Adaptive Management Work Group, Technical Work Group, and other interested parties through written reports or oral presentations periodically.

Budget

FY2010

BIO 7.R1.10	
Water-Quality Monitoring of Lake Powell and the Glen Canyon Dam Tailwater (FY2007–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	166,152
GCMRC Project Related Travel / Training (21% Burden)	11,000
GCMRC Operations / Supplies / Publishing (21% Burden)	23,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	10,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	20,000
Project Subtotal	**$ 230,152**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	45,350
Project Total (Gross)	**$ 275,502**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	8.7%

FY2011

BIO 7.R1.11	
Water-Quality Monitoring of Lake Powell and the Glen Canyon Dam Tailwater (FY2007–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	172,234
GCMRC Project Related Travel / Training (21% Burden)	12,000
GCMRC Operations / Supplies / Publishing (21% Burden)	24,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	10,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	21,000
Project Subtotal	**$ 239,234**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	47,108

Project Total (Gross)	**$ 286,342**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	8.8%

PHY 7.M1.10–11—Integrated Quality of Water Monitoring (below Glen Canyon Dam)

Start Date

October 2006

End Date

Ongoing. FY2010 and FY2011 will be the fourth and fifth years of a project that was initiated to perform core monitoring to meet the information needs related to GCDAMP goals 7 and 8. This monitoring project follows a 6-year research and development phase conducted from FY2001 to FY2006. No substantive difference is anticipated between FY2010 and FY2011 activities.

Principal Investigator

David Topping, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

The downstream integrated quality of water (IQW) project focuses on the main channel of the Colorado River from the tailwaters of GCD (RM -15) downstream to the upper end of Lake Mead (as measured at the gaging station above Diamond Creek at RM 226). The project also includes a combination of monitoring and modeling of tributary sediment inputs. Sediment and flow monitoring activities are conducted for the Paria River at Lees Ferry, the Little Colorado River (LCR) near Cameron, Arizona, the LCR above the Colorado River confluence, and various lesser tributaries in Glen, Marble, and Grand Canyons.

Project Goals

The primary objectives of the downstream IQW monitoring project concern the measurement of water stage and discharge throughout the river ecosystem, and measurement of IQW parameters of water temperature, specific conductance, dissolved oxygen, turbidity, and suspended sediment concentration and grain size. Although the focus is on monitoring, the project also supports research related to stable flow testing, evaluation of alternative fluctuating flows, tests of high flows, and ongoing development and evaluation of numerical modeling. In some instances, monitoring activities are closely related to experimental activities. For example, monitoring of the sediment budget may be considered core monitoring, but it is also required to assess a trigger for high flows such that this monitoring may also be considered experimental research support. In the section on project tasks, the individual project elements are described.

In addition, the IQW monitoring project directly supports achievement of the following GCDAMP goals:

> **Goal 7:** Establish water temperature, quality, and flow dynamics to achieve GCDAMP ecosystem goals.
>
> **Goal 8:** Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

Because this monitoring project addresses the physical framework of the ecosystem, which underlies many biological, cultural, and recreational resource objectives, it indirectly supports achievement of almost all other GCDAMP goals, including:

Goal 1: Protect or improve the aquatic food base so that it will support viable populations of desired species at higher trophic levels.

The downstream IQW monitoring project supports this goal by providing information on flows, water temperature, and turbidity that aids in food base studies, such as the assessment of primary productivity and allochthonous inputs.

Goal 2: Maintain or attain a viable population of existing native fish, remove jeopardy for HBC and razorback sucker, and prevent adverse modification to their critical habitats.

The downstream IQW monitoring project supports the native fish program by providing nearshore water temperature data for the assessment of growth rates, sediment concentration data that are used to adjust for catch efficiency in population models, flow and stage data that are important to understanding the effects of nearshore habitat disruption caused by fluctuating flows, and data on sandbars and resulting backwater habitats that are helpful in understanding the importance of sandbars for native fish.

Goal 4: Maintain a wild reproducing population of RBT above the Paria River to the extent practicable and consistent with the maintenance of viable populations of native fish.

The downstream IQW monitoring project monitors dam releases and Glen Canyon IQW, which are critically important when dissolved oxygen levels are low, requiring modifications to release patterns in order to raise oxygen levels.

Goal 6: Protect or improve the biotic riparian and spring communities within the CRE, including threatened and endangered species and their critical habitat.

The downstream IQW monitoring project also tracks the transport and fate of fine sediment, which provides the substrate for riparian vegetation and marsh communities.

Goal 9: Maintain or improve the quality of recreational experiences for users of the CRE within the framework of GCDAMP ecosystem goals.

The downstream IQW monitoring project also produces monitoring data and supports experimental and modeling research to understand flow dynamics and the size and abundance of sandbars, which are resources that affect the recreational experiences of Colorado River users such as rafters and fishermen.

Goal 11: Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations.

The downstream IQW monitoring project also provides monitoring data on riverine sandbars, which are a source of sediment, through aeolian transport, to high elevation sand deposits that contain archaeological resources. In addition, the downstream IQW monitoring project has also developed stage modeling capabilities that can assess the flow level inundating a given cultural site.

In August 2004, the AMWG reviewed these goals and identified priority questions. The top five priority questions are as follows:

Priority 1: Why are HBC not thriving, and what can we do about it? How many HBC are there and how are they doing?

Priority 2: Which cultural resources, including TCPs, are within the area of potential effect (APE), which should we treat, and how do we best protect them? What is the status and trends of cultural resources and what are the agents of deterioration?

Priority 3: What is the best flow regime?

Priority 4: What is the impact of sediment loss and what should we do about it?

Priority 5: What will happen when a TCD is tested or implemented? How should it be operated? Are safeguards needed for management?

The downstream IQW monitoring project provides direct support to some of the priority questions, while indirectly supporting others. Monitoring and research on flows, sediment transport, and water temperature support priority questions 3, 4, and 5 directly and indirectly support priority questions 1 and 2 by providing information on the general physical framework of the riverine environment.

Need for the Project

Information on flow, water quality, and suspended sediment transport is critical to understanding the physical environment upon which biological and sociocultural resources depend. In order to understand the responses of these resources to dam operations, we must understand and monitor the effects of dam operations on the physical environment. The goal of the downstream IQW project is to provide this information and link dam operations to changes in the physical environment.

Strategic Science Questions

The downstream IQW monitoring project is designed with the goal of providing data that supports answering the two primary physical resources questions identified during the knowledge assessment workshop conducted in the summer of 2005, as follows:

SSQ 4-1. Is there a "Flow-Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

Also, as detailed throughout this project description, the downstream IQW monitoring project provides information on the physical environment that is critical to other resource areas and will thus contribute indirectly to answering a variety of other science questions related to other resources.

Information Needs Addressed

The downstream IQW monitoring project directly addresses several of the CMINs and RINs related to GCDAMP goals 7 and 8. Selections of the information needs that are addressed by downstream IQW monitoring project are listed below. The downstream IQW monitoring project addresses many more CMINs, but the ones listed below are considered most relevant to answering the science questions outlined above.

CMIN 7.4.2. Determine and track flow releases (gage data and SCADA data; time interval still TBD) from Glen Canyon Dam, under all operating conditions, particularly related to flow duration, upramp, and downramp conditions (parameters are upramp and downramp rates, volume, daily minimum and maximum).

CMIN 7.1.2. Determine and track LCR discharge and temperature near the mouth (below springs).

CMIN 7.1.1. Determine the water temperature dynamics in the mainstem, tributaries (as appropriate, temperature only in mainstem and LCR), backwaters, and nearshore areas throughout the Colorado River ecosystem.

CMIN 8.1.3. Track, as appropriate, the monthly sand and silt/clay volumes and grain-size characteristics, by reach, as measured or estimated at the Paria and LCR [near Cameron, Ariz., and above the confluence] stations, other major tributaries like Kanab and Havasu Creeks, and "lesser" tributaries?

CMIN 8.1.2. What are the monthly sand and silt/clay export volumes and grain-size characteristics, by reach, as measured or estimated at Lees Ferry, Lower Marble Canyon, Grand Canyon, and Diamond Creek Stations?

The monitoring data from the downstream IQW monitoring project not only fulfill the CMINs listed above, but are also intended to feed new information directly into modeling efforts (see PHY 7.R2.10) that will allow sediment transport modelers the opportunity to address RINs related to GCDAMP goals 7 and 8.

RIN 7.4.1. What is the desired range of seasonal and annual flow dynamics associated with powerplant operations, BHBFs, and habitat maintenance flows, or other flows that meet GCDAMP goals and objectives?

RIN 7.3.1. Develop simulation models for Lake Powell and the Colorado River to predict water-quality conditions under various operating scenarios, supplant monitoring efforts, and elucidate understanding of the effects of dam operations, climate, and basin hydrology on Colorado River water quality.

RIN 8.5.1. What elements of ROD operations (upramp, downramp, maximum and minimum flow, MLFF, high modified flow (HMF), and BHBF) are most/least critical to conserving new fine sediment inputs, and stabilizing sediment deposits above the 25,000 cfs stage?

Methods and Tasks

FY2010

Discharge, stage, water temperature, specific conductance, turbidity, and suspended sediment data are collected using standard USGS protocols with quality assurance/quality control (QA/QC) (Rantz and others, 1982a). Suspended sediment sampling is supplemented through the use of emerging technologies, including acoustics and laser diffraction (Melis and others, 2003; Topping and others, 2004, 2006b, 2007). Stage, water temperature (Voichick and Wright, 2007), specific conductance (Voichick, 2008), turbidity, and suspended sediment surrogates (acoustics and laser diffraction) are monitored with in situ instrumentation recording at 15 minute intervals. Water discharge is measured episodically and used to develop a stage discharge rating curve, providing 15-minute flow records (Rantz and others, 1982b). Similarly, suspended sediment concentration is measured episodically using standard USGS protocols (Edwards and Glysson, 1999) and used to calibrate acoustic and laser diffraction instrumentation, providing 15-minute records of concentration (sand and silt/clay), and sand grain size.

Flow and Stage Monitoring

Continued monitoring of flow and stage at established mainstem locations and major tributaries (RM -15, RM 0, RM 30, RM 61, RM 87, RM 166, RM 225, Paria River at the Highway 89 bridge and near Lees Ferry, and two sites on the LCR). Category(s): core monitoring. Schedule: ongoing. Official surface water records are collected at Paria River at the Highway 89 bridge and published by the USGS Utah Water Science Center. Official surface water records are collected and published by the

USGS Arizona Water Science Center at the following tributary gage sites: Paria River near Lees Ferry, Ariz.; LCR near Cameron, Ariz.; LCR above the mouth near Desert View, Ariz.; Kanab Creek near Kanab, Utah; Havasu Creek above the mouth near Supai, Ariz.; and at the mainstem gages at RM 0, RM 87, and RM 225, Ariz. The RM -15 flow measurements are reported by Reclamation.

Quality-of-Water Monitoring

Continued monitoring of water temperature at established mainstem locations and major tributaries (RM -15, RM 0, RM 30, RM 61, RM 87, RM 166, RM 225, RM 246, Paria River at Lees Ferry, two sites on the LCR, and Kanab and Havasu Creeks). Continue a new nearshore/backwater temperature-monitoring program at selected sites. Continue monitoring of specific conductivity at established stations (RM -15, RM 0, RM 30, RM 61, RM 87, and RM 225). Continue monitoring of turbidity at established stations (RM 30, RM 61, RM 87, and RM 225). Continue monitoring of dissolved oxygen at established stations (RM -15, RM 0, and RM 225).

Suspended-Sediment Flux Monitoring

Continued monitoring of suspended sediment flux at established mainstem locations and major tributaries (RM 30, RM 61, RM 87, RM 166, RM 225, Paria River at Lees Ferry, and several sites along the lower LCR and it major sand supplying tributary, Moenkopi Wash). Because sediment based high flow triggers are based on sediment retention within the mainstem and tributary supplied sand is exported quickly downstream under all but the lowest dam releases, it is insufficient to monitor tributary sand inputs only.

Coordination with Other Resource Areas

Regular meetings and interaction with other resource area personnel, particularly at the program manager level, in order to facilitate an ecosystem approach to our scientific studies and ensure that the downstream IQW monitoring project is providing useful information regarding the physical environment to the other resource areas. Category(s): Program Management. Schedule: ongoing.

FY2011

The tasks and methods are expected to be the same for FY2011 as for FY2010.

Links/Relationships to Other Projects

Long-term Monitoring for Changes in Sediment Storage -- SedTrend

The downstream IQW monitoring project is closely related to the SedTrend component of the program for long-term monitoring of sediment storage that is described under goal 8, below. The downstream IQW monitoring includes the tracking of sediment fluxes entering and exiting each of the five sediment monitoring segments over short time scales (up to ~ 5 years) for planning high flows or other dam operations designed to improve or maintain sandbars. The SedTrend program uses direct measurements of channel topography and bathymetry to track long-term (5 years and longer) changes in sediment storage for the same monitoring segments.

Aquatic Food Web Research

The downstream IQW monitoring project supports research focused on the food web of the river ecosystem by providing continuous data on surface flow in the main channel and major tributaries, as well as related IQW data, such as water temperature, specific conductivity, dissolved oxygen, and suspended sediment concentrations and grain size for suspended particles in transport.

Fisheries Monitoring and Research

The downstream IQW monitoring project also supports science activities in the fisheries program by providing flow and IQW data that may be used by fisheries biologists in evaluating their fish catch data, as well as growth, movement, and habitat use information.

Logistics

This project requires two motorized river trips annually. Project needs require that the trips occur at approximately 6-month intervals. Motors are required for sampling activities and servicing the instrumented gage sites. Typically, the trips have two support boats and one technical boat. The current plan is to continue with one trip in February and one trip in August.

Products/Reports

FY2010

- Streamflow, stage, and tributary sediment data will be published annually in Arizona and Utah Water Resources Data reports (surface water and sediment records published by the USGS Utah and Arizona Water Science Centers) and served through the GCMRC Web page (http://www.gcmrc.gov/products/) (data delivered on or before February 28, 2011).
- Mainstem sediment transport and IQW data will be served through the GCMRC web page and a web-based application will be implemented to provide stakeholders and interested public with the ability to perform interactive online data visualization and analysis.
- Conference abstracts and proceedings articles (2–4 annually), journal articles (1–3 annually), and presentations at stakeholder meetings will result from this project.
- All work conducted under the IQW project will be summarized in annual reports, with the FY2010 report to be completed by January 1, 2011.

FY2011

- Streamflow, stage, and tributary sediment data will be published annually in Arizona and Utah Water Resources Data reports (surface water and sediment records published by the USGS Utah and Arizona Water Science Centers) and served through the GCMRC Web page (http://www.gcmrc.gov/products/) (data delivered on or before February 28, 2012).
- Mainstem sediment transport and water-quality data will be served through the GCMRC web page and a web-based application will be implemented to provide stakeholders and interested public with the ability to perform interactive online data visualization and analysis.
- Conference abstracts and proceedings articles (2–4 annually), journal articles (1–3 annually), and presentations at stakeholder meetings will result from this project.
- All work conducted under the IQW project will be summarized in annual reports, with the FY2011 report to be completed by January 1, 2012.

Budget

FY2010

PHY 7.M1.10	
Integrated Quality of Water Monitoring (below Glen Canyon Dam) (FY2007–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	397,262
GCMRC Project Related Travel / Training (21% Burden)	9,270
GCMRC Operations / Supplies / Publishing (21% Burden)	30,900
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	9,270
GCDAMP Logistical Support (21% Burden)	60,770
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	365,650
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 873,122**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	106,569
Project Total (Gross)	**$ 979,691**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	45.4%

FY2011

PHY 7.M1.11	
Integrated Quality of Water Monitoring (below Glen Canyon Dam) (FY2007–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	423,084
GCMRC Project Related Travel / Training (21% Burden)	9,548
GCMRC Operations / Supplies / Publishing (21% Burden)	31,827
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	9,548
GCDAMP Logistical Support (21% Burden)	62,593
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	376,620
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 913,220**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	112,686
Project Total (Gross)	**$ 1,025,906**

Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	44.7%

PHY 7.R2.10—Integrated Flow, Temperature, and Sediment Modeling

PHY 7.R3.11—Modeling Support

Start Date

October 2008

End Date

September 2010 for PHY 7.R2.10 and ongoing for PHY 7.R3.11. FY2010 will mark the end of a 2-year model development period; however it is expected that support for model development and improvements will continue in parallel to the monitoring programs. As new data are collected, existing models can be continuously tested, improved, and applied.

Principal Investigators

Scott A. Wright, U.S. Geological Survey, California Water Science Center; Jonathan Nelson, U.S. Geological Survey, National Research Program; Mark Schmeeckle, Arizona State University; David J. Topping, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; Peter R. Wilcock, Johns Hopkins University; Paul E. Grams, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; and David M. Rubin, U.S. Geological Survey, Marine Geology Team

Geographic Scope

The one-dimensional flow, temperature, and sediment transport modeling activities are spatially parallel to the IQW project and also focus on the main channel of the CRE between GCD (RM -15) to Diamond Creek (RM 226). Multidimensional modeling efforts will be applied at specific locations where appropriate topographic, bathymetric, and other calibration data have been collected.

Project Goals

The modeling initiative is designed to advance the predictive modeling capabilities needed to predict the fate of flow releases from GCD and associated water-quality constituents such as temperature and suspended sediment. Advancements in both detailed multidimensional models, which can only be applied to a few specific locations, and general one-dimensional models, which can be applied to the entire CRE, is required to improve the ability to predict downstream thermal regimes and the fate of fine sediment inputs that enter the ecosystem from sources such as the Paria and Little Colorado Rivers.

Ongoing development of models to simulate flow, sediment transport, and downstream water temperature are intended to be closely interfaced with ongoing monitoring activities throughout the science program. The downstream IQW monitoring project includes measurements of surface flow throughout the river ecosystem, as well as monitoring of IQW parameters such as temperature, specific conductivity, dissolved oxygen, and suspended sediment transport. These projects directly support achievement of the following GCDAMP goals:

> **Goal 7**: Establish water temperature, quality, and flow dynamics to achieve GCDAMP ecosystem goals.

Goal 8: Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

Need for Project

Modeling capability is needed to provide predictive capacity in linking dam operations with changes in the physical environment, including water flow, sediment conditions, and temperature. Better models for water flow are needed to predict the depth and velocity of flow for specified locations for specified dam operations. Models for sediment transport are needed to help determine the optimal magnitude and duration for high-flow releases and estimate the potential long-term impact of changes in dam operations or sediment supply conditions. Temperature models are needed to link dam operations with temperature dynamics in the downstream channel and, in particular, nearshore habitats. Thus, the goal of the modeling activities is to provide increased predictive capabilities in the form of simulations that can be used as planning tools for linking dam operations to changes in the physical environment. Models of the physical system are also needed to develop and expand interdisciplinary relationships with biological, cultural, economic, and recreational elements of GCDAMP.

Strategic Science Questions

The integrated modeling activities are designed with the objective of providing predictive capability that supports answering the two primary physical resource questions identified during the knowledge assessment workshop conducted in the summer of 2005:

SSQ 4-1. Is there a "Flow-Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

In the process of developing a formal project proposal in FY2009, the current team of modeling scientists listed five related science and related management questions that the project seeks to address:

- Science question: How do eddy sandbars evolve for a given sediment supply and flow hydrograph, including short duration high-flow releases?
- Related management question: What is the "optimal" high-flow hydrograph (peak and duration) for a given supply condition?
- Science question: How are tributary sediment inputs transported through the mainstem for a given flow hydrograph?
- Related management question: How long will tributary sediments be available (and where will they be) for a given operation (that is, monthly volume, daily peak, daily range)?
- Science question: How does the long-term (that is, decadal scale) sand budget evolve for a given flow hydrograph and tributary sediment supply (and/or sediment augmentation)?
- Related management question: How do different operations compare with respect to long-term sustainability?
- Science question: What controls the slope stability of sandbars that fill and drain on a daily basis due to fluctuating flows?
- Management: How do various ramping rates affect the stability of sandbars?

- Science question: How does channel complexity and habitat type affect shoreline water temperature distribution and dynamics?
- Related management question: Do various fluctuating and steady flow regimes affect shoreline water temperature differently?

Information Needs Addressed

The modeling project directly addresses several of the RINs related to GCDAMP goals 7 and 8:

RIN 7.4.1. What is the desired range of seasonal and annual flow dynamics associated with powerplant operations, BHBFs, and habitat maintenance flows, or other flows that meet GCDAMP goals and objectives?

RIN 7.3.1. Develop simulation models for Lake Powell and the Colorado River to predict water-quality conditions under various operating scenarios, supplant monitoring efforts, and elucidate understanding of the effects of dam operations, climate, and basin hydrology on Colorado River water quality.

RIN 8.5.1. What elements of ROD operations (upramp, downramp, maximum and minimum flow, MLFF, HMF, and BHBF) are most/least critical to conserving new fine sediment inputs, and stabilizing sediment deposits above the 25,000 cfs stage?

Methods and Tasks

The present modeling approach explicitly acknowledges that a suite of modeling tools is required to address the various science and management questions that are outlined above, because these questions span a wide range of time and spatial scales. For example, models appropriate for simulating the evolution of an individual sandbar during a high-flow release are not appropriate for simulating the long-term (decadal) sand budget for the canyon. In general, models of short time scales and high spatial resolution can apply fundamental governing equations (though some empiricism is always required) whereas models of longer time scales require increasing degrees of simplifying assumptions and substantially more empirical data. Thus, a variety of modeling approaches are required to address the disparity in scales, potentially with information sharing between the models. To this end, we have outlined four basic modeling approaches that are appropriate for addressing the set of questions outlined above, as follows:

- Eddy scale modeling (ESM): This approach is designed to simulate flow, sediment transport, morphology, and temperature dynamics at the scale of individual eddies. Resolution of these finer spatial scales limits the length of simulation that can be performed due to computational constraints, such that this modeling approach is appropriate for time scales of days to weeks. The short time scale and high spatial resolution allows for the use of numerical modeling tools based on basic conservation equations. However, even at these scales some simplifications are necessary such that model calibration is required. The parameterization and calibration of the ESMs will be accomplished using the high-resolution velocity, sediment transport, and bathymetric data collected in middle Marble Canyon (Eminence and Willie Taylor eddies) during the March 2008 high-flow release. The temperature component of the ESMs will be calibrated using water temperature data collected in a range of shoreline habitat types at various locations along the river over the past several years.
- Bar stability modeling (BSM): The ESMs predict transport, erosion, and deposition based on shear stress imparted from the flow onto the bed of the river, but do not account for slope failures resulting from elevated pore water pressures during rising and falling river stages. Because normal hydropower dam operations include daily flow fluctuations, this bar failure mechanism is important to understand when considering alternative flow ramping rates. The

BSM is applied to an individual bar in a two-dimensional profile (that is, a vertical cut through the bar face). In the future, the model could be linked to the ESMs to incorporate the failed material back into the flow.

- Reach scale modeling (RSM): The ESMs are not applicable to broader spatial scales and longer time scales. For these scales, further simplifications are required in order to be computationally feasible. There are several potential applications for reach scale models in Grand Canyon. One application is modeling the cross-sectionally averaged (that is, one-dimensional) mainstem sediment transport and temperature dynamics. These models can be used to simulate the fate of tributary inputs as they move downstream through the mainstem, and the downstream warming of dam releases that occurs for most of the year. This information can be used to evaluate various dam release scenarios (for flow and possibly temperature control), and the models can also be used to deliver boundary conditions to the ESMs. The RSM for mainstem temperature has already been developed, tested, and documented (Anderson and Wright, 2007). A RSM for sediment transport has been developed and documented (Wiele and others, 2007) but was deemed in need of further testing and potential refinement by the modeling review panel. This further testing is described in Task 2 of the following section.
- Decadal scale modeling (DSM): The third modeling approach is designed to simulate the long-term sand budget for the river at relatively low spatial resolution. The unsteady, one-dimensional RSMs described above, while substantially simplified from the ESMs, are still too complex to apply to decadal time scales particularly if the goal is to simulate a range of potential future conditions, for example, with Monte Carlo simulation. This approach relies heavily on high-resolution sand transport data that is currently collected at several sites along the river (Topping and others, 2006b). The basic methodology is to allow the relationship between sand concentration and discharge to shift up and down depending on the level of sand supply in the system (that is, a "shifting rating curve"), a phenomenon that has been observed and substantially documented since the 1996 HFE. Because of the empirical nature of the approach, the sand budget can only be resolved at the same spatial resolution as the sand transport monitoring, currently ~30 mile reaches encompassing upper Marble Canyon (river miles 0 to 30), lower Marble Canyon (river miles 30 to 61) and Eastern Grand Canyon (river miles 61 to 87).

The overall modeling approach (table 5) is similar in many respects to that pursued by Wiele and others (2007) leading to the development of their RSM for sand transport. However, our approach will go beyond this previous effort by taking advantage of the development of more advanced modeling tools (for example, Delft3D) and, most importantly, the recent availability of several new data sets, including:

- high-resolution sand concentration and grain-size data for the boundaries of the DSM reaches, described above,
- repeat topographic and multibeam bathymetric surveys of several reaches that are 3 to 5 km in length,
- repeat surveys of surface grain-size for the same short reaches, and
- detailed repeat surveys of bathymetry and velocity structure of two eddies during the March 2008 high-flow release.

In addition, a multibeam bathymetric survey of one entire 30-mile segment bracketed by sediment monitoring stations was collected in FY2009. The availability of these data sets allows for significant advancements in all four types of modeling approaches outlined above. The modeling project must be closely linked with the monitoring programs in order to facilitate these advancements.

Table 5. Summary of modeling approach.

Modeling approach	Time scale	Spatial scale and resolution	Brief description	Primary questions addressed
Eddy scale (ESM)	Days to weeks	Individual eddies or short reaches resolved on meter scale grids	Multi-dimensional models of flow, sediment, and heat. Physically-based with relatively little empiricism.	How do eddy sandbars evolve? What is the "optimal" high-flow hydrograph shape (peak and duration)?
Bar stability (BSM)	Days	2D slices of individual sandbar faces	Slope stability modeling in the presence of rising and falling water stage; method of slices	How do various ramping rates affect the stability of sandbars?
Reach scale (RSM)	Months to years	Long reaches resolved at widely spaced (~0.1-1 km) cross-sections	One-dimensional models of flow, sediment, and heat. Physically based but with substantial empiricism.	How are tributary sediments transported through the mainstem? At what rate does downstream warming occur in the mainstem?
Decadal scale (DSM)	Years to decades	Long reaches resolved at the resolution of the monitoring sites	Sand budget calculations using shifting rating curves. Highly empirical with a minimum amount of physics.	How do various dam operations compare with respect to the long-term sand budget?

In addition to developing specific modeling tools, the project must also focus on the application of models to meet stakeholder and management needs. Integration of the modeling approaches will provide a suite of tools that incorporates appropriate processes over short and long time scales, thereby allowing predictions of water temperature dynamics, the long-term sand budget, or the response of eddy morphology to hypothetical hydrographs, dam release temperatures, and tributary sand supply rates. This approach captures the importance of tributary inputs, the local storage of sediment in the mainstem that can be made available by higher flows for storage in eddies, the processes of exchange between the eddies and mainstem over short time scales, and the potential for mechanical failure of the eddy deposits. We believe it is the simplest scientifically defensible methodology for relating dam management and eddy morphology.

Specific modeling applications must be devised in close cooperation with stakeholders of the GCDAMP. This cooperation requires information sharing so that 1) the stakeholders clearly understand the capabilities of the models, and 2) the modelers clearly understand the desired scenarios to be modeled. Below are thee examples of potential applications of the models, for illustrative purposes.

Example 1: Predicting the long-term sand budget for a range of dam release scenarios. A matrix has already been developed by GCDAMP stakeholders delineating a range of fluctuating and steady flows as well as a range of annual release volumes. This type of question is ideally suited for the shifting rating curve model, and was the motivation for development of such a model. The model can also

evaluate the effects of a range of tributary sand supply conditions. Once up and running, it will be relatively easy to evaluate a wide range of flow conditions on the long-term sand budget, due to the simplicity of the model formulation. Korman will refine an existing model of downstream flows based on operating constraints to drive the sand budget model.

Example 2: Designing a hydrograph for a high-flow event. If substantial tributary inputs occur in the future and a high-flow event is scheduled, the suite of models can be used to evaluate various proposals for the hydrograph (that is, peak, duration, ramping rates). First, the DSM and/or RSM would be run to estimate the distribution of new tributary sand throughout the canyon and the concentrations during the high-flow. The ESMs and BSM would then be run for the quantification sites to evaluate the sandbar responses to the various hydrographs, allowing for tradeoff analysis and selection of a hydrograph.

Example 3: Modeling in support of nearshore ecology. Over the next several years, extensive fieldwork will be occurring in the reach below LCR for the study of the ecology of nearshore habitats, in particular their importance to native fish. The RMS and ESM temperature models can be used to interpolate and extrapolate estimates of water temperature in space and time throughout the study reach. Thus, high resolution (space and time) estimates of water temperature (as well as depth and velocity) can be developed and used to assist interpretation of native fish habitat use.

FY2010

- Development of decadal scale models: Completion of shifting rating curve model. The shifting rating curve model is being worked on in FY2009. Work in FY2010 is expected to consist of final publication and applications, discussed under Task 5, below.
- Development of reach scale models: Testing and calibration of existing sand routing models. Work on this task is occurring in FY2009. Work in FY2010 is expected to include the finalization of this task, including recommendations for future developments of reach scale models.
- Development of eddy scale models: Testing and calibration of eddy scale models. This work is commencing in FY2009 applying the model to the sites where calibration data were collected during the FY2008 high-flow experiment. Work will continue in FY2010 with the expansion to up to 10 to 15 additional sites.
- Bar stability modeling and experiments. Work on this task is occurring in FY2009 and is expected to be completed during FY2010.
- Modeling applications. Work on this task in FY2010 is expected to consist of application of the shifting rating curve model to various dam release scenarios and the use of eddy scale models in designing high-flow hydrographs and understanding nearshore temperature dynamics.

FY2011

The FY2009–10 work on decadal scale models, reach scale models, and bar stability models is expected to be complete by the end of FY2010. It is expected that FY2011 will include some additional work on eddy scale models, but with a primary focus on model integration and application. Depending on the outcome of the FY2009–10 evaluation of existing reach scale models, additional work on reach scale models may be recommended for FY2011.

Links/Relationship to Other Projects

Because ongoing modeling efforts are linked to the downstream IQW monitoring project, it is also intended to address and support elements of the physical framework of the ecosystem, which underlies

many biological, cultural, and recreational resource objectives. As a result, the modeling efforts indirectly support achievement of almost all other GCDAMP goals, as described in the previous section on PHY 7.M1.10. The ongoing activities associated with the development of simulation capabilities and verification of existing models can benefit from monitoring data from the downstream IQW project. These simulation models include flow routing, suspended sediment transport, sandbar evolution, and downstream thermal simulations throughout the main channel. Improved predictive capabilities for physical resources related to dam operations will be of great value as a support tool in planning future experimental treatments, as well as evaluating proposed management actions in the river ecosystem that generally relate to GCDAMP goal 1, goal 2, goal 4, goal 6, goal 9, and goal 11. In addition, goal 12 is also supported by efforts to advance modeling activities for the ecosystem.

Aquatic Food Web Research

Both the downstream IQW monitoring project and its modeling support link to thermal and suspended sediment transport can help to support new research on the river ecosystem food web by providing continuous data on surface flow in the main channel and major tributaries, as well as related IQW data such as water temperature, specific conductivity, dissolved oxygen, suspended sediment concentrations, and suspended particle grain size. This project and its modeling support link can also provide simulations for predicting downstream boundary conditions that limit in-stream productivity.

Fisheries Monitoring and Research

The downstream IQW modeling activities provide support beyond IQW data by making simulations for physical habitat changes, such as backwaters, available to fishery scientists before future HFE tests. Such information can assist scientists in planning better-integrated studies.

Logistics

This project has no logistical requirements.

Products/Reports

FY2010

- The GCMRC convened modeling workshops in FY2008 and FY2009; additional workshops will be scheduled in FY2010 and are expected to focus on modeling results and applications
- Testing and refinement of nearshore water-temperature-modeling capabilities, including detailed multidimensional models of areas with available bathymetry. This work is in progress in FY2009 and will be continued, resulting in peer reviewed publications
- Testing and refinement of multidimensional models of eddy-sandbar environments. Work in progress during FY2009 includes application at sites where data were collected during the FY2008 HFE. Work to be conducted in FY2010 will expand the application to an additional 10 to 15 sites
- Experimentally validated bar-face stability model that managers can use to evaluate the mass-failure potential of sandbar beaches under differing dam operation scenarios
- Documentation and calibration information for existing one-dimensional sand-routing model
- Preparation of conference abstracts and proceedings articles (more than one per year) and journal articles (more than one per year)
- Presentations at GCDAMP meetings (as necessary)
- All work conducted under the integrated modeling project will be summarized in annual reports, with the FY2010 report to be completed by January 1, 2011

FY2011

At the funding level included in this work plan, the modeling project transitions from a research phase to an applications phase in FY2011 that includes fewer new products but continued stakeholder interaction.

- Stakeholder workshops on modeling results and applications are expected to continue through FY2011
- Presentations at GCDAMP meetings (as necessary)
- Preparation of conference abstracts, proceedings articles, and journal articles (one or more per year)
- All work conducted under the integrated modeling project will be summarized in annual reports, with the FY2011 report to be completed by January 1, 2012

Budget

FY2010

PHY 7.R2.10	
Integrated Flow, Sediment Transport and Temperature Modeling of the CRE (FY2009–10)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	70,158
GCMRC Project Related Travel / Training (21% Burden)	6,000
GCMRC Operations / Supplies / Publishing (21% Burden)	8,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	9,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	156,154
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	25,000
Project Subtotal	**$274,312**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	21,086
Project Total (Gross)	**$ 295,398**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	66.0%

FY2011

PHY 7.R3.11	
Modeling Support & Temperature Models (FY2011–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	74,718
GCMRC Project Related Travel / Training (21% Burden)	1,980
GCMRC Operations / Supplies / Publishing (21% Burden)	4,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	4,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	35,543
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 120,241**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	17,787
Project Total (Gross)	**$ 138,028**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	29.6%

GCDAMP Goal 8—Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve the Adaptive Management Program ecosystem goals.

PHY 8.M2.10–11— Integrated Long-term Monitoring of Systemwide Changes in Sediment Storage

Start Date

October 2008

End Date

Ongoing (FY2010 will be the second year of the project)

Principal Investigator(s)

Matt Kaplinski, Joseph E. Hazel, Jr., and Roderic Parnell, Northern Arizona University, Department of Geology; David J. Topping and Paul E. Grams, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Core monitoring for the sediment budget and sandbar status throughout the CRE utilizing direct topographic/bathymetric measurements and remote sensing is focused on detecting long-term (5-year to multidecadal) trends in the CRE sediment budget for both fine (sand and finer material) and coarse sediment. In addition, this project utilizes a combination of direct topographic measurement and remote sensing to monitor the status of sandbars above the stage associated with a discharge of 8,000 cubic feet per second (cfs). The total geographic extent of this monitoring is from GCD to the upper end of Lake Mead (near Separation Canyon). The airborne remote sensing component occurred in spring FY2009 and covered the entire geographic extent. The next overflight is expected to occur in spring FY2013. During FY2009, channel mapping occurred from river mile (RM) 30 to RM 61, referred to herein as lower Marble Canyon. For FY2010, no channel mapping or sandbar monitoring is scheduled (see below). For FY2011, channel mapping is planned to resume with the segment between RM 166 and RM 226. Sandbars study sites located throughout the CRE are monitored on alternating years; a survey is scheduled for fall FY2009 (funded in the FY2009 work plan) with the next survey scheduled for fall FY2011.

Project Goals

Achieving the goal of maintaining or expanding sandbars requires a careful balance between the two competing effects of dam releases on fine sediment. High releases in excess of powerplant capacity are needed to build sandbars above the zone associated with normal dam operations. However, in the absence of tributary sediment inputs, both high flows and normal dam operations result in net export of fine sediment. Thus, GCMRC has recommended that high flows be conducted only during periods of relative fine sediment enrichment in the main channel that occur following tributary sediment inputs. The magnitude of tributary inputs and main channel enrichment are tracked by the goal 7 Mass Balance program, which provides the information needed to appropriately time high flows. Yet, the continued effectiveness of high flows to build sandbars also requires that total fine sediment storage is

maintained or increased over periods spanning multiple high flows and intervening dam operations. Progressive depletion of fine sediment storage is likely to result in a decrease in the ability of high flows to build sandbars. Because uncertainties in sediment flux measurements accumulate over time, the goal 7 monitoring cannot be used to monitor trends in storage over these 5-year to decadal periods. The purpose of the goal 8 monitoring is to collect the data that will demonstrate whether the net result of dam operations (including high flows and powerplant operations) and tributary sediment inputs is accumulation, maintenance, or depletion of sand storage. More specifically, the "SedTrend" monitoring is designed to determine magnitudes and trends in fine sediment storage throughout the CRE in the main channel and eddies for three major sand-storage elevation zones:

- below the stage associated with a discharge of 8,000 cfs where over 90 percent of the fine sediment in the CRE is typically stored,
- between the stages associated with discharges of 8,000 and 25,000 cfs, and
- above the stage associated with a discharge of 25,000 cfs.

Secondary goals of this project include tracking trends in sandbar area, volume, and distribution (in support of goal 9), measurements of backwater geometry and distribution (in support of goal 2), and monitoring of the availability of open dry sand on sandbars that can be transported by the wind upslope into archaeological sites (in support of goal 11).

The sediment monitoring program directly supports achievement of the following GCDAMP goals:

Goal 8: Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve GCDAMP ecosystem goals.

Goal 9: Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem within the framework of GCDAMP ecosystem goals. The monitoring provides information on the size and abundance of sandbars, which are resources that affect the recreational experiences of Colorado River users.

Goal 11: Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations. The program includes monitoring sandbars that provide a source of sediment, through aeolian transport, to high-elevation sand deposits that contain archaeological resources.

Because sediment monitoring addresses the physical framework of the ecosystem, which underlies many biological resource objectives, it also indirectly supports achievement of the following GCDAMP goals:

Goal 1: Protect or improve the aquatic food base so that it will support viable populations of desired species at higher trophic levels. The SedTrend monitoring supports this goal by providing information on the size and distribution of channel substrate.

Goal 2: Maintain or attain a viable population of existing native fish, remove jeopardy for humpback chub and razorback sucker, and prevent adverse modification to their critical habitats. The SedTrend and sandbar monitoring supports this goal by providing information on sandbars that create backwater habitats.

Goal 6: Protect or improve the biotic riparian and spring communities within the Colorado River ecosystem, including threatened and endangered species and their critical habitat. The SedTrend and sandbar monitoring tracks the status of the fine sediment deposits that provides the substrate for riparian vegetation and marsh communities.

Need for Project

Completion of Glen Canyon Dam in 1963 resulted in at least a 90 percent reduction in sediment supply to the CRE in Grand Canyon (Topping and others, 2000). Moreover, operations of the dam tend to result in net export of sand and finer sediment in most years (Topping and others, 2000). In response to this reduction in sand supply and the alteration of the natural hydrograph by dam operations, sandbars in Marble Canyon and the upstream part of Grand Canyon have substantially decreased in size (Schmidt and others, 2004) and are still in decline under normal powerplant operations at the dam (Wright and others, 2005).

The primary signal for fine sediment is the change in storage volume of the fine sediment below the 8,000 cfs water stage. While the quality of water monitoring program tracks the fluxes of fine sediment and enables calculation of the change in storage, the uncertainty in these estimates accumulates and restricts the use of that method to time scales of ~5 years or less. The essential data to detect trends in storage change over periods longer than ~5 years are repeat measurements of channel bathymetry that are compared to determine change in storage between the measurement intervals. Because of technological and logistical constraints, additional monitoring is required to track trends in high elevation sand storage. For this monitoring, the essential parameters that must be measured are area and volume of sand exposed above the 8,000 cfs stage.

Growing concern about the effects of the operations of GCD on the CRE led to the initiation of systematic measurements of sandbars in the 1970s (Dolan and others, 1974; Howard, 1975; Howard and Dolan, 1981). This sandbar monitoring program was revisited in the 1980s (Schmidt and Graf, 1990; Beus and others, 1992), and eventually led to the sandbar monitoring program conducted by NAU during the 1990s (Hazel and others, 1999; Schmidt and others, 2004). Evaluation begun in the 1990s and finalized in the geomorphic synthesis of Schmidt and others (2004) indicated that the observations of change made during these site based programs were not necessarily representative of changes in the fine sediment resource over longer reaches of the Colorado River, because these programs utilized surveys of relatively small areas and the variability between sites was large. Moreover, the fact that substantial positive changes in sediment volume were observed in these site based programs during periods when no sediment entered the system called into question the value of sediment budgeting based on monitoring of small sites (Hazel and others, 2006). In contrast to the large variability within the site based NAU data, analysis of cross-section data collected by the USGS indicated near universal scour of sediment from the CRE during the 1990s (Flynn and Hornewer, 2003). These observations led to the initiation in 1999 of flux based monitoring. By 2001, research and development activities led to the current reach based Mass Balance project that combines conventional sediment transport sampling with sediment surrogate techniques to provide a high resolution sand flux monitoring data set used for calculating the fine sediment mass balance systemwide.

These previous research and monitoring efforts guided the development of the current fine sediment core-monitoring plan. Results from the 2002–05 period of the Mass Balance project demonstrated that 90 percent or more of the fine sediment is stored in the eddies and channels at elevations lower than the 8,000 cfs stage (Hazel and others, 2006). This study also demonstrated that change in low elevation sediment storage computed from repeat measurements over short (~ 15 km) reaches is not consistent with the change in storage computed based on the measurements of sediment transport over longer (~50 km) reaches (Topping and others, 2006a). While the measurements of sediment transport that are made as part of the Mass Balance project are used to detect changes in sediment storage in long reaches over short timescales (up to ~ 5 years), accumulated uncertainty in these measurements will prevent the determination of longer term trends in sediment storage with adequate certainty. Transport monitoring is necessary to track the accumulation and fate of tributary inputs and provide information needed to plan high-flow events. However, in order to determine whether sediment storage in the system as a whole is increasing, decreasing, or stable requires repeat measurements of sand storage throughout the entire system. For these reasons, goal 8 fine sediment monitoring includes systemwide measurements of channel and eddy sand storage in addition to monitoring related to high elevation sandbars, campsites, and backwaters.

At the FY2004 AMWG priority setting workshop, questions relating specifically to sediment were identified within three of the top five priorities of the GCDAMP:

GCDAMP Priority 4: What is the impact of sediment loss and what should we do about it?

GCDAMP Priority 3: What is the best flow regime?

GCDAMP Priority 2: Which cultural resources, including traditional cultural properties, are within the Area of Potential Effect, which should we treat, and how do we best protect them? What is the status and trends of cultural resources and what are the agents of deterioration?

Strategic Science Questions

Several SSQs were identified by scientists and managers during the knowledge assessment workshop conducted in the summer of 2005 (Melis and others, 2006). The SedTrend monitoring project provides valuable information to help answer several of the questions related to sediment conservation, and in particular the following primary sediment question:

SSQ 4-1. Is there a "Flow Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will rebuild and maintain sandbar habitats over decadal timescales?

Information Needs Addressed

The 2003 GCDAMP Strategic Plan identified Core-monitoring Information Needs (CMINs) related to sediment storage (goal 8). The CMINS that are addressed by the SedTrend and sandbar monitoring are listed below. For each, the prioritization ranking applied by the GCDAMP Science Planning Group (SPG) in 2006 is also included.

CMIN 8.1.1. Determine and track the biennial sandbar area and fine-sediment volume and grain-size changes within eddies below 5,000 cfs stage, by reach. (fourth-ranked goal 8 CMIN).

CMIN 8.2.1. Track, as appropriate, the biennial or annual sandbar area, volume. and grain-size changes within and outside of eddies between 5,000 and 25,000 cfs stage, by reach. (second-ranked goal 8 CMIN).

CMIN 8.5.1. Track, as appropriate, the biennial sandbar area, volume, and grain-size changes above 25,000 cfs stage, by reach (fifth-ranked goal 8 CMIN).

SedTrend monitoring also addresses this unranked goal 8 CMIN:

CMIN 8.6.1. Track, as appropriate, changes in coarse sediment (> 2 mm) abundance and distribution.

The SedTrend and sandbar monitoring also directly address this top-ranked goal 9 CMIN priority (jointly with REC 9.R1.10: Sandbar and Campable Area Monitoring):

CMIN 9.3.1. Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons (top-ranked goal 9 CMIN).

Developing and testing monitoring protocols for these CMINs was the primary focus of research and development conducted during FY1998–2006, and was reviewed during the physical sciences protocols evaluation program, SEDS-PEP III (Wohl and others, 2006).

Methods and Tasks

FY2010 and FY2011

During the FY2010–11 period, SedTrend and sandbar monitoring will include work on all three tasks described below. Task 1 sandbar monitoring will be completed using protocols described by Hazel and others (1999); Task 3 is conducted using standard ground based surveying protocols and multibeam sonar bathymetric surveying protocols described in Kaplinski and others (2000, 2007). The grain size data collected under task 3 (recommended by the final PEP, Wohl and others, 2006) are collected and processed using protocols described in Rubin and others (2006, 2007) and Rubin (2004). The task 2 systemwide inventory of high elevation sand deposits is described in section DASA 12.D9.10 of this work plan.

Task 1. Monitoring High-Elevation Sandbar Study Sites

Task 1 consists of monitoring of the area and volume of fine sediment above the stage associated with 8,000 cfs for subsets of sandbars and campsites throughout the CRE using conventional ground based surveying methods. This data set is commonly referred to as the "Northern Arizona University (NAU) sandbar time series" and is the longest running data set on the state of sandbars currently available (initiated in 1990). As an element of the goal 8 core-monitoring program, it is essential that GCMRC and cooperators prepare a comprehensive report on the methods and data that result from this monitoring such that the entire data series and subsequent updates may be made publically available through the GCMRC online database. This reporting will be the major work product for this task in FY2010. Monitoring will resume in FY2011 and occur in alternating years thereafter. Previous results from this monitoring have shown steady declines in sandbar area and volume between high-flow events (Wright and others, 2005). Thus, except around high flows, biennial monitoring will be sufficient to document future trends in sandbar area and volume. This task is conducted in coordination with goal 9 campsite monitoring, described under project REC 9.R1.10 and REC 9.R1.11.

Task 2. Repeat Systemwide Inventory of High Elevation Sand Deposits

Approximately once every 4 years (but only in years without BHBFs or HFEs), the systemwide area of fine sediment above the stage associated with a discharge of 8,000 cfs (that is, approximately 10 percent of the fine sediment in the CRE) will be monitored using orthrectified aerial photography images collected during overflights (the volume of fine sediment may also be monitored if light detection and ranging [LiDAR] sensors are deployed). These remote sensing data are used to help monitor the magnitude and trends in campsite area, backwater area and distribution, and the availability of open dry sand on sandbars, as well as for monitoring of other resource areas such as riparian vegetation. These data will also be used to help quantify the inputs of gravel from tributaries. These gravel inputs provide important substrate for the aquatic food web. The overflight consisting of 4-band images occurred in May 2009. Analysis of these images will occur in FY2010 and is described in the coordinated image analysis project, DASA 12.D9.10-11.

Task 3. Monitoring In-Channel Sediment Storage--SedTrend

Monitoring of the area and volume of fine sediment at all elevations over long reaches is designed to occur each year that a high flow does not occur using multibeam bathymetric surveys, ground based topographic surveys, underwater video transects, and underwater camera measurements of bed grain size. This task is planned to be performed on a systemwide basis every 5–10 years in order to estimate fine sediment budgets over timescales for which the goal 7 mass balance sediment budgets likely become inconclusive due to accumulating measurement errors. In addition to providing this key sediment budget information (that is, the status of the fine sediment "bank account"), these data will provide information on the location and geometries of backwaters thought to be important habitat for native fish. Currently, it is logistically impossible to survey the bathymetry of the entire river in any given year. Therefore, a different reach of the river will be surveyed each year on a rotating basis. The

reaches will correspond to the segments outlined in the goal 7 Mass Balance project, such that upon completion of a repeat survey for a given reach, all components of the sediment budget for that reach will have been measured directly. The reaches are as follows: reach 1, RM 0 to RM 30 (upper Marble Canyon); reach 2, RM 30 to RM 61 (lower Marble Canyon); reach 3, RM 61 to RM 87 (eastern Grand Canyon); reach 4, RM 87 to RM 166 (central Grand Canyon); reach 5, RM 166 to RM 226 (western Grand Canyon).

These surveys are scheduled for late spring and will only be completed in years without high flows. In the absence of high-flow experiments, each reach would be surveyed every 5 years, or, if a high-flow experiment occurred on average every other year, then each reach would be surveyed on average every 10 years. This 5–10 year interval between repeat bathymetric and topographic surveys coupled with the Mass Balance flux monitoring is expected to provide a robust quantification of long-term trends in the fine sediment budget. Because reaches 4 and 5 are much longer than reaches 1 through 3, it is possible that portions of these reaches will not be surveyed. Existing data will be used to identify the portions of these reaches that are most likely to store fine sediment. It is also possible that continued technological advancements and improvements in methods will allow for complete surveys of these reaches in the future.

The schedule for SedTrend monitoring under goal 8 is complicated by the potential for high-flow experiments. It is advantageous for task 2 remote sensing missions and task 3 channel monitoring surveys to occur in years without experiments so that the monitoring data are not dominated by the effects of a single high-flow test. Rather, remote sensing and reach survey monitoring should represent the integral response of the system to several years of dam operations and tributary inputs. Further, logistical constraints would make it difficult to conduct the remote sensing and channel mapping in addition to high-flow monitoring. Thus, without knowing the exact frequency of experiments, it is impossible to outline the exact schedule for SedTrend monitoring.

In FY2009, channel mapping data were collected in reach 2 (RM 30 to RM 61). Significant analyses of these data are required to ensure the data meet the needs of the planned monitoring program within acceptable ranges of certainty. The desired outcome of a computation of change in storage over a long reach requires that we have a thorough examination of error and uncertainty such that we can apply confidence levels to these computations. Although repeat measurements of topographic and bathymetry have been used routinely in the GCMRC monitoring over the past 10 years and longer, the channel mapping project represents a significant scaling upwards of these methods. Thus, new methods and analyses must be applied to these data. Because GCMRC staff and cooperators have been engaged in analysis and reporting related to the FY2008 high-flow experiment for much of FY2009, and budgetary constraints limit the number of scientists that can be involved in the project, GCMRC has proposed that data collection be suspended for FY2010 and all resources be directed towards analysis and reporting.

The essential analyses that will be completed in FY2010 will include uncertainty analyses, change detection analyses, and mass balance analyses. The uncertainty analysis is the necessary first step and will begin with an independent assessment of the uncertainty in the bathymetric surfaces. This uncertainty estimate will be integrated with existing uncertainty assessments for terrestrial topographic data and methods will be developed to apply the uncertainty quantification to the joint topographic-bathymetric surfaces. Change detection analyses will then be performed comparing the area surveyed in FY2009 with previous measurements made in the reach between 30-mile and 61-mile. Because the entire 30-mile reach has never been surveyed completely in a single episode, these comparisons will be for segments of that reach. The uncertainty assessment will be incorporated in the change detection analyses such that areas of significant change can be distinguished from insignificant change and that confidence levels can be provided for areas of significant change. Finally, the change detection analysis will be used to compute changes in sediment storage or “mass balance” where possible. These mass balance calculations will also incorporate the uncertainty assessment. The outcome at the conclusion of FY2010 will be a report or series of reports describing the methods and results of these analyses.

Data collection will resume in FY2011 with the segment between RM 166 and RM 226. This segment has been proposed because of its location in western Grand Canyon. This reach is the most likely to have a positive mass balance owing to its downstream location. Thus, a positive mass balance following repeat mapping in this reach would indicate the possibility of a positive mass balance for upstream reaches while a negative mass balance would suggest that upstream reaches most likely have a negative mass balance.

Summary Schedule of Goal 8 Tasks

Table 7 presents two possible 10-year schedules based on different assumptions regarding high-flow frequency for illustrative purposes. The first is the schedule in the absence of high-flow experiment where the exact schedule can be delineated. The second schedule assumes that high-flow experiments occur every other year, which would be the approximate frequency under previous triggers based on tributary sediment supply. In reality, even if the frequency were every other year on average, there would likely be periods with successive years of experiments and successive years without tests such that the core-monitoring schedule for remote sensing and reach surveys must be flexible. The sequence of the channel mapping surveys is based on priority for long-term monitoring. Reaches 2 and 5 are likely to be the best indicators of long-term trends because they are not immediately downstream from major tributaries and are, therefore, likely to have smaller fluctuations in storage resulting from tributary inputs. The sequence is interrupted by an early resurvey of reach 2. This will allow calculation of a change in fine sediment storage for this reach over a time period for which the uncertainty in the goal 7 mass balance is well constrained. This will also provide an early demonstration of how the long-term SedTrend monitoring data will be analyzed and presented.

Table 7. Alternative schedules for the completion of the tasks outlined under project PHY 8.M1.10-11.

Year	Schedule without high-flow experiment			With high-flow experiments every other year		
	Task 1: subsample campsites/ sandbars	Task 2: 4-year overflights	Task 3: SedTrend channel mapping	Task 1: subsample campsites/ sandbars	Task 2: 4-year overflights	Task 3: SedTrend channel mapping
2009	X	X	Reach 2	X	X	Reach 2
2010 (high-flow experiment)			Suspend data collection	*		
2011	X		Reach 5	X		Reach 5
2012 (high-flow experiment)			Reach 2	*		
2013	X	X	Reach 3	X	X	Reach 2
2014 (high-flow experiment)			Reach 1	*		
2015	X		Reach 4	X		Reach 3
2016 (high-flow experiment)			Reach 2	*		
2017	X	X	Reach 5	X	X	Reach 1
2018 (high-flow experiment)			Reach 3	*		

*Additional monitoring may occur as part of the HFE

Links/Relationships to Other Projects

SedTrend monitoring provides data (that is, maps showing the topography and distribution of sediment types over about 30-mile reaches of the river) that are essential to the development and testing of numerical predictive models of discharge, stage, sediment transport, and sandbar morphology. These predictive models can be used to evaluate a wide range of resource responses, such as the fate of sandbar habitats, to various dam release scenarios, such as HFEs, steady flows, fluctuating flows, etc.

SedTrend monitoring provides data to be used to evaluate the effectiveness of dam operations (including high-flow experiments) for rebuilding and maintaining sandbars in the CRE. Additionally, SedTrend monitoring will provide the data showing whether dam operations continue to mine the long-term fine sediment reserve stored at elevations below the stage associated with a discharge of 8,000 cfs (more than 90 percent of the fine sediment in the system is currently stored below this elevation). If the amount of sediment in this "bank account" continues to decrease, then operations will ultimately not be able to sustain fine sediment resources at higher elevations.

Sandbar monitoring supports the campsite inventories conducted under goal 9 by characterizing the status and trends of the sandbars used as campsites (covered under project REC 9.R1.10–11: sandbar and campable area monitoring under goal 9).

SedTrend and sandbar monitoring support goal 11 by characterizing the status of fine sediment at higher elevations in and around cultural sites, and by characterizing the amount of open dry sand available to be transported by the wind into these cultural sites.

SedTrend monitoring also supports new research focused on the food web of the river ecosystem by providing data on the input of gravel used as a substrate by the aquatic food web (goal 1).

SedTrend monitoring provides information on the distribution of the fine sediment deposits that form the substrate for the riparian ecology (goal 6).

Finally, SedTrend and sandbar monitoring supports science activities in the fisheries program by providing the data to characterize the locations and geometries of backwaters thought to be important habitat for native fish (goal 2).

Logistics

This project requires no logistical support in FY2010. In FY2011, logistical support is required for one "channel mapping" trip in the spring (May) and one "sandbar and campsite survey" trip in the fall (October). The channel mapping trip is a motorized trip that requires at least three technical boats, two of which are dedicated sonar boats, and at least two support boats. The sandbar survey trip is a rowing trip.

Products/Reports

FY2010

The SedTrend channel mapping will ultimately result in decadal timescale sediment budgets for each of the five channel mapping segments, providing information on the long-term status of the fine sediment reserve. These sediment budgets will also be compared to the sediment budgets computed for these reaches under the complementary mass balance project described under goal 7. These comparisons, however, cannot be made until the segment mapped in FY2009 is repeated.

- Data series report and journal article on the Northern Arizona University sandbar data, 1990-2009

- Topographic/bathymetric maps of the RM 29 to RM 61 segment mapped during the FY2009 SedTrend field work
- Analysis of uncertainty in the SedTrend topographic/bathymetric maps. This analysis is necessary to demonstrate that maps generated over long reaches have sufficient accuracy that they can be used to compute changes in fine sediment storage within acceptable levels of uncertainty. This analysis will result in one or more peer reviewed reports and journal articles
- Comparisons between the data collected in lower Marble Canyon in FY2009 and multibeam-sonar data collected in parts of lower Marble Canyon between FY2000 and FY2008 to evaluate volume changes in the fine sediment reserve, resulting in at least one peer reviewed report or journal article
- Preparation of conference abstracts and/or proceedings articles
- Presentations at GCDAMP meetings (as necessary)
- All work conducted for the SedTrend and sandbar monitoring project will be summarized in annual reports, with the FY2010 report to be completed by January 1, 2011

FY2011

Collection of channel mapping data for the SedTrend project and sandbar monitoring will both occur in FY2011. These data will not be fully processed and reported until FY2012.

- Collection of SedTrend channel mapping data for an additional one of the five channel mapping segments. Currently, this work is planned to occur in the segment between RM 166 and RM 225
- Repeat surveys of the NAU sandbar study sites
- Finalization of reports listed above for FY2010
- Preparation of conference abstracts and/or proceedings articles
- Presentations at GCDAMP meetings (as necessary)
- All work conducted for the SedTrend and sandbar monitoring project will be summarized in annual reports, with the FY2011 report to be completed by January 1, 2012

Budget

FY2010

PHY 8 M2.10	
Integrated Long-term Monitoring of Systemwide Changes in Sediment Storage (FY2009–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	50,725
GCMRC Project Related Travel / Training (21% Burden)	4,120
GCMRC Operations / Supplies / Publishing (21% Burden)	7,500
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	135,951
Project Subtotal	**$ 198,296**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	21,372
Project Total (Gross)	**$ 219,668**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	68.6%

FY2011

PHY 8 M2.11	
Integrated Long-term Monitoring of Systemwide Changes in Sediment Storage (FY2009–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	66,747
GCMRC Project Related Travel / Training (21% Burden)	2,122
GCMRC Operations / Supplies / Publishing (21% Burden)	11,157
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	31,523
GCDAMP Logistical Support (21% Burden)	62,622
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	161,413
Project Subtotal	**$ 335,584**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	46,406
Project Total (Gross)	**$ 381,990**
Percent Outsourced (Outside of GCMRC; includes 50% of	57.4%

Logistics)	

GCDAMP Goal 9—Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of GCDAMP ecosystem goals.

REC 9.R1.10–11—Campsite Area Monitoring

Start Date

October 1998 (This project is a continuation of a monitoring project that has been occurring annually since 1998.)

End Date

Ongoing

Principal Investigators

R. Parnell, M. Kaplinski, and J. Hazel, Northern Arizona University, Geology Department; in cooperation with U.S. Geological Survey, Grand Canyon Monitoring and Research Center staff scientists and a cooperating recreation specialist (TBD).

Geographic Scope

Campable area monitoring for GCDAMP has historically focused on monitoring campable space at approximately 31 sandbars located along the main channel of the Colorado River between Lees Ferry (RM 0) and Diamond Creek (RM 226).

Campsites in the reach below Diamond Creek are of interest to NPS and tribal managers due to the increasing recreational use of the "Diamond Down" reach and the fact that persistent sandbars are now exposed along a flowing river reach as a result of the recent years of lower reservoir elevations and sand storage in Lake Mead. Therefore, additional sandbar campsites between RM 226 and the western boundary of the geographical scope of the GCDAMP program (approximately RM 278) may be included in future versions of this monitoring project (after FY2010).

Project Goals

The goal of this project is to track change in campable area using established monitoring protocols (repeat total station surveys) while alternative monitoring approaches using remotely sensed data are being explored and evaluated (see project REC 9.R2.10/DASA 12.D9.10):

The specific objectives of this study include the following:

- Measure campsite area at a series of long-term monitoring sandbar sites;
- Evaluate changes in campsite area in relation to changes in bar volume and topography; and
- Evaluate how changes in campsite area affect other attributes that relate to camp site quality and visitor experience.

Need for Project

Public concern with the ongoing loss of sandbar "beaches" and recreational capacity in the Colorado River corridor was a key factor leading to the development of the 1995 Glen Canyon Dam Final Environmental Impact Statement and passage of the Grand Canyon Protection Act (GCPA) in 1992. Given that the supply of new sand below the dam is estimated to be about 6 percent of the pre-dam supply in Marble Canyon and about 16 percent of the pre-dam supply below the confluence with the LCR (RM 61–278), there is still uncertainty about the future fate and long-term sustainability of sandbar campsites below GCD under proposed operational strategies intended to promote sand conservation of tributary inputs. The protection of visitor use values is specifically identified as a goal of GCPA. This project directly addresses one element of the top priority core-monitoring information need (change in campsite size) for goal 9 of the GCDAMP Strategic Plan, and indirectly addresses aspects of campsite quality and visitor experience quality. This project will provide data to managers about the status and trend of campsite area throughout the CRE below GCD at sites that have been monitored annually since 1998.

Strategic Science Questions

In terms of questions that are specific to the AMP goals for recreation, this project directly addresses the following SSQ:

> **SSQ 3-9.** How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?

Because campsite size can affect visitor experience, this project also indirectly addresses two other important science questions related to recreation in the CRE:

> **SSQ 3-7.** How do dam-controlled flows affect visitors' recreational experiences, and what is/are the optimal flows for maintaining a high-quality recreational experience in the CRE?

> **SSQ 3-8.** What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes?

Indirectly, this project is also relevant to resolving the primary strategic science question for sediment, in that it provides another measurement of sandbar habitat (in this case, human habitat):

> **SSQ 4-1.** Is there a "Flow Only" operation (that is,, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

Information Needs Addressed

This project directly addresses one part of the top priority CMIN for goal 9 (campsite size):

> **CMIN 9.3.1.** Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons. (This project specifically addresses the part of the CMIN concerned with campsite size.)

This project partially addresses a second campsite CMIN (9.3.2) that is closely related to the top priority CMIN for camping beaches (Note: The Science Planning Group of the TWG recommended that CMINs 9.3.1 and 9.3.2 be combined as one):

> **CMIN 9.3.2.** Determine and track the effects of ROD operations on the size, quality, and distribution of camping beaches in the CRE.

This monitoring project also contributes to tracking the long-term effects of the FY2008 experimental flow on camping beaches (campable area), as defined by EIN 9.3.1:

> **EIN 9.3.1.** How do the size, quality, and distribution of camping beaches change in response to an experiment performed under the ROD, unanticipated event, or other management action?

Methods and Tasks

Repeat surveys of sandbars have been conducted since 1990 using trained field personnel under the joint direction of the GCMRC's survey department staff and scientists from the NAU Department of Geology. Campable area survey protocols were subsequently established and have been applied consistently to a sub-set of these long-term sandbar monitoring sites by the same team of NAU scientists since 1998 (Kaplinski and others, 2005). As described in the SCORE report (Kaplinski and others, 2005, p. 196), campable area surveys are conducted annually in the fall, at the conclusion of the prime river recreation season. Survey crews from NAU Department of Geology survey the study sites using standard total station survey techniques (U.S. Army Corps of Engineers, 1994). Topographic data are collected and referenced to Ariz. State Plane Coordinates generated through the GCMRC's survey control network throughout the CRE. Data are reduced and analyzed by the NAU team in cooperation with GCMRC partners and presented in a variety of formats, but most typically are reported as cumulative area totals. The campable areas are also assessed relative to flow and stage elevations linked to dam operations. These data will be integrated with and analyzed in relation to sandbar measurement data (area and volume relative to stage elevations) that are being collected as a component of the core-monitoring program for sediment (see project PHY 8.M2.10–11).

Surveyors follow the criteria of Kearsley (1995) and Kearsley and Quartaroli (1997) to identify campable area. Campable area is defined as "a smooth substrate (preferably sand) with no more than 8 degrees of slope with little or no vegetation" (Kaplinski and others, 2005, p.196). Although the goal is to capture the total campable area at each site, camping areas located at considerable distance (>100 m) from the main mooring/cooking areas are generally not included in the totals. In the future, these protocols may be adjusted to measure all campable area with variable slope criteria within the NPS-defined campsite boundaries using remotely sensed data (see research project description REC 9.R2.10/DASA 12.D9.10–11); however, until new protocols are tested and refined, the existing monitoring program will continue.

FY2010

We propose to focus FY2010 work primarily on compiling, analyzing, and synthesizing the campable area data that has been collected by NAU for the past 10+ years and analyzing it in relation to changes in sandbar area and topography. Specifically, in FY2010, researchers will compile all accumulated survey data concerning changes in campable area, analyze it on a site-by-site basis as well as in terms of cumulative trends data, and produce a report synthesizing the results of these analyses comprehensively. In addition, GCMRC will continue to support Grand Canyon River Guides with a modest amount of funding ($10K) to continue the collection, analysis, digitizing, and archiving of photographic records of change occurring at 45 popular campsites. These data, which are collected by river guides on a volunteer basis and compiled, digitized, and analyzed by a paid staff person, provide another form of monitoring data targeted at tracking changes in campsite area, shoreline/mooring characteristics, and overall camp quality through time.

FY2011

In FY2011, upon completion of the site specific and synthetic campsite area analyses and the comprehensive report, GCMRC will convene a PEP to specifically review existing monitoring protocols for campsites. Upon completion of this PEP, monitoring of campsites will recommence, subject to revisions recommended by the PEP. The FY2011 budget anticipates that a program of tracking changes in campsite area that is generally similar to the one that has been in place for the past

10 years will continue in future years (perhaps supplemented with additional protocols designed to track other important campsite attributes such as campsite distribution and visitor experience quality factors.)

Links/Relationships to Other Projects

Sandbar Monitoring

This monitoring project will continue to occur in conjunction with and will be analyzed in relation to the data collected from NAU's long-term sandbar monitoring sites, a project that has been underway since the early 1990s. The campable area surveys that this project focuses on have occurred annually at a subset of the NAU sandbar sites since 1998. Both the NAU sandbar survey and campable area monitoring projects are concerned with monitoring sandbar sediment, albeit in different respects. The NAU sandbar survey tracks changes in total area and volume of the sandbars above the 5,000 cfs level, while the campable area monitoring project specifically evaluates changes in the amount of campable area available at a subset of these sandbar sites. In combination, these two projects provide a relatively holistic assessment of how flows are affecting the sandbar habitats used by recreational boaters for camping.

Campsite Inventory and GIS Atlas

The sites being assessed by this monitoring project constitute a relatively small and non-random (but fairly representative – see Schmidt and others, 2004) subset of the total number of campsites located throughout the river ecosystem. Data resulting from this monitoring project will be incorporated into the GIS campsite atlas in FY2010–11 (REC 9.R3.10-11). In addition, these data will be used to assess the quality and accuracy of campable area data derived from remotely sensed imagery (see project REC 9.R2.10/DASA 12.D9.10–11.)

Changes in High Elevation Sand Availability

In addition to recreation resources, sandbars are closely linked with other resources of GCDAMP concern, such as terrestrial and aquatic habitats related to native fish rearing areas (backwaters) and cultural site preservation. Campable area monitoring provides information on changes in area of open sand above the active fluctuating flow operating zone (above 25,000 cfs stage) and indirectly provides information about whether sand storage in those areas is stable, increasing, or decreasing through time in response to normal operations or experimental high flows intended to promote conservation of new sand supplies. The abundance of open sand areas along shorelines also provides another indirect measurement of the potentially available sand for transport by wind to higher elevations where archaeological preservation sites are located. In the future, additional process studies at such cultural sites may be tied to sandbar monitoring at existing camping sites that are proximal to cultural research sites.

Logistics

A single oar powered river trip is currently planned for September–October 2009 that will be supported with FY2009 funding. In FY2010, no river trip will occur; instead, researchers will devote all of FY2010 to compiling, synthesizing, and reporting on the work that has been conducted for this project over the past 10 years and integrating these results with the synthesis of results from sandbar surveys and from past experimental high flows (1996, 2004, and 2008.) In FY2011, fieldwork will resume with an oar trip planned for late September–early October 2011.

Products/Reports

A comprehensive, synthetic, peer reviewed report documenting the change in campable area over the past 10 years and relating these changes to other monitored changes, such as sandbar area and volume,

will be prepared in FY2010. This report, and the data gathered as a result of this project, will be served through the GCMRC web site and Campsite GIS Atlas. Project findings will also be presented at the biennial GCMRC science symposium.

Budget

FY2010

REC 9.R1.10	
Campsite Area Monitoring (FY1998–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	7,200
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	3,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	62,000
Project Subtotal	**$ 72,200**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	5,918
Project Total (Gross)	**$ 78,118**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	85.9%

FY2011

REC 9.R1.11	
Campsite Area Monitoring (FY1998–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	7,500
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	3,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	8,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	52,500
Project Subtotal	**$ 71,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	7,082
Project Total (Gross)	**$ 78,082**
Percent Outsourced (Outside of GCMRC; includes 50% of	79.6%

Logistics)	

REC 9.R3.10–11—Expand and Analyze Campsite Data in the GIS Atlas

Start Date

2007

End Date

September 30, 2011

Principal Investigators

Helen Fairley, Sociocultural Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, with GCMRC staff support.

Geographic Scope

Entire Colorado River ecosystem (CRE), from base of Glen Canyon Dam (GCD) to Lake Mead (Mile 277).

Project Goals

The goals of this project are to expand the existing GIS campsite atlas database and start using the atlas as a tool for analyzing and documenting changes in campsite attributes that are potentially being affected by dam controlled flows. These goals will be accomplished by:

- adding recently collected campsite related data to the atlas database,
- continuing to expand the legacy data component of the atlas, and
- beginning the process of analyzing the currently compiled campsite data in terms of documenting changes in the spatial extent, geographic distribution, and associated attributes of campsites located throughout the CRE.

The atlas currently contains tabular data on current campsite attributes that are important to maintaining a high quality recreation experience in the CRE and that have the potential to be affected by flows (for example, campable area, amount of open sand area, type and amount of vegetation cover, and shoreline/mooring characteristics under varying flows.) The atlas also documents the locations and attributes of past campsites identified in previous inventories that have since disappeared due to loss of sediment and/or vegetation encroachment. The atlas is designed to serve as the primary electronic repository for all data (for example, repeat photographs, campable area survey data, vegetation transect data, human impact data, etc.) that have been collected for campsites over the past few decades, and it also serves as the baseline "status" record for future monitoring and research projects. It defines the boundaries of current campsites in a GIS environment so that future evaluations that rely on remotely sensed data and statistical samples to quantify change in campsite attributes relative to dam operations have a common spatial basis for evaluating change through time.

Need for Project

Baseline inventories provide the foundation for long-term monitoring programs and research studies. Comprehensive campsite inventories in the CRE conducted initially in 1973 were repeated in1984 (Weeden and others, 1975; Brian and Thomas, 1984) and again in the 1990s. The last comprehensive campsite inventory was completed 18 years ago in 1991 (Kearsley and Warren, 1993). The 1991 inventory showed a dramatic decline in number and size of campsites compared with previous inventories (Kaplinski and others, 2005). As conditions change, additional comprehensive inventories are needed periodically to assess status and trends related to camp size, quality, and distribution throughout the CRE. The atlas provides the baseline data against which future changes can be

assessed. This atlas will also serve as the central repository for all campsite data collected during future inventory and monitoring projects. The FY2005 recreation PEP identified the development of this atlas as the highest priority research need under management objective 9.3. In addition to assessing overall changes in campsite area and distribution, there is a need to understand the specific factors contributing to changes in campsite area through time. The work proposed in FY2010–11 will focus on causal issues by evaluating the role of vegetation in affecting available camping area and influencing the quality of campsites through time.

Strategic Science Questions

This project directly addresses the following strategic science question:

> **SSQ 3-9.** How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?

Indirectly, this project will also provide information that is relevant for addressing a second strategic science question about the effects of flows on the quality of recreational experience in the CRE:

> **SSQ 3-8.** What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes?

Information Needs Addressed

This project is designed to address management objective 9.3 and specifically, the AMP's top priority CMIN for Goal 9:

> **CMIN 9.3.1.** Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons.

CMIN 9.3.1 is very closely related to a second CMIN under Management Objective. 9.3

> **CMIN 9.3.2.** Determine and track the effects of ROD operations on the size, quality, and distribution of camping beaches in the CRE.

The current recreation monitoring program focuses primarily on one aspect of CMIN 9.3.1: campsite size. Component 3 of this project will contribute information relative to elucidating the role of vegetation encroachment on campsite size, but in addition, it will develop additional data relevant to tracking the other key relevant campsite variables, for example, campsite distribution and quality. Through analyzing the FY2002, FY2005, and FY2009 post-experimental flows imagery in relation to campsites, this project will also contribute valuable information relative to interpreting the effects of experimental flows on camping sites, as defined by EIN 9.3.1.

> **EIN 9.3.1.** How do the size, quality, and distribution of camping beaches change in response to an experiment performed under the ROD, unanticipated event, or other management action?

Methods and Tasks

The work proposed in FY2010–11 will involve three primary components;

- incorporate data from FY2008–09 campsite monitoring efforts and the FY2008–09 campsite-related HFE studies to the GIS atlas;
- scan additional maps, slides, and photographs and incorporate additional legacy data from past campsite monitoring projects into the atlas; and
- analyze vegetation encroachment at both the NAU long-term sandbar sites and at a random sample of campsites using multiple lines of evidence, including the campsite polygon data

overlaid on FY2002, FY2005, and FY2009 overflight imagery and oblique photographic records from a sample of campsites.

- Tabular data, survey data, supporting metadata, and photographs collected in 2008 and 2009 will be scanned and linked to GIS/spatial data
- Using aerial imagery collected in 2002, 2005, and 2009, we will analyze the amount of vegetation contained within the established polygon boundaries at the NAU sandbar sites and at a randomly-selected sample of sites to determine how much vegetation encroachment has contributed to changing campable area through time

Links/Relationships to Other Projects

The GIS atlas is designed to serve as the definitive source for information on prior and current campsite inventory data. It provides a foundation and repository for all future research and monitoring projects related to CRE campsites. In addition to meeting GCDAMP needs, data from this project will be used by the National Park Service as they develop implementation plans and resource monitoring projects tied to the Colorado River Management Plan. For example, in addition to documenting areas used for recreational camping, the GIS campsite layer documents areas of the CRE most heavily used and impacted by humans. This information will be useful for assessing human impacts rates on nearby cultural resources such as archaeological sites and TCPs.

Logistics

Fieldwork required to verify or update the atlas data will be accomplished through a single oar powered trip in FY2010.

Products/Reports

An assessment of the role of vegetation in affecting campsite area will be published as a Scientific Investigation Report in FY2011.

Budget

FY2010

REC 9.R3.10	
Expand and Analyze Campsite Data in the GIS Atlas (FY07—FY11)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	40,000
GCMRC Project Related Travel / Training (21% Burden)	3,000
GCMRC Operations / Supplies / Publishing (21% Burden)	4,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	15,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 62,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	13,020

Project Total (Gross)	**$ 75,020**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	12.1%

FY2011

REC 9.R3.11	
Expand and Analyze Campsite Data in the GIS Atlas (FY07—FY11)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	43,000
GCMRC Project Related Travel / Training (21% Burden)	3,000
GCMRC Operations / Supplies / Publishing (21% Burden)	4,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 50,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	10,500
Project Total (Gross)	**$ 60,500**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

GCDAMP Goal 10—Maintain power production capacity and energy generation, and increase where feasible and advisable, within the framework of the Adaptive Management ecosystem goals.

HYD 10.M1.10–11—Monitor Power Generation and Market Values under Current and Future Dam Operations

Start Date

October 2006

End Date

Ongoing

Principal Investigators

Data will be provided by Western Area Power Administration and distributed via the U.S. Geological Survey, Grand Canyon Monitoring and Research Center Website

Geographic Scope

Hydropower generation data and market values for the energy generated by Glen Canyon Dam

Project Goals

The goal of this core-monitoring project is to monitor and document hourly hydropower generation and potential opportunity (replacement) costs under current and future flow regimes.

Need for Project

Power generated at GCD is marketed mostly in six western states by the Department of Energy's Western Area Power Administration (WAPA). WAPA's primary mission is to sell power from Federal water project powerplants under statutory criteria in the Reclamation Project Act of 1939, the Flood Control Act of 1944, and the Colorado River Storage Project (CRSP) Act of 1956. These criteria include the following:

- Preference in the sale of power must go to municipalities, public corporations, cooperatives, and other nonprofit organizations.
- Power must be marketed at the lowest possible rates consistent with sound business practices.
- Revenues generated from power sales must pay for power generation and all allocated investment costs under the original CRSP Act.
- Projects should generate the greatest amount of power and energy that can be sold at firm power and energy rates, consistent with other project purposes.

Tracking generation (as impacted by operations for other project purposes), power market rates, necessary power purchases, and Basin Fund cash flow provides the means to assess the impact of changes in GCD operations in relation to the four statutory criteria.

Currently, there are no ongoing core-monitoring activities related to goal 10. Although data on GCD hydropower generation and opportunity costs under MLFF operations are currently being gathered by Reclamation and WAPA as routine agency functions, these data are not readily accessible to the GCDAMP. The need for this information in a readily accessible format has been identified as a program need, and this project will help to fill this critical information gap.

Strategic Science Questions

Primary SSQs addressed:

> **SSQ 3-3.** What are the hydropower replacement costs of the modified low fluctuating flow (MLFF) annually since 1996?
>
> **SSQ 3-4.** What are the projected hydropower costs associated with the various alternative flow regimes being discussed for future experimental science (as defined in the next phase experimental design)?

Information Needs Addressed

This project responds to the core-monitoring information need for goal 10, as originally articulated in the FY2003 version of the GCDAMP Strategic Plan, and redefined by the SPG:

> **IN 10.1.** Determine and track the impacts to power users from implementation of ROD dam operations and segregate those effects from other causes such as changes in the power market.
>
> **CMIN 10.1.1 (as redefined by SPG).** Determine and track the marketable capacity and energy produced through dam operations in relation to the various release scenarios (daily fluctuation limit, upramp and downramp limits, etc.).

Methods and Tasks

WAPA and Reclamation continuously schedule and monitor power generation to meet anticipated and real-time power demand. This information is available on an hourly time step reported daily, weekly, and monthly from System Control and Data Acquisition (SCADA) data. WAPA and its customers track power source, availability, and market changes on an hourly basis in assessing the need, cost, and accessibility for additional power resources to meet contractual obligations or unanticipated demand. Market pricing, resulting cost of purchases, and the impact on Basin Fund cash flow are recorded in the WAPA Energy Tracking Database (ISA). This information is reported monthly and annually and is available through WAPA-CRSP, but not publicly published. Table 6 summarizes the metrics and frequency of data collection for power costs.

Table 6. Metrics and frequency of data collection for power costs.

Objective	Parameters	Methods	Location(s)	Frequency	Accuracy and precision
Monitor monthly energy generation	MW	SCADA	SCADA Phoenix – Dumped Energy Manageme nt System (ISA)	Hourly	N/A
Monitor hourly power market price	$/MWH	WAPA Energy Tracking Database (ISA)	WAPA – Montrose	Hourly	N/A
Monitor monthly firming power purchases	$ and MW purchased	WAPA Energy Tracking Database (ISA)	WAPA-Montrose	Monthly	N/A
Monitor monthly Basin Fund Balance	$	WAPA Energy Tracking Database (ISA)	WAPA-CRSP	Monthly	N/A

Data Sources

Energy generated: The SCADA system that measures generation at GCD is reported to a database that is accessible by the WAPA Phoenix, Ariz, office. Currently, those data are input into the CRSP-Montrose office ISA, and from ISA monthly generation is calculated by summing all the hourly values. Hourly generation totals are not currently reported but can be accessed by WAPA-CRSP or WAPA-Montrose. For the purposes of this project, hourly data will be reported.

Hourly market prices: Market prices vary at different purchase points throughout the system. The price that WAPA-Montrose pays for power is pertinent to WAPA and its customers. This value is available only for the hours in which WAPA buys or sells power; therefore, the data set is incomplete. If complete data is needed by WAPA-Montrose, they may look at the Dow Jones for a representative point of sale and record that data price. These data can be accessed via the Web and reported to an Excel spreadsheet if access is requested and granted by WAPA-Montrose.

Basin fund balance: The financial manager for the CRSP office completes an end-of-month cash balance and Basin Fund balance report found on WAPA's Web site. The reports are usually completed by the 15th of the following month. These data will be for the previous month's billing on the 2 months previous services.

Monthly firming purchases: These data are found in the WAPA-Montrose TDB database. Purchases made by WAPA for customers are reported by the 10th of the following month, broken out by customer (purchased from). This report is sent to WAPA and can be made available to the public via GCMRC's Web site.

Links/Relationships to Other Projects

This project is specifically related to the current overall long-term planning needs of the GCDAMP.

Logistics

There are no logistical needs to this project.

Products/Reports

Hourly data will be collected by WAPA and made available to the GCMRC on a daily basis. These data will be served through the GCMRC Web site. Monthly data will be made available to the GCMRC at the conclusion of each month.

Budget

FY2010

HYD 10.M1.10	
Monitor Power Generation and Market Values under Current and Future Dam Operations (FY2007–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	5,000
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	3,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 8,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	1,680
Project Total (Gross)	**$ 9,680**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

HYD 10.M1.11	
Monitor Power Generation and Market Values under Current and Future Dam Operations (FY2007–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	5,500
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	3,500
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 9,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	1,890
Project Total (Gross)	**$ 10,890**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

GCDAMP Goal 11—Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations.

CUL 11.R1.10–11—Cultural Research and Development towards Core Monitoring, Phase II

Start Date

October 2005

End Date

September 2012

Principal Investigators

Helen Fairley, U.S. Geological Survey, Grand Canyon Monitoring and Research Center. Individual tasks are being accomplished using a combination of Grand Canyon Monitoring and Research Center personnel and various federal and academic cooperators.

Geographic Scope

Colorado River ecosystem as defined in the Glen Canyon Dam Adaptive Management Program Strategic Plan

Project Goals

The overarching goal of this project is to develop an interrelated suite of objective, quantitative monitoring protocols for assessing the effects of GCD operations and the efficacy of various management actions at archaeological sites and other cultural resources that are valued by the American people. Monitoring protocols are being specifically designed to track status and trends in archaeological site condition on an ecosystem-wide basis and assess where, how rapidly, and in what respects cultural sites are changing under current (and future) dam operations. The protocols are being evaluated in terms of their suitability for being applied in a routine, systematic manner in the logistically challenging field setting of Grand Canyon National Park. The monitoring program is also being designed to:

- generate data useful for studying effects of experimental flow and non-flow actions on cultural resources in the CRE;
- provide data suitable for informing and/or building future geomorphic models, and
- provide data useful for determining future treatment needs at archaeological sites and the most effective treatment methods, regardless of the ultimate cause of the deterioration.

Need for Project

Grand Canyon is one of the classic erosional landscapes of the world. Recent ggeomorphic studies (for example, Lucchitta and others, 2000; Pederson and others, 2006) document a dynamic landscape that is continuously changing in response to tectonic forces, climatic factors, and ongoing erosion by the

Colorado River. While some erosion of unconsolidated deposits in the Colorado River corridor and the cultural resources contained in them is inevitable given these dynamic environmental conditions, past studies (for example, Hereford and others, 1993) indicate that erosion of the Holocene-age sediment that forms the substrate of many cultural sites in the CRE appears to have increased within the past few decades. Several hypotheses have been proposed to explain this purported increase in erosion including changes in the intensity of rainfall and regional precipitation patterns during the 1970s-early 1980s, the ongoing removal of sediment and lack of replenishment due to dam operations, and secondary effects related to increased visitation and cumulative impacts from recreational use of the river corridor (Hereford and others, 1993; Thompson and others, 2000; Fairley 2005). Regardless of what ultimately is causing observed changes in cultural resource condition (for example, Leap and others, 2000), the AMP is charged with tracking the status and trends of cultural resources in the CRE, evaluating the role that dam operations play in influencing resource condition, and determining how best to mitigate effects to National Park resources due to dam operations, Development of an accurate, reliable, and objective monitoring program to track the amount and rate of change occurring at cultural sites in the CRE is therefore a key need of this program.

The National Park Service began monitoring cultural sites in the river corridor during the late 1970s and continues to do so to meet its statutory responsibilities as a federal land managing agency; however, past NPS monitoring programs were not specifically designed to objectively assess dam effects or track the efficacy of management actions undertaken to control erosion. In FY2000, a cultural PEP convened by GCMRC on behalf of the GCDAMP recommended redesigning the Park Services' FY1999–2000 Programmatic Agreement Monitoring Program to focus more specifically on tracking effects of dam operations and evaluating the efficacy of erosion control efforts (Doelle, 2000). Subsequently, the Science Planning Group (SPG) and Cultural Resources Ad Hoc Group (CRAHG) redefined the primary core monitoring need for historic properties in the CRE to be the following: track status and trends of site condition and integrity through monitoring rates of erosion, visitor impacts, and other variables or processes known to affect cultural site condition. This project is exploring and evaluating various options for measuring change and achieving these defined monitoring objectives.

Strategic Science Questions

This research and development project, and the future cultural monitoring program, is designed to address two primary SSQs:

> **SSQ 2-1.** Do dam-controlled flows affect (increase or decrease) rates of erosion, and vegetation growth, at archaeological sites and TCP sites in the CRE, and if so, how?
>
> **SSQ 2-4.** How effective are various treatments (e.g., check dams, vegetation management, etc.) in slowing rates of erosion at archaeological sites over the long term?

Information Needs Addressed

This project is a research and development effort aimed at addressing the highest priority CMIN for historic properties (as revised by the CRAHG and SPG in fall 2005), specifically, the properties known as archaeological sites:

> **CMIN 11.1.1 (**SPG revised**).** Determine the condition and integrity of prehistoric and historic sites in the CRE through tracking rates of erosion, visitor impacts, and other relevant variables. Determine the condition and integrity of TCPs in the CRE.

This project also directly addresses EIN 11.1 (formerly CMIN 11.1.2 of the GCDAMP Strategic Plan renumbered by CRAHG/SPG as EIN 11.1):

EIN 11.1. Determine the efficacy of treatments for mitigation of adverse effects to historic properties.

Additionally, this project addresses an AMP research IN (formerly identified as CMIN 11.1.4 in the 2001 GCDAMP Strategic Plan):

- How effective is monitoring, what are the appropriate strategies to capture change at an archaeological site—qualitative, quantitative?

Methods and Tasks

This cultural monitoring project is part of a phased program of research and development towards implementation of a long-term core-monitoring program. The first phase of this project (Phase I) began in the spring of 2006 and focused on completing a comprehensive assessment of the geomorphic and archaeological attributes of sites to aid in the development of the long-term monitoring approach. It also involved testing a variety of survey techniques for objectively measuring change in resource condition.

When the project was initially conceived, Phase I was intended to continue for 2 years (FY2006–07), and FY2008 was intended to be the first year of a 3-year monitoring cycle employing the refined protocols developed during the preceding phase. However, a later than anticipated start in FY2006, coupled with the high-flow experiment in FY2008, delayed the project schedule by approximately 8 months. Therefore, FY2008 became a transitional year in which we continued to build on several research and development activities initiated in FY2006, including:

- continuing to gather data on several short term, small scale studies to evaluate the effectiveness, efficiency, and accuracy of various field measurement techniques before implementing them as part of a long-term monitoring program (weather monitoring, LiDAR mapping, and thalweg survey measurements at a subset of sites);
- compiling, analyzing, and preparing reports on all the data collected during the previous 2 years of field work; and
- compiling and evaluating legacy data needed for assessing geomorphic characteristics related to site stability and preparing the GIS foundation for the future monitoring program.

In spring FY2010 (assuming we are permitted to complete Phase I work in fall FY2009), we will begin to implement the pilot monitoring program. The scope of this project encompasses the full range of archaeological resources located in the area of potential affect from dam operations. The actual number of archaeological sites that will be included in the pilot monitoring program will be determined upon completion of the data analysis phase of this project (currently underway). The ultimate outcome of this research and development effort will be a final report recommending specific monitoring protocols. The program will ultimately be subject to a final review by a PEP in FY2012, with additional refinement of protocols (if necessary) before being implemented as the long-term program. Below is the list of tasks proposed for implementation in FY2010–11.

Continue to Monitor Topographic Change and Establish New Baseline Topographic Records for Future Change-detection Purposes

In FY2010–11, we will continue to develop baseline data needed for tracking topographic change at archaeological sites using a combination of conventional total station mapping (or RTK GPS) for gully surveys and ground based high density LiDAR data for site surfaces at a sample of study sites. Ground based surveys will be directed by either GCMRC personnel or by cooperating scientists following methods employed and refined in Phase I to capture topographic and other types of surface changes using high density data collection methods (for example, Yeatts, 1996; Hazel and others, 2000; Pederson and others, 2003; Collins and others, 2008, 2009). LiDAR data will be manually edited and

filtered to produce a “bare-earth” terrain model without reflections from vegetation canopy. These highly accurate three-dimensional surface maps will be duplicated in future years using the same methodology to document the amount, rate, and location of erosion and deposition, vegetation encroachment, and structural deterioration occurring at sites; we also intend to continue to explore the utility of LiDAR for tracking changes in soil crust cover and artifact movement, both of which are strong indicators of site stability. GCMRC intends to work with NPS staff in summer 2009 to try and resolve NPS issues surrounding the use of ground based LiDAR for monitoring archaeological sites.

Weather Monitoring

In FY2007, 10 weather stations were established at 8 study sites in the CRE. The study sites include the same ones where gully measurements and LiDAR surveys are occurring, plus two additional sites. In FY2008 and continuing through FY2009, two additional stations, plus four additional sand traps were installed to capture data specifically related to monitoring effects of the FY2008 HFE. In FY2010–11, these stations will continue to collect data on precipitation amount and intensity, wind direction and velocity, temperature, humidity, barometric pressure, and sediment transport rates. Because of the spatially isolated nature of monsoon thunderstorms and the significant role that precipitation and wind play in downcutting and backfilling gullies, weather stations and sand traps have been distributed throughout the length of the river corridor, in proximity to several sites that will continue to be monitored periodically in future years, so that changes detected from repeat topographic mapping can be related to timing and duration of local or regional weather events. GCMRC staff is managing equipment maintenance, data collection, and sediment sample processing tasks internally; data processing and analysis is being handled through an internal USGS sub-allocation to USGS Western Coastal Geology and Marine Division.

Supplementary Site Condition Evaluations

Concurrent with the topographic monitoring work, observational data will be collected on surface indicators of condition using a standardized recording format. These data will document a combination of indicators that reflect both geomorphic and human agents of change affecting site condition and integrity in the CRE.

Geomorphic Legacy Data Compilation and Workshop

In FY2010, per request of AMWG, GCMRC will work with interested stakeholders to define the scope and desired outcomes of a geomorphic model to help inform the AMP about the geomorphic process affecting cultural sites in the CRE, the predicted vulnerability of sites to future deterioration, and the likelihood for reducing erosion rates using check dams or other erosion control methods. Previously, in September 2007, an independent panel of scientists had strongly recommended that any future monitoring program should be structured in relation to a model that articulates current scientific understanding of the factors and processes affecting site condition. Other independent scientific panels have made similar recommendations in the past, either by recommending development of quantitative geomorphic models (geomorphology symposium panel, FY2005) or GIS data and maps of the Holocene deposits (cultural PEP panel, FY2000) to help inform the future cultural resources monitoring program. GCMRC staff concluded that a comprehensive assessment of existing geomorphic data was the first step needed; this work is currently (FY2009) underway through a cooperative agreement with Utah State University. While still in progress, it is clear from the analysis conducted to date that additional work will be needed in FY2010 to bring existing legacy together in a format that will be useful for developing a geomorphic model and long-term monitoring plan. Therefore, in FY2010 we will direct a small portion of the cultural monitoring research and development budget towards continuing this legacy data compilation, part of which will be used to host one or two workshops to resolve issues related to the interpretation and integration of the various geomorphic legacy data sets collected from the CRE over the past 30 years and to define a general scope of work for a future request for proposal to design a predictive geomorphic model.

Links/Relationships to Other Projects

This project builds upon several past research efforts, including the previous work of Draut and Rubin (2005, 2006), Pederson and others (2003), and Damp and others (2007.) Specifically, it builds upon the work of Draut and Rubin (2005, 2006) by extending the weather monitoring record and measurements of Aeolian sand transport at selected locations in the CRE. It also expands information on gully erosion rates initiated by Utah State University (USU) in FY 2001–02 and continued in FY2006–07, and it expands on the geomorphic baseline data set collected for the 151site treatment plan (Damp and others, 2007). This study is also closely linked to the NPS CRMP implementation effort. Monitoring protocols for assessing impacts of human visitation at archaeological sites are being developed independently by NPS to serve the monitoring needs of the CRMP. The quantitative approaches for monitoring change in archaeological site condition that are being developed through the current R&D project are designed to complement the observational monitoring protocols proposed by NPS for CRMP compliance purposes.

Other ongoing projects that have benefited or are likely to benefit from the work being undertaken for the cultural monitoring research and development effort include:

- the integrated flow, temperature, and sediment modeling project (temperature data from the weather stations);
- the vegetation monitoring program (the full suite of weather data which may be useful for interpreting observed changes in vegetation);
- the conceptual modeling project (data on terrestrial/geomorphic processes); and
- the geomorphic model project proposed for FY2010–11 (specific monitoring data related to geomorphic processes and rates of change will be used to populate the model.)

Opportunities for integrating the results of this research and development effort with those of the tribal monitoring projects will be explored after completing the initial research and development phase of this project. This delay in integration is necessary in order for the needs and approaches of the tribal monitoring programs and the Federal agencies to be articulated and the appropriate protocols identified. Integration of monitoring efforts, as appropriate, will occur during implementation of the pilot monitoring phase (FY2010−11).

Logistics

Two motor-supported river trips will occur during the motor season (April and September) in FY2010 and FY2011.

Products/Reports

A report synthesizing the results of the Phase I research (2006–09) will be completed in FY10. Cooperators will prepare annual descriptive reports during Phase II of the pilot monitoring program. In addition, a synthetic peer-reviewed report summarizing the entire project will be prepared at the conclusion of this study.

Budget

FY2010

CUL 11.R1.10	
Cultural Research and Development towards Core Monitoring, Phase II (FY2006–12)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	95,000
GCMRC Project Related Travel / Training (21% Burden)	3,500
GCMRC Operations / Supplies / Publishing (21% Burden)	10,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	8,000
GCDAMP Logistical Support (21% Burden)	58,500
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	130,000
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	30,000
Project Subtotal	**$ 335,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	38,577
Project Total (Gross)	**$ 373,577**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	56.5%

FY2011

CUL 11.R1.11	
Cultural Research and Development towards Core Monitoring, Phase II (FY2006–12)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	96,000
GCMRC Project Related Travel / Training (21% Burden)	4,000
GCMRC Operations / Supplies / Publishing (21% Burden)	10,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	8,000
GCDAMP Logistical Support (21% Burden)	60,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	136,000
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	10,000
Project Subtotal	**$ 324,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	37,989
Project Total (Gross)	**$ 361,989**

Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	54.3%

GCDAMP Goal 12—Maintain a high-quality monitoring, research, and adaptive management program

DASA 12.D1.10—Quadrennial Remote-Sensing Overflight

Start Date

October 2007

End Date

Ongoing

Principal Investigator

Philip A. Davis, U.S. Geological Survey, Western Mineral Resources Science Center

Geographic Scope

Entire Colorado River ecosystem corridor from forebay of Glen Canyon Dam to upper Lake Mead and, for specific resources, site specific

Project Goals

Conduct aerial overflights to acquire digital imagery and topography of the CRE: mission planning, contract solicitation, mission execution, and ground support.

Need for Project

The quadrennial overflight will be conducted in FY2013. The airborne data to be collected are multispectral orthorectified images of the CRE. Area and volumetric analysis of these data sets are used to identify and classify elements of interest. Comparison of data sets acquired over time allow for change detection as long as the data continue to be collected. Airborne data is the basis for many of the science questions and research activities conducted in the Grand Canyon. Application examples include the following:

- Characterization of nearshore habitat used by small fish may lead to new directions in population estimates and life stage resource preference
- Shoreline location and character at different flow regimes and the distance to cultural sites.
- Document possible loss of vegetation at old high water zone
- Geomorphic characteristics of the CRE 8,000 to 25,000 cfs at 2-m resolution may be applied to quantifying biomass and production estimates
- Existence and change detection of areas of possible terrestrial organic input contributing to the carbon budget; riparian zone community composition; sandbar habitat including vegetation encroachment on camp site areas; backwaters, marshes, debris fans, cobble bars, and talus
- Maps used for positioning GCMRC monitoring areas are a few of the applications of airborne data

A primary fiscal objective is to reserve sufficient funding to cover mission costs during implementation. No salaries are funded for this project; work performed will be addressed by GIS personnel funded by the GIS general support project (DASA 12.D5) and the Integrated Image Analysis and Change Detection project (DASA 12.D9). Because of the dependent nature of remote sensing and GIS technologies, products described in this project will result from a combination of efforts across multiple DASA projects.

In addition, we anticipate performing an airborne data collection that addresses more specific issues. The following instrument is currently being considered with its purpose and funding source identified.

- Hyperspectral deferred in FY2010
- $200,000 contribution to FY2013 overflight deferred in FY2011

Strategic Science Questions

Some of the resource areas and science questions identified during the 2005 Knowledge Assessment and found within the GCMRC's Strategic Science Plan and Monitoring and Research Plan (see appendix A) that can be addressed with airborne image data include those listed below.

Additional SSQs addressed:

SSQ 4-1. Is there a "Flow-Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

- Sandbar detection and analysis comparisons between data sets (that is, 2002, 2004, 2005, 2009, 2013)

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

- If funding allows, a Forward Looking Infrared instrument returns a data set that may be used to characterize river temperatures throughout the CRE.

SSQ 1-7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?

- Two meter resolution shoreline geomorphic mapping may provide nearshore habitat characteristics linking resource preference with native fish.

SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?

- Detection and change analysis of vegetation presence and density may be linked to erosion studies.

SSQ 2-2. How do flows impact old high-water zone terraces in the CRE (where the majority of archaeological sites occur), and what kinds of important information about the historical ecology and human history of the CRE are being lost due to ongoing erosion of the Holocene sedimentary deposits?

- Sand detection and change analysis may provide further insight.

SSQ 3-9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?

- Sand/Vegetation and encroachment detection and change analysis are a key factor.

Information Needs Addressed

Numerous GCDAMP goals and resource area programs that are concerned with remote sensing analysis are the chief beneficiaries.

IN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

- Canyonwide detection and change analysis of detectable resources such as sand and vegetation propagate to provide information on campsite areas, cultural sites, and food base potentials in the 8 to 25k zone.

CMIN 4.1.6. Determine quantity and quality of spawning habitat for RBT in the Lees Ferry reach as measured at 5-year intervals.

- Two meter resolution shoreline geomorphic mapping may provide nearshore habitat characteristics to provide quantitative estimates RBT spawning habitat.

CMIN 6.1.1. Determine and track the abundance, composition, distribution, and area of the marsh community as measured at 5-year or other appropriate intervals based on life cycles of the species and rates of change for the community.

- Marsh detection algorithms may be developed for tracking this resource.

CMIN 6.4.1. Determine and track composition, abundance, and distribution of the sand beach community as measured at 5-year or other appropriate intervals based on life cycles of the species and rates of change for the community.

- Sand detection methodologies may quantify areas where these communities exist.

CMIN 9.3.1. Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons.

- Sand and vegetation detection / change methodologies may quantify these areas for tracking.

RIN 6.1.1. How have the abundance, composition, distribution, and area of the marsh community changed since dam closure (1963), high flows (1984), interim flows (1991), and the implementation of ROD operations (1996)?

- Marsh detection algorithms modified for legacy overflights may provide a quantitative analysis.

RIN 8.6.1. How do ongoing inputs of coarse-sediment from tributaries influence storage of fine sediment within pools, runs and eddies throughout the CRE?

- Inventory of eddies combined with sand detection may provide part of the picture.

EIN 4.1.1. How does RBT abundance, proportional stock density, length at age, condition, spawning habitat, natural recruitment, whirling disease and other parasitic infections change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

- Two meter resolution geomorphic mapping may provide new insight to resource preference and stock assessments.

EIN 6.1.1. How do marsh community abundance, composition, distribution, and area change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

- Marsh detection algorithms may be developed for tracking this resource.

EIN 6.4.1. How do the abundance, composition, and distribution of the sand beach community change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

- Sand detection methodologies may quantify areas where these communities exist.

EIN 9.3.1. How do the size, quality, and distribution of camping beaches change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

- Sand and vegetation detection / change methodologies may quantify these areas for tracking.

In total, approximately one-third of the GCDAMP information needs may be directly or indirectly addressed through analysis and use of the systemwide digital imagery.

Methods and Tasks

FY2010–14

- Project will closely coordinate with Reclamation on flows and the overall project will be coordinated closely with NPS, as well as NPS and DOI Aviation Officers.
- Remote sensing instruments deployed in fixed wing aircraft or helicopters are flown over the CRE to produce canyonwide data sets.
- A steady flow for a period of 6–7 days is required for full coverage of the CRE (weather conditions are a large factor and required extending constant flows for 10 days during the FY2009 overflight). A steady flow rate of 8,000 cfs is required to allow comparisons/change detection with previous overflight data sets. Regulation and Spinning Reserves to be picked up by other dams in the Colorado River Storage Project.
- Optimally the overflight occurs as close to the summer solstice (June 21 in non-leap years) as possible to minimize shadowing in the optical sensor data sets. Several previous overflights have been conducted around the Memorial Day holiday to minimize Glen Canyon Dam revenue loss; and this same timeframe is proposed for the FY2013 overflight.
- Efforts will be focused on obtaining a contractor that can provide greatest accuracy, greatest number of spectral bands, and a variety of onboard imaging instruments. Delivery of orthorectified images is expected early in FY2014.
- A data collection permit must be reviewed and updated through Grand Canyon National Park to reflect the types of remote sensing technologies that will be required to help fulfill the core-monitoring and experimental research needs for all GCMRC programs.
- DASA and survey support will include deploying Rim GPS Reference points during overflight.

Links/Relationships to Other Projects

Acquisition of systemwide digital images in this project supports addressing numerous resource questions within other programs, such as abundance and systemwide distribution of both aquatic and terrestrial habitats related to fish, vegetation, and availability and status of campsites along the CRE. The digital products procured by the DASA directly support a varied array of projects within GCDAMP goals 1–11, such as detecting shoreline habitat and changes tied to dam operations and high-flow experiments. Additionally, these data are used in terrestrial vegetation and sandbar mapping projects for determining surface texture and land cover classifications within designated study reaches, as well as canyonwide over subsequent years following the overflights (trend analysis).

Logistics

This will require rim support by GCMRC personnel to occupy three nearby base stations.

Products/Reports

FY2010

- All data sets are proposed to be served through an instance of Environmental Systems Research Institute (ESRI) ArcGIS Server.

FY2014

- Overflight data will be documented with metadata files conforming to the Federal Geographic Data Committee (FGDC) standards
  - The data sets are proposed to be served through an instance of Environmental Systems Research Institute (ESRI) ArcGIS Server

Budget

FY2010

DASA 12.D1.10	
Quadrennial Remote-Sensing Overflight FY2008–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	188,519
Project Subtotal	**$ 188,519**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	11,481
Project Total (Gross)	**$ 200,000**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	100.0%

DASA 12.D2.10–11—Grand Canyon Integrated Oracle Database Management System

Start Date

2007

End Date

Ongoing

Principal Investigator

Paul Alley, Database Administrator, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Grand Canyon Monitoring and Research Center study area, from the forebay of Lake Powell to upper Lake Mead

Project Goals

The goal of the database management system at the GCMRC is to provide an organized, secure, and readily available electronic repository for all scientific data collected in the ongoing research and monitoring activities of GCMRC. The relational database management system (RDBMS) also serves as the electronic storage foundation of GCMRC's GIS, providing the repository for all aerial photography, survey control, and geographic layers. The program is therefore a vital component of the decision support process and for the adaptive management of the GCD.

Need for Project

This project establishes the electronic repository and tools necessary to analyze and interpret scientific data collected by the GCMRC, thereby providing a fundamental support service to GCMRC scientific investigations and decision support processes.

Strategic Science Questions

This project provides the foundation for all projects concerned with scientific data analysis.

Information Needs Addressed

Provides access for analysis for all GCMRC data sets

RIN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

RIN 12.3.1. As necessary, investigate the most effective methods to integrate and synthesize resource data.

RIN 12.5.4. What is the most effective way to distribute information to our stakeholders and the public in a secure and accessible fashion?

Methods and Tasks

Working with data stewards from each scientific program at the GCMRC, the integrated database design will be extended in modular fashion to accommodate both newly collected data, such as with aquatic food base monitoring, and legacy data that have yet to be imported into the RDBMS. This process involves extensive review of existing data sets as well as current data collection protocols, and the information needs of each discipline. As these information needs are fully understood by programming staff, applications will be written that enable users to extract related data sets from the RDBMS and perform appropriate analyses. Generally these applications are written with a Web or Windows Application interface.

The following are core tasks that will continue during FY2010–11:

- Electronically archive all incoming data sets in their original form
- Error check and import newly collected data sets to the centralized RDBMS
- Administer database, including backup, recovery, and security
- Continue to consolidate and import legacy data to the system
- Continue to support data acquisition, import, and analyses by disciplines such as fish and water sampling in the Colorado River, and survey control
- Extend database structure to incorporate newly acquired data sets, such as aquatic food base and daily downstream water quality
- Extend routines to automate the process of error checking and importing data sets
- Extend Web application architecture to distribute newly collected data sets
- Provide data analysis support for scientific monitoring and research analyses
- Integrate tabular and spatial data sets in conjunction with DASA GIS staff

Links/Relationships to Other Projects

Most programs generate data sets that will be archived, served, and analyzed using DASA database services. The best example of the power and utility of the Oracle database is its ability to handle terabytes of data generated in multiple years such as those data that are associated with systemwide airborne digital imagery. Additionally, data stewards from all GCMRC programs utilize the DASA database management system to archive and serve tabular data sets through a single data management application tailored specifically for each project. DASA database staff assists projects with field data collection by developing software and other data collection strategies that help ensure observed field data is collected, organized, and securely archived for future analysis.

Logistics

There are no logistical needs for this project.

Products/Reports

Database modules and Web applications (as data become available from researchers):

FY2010

- Database modules and Web applications
    - Photo Databases

        - Repeat Photography
            - Stanton 100 year time span
            - Jack Schmitt USU Sandbars
        - Grams Time Series Sandbars
        - Fairley Campsite Photos
        - Kohl GCMRC Control Grid Locations
        - General Structure for additional Photo Data sets
    - Application to integrate power data, as provided by WAPA, into DASA data management system
- Applications and Software:
    - Version 2 Refactor of DASA mSystem Data-Sync-Web-Server application
    - Version 2 Refactor of Mark–recapture specimen tag synchronization
    - Field-based electronic data collection system(s) for nearshore ecology
- Annual progress report summarizing activities will be provided by December 15, 2010

FY2011

- Database modules and Web applications
    - Survey Control points
    - Integrated tabular/GIS data query tools
    - Integrate fish database into DASA data management system
- Applications and Software:
    - Supplement DASA mSystem data-sync application with additional validation and error checking; Web delivery of downloadable metadata
    - Develop software for documenting and archiving incoming data sets/reports
    - Online interactive data visualization and analysis tools on GCMRC Web site
- Annual progress report summarizing activities will be provided by December 15, 2011

Budget

FY2010

DASA 12.D2.10	
Grand Canyon Integrated Oracle Database Management System (FY2007–08)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	137,899
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 137,899**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	28,959
Project Total (Gross)	**$ 166,858**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

DASA 12.D2.11	
Grand Canyon Integrated Oracle Database Management System (FY2007–08)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	137,899
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 137,899**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	28,959
Project Total (Gross)	**$ 166,858**
Percent Outsourced (Outside of GCMRC; includes 50% of	0%

Logistics)	

DASA 12.D3.10–11—Library Operations

Start Date

October 2007

End Date

Ongoing

Principal Investigator

Esther Hamilton, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Grand Canyon Monitoring and Research Center study area—forebay of Glen Canyon Dam to upper Lake Mead

Project Goals

Library operations facilitate monitoring and research by providing a centralized repository for hard copy information such as books, reports, maps, photography, and videos. The library converts hard copy materials to digital format and stores the digital files on long-term optical media for preservation and for on-line distribution. The library maintains the on-line catalogue of library materials to facilitate information search and retrieval or digital reports. The library houses original and duplicate copies of all digital remote-sensing data and selectively converts historical aerial photography to digital format in order to preserve and to use such data to extend research and monitoring back in time.

Need for Project

The GCMRC library acts as the physical repository for reports and data generated by GCMRC scientists as well as materials related to the Colorado River, Grand Canyon, and adaptive management. The digital conversion of historical data, not only preserves the data, but also makes it available for scientific analysis.

Strategic Science Questions

This project provides a research materials and remote-sensing data (recent and historical) that allow all programs access to data covering a large timeframe in order to address scientific issues over decadal scales in the past.

Information Needs Addressed

The library provides access to current and historical scientific findings of the GCDAMP.

> **RIN 12.5.4.** What is the most effective way to distribute information to our stakeholders and the public in a secure and accessible fashion?
>
> **IN 12.1.** Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

CMIN 6.1.1. Determine and track the abundance, composition, distribution, and area of the marsh community as measured at 5-year or other appropriate intervals based on life cycles of the species and rates of change for the community.

RIN 6.1.1. How have the abundance, composition, distribution, and area of the marsh community changed since dam closure (1963), high flows (1984), interim flows (1991), and the implementation of Record of Decision operations (1996)?

RIN 6.4.1. How have the abundance, composition, and distribution of the sand beach community changed since dam closure (1963), high flows (1984), interim flows (1991), and the implementation of Record of Decision operations (1996)?

EIN 6.1.1. How do marsh community abundance, composition, distribution, and area change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

Methods and Tasks

The library catalogs all new materials that come from staff scientists, contractors, and cooperators as well as items related to Grand Canyon, the Colorado River, and adaptive management. Library staff provides support to cooperators, contractors, and staff scientists by researching and obtaining current and legacy articles and reports related to science projects.

Library operations facilitate monitoring and research by providing a centralized repository for hard copy information such as books, reports, maps, photography, and videos, which will someday be completely digital. The following are specific functions of the library:

- Scanning and converting paper reports into digital PDF files, making the documents searchable by using optical character recognition software (depending on quality of hardcopy and as time allows), and then posting the files in the library database on the GCMRC Web site
- Scanning relevant analog aerial film and photos using the Vexcel Ultrascan 5000, allowing the digital images to be used for 2-D and 3-D analyses, such detection of changes in area, height, volume, and surface material, as well as investigations of cause-effect relations.
- Digitizing flight line maps to provide a searchable mechanism to locate individual scanned aerial photos
- Converting VHS tapes to DVDs
- Scanning legacy slides to create digital images using the Nikon SuperCoolScan scanner

Links/Relationships to Other Projects

This project supports all other projects.

Logistics

There are no logistical needs for this project.

Products/Reports

FY2010

- Up-to-date on-line library catalog, which provides access to more than 8,000 publications.
- Catalog records of all materials (continually updated).

- Assistance to cooperators, stakeholders, media contacts, and the public by providing access to reports, aerial photos, maps, slides, and photos in hard copy and digital form.
- Research in locating contemporary and legacy materials.
- A research facility for researchers, GCMRC employees, cooperators, and the public.
- Access to 17,652 aerial photographs, 9,000 digital aerial images, 8,000 hard-copy reports, 8,000 photos and slides, and 700 videos in broadcast and VHS format. In addition, once the library scanning project is complete, this information will be available in digital format from the library via digital media such as DVD and online via the Web.
- Scientific appraisal of all available historical data in order to prioritize the scanning process and to obtain a firm understanding of the schedule required to complete digital conversions based on established priorities.
- As these conversion products are produced, they are cataloged and made available.
- Annual progress report summarizing major results will be provided by December 15, 2010.

FY2011

- Same as FY2010
- Annual progress report summarizing major results will be provided by December 15, 2011.

Budget

FY2010

DASA 12.D3.10	
Library Operations (FY2008–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	56,058
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	10,275
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 66,333**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	13,930
Project Total (Gross)	**$ 80,263**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

DASA 12.D3.11	
Library Operations (FY2008–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	65,049
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 65,049**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	13,660
Project Total (Gross)	**$ 78,709**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

DASA 12.D5.10–11—GIS Support for Integrated Analyses and Projects, GIS Lead

Start Date

2007

End Date

Ongoing

Principal Investigator

Thomas Gushue, GIS Coordinator, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Colorado River ecosystem corridor between Glen Canyon Dam and Lake Mead, and the greater Colorado River Basin

Project Goals

Advanced spatial analysis in support of GCMRC projects; Creation of specialized maps and intuitive data retrieval specific to individual project needs; consultation and instruction related to GIS operation and spatial data analysis for GCMRC staff; management and dissemination of spatial data.

Need for Project

The role of GIS has grown within GCMRC over the past few years, providing for extended applications across all resource programs and allowing for advanced spatial data analysis in support of on-going GCMRC projects. The demand for spatial analysis and customized GIS applications continues to increase ever year as the technology matures and becomes integrated with strategic science efforts. The GIS program is inherently service oriented, providing spatial database development and programming and analysis support to the science programs and their cooperators on both a planned and an as-needed basis. Given this increased demand, the GIS program must also expand to provide a consistent level of expertise and support to specific projects.

To continue functioning in this capacity it is imperative to factor in designated blocks of time to maintain and in some cases improve the level of GIS support. GIS general support benefits core-monitoring, experimental programs, and research and development projects alike in the form of GIS and remote-sensing software installation, maintenance and support, creation and maintenance of spatial databases used by science projects, and the development of mapping and analysis tools for use by GCMRC staff and cooperators across all resource programs. A need also exists for more advanced support directed at specific GIS application development and analysis of available spatial data. This higher level of support is often achieved through automation of data processing and manipulation procedures to standardize and streamline repetitive tasks as well as provide a basis for standard operating procedures.

DASA projects: DASA 12.D1.10–11: Quadrennial and Resource-Specific Remote Sensing Overflight and DASA 12.D9.10–11: Integrated Image Analysis and Change Detection are dependent on efforts funded through this project.

Strategic Science Questions

The spatial aspects of Grand Canyon investigations are addressed in this project.

Information Needs Addressed

IN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

RIN 12.3.1. As necessary, investigate the most effective methods to integrate and synthesize resource data.

RIN 12.5.4. What is the most effective way to distribute information to our stakeholders and the public in a secure and accessible fashion?

Methods and Tasks

The collection of spatial data is achieved through a variety of methods that include, but are not limited to, remote sensing data collection missions, traditional survey and global positioning system (GPS) operations, field mapping using hard copy map or pen tablet computers, onscreen digitizing using previously collected remote sensing data as source information, and through other standard data entry methods. Spatial data are generally stored in one of the standard ESRI file types (shape file, coverage, geodatabase) as well as in ASCII format. Methods used for spatial data processing and analysis will vary depending on the questions that need to be answered.

Links/Relationships to Other Projects

Most GCMRC projects have a spatial component tied to the data being collected in support of the science questions developed for each project. The GIS provides a stable platform upon which all data collected along the CRE are catalogued within a consistent spatial reference system and maintained in consistent file formats with appropriate metadata. At the most basic level, this allows for the overlaying and querying of data sets collected from any and all projects within the GCMRC. Utilization of these technologies goes beyond this creating a platform for conducting fully integrated spatial analysis in support of scientific research.

Logistics

There are no logistical needs for this project.

Products/Reports

As a result of GIS support, a wide range of products will be produced:

- Maps for publications; generation and printing of maps and graphics for posters
- Creation of improved base maps for Lake Powell and Grand Canyon
- Instructional sessions for staff, cooperators, and contractors on GIS layer development, integration and analysis
- Advanced spatial analysis for monitoring projects
- Annual progress report summarizing major results will be provided by December 15, 2010 and 2011

Budget

FY2010

DASA 12.D5.10	
GIS Support for Integrated Analyses and Projects, GIS Lead (FY2007–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	179,797
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	4,300
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	121,712
Project Subtotal	**$ 305,809**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	46,073
Project Total (Gross)	**$ 351,882**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	39.8%

FY2011

DASA 12.D5.11	
GIS Support for Integrated Analyses and Projects, GIS Lead (FY2007–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	185,204
GCMRC Project Related Travel / Training (21% Burden)	2,000
GCMRC Operations / Supplies / Publishing (21% Burden)	2,300
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	129,014
Project Subtotal	**$ 318,518**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	47,653
Project Total (Gross)	**$ 366,171**

Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	40.5%

DASA 12.D8.10–11—Biometrics and General Analysis

Start Date

2010

End Date

Ongoing

Principal Investigator

L.G. Coggins, Jr., U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Associated projects within the Colorado River ecosystem

Project Goals

The primary goal of the GCMRC Biometrics position is to provide necessary and relevant statistical and modeling support in planning and analyzing science projects conducted or supported by GCMRC and the AMP. Additionally, the GCMRC biometrician will conduct focused research in areas such as model development and analytical techniques to further the science capability of the GCMRC.

Need for Project

GCMRC has identified the need for greater technical oversight and rigor with regard to study planning and analysis of some AMP sponsored projects. This need includes both projects conducted primarily by GCMRC staff and cooperating scientists. To meet this need GCMRC will employ a staff biometrician whose role will be to provide analysis and modeling support for AMP sponsored projects, particularly in the biological discipline. As needed, this support will focus primarily in assisting in the development and review of research and study plans as well as data analysis and modeling. Additionally, GCMRC recognizes the need to provide additional training opportunities in analytical techniques for GCMRC staff and cooperating scientists. The biometrician position will support this need by conducting workshops (4-5 days) on topics relevant to current statistical and modeling challenges faced by GCMRC staff and cooperating scientists. Recently identified topics include: basic probability models and likelihood based inference, occupancy rate estimation, capture-recapture models, hierarchical Bayes modeling, simulation techniques to inform study design, and ecosystem modeling using Ecopath/Ecosim models.

Strategic Science Questions

This project is a primary support project that provides study design and data analysis guidance to the projects, so provides secondary support to a number of SSQs. The role of the biometrician is to support GCMRC and cooperating scientists in developing greater certainty about their study designs and results, so it is anticipated that many SSQs will be addressed in this and future years. For example, the primary SSQs this project will support is:

> **SSQ 1-1:** To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the main stem, survival of young-of-year and juvenile stages in the main stem, or by changes in growth and maturation in the adult population as influenced by main stem conditions?

SSQ 1-2. Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile HBC to the adult population?

Information Needs Addressed

This project is a primary support project that provides study design and data analysis guidance to the projects, so provides secondary support to a number of information needs. As an example of the RINs most directly addressed by this project, in FY2010 task 1 below will support modeling to investigate patterns in native and nonnative fish population abundance and distribution allowing for comparison with various environmental factors. Other RINs about fish responses to environmental conditions that can be partially addressed with this modeling effort include the following:

RIN 2.2.8. What combination of dam release patterns and nonnative fish control facilitates successful spawning and recruitment of humpback chub in the Colorado River ecosystem?

RIN 2.4.2. Determine if suppression of nonnative predators and competitors increases native fish populations.

Methods and Tasks

Anticipated tasks for this project during FY2010 include:

- Assist in the development of Ecopath/Ecosim models for key reaches of the Colorado River associated with project PLAN 12.P1.10.
- Assist GCMRC fisheries biologist, cooperating scientists, and the biology program manager in evaluating implications to the ability to detect changes in fisheries resources associated with recommended changes to the fisheries monitoring program by the 2009 Fisheries Monitoring Protocol Evaluation Panel.
- Assist Arizona Game and Fish Department cooperating scientists in analyzing fisheries mechanical removal data from project BIO 2.R17.10 using hierarchical Bayes depletion models.
- Assist in study planning and analysis of PIT tag data collected from project BIO 2.R13.10.
- Assist with study design and analysis of fish capture-recapture data from the Nearshore Ecology Project (BIO 2.R15.10) to estimate fish abundance and occupancy rate among various habitat types.
- Assist with analysis of terrestrial, aquatic food base, or other data from AMP sponsored projects as needed.
- Conduct two or three approximately 5-day workshops on the following or related topics: basic probability models and likelihood-based inference, occupancy-rate estimation, capture-recapture models, hierarchical Bayes modeling, simulation techniques to inform study design, and ecosystem modeling using Ecopath/Ecosim models.

Anticipated tasks for this project during FY2011 include:

- Assist in the development of Ecopath/Ecosim models for key reaches of the Colorado River associated with project PLAN 12.P1.11.
- Assist Arizona Game and Fish Department cooperating scientists in analyzing fisheries mechanical removal data from project BIO 2.R17.10 using hierarchical Bayes depletion models.

- Assist in study planning and analysis of PIT tag data collected from project BIO 2.R13.10.
- Assist with study design and analysis of fish capture-recapture data from the Nearshore Ecology Project (BIO 2.R15.11) to estimate fish abundance and occupancy rate among various habitat types.
- Assist with analysis of terrestrial, food base, or other data from AMP sponsored projects as needed.
- Conduct two or three approximately 5 day workshops on the following or related topics: basic probability models and likelihood-based inference, occupancy-rate estimation, capture-recapture models, hierarchical Bayes modeling, simulation techniques to inform study design, and ecosystem modeling using Ecopath/Ecosim models.

Links/Relationships to Other Projects

This project is primarily a support project to the projects listed above.

Logistics

There are no logistical needs for this project.

Products/Reports

This project will contribute to and co-author, as appropriate, reports and manuscripts associated with the tasks above and other projects associated with Goals 1, 2, 4, and others as needed.

Budget

FY2010

DASA 12.D8.10	
Biometrics and General Analysis (FY2010–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	126,784
GCMRC Project Related Travel / Training (21% Burden)	3,000
GCMRC Operations / Supplies / Publishing (21% Burden)	7,275
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 137,059**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	28,782
Project Total (Gross)	**$ 165,841**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

DASA 12.D8.11	
Biometrics and General Analysis (FY2010–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	137,058
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 137,058**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	28,782
Project Total (Gross)	**$ 165,840**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

DASA 12.D9.10–11—Integrated Image Analysis and Change Detection

Start Date

October 2010

End Date

Ongoing

Principal Investigators

Philip A. Davis, U.S. Geological Survey, Western Mineral Resources Science Center; and Glenn Bennett, Paul Grams, Barbara Ralston, and Helen Fairley, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Colorado River ecosystem corridor between the forebay of Glen Canyon Dam and upper Lake Mead

Project Goals

The purpose of this project is to provide coordinated, comprehensive analyses of the remotely sensed data that were acquired in May 2009 to address a diverse set of monitoring and research questions. The primary data sets that will be analyzed consist of the 4-band digital images and a digital surface model (DSM) of elevation of the river corridor between Glen Canyon Dam and Lake Mead. The primary objectives of the analyses are to:

- produce a systemwide land cover map that depicts bare sand (and sandbars), cobble bars, debris fans, bedrock, cliff, and gross vegetation above the 8,000 cfs (the flow stage at which the data were acquired); these data depict shoreline habitats;
- produce a vegetation map up to the old high water zone at the community classification level or better;
- determine if the photogrammetric DSM provides a sufficient accuracy to examine volumetric change in the sandbars and, if so, determine those volumetric changes; and
- determine if changes in vegetation have affected established campsites.

All four of these objectives will include a temporal analysis of changes observed from such databases derived from similar airborne data acquired during FY2002, FY2005, and FY2009.

Additional project components consider other remotely sensed databases previously collected as aerial photographs or planned for collection as digital imagery or topography in FY2010. These components include:

- photogrammetric analyses of historical aerial photography – Deferred in FY2010
- detailed analyses of hyperspectral imagery – Deferred in FY2010
- evaluation of DSM and image data from FY2002, FY2005, and FY2009 as a remote sensing surrogate for ground surveys to determine and monitor campable area on a systemwide basis and to determine the effects of vegetation encroachment on campable area;
- analysis of historical aerial photography to determine pre- and post-dam erosion near selected archaeological sites; and

- analysis of historical aerial color-infrared photography to classify the vegetation within selected areas during allowable periods in order to extend temporal vegetation change analyses to be extended back in time.

There are few processing aspects of any particular remote-sensing data set that are considered standard and can be applied without some modification and judgment. The DASA Program will continue efforts to increase accuracy and precision of derived data set products. It is possible that the development of new algorithms and processing techniques needed to improve results and better meet program requirements may delay the delivery of the analysis

Need for Project

Remotely sensed data are essential to provide a robust tracking of the status of certain physical, biological, and cultural attributes of the CRE. Ground based monitoring provides detailed observations but is limited by the number of study sites, resulting in under sampling and poor ability to infer systemwide trends.

Monitoring Vegetation

To support analysis of the impacts of dam operations, climate, and meteorology on riparian vegetation, airborne image data collected in FY2009 will be used to update the vegetation map published in 2008 (Ralston and others, 2008) that was produced using FY2002 airborne image data. This analysis will address questions such as: What is the total gain or loss of riparian vegetation in the new and old high water zones relative to FY2002, FY2005, and FY2009? How are the gains or losses in vegetation represented among the vegetation classes within each hydrologic zone? What are the limitations of 4-band imagery on riparian vegetation monitoring? Can hyperspectral imagery provide vegetation classification at the community level, provide species compositions of classes, correctly classify woody and senescent vegetation as to their species, and map crytogamic soil?

Monitoring Sediment, Sandbars, and Shoreline Habitats

To support the analysis of impacts of dam operations, climate, and meteorology on the stability of sand deposits, especially different sediment deposits that provide wildlife habitats, airborne image and DSM data and historical aerial photographic imagery and derived topographic data will be used to evaluate cause-effect relations and to determine various protocols for mitigation of adverse effects, where possible.

Monitoring Campable Beaches

To support the analysis of impacts of dam operations, climate, and meteorology on campable beaches systemwide, airborne image and DSM data will be used to evaluate campsite quality (determined by surface area and slope), as well as the factors that have affected quality, such as vegetation encroachment, surface water and wind erosion of sand, dissection by erosional processes, etc.

Monitoring Archaeological Sites

To support the analysis of impacts of dam operations, climate, meteorology, and visitors on selected archaeological sites, high resolution airborne photography and photogrammetric derived from these imagery will be used to examine erosion rates and surface modifications within the pre-dam and post-dam eras. High-resolution LiDAR topography and imagery will be analyzed in order to monitor present day surface changes, causal processes, and mitigation efforts.

Strategic Science Questions

Riparian Vegetation

SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?

SSQ 4-2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of young-of-year (YoY) and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possible mortality of young humpback chub) associated with high flows?

SSQ 5-7. How do warmer releases affect viability and productivity of native/nonnative vegetation?

GCDAMP goal 6 is directed at the protection or improvement of riparian and spring communities. This goal is based on the recognition that the riparian and spring environments are hosts for some endangered species like the Southwestern willow flycatcher (*Empidonax traillii extimus*). The protection of these species' critical habitats is part of this goal. Riparian plant communities can be viewed at either a single resource level without ecosystem linkages, or at an integrative level where riparian vegetation is linked to aquatic and terrestrial ecosystem processes (for example, when it contributes to secondary production and cover). Riparian plant communities interact with cultural resources associated with recreation (for example, camping sites) and TCPs, or affects aeolian sand transport and possibly archaeological site erosion rates. Understanding how riparian vegetation responds to flows and affects other resources of concern forms a basis for managing critical resources like native fish, archaeological properties, and recreational resources.

Sandbar and Backwater Habitats

SSQ 3.1. Is there a "Flow-Only" operation (that is, a strategy for dam releases, including managing tributary inputs with HFEs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

SSQ 4.2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possibly mortality of young humpback chub) associated with high flows?

Campable Beaches

In terms of questions that are specific to the AMP goals for recreation, this project directly addresses the following SSQ:

SSQ 3-9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?

Because campsite size can affect visitor experience, this project also indirectly addresses two other important science questions related to recreation in the CRE:

SSQ 3-7. How do dam-controlled flows affect visitors' recreational experiences, and what is/are the optimal flows for maintaining a high-quality recreational experience in the CRE?

SSQ 3-8. What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes?

Archaeological Sites

This research and development project, and the future cultural monitoring program, is designed to addresses two primary SSQs:

> **SSQ 2-1.** Do dam-controlled flows affect (increase or decrease) rates of erosion, and vegetation growth, at archaeological sites and TCP sites in the CRE, and if so, how?
>
> **SSQ 2-4.** How effective are various treatments (e.g., check dams, vegetation management, etc.) in slowing rates of erosion at archaeological sites over the long term?

Other Science Questions

- What is the rate of change in eddy storage (erosion) during time intervals between high-flow tests?
- What are the most appropriate methods for detecting change in shoreline habitat along the entire CRE, given the available data sets collected using different technologies (scanned analog vs. digital), different platforms (Leica ADS-40/ISTAR vs. DMC/3001, Inc.), and different image resolutions (30 cm, 22 cm, or 18 cm)? What is the most appropriate scale/minimum mapping unit to map the shoreline habitat for all years in order to support related science questions?
- What level of change can be detected in shoreline habitat using remotely sensed data collected in the past 5 years? What changes have occurred to the shoreline habitat across the CRE in the past 5 years?
- Where have the most significant changes taken place in shoreline habitat along the CRE in the past 5 years, and within which shoreline habitat classes are the most noticeable changes seen? How does the shoreline habitat relate to backwater environments/habitats? What have changes in backwater abundance/size/shape occurred over the past 5 years?
- As historical analog overflights become available in digital format, can the timeline be extended back to previous years?

A time-series comparison of shoreline characteristics may prove quite useful for the following SSQ:

> **SSQ 1-7.** Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?

Information Needs Addressed

Riparian Vegetation

The primary information needs for riparian vegetation addressed by tasks within this project are CMINs 6.1.1., 6.2.1, 6.5.1, and 6.6.1, which are summarized as the following:

- Determine and track the abundance, composition, distribution, and area of terrestrial native and nonnative vegetation species in the CRE.
- Determine parameters and metrics to be measured, and the information needs that address each element.
- Determine how the abundance, composition, and distribution of the OHWZ, NHWZ, and sand beach community have changed since dam closure (1963), high flows (1984), interim flows (1991), and the implementation of ROD operations (RIN 6.2.1, 6.3.1, 6.4.1, 6.5.1, 6.5.2, 6.5.3).

These information needs will be addressed through the following actions:

- Semidecadal color infrared digital imagery mapping that quantifies (1) area change of dominant overstory species, (2) community composition and possibly changes in understory community composition through ground truthing associated with mapping, and (3) coarse primary productivity estimates for riparian vegetation.

Vegetation transects/grid surveys conducted at an appropriate frequency that correlate with river stage elevations of 15,000, 25,000, 35,000, 45,000, and 60,000 cubic feet per second. Quantifies cover, richness and diversity, and wetland species scores at each stage elevation. This work is most informative for herbaceous annuals and perennials, including invasive species. This component may incorporate marsh-monitoring needs of Tribes.

Sandbar and Backwater Habitats

IN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

CMIN 2.1.2 Determine and track recruitment (identify life stage), abundance and distribution of HBC in the LCR

CMIN 2.6.1 Determine and track the abundance and distribution of flannelmouth sucker, bluehead sucker, and speckled dace populations in the Colorado River ecosystem.

CMIN 8.2.1. Track, as appropriate, the biennial sandbar area, volume, and grain-size changes outside of eddies between 5,000 and 25,000 cfs stage, by reach.

CMIN 8.4.1. Track, as appropriate, the biennial or annual sandbar area, volume, and grain-size changes within eddies between 5,000 and 25,000 cfs stage, by reach.

EIN 6.4.1. How does the abundance, composition, and distribution of the sand beach community change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

Campable Beaches

This project directly addresses one part of the top priority CMIN for goal 9 (campsite size):

CMIN 9.3.1. Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons. (This project specifically addresses the part of the CMIN concerned with campsite size.)

This project partially addresses a second campsite CMIN (9.3.2) that is closely related to the top-priority CMIN for camping beaches (Note: The Science Planning Group of the TWG recommended that-CMINs 9.3.1 and 9.3.2 be combined as one):

CMIN 9.3.2. Determine and track the effects of ROD operations on the size, quality, and distribution of camping beaches in the CRE.

This monitoring project also contributes to tracking the long-term effects of the FY2008 experimental flow on camping beaches (campable area), as defined by EIN 9.3.1:

EIN 9.3.1. How do the size, quality, and distribution of camping beaches change in response to an experiment performed under the ROD, unanticipated event, or other management action?

Archaeological Sites

This project is a research and development effort aimed at addressing the highest priority CMIN for historic properties (as revised by the CRAHG and SPG in fall 2005), specifically, the properties known as archaeological sites:

> **CMIN 11.1.1 (**SPG revised**).** Determine the condition and integrity of prehistoric and historic sites in the CRE through tracking rates of erosion, visitor impacts, and other relevant variables. Determine the condition and integrity of TCPs in the CRE.

This project also directly addresses EIN 11.1 (formerly CMIN 11.1.2 of the GCDAMP Strategic Plan renumbered by CRAHG/SPG as EIN 11.1):

- **EIN 11.1.** Determine the efficacy of treatments for mitigation of adverse effects to historic properties.

This project also addresses an AMP research IN (no number) (formerly identified as CMIN 11.1.4 in the GCDAMP Strategic Plan):

- How effective is monitoring, what are the appropriate strategies to capture change at an archaeological site—qualitative, quantitative?

Methods and Tasks

FY2010

Monitoring Systemwide Trends in Subaerial Sandbar Area (Lead Scientist – P. Grams)

Annual or biennial monitoring of approximately 45 sandbars (PHY 8.M2.10–11) provides monitoring information on the area and volume of sand for these long-term study sites, many of which are also important recreation sites. The ground based monitoring does not, however, adequately sample the over 2,000 sandbars that have been identified by analysis of the FY2002 and FY2005 overflight images. This project will analyze the FY2009 overflight images to provide long-term monitoring of exposed sand above the 8,000 cfs stage throughout the CRE. This project will also provide an updated shoreline habitat classification based on the 2009 images. The updated shoreline habitat classification will be used by the nearshore ecology project to assist in associating fish capture data with physical habitat characteristics.

The images will first be analyzed to classify the extent of sand and vegetation (discussed below) using methods developed to classify the FY2002 and FY2005 images. The sand classification uses image-processing algorithms that rely on roughness and brightness characteristics to distinguish sand from other surface material (Gushue and others, in press). Following these automated routines, sand areas are manually inspected for error and consistency. More stable features such as bedrock, talus, and debris fans will not be reclassified but will be inspected. The updated shoreline habitat classification will require updating the modeled shorelines for a range of discharges. This will be accomplished using existing modeled water-surface elevations (Magirl and others, 2008) and the May 2009 digital elevation model that will be provided by the contractors responsible for the collection and processing of the FY2009 overflight data.

This project will result in:

- digital surficial geologic maps showing areas of sand and other map units,
- updated “virtual” shorelines based on the May 2009 digital elevation model,
- updated shoreline habitat classification for a range of discharges, and

- a peer reviewed report or journal article describing the results.

Monitoring Systemwide Trends in Vegetation (Lead Scientist – B. Ralston)

This task will use the FY2009 airborne imagery to classify all vegetation up to the old-high-water flow stage to at least the association level. This classification will use the 4-band reflectance data and vegetation texture (derived from a statistical analysis of the near-infrared band imagery) and the same classification methods established for and performed on the FY2002 image data. The FY2009 image data should be better than previous imagery, thus improved (more detailed) vegetation compositional data may be derived from this analysis. This analysis may be completed in FY2010. When completed, the biological program will perform change detection analyses within FY2011, which should provide insights into systemwide vegetation changes at the association level. The FY2009 vegetation map database will be published as a USGS Digital Data Series.

Analysis of Historical Aerial Photographs to Determine 1984 Sandbar Topography (Lead Scientist – P. Grams)

Deferred in FY2010

Evaluation of Airborne DSM and Imagery Data as a Surrogate for Ground-based Surveys to Calculate Campable Area on a Systemwide Basis (Lead Scientist – H. Fairley)

Campable area is defined as an open, smooth substrate measuring at least 1x2 m with a slope of less than 8 degrees. Changes in campable area in the CRE are currently being monitored as part of the NAU long-term sandbar monitoring project. However, this sampling is limited in scope due to logistical issues. This task will explore the feasibility of using the systemwide airborne DSM data, in combination with its imagery, to define campable area throughout the entire CRE, in lieu of or in addition to repeat ground surveys. The initial analysis will be conducted between river miles 30 and 50 where there are multiple campable areas with FY2009 ground survey data. In FY2010, DASA will provide the initial bare sand land-cover map and the slope map generated from the DSM derived from the FY2009 airborne data collection. If the remote sensing results show a strong correlation with the survey data, campable area will then be calculated for the system as a whole using the remotely sensed data by the cultural program, but their systemwide analysis will probably be performed in FY2011, when the systemwide land-cover database is completed. Cultural resources personnel will publish results.

Digital Analysis of Historical Aerial Photography to Determine Erosion Near Archaeological Sites within the Pre- and Postdam Era (Lead Scientist – H. Fairley)

Erosion of archaeological sites is ongoing in the CRE, but rates of erosion are hypothesized to have increased under post-dam conditions, due to a variety of factors, but this is just a hypothesis at this time. The purpose of this task is to evaluate whether scanned aerial photography from the pre-dam and post-dam eras can be georectified with sufficient accuracy to determine and quantify areal changes due to gully erosion and also potentially to determine the volume of material that has been removed from specific areas between 1935–65 and 1966–96. DASA will provide the initial georectification products and with acceptable results will transfer that technology to the cultural program for application. In FY2010, a pilot study will be conducted to evaluate the areal accuracy provided by georectification of scanned aerial photographs for a few selected areas in the CRE with known archaeological site concentrations. If these results provide acceptable accuracy, further rectification will then be performed on other areas to determine where change has occurred and quantify its type and area. Cultural resources personnel will publish results.

Methods and Tasks

FY2011

Evaluation of FY2009 Airborne Photogrammetric Elevation Data to Detect Systemwide Trends in Sandbar Elevation (Lead Scientist – P. Grams)

The project for high elevation sandbar monitoring, described above, uses established methods to monitor trends in sand area. It is known that significant changes in sandbar volume can occur while area does not change significantly (Hazel and others, 1999), which can affect the utility of sandbars as campsites or habitats. The purpose of this task is to evaluate the feasibility of monitoring sandbar elevation and volume changes throughout the CRE using remotely sensed data. The FY2009 airborne data collection provides a DSM (elevation model) derived by digital photogrammetric methods. If the DSM meets our requested 30-cm vertical accuracy, this task will use that DSM to evaluate its potential for monitoring systemwide changes in sand elevation. This analysis will use the ground-based measurements of sandbar topography made immediately before the May 2009 overflight as a basis for the evaluation. This project will result in topographic maps of sand areas system wide and an annual report. Our FY2002 DSM has a vertical accuracy of 25 cm; if the FY2009 DSM has similar or better accuracy, we will perform systemwide sand elevation change detection within this 7-year interval, and will produce a peer reviewed report or journal article.

Analysis of Historical Aerial Photographs to Determine 1984 Sandbar Topography (Lead Scientist – P. Grams)

Deferred in FY2011

Analysis of Hyperspectral Imagery for Improved Vegetation Mapping and Monitoring (Lead Scientist – B. Ralston)

Deferred in FY2011

Analysis of Historical Aerial Photography to Determine Vegetation Changes Since 1980s (Lead Scientist – B. Ralston)

GCMRC has 1988 color-infrared photographic film at a scale of 1:4,800 (7 cm resolution) for the entire CRE, which is the oldest image data useful for mapping vegetation. These data will be visually examined relative to FY2002 and FY2009 imagery to determine areas with large diverse vegetation patches where there has been both notable change and little to no change. Currently, there are about 50 large vegetation patches within the Canyon; such patches may have been more or less abundant or in different locations in 1988. The 1988 analog photographs that cover these selected areas will be digitally scanned, georectified to FY2002/2009 image data, and classified, similar to the FY2002 and FY2009 digital imagery, to produce a 1988 vegetation maps of the areas. Change analyses will be performed in order to determine what changed, the areal amount, and possible causes. The registered digital data will be stored in the GCMRC archives and the results of the investigation will be published within the USGS or in a journal.

Digital Analysis of Historical Aerial Photography to Determine Erosion Near Archaeological Sites within the Pre- and Postdam Era (Lead Scientist – H. Fairley)

In FY2011, the sites shown to have areal change will be examined by the stereo photogrammetric method developed in a previous task in an attempt to quantify volumetric change. If successful, this technique would then be applied to a larger portion of the river corridor as part of a future analysis to compare pre-dam erosion rates to post-dam erosion rates. DASA will provide the initial photogrammetric tests in FY2011, and will then transfer the technology to the cultural program for application and for reporting their results.

Investigation of How Changes in Vegetation have Affected Campable Areas (Lead Scientist – H. Fairley)

According to analysis of long-term monitoring data collected by NAU, campable area is declining faster than sandbar area, suggesting that factors other than sandbar erosion are contributing to loss of campable area in the CRE. Researchers have speculated that the loss of campable area may be due in large measure to vegetation encroachment (Kaplinski and others, 2005), but reliable, objective data to support or refute this assumption is currently lacking. The goal of this analysis is to compare vegetated areas in FY2002, FY2005, and FY2009 aerial imagery at a random sample of campsite areas identified in the GIS campsite atlas and calculate the amount of vegetated area change within each campsite polygon and within the sample as a whole from one year to the next. We will also compare changes in campable area calculated by NAU using total station surveys at long-term sandbar/campsite sites with changes in vegetated areas in the aerial imagery. Oblique photo records will also be analyzed to supplement analyses using aerial digital imagery. Cultural resources personnel will report the findings.

Links/Relationships to Other Projects

A number of projects in the past few years have used the shoreline habitat data developed from the March 2000 imagery data set. Shoreline habitat type has been used in conjunction with native and nonnative downstream fish sampling in the mainstem of the Colorado River, and it has also been used as a guide to delineate sampling sites of redds in Glen and Marble Canyons. Similarly, these data are currently being incorporated into the new aquatic food base initiative at the GCMRC. This layer has also been applied to studies of the terrestrial environment, including the vegetation mapping project and initial campsite monitoring efforts conducted over the past 2 years. It is expected that new, more recent classifications will be used in similar fashion for future analysis. With newer tools, it may be possible to more closely relate habitat availability with catch rates. In the sediment realm, reworking previously collected multibeam data to align with the current GCMRC control network will allow for change detection in upper Marble Canyon in FY2010.

Products/Reports

FY2010

- Digital land-cover maps based on the FY2009 data showing sand units, gross vegetation, and other map units will be published as a USGS Digital Data Series and the subsequent temporal change results will be published as a journal article.
- Updated “virtual” shorelines based on the May 2009 digital elevation model will be produced and placed on the ArcGIS Server.
- Updated shoreline habitat classification for a range of discharges will be published as a USGS Open-File Report.
- The FY2009 vegetation map database derived from the FY2009 image data will be published as a USGS Digital Data Series and Open-File Report, along with subsequent temporal change analysis using the FY2002 vegetation map. Digital elevation models using digitally scanned 1984 stereo photographs and results from our evaluations of the results will be reported in an annual report and included in a peer reviewed report or journal article
- Published USGS report or journal article on the use of remote sensing data to determine campsite suitability and its changes over time.
- Published USGS report on the use of historical aerial photography and contemporary airborne digital imagery to detect surficial changes within archaeological sites. All data sets are proposed to be served through an instance of Environmental Systems Research Institute (ESRI) ArcGIS Server.

FY2011

- Topographic maps produced from the FY2009 image data will be published as a USGS Digital Data Series and in an annual report. Results from our systemwide sand elevation change detection between FY2002 and FY2009 will be published in a peer reviewed report or journal article.
- Results from our integrated, long-term topographic analyses for sandbars will be included in an annual report and in a peer reviewed report or journal article produced in cooperation with project PHY 8.M2.10–11.
- The results of the hyperspectral data analysis – Deferred in FY2011
- The registered digital data produced from 1988 aerial photography for historical vegetation analysis will be stored in the GCMRC archives and the results of the vegetation change investigation will be published within the USGS or in a journal article.
- Published USGS report or journal articles describing long-term surficial and volumetric changes within archaeological sites.
- Published USGS report on the observed effects of vegetation encroachment on campable area over time.
- All data sets that have cleared USGS Fundamental Science Practices review and approval are proposed to be served through an instance of Environmental Systems Research Institute (ESRI) ArcGIS Server.

Budget

FY2010

DASA 12.D9.10	
Integrated Image Analysis and Change Detection (FY2010–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	87,231
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	121,712
Project Subtotal	**$ 208,943**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	25,731
Project Total (Gross)	**$ 234,674**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	58.3%

FY2011

DASA 12.D9.11	
Integrated Image Analysis and Change Detection (FY2010–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	89,761
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	129,014
Project Subtotal	**$ 218,775**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	26,707
Project Total (Gross)	**$ 245,482**
Percent Outsourced (Outside of GCMRC; includes 50% of	59.0%

Logistics)	

PLAN 12.P1.10–11— Support and Enhancement of Ecosystem Modeling Efforts

Start Date

August 2008

End Date

December 2011

Principal Investigators

Carl Walters, University of British Columbia
CO-I(s): Scott Wright, U.S. Geological Survey, California Water Science Center, William Pine, University of Florida, Karen Limburg, University of New York, Syracuse (SUNY), Robert Hall, University of Wyoming, Emma Rossi-Marshall, Loyola University, Colden Baxter, Idaho State University, Josh Korman, Ecometric Research, Inc.; Lew Coggins, Ted Kennedy, Kara Hilwig and Mike Yard, U.S. Geological Survey Grand Canyon Monitoring and Research Center, Dale Robertson, U.S. Geological Survey, Wisconsin Water Science Center

Geographic Scope

Continued research and decision support for review, revision, upgrade and use of various ecosystem models in collaboration with Senior Ecologist and other cooperators; Includes additional support from GCMRC staff, Senior Ecologist, and select cooperators

Entire Grand Canyon Monitoring and Research Center study area, from the forebay of Lake Powell to upper Lake Mead. During FY2010–11, the work will focus mainly in the Lees Ferry and LCR confluence reaches of the Colorado River, where current aquatic ecosystem values and monitoring (rainbow trout, native fish) are concentrated. Some monitoring evaluations and data analysis will extend from GCD to Lake Mead, especially to evaluate longitudinal changes in aquatic system productivity and carrying capacity for native fish.

Project Goals

The main aim of this project will be to provide advisory assistance to GCMRC scientists and cooperators on data analysis methods and integration of physical and biological research data into models for response of aquatic ecosystem indicator variables to possible management actions. The goal of such modeling is to provide screening of alternative adaptive management proposals for improving responses of performance indicators such as abundance of humpback chub. These models are likely to be developed in an Ecopath/Ecosim platform, but other methods may be employed.

A secondary objective of the Senior Ecologist will be to assist GCMRC scientists and cooperators in communicating research results and quantitative modeling analyses to each other and to GCDAMP stakeholders (TWG, AMWG), via structured workshops that use advanced ecosystem modeling as a means to enhance communication and explore policy options. Emphasis in this phase of the research (FY2009–11) remains focused on the aquatic elements of the CRE below GCD (primarily, GCDAMP goals #1 through 4 and 7–8).

During FY2010, the flow and sediment submodel of the existing Grand Canyon Ecosystem Model (GCEM) shall be fully revised to include a new shifting rating curve for suspended sand transport (routing of Paria and Little Colorado Rivers sand inputs downstream through current monitoring reaches upstream of Lake Mead) by Wright and Korman. This 1-dimensional sand routing model will

result in a 20-year-long hind cast simulation (1989 to 2009) of suspended sediment concentrations that will then be made available to the Ecopath/Ecosim modeling team of Walters and others for their use.

Need for Project

While a variety of experimental management policies have been implemented in recent years, analysis and communication of results and responses of indicators to policies have not been completed. More complete analysis and subsequent communication of the results of analysis (including modeling) will allow more effective selection of further experimental tests. For example, the LSSF flow experiment of summer 2000 was not fully evaluated until 2008, and likewise there have not been definitive reviews of all high-flow experimental results (1996 to 2008) or the effects of mechanical removal of nonnative fish, although the synthesis of flow tests and nonnative control analyses are now forthcoming. Such analyses have been hampered by confounding of multiple factors in causing changes (for example, temperature changes have made it hard to interpret fish responses to mechanical removal). Modeling tools provided by the Senior Ecologist (Walters) can help to at least clarify alternative hypotheses about the possible roles and relative importance of the factors.

Additional advancement of the flow and sediment elements of the existing GCEM is also planned as an additional element of the new Integrated Flow, Sediment, and Temperature Modeling research project (Wright and others in collaboration with Korman and Walters) as a further means of assessing fine sediment dynamics associated with various stakeholder planning needs and associated tasks tied to developing desired future conditions for GCDAMP goals.

Strategic Science Questions

The ecological modeling efforts will be directed at addressing priority AMWG questions, SSQs, and additional science questions (SAs) - provided by the Science Advisors (SA) in the integrated modeling efforts, as follows:

Abundance trends of rainbow trout in the Lees Ferry reach:

> **SSQ 1-4.** Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action?

This question also applies to future removal programs targeting other nonnative species.

> **SSQ 1-8.** How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

Abundance trends in native fish below the Lees Ferry reach:

> **SSQ 1-1.** To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?
>
> **SA 1.** What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on young of year and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?
>
> **SA 2.** What are the most probably positive and negative impacts of warming the Colorado River on humpback chub adults and juveniles?]

Linkages between (productivity) food web changes and fish population changes:

> **SSQ 3-5.** How is invertebrate flux affected by water quality (for example, temperature, nutrient concentrations, turbidity) and dam operations?

SA 1. What are the most limiting factors to successful HBC adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

Responses of native fish to mechanical removal of nonnative fish, fall steady flows, and backwaters created by experimental high flows:

SSQ 1-2. Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile HBC to the adult population?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

Using the new shifting rating curve method for routing suspended sand through the CRE, the project will produced advanced simulations for flow operations at Glen Canyon Dam and fate of tributary supplied sand inputs:

SSQ 4-1. Is there a "Flow Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will rebuild and maintain sandbar habitats over decadal timescales?

Note: Results from element 5, will integrate suspended-sediment simulations with aquatic/fish simulations within the Ecopath/Ecosim modeling being developed by Walters and others.

Methods and Tasks

FY2010

1. Senior Ecologist (Walters) will lead in development of individual-based simulation model (IBM) for native fish in Grand Canyon, for use in evaluation of mark-recapture population estimation methods and prediction of responses to experimental management policies. An early version of this model was developed in FY2009 to evaluate apparent retrospective biases in assessment of HBC abundances. The program will be further developed to represent other native fish (flannelmouth sucker, bluehead sucker) and for simulation of recent changes in tagging protocols that should allow earlier assessment of recruitment responses to management actions.
2. Senior Ecologist (Walters) will lead fisheries team (GCMRC fish biologist and Biometrician (Coggins)) in advanced development of stock assessment for native suckers (flannelmouth, bluehead) in Grand Canyon to complement existing assessments for HBC and to provide more accurate abundance trends for use in testing ecosystem models that represent competition and predation interactions among native and nonnative fish. This will involve working with GCMRC scientists to develop ASMR models using the sucker data, and analysis of historical length-frequency data to provide growth curve inputs for the ASMR back-calculation of age at tagging.
3. Senior Ecologist (Walters) will lead in development and testing of Ecopath/Ecosim (EwE) models for food web interactions in the aquatic communities of the Lees Ferry and Little Colorado reaches of Grand Canyon. This will involve continued development and fitting to historical abundance trend data of EwE models developed during FY2009 in cooperation with GCMRC scientists. Model parameter estimates will be refined using information provided by GCMRC cooperators, and formal parameter estimation procedures will be applied to estimate key production parameters by fitting the models to historical fish population trend data for 1990–2009.

4. Senior Ecologist (Walters) will lead in use of the GCEM ecosystem model to reconstruct historical changes in the Colorado River food base for native and nonnative fish, associated with changes in diurnal flow regimes and turbidity conditions caused by tributary sediment inputs. The EwE food web models in task 3 above need to be fitted to historical abundance trend data, and that model fitting will be misleading unless the EwE models are provided with realistic time forcing data on past changes in primary and secondary (insect, amphipod) production owing to change in turbidity. The GCEM model will be run with historical tributary sediment inputs, along with refined estimates of regrowth rates of primary producers following periods of low productivity due to high turbidity, to provide monthly estimates for 1990–2009 of food biomass likely to have been available to native and nonnative fish in reaches of Grand Canyon near and below the LCR.
5. Ongoing collaboration with University of Florida and University of New York at Syracuse – Evaluation of pilot study results from flannelmouth sucker otolith analyses resulting from cooperative research with University of Florida and SUNY (Pine and Limburg). This task will employ geochemical signatures in water and native fish otoliths to infer natal origin, tributary habitat use, and migration patterns. The project will conduct pilot analyses of flannelmouth sucker otoliths and water samples collected in FY2008. Preliminary analyses of the water samples suggest promising uniqueness among Colorado River tributaries for describing patterns in flannelmouth sucker otoliths associated with ontogenetic shifts in tributary versus Colorado River occupancy. If these pilot analyses are fruitful, additional analyses with HBC otoliths are possible to better understand changes in HBC rearing habitat and tributary use. One use of the knowledge gained in pursuit of this task will be to better parameterize and justify relationships imbedded in aquatic ecosystem models (for example, Ecopath/Ecosim) that describe ontogenetic shifts in native fish use of tributaries during early life history stanzas. This effort is tied in with the next task also.
6. Senior Ecologist (Walters) will participate in field work and analysis of the Nearshore Ecology (NSE) project with objective of troubleshooting field methods and data analysis procedures, with particular emphasis on assessment of changes in native fish dispersal and survival rates in relation to changes from fluctuating to fall steady flows.
7. Senior Ecologist (Walters) will participate in high-flow experimental synthesis reporting as advisor and possibly co-author on biological outcomes report.
8. Cooperators (Wright and Korman) will collaborate with Senior Ecologist (Walters) and GCMRC to further develop physical submodel element (sand routing) of the GCEM to include use of updated Colorado River Basin hydrology and shifting rating curve algorithm.

FY2011

- Similar to those associated with FY2010 (tasks 1 through 7 will continue into FY2011, while task 8 is to be concluded in FY2010).

Links/Relationships to Other Projects

This project will uses data from all studies that collect information on the aquatic biota of Glen, Marble, and Grand Canyons, including the aquatic food web, HBC monitoring, Lees Ferry trout monitoring, mechanical removal, nonnative fish monitoring, and the NSE project. The main benefits to the projects listed will be to provide novel analyses of data and methods for linking project results into overall conceptual and quantitative models for response of the Colorado River aquatic ecosystem to management changes. The flow and sediment modeling elements of this project are linked most closely to the Integrated Flow, Sediment, and Temperature Modeling project.

Logistics

There are no logistical needs for this project

Products/Reports

FY2010

- ChubIBM.exe computer program, narrative review for GCMRC fish scientists on probable biases and precision of future population estimates (Walters and others).
- Spreadsheets for use by GCMRC scientists in checking ASMR results from existing assessment programs, stock assessment report providing abundance trend estimates for sucker species (Walters and others).
- Revised flow and suspended-sediment submodel of the GCEM, including the recently innovated "shifting rating curve" for sand transport that will be reported by Wright and others (manuscript currently in preparation). This work is being integrated with ongoing modeling research funded in FY2010 (Wright and Korman).
- Ecopath/Ecosim (EwE) Access database (mdb) with improved models and historical forcing data, including forcing time series data from updated GCEM, narrative report sections for use by GCMRC scientists in preparation of peer-reviewed papers on findings from the EwE models and GCEM/EwE model linkage (Walters and others).
- Senior Ecologist (Walters) will lead a science workshop for GCMRC scientists and cooperators in February/March 2010 to evaluate ecosystem model performance and produce a consensus scientific report on role of trophic interactions (food base changes, predator-prey interactions) in causing recent changes in native and nonnative fish abundances.
- Oral presentation (Walters) of the consensus ecosystem response report in a workshop/retreat for GCDAMP stakeholders (TWG, AMWG) in April 2010 (proposed venue - Saguaro Lake Ranch, Ariz).
- Oral presentation (Wright and Korman) to TWG on progress of physical submodel upgrade (shifting sand rating curve model), along with simulations of suspended-sediment concentrations between Lees Ferry and Diamond Creek (output delivered to Walters for use in Ecopath/Ecosim model) during fall/winter 2009–10.
- Results of isotopic analyses of flannelmouth sucker otoliths from Limburg's SUNY laboratory.

FY2011

- Submission of refereed journal article with Josh Korman on "Surprise and opportunity in Grand Canyon ecosystem management"
- Contributions by Senior Ecologist and co-investigators to the high-flow experimental synthesis (proposed as report by Schmidt and others) relating to the sediment and biological responses associated with the 1996, 2004 and 2008 experimental releases.
- Multi-attribute tradeoff analysis (MATA) workshop deferred in FY2011

Budgets

FY2010

PLAN 12.P1.10	
Support and Enhancement of Ecosystem Modeling Efforts (FY2008–12)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	97,454
GCMRC Project Related Travel / Training (21% Burden)	36,000
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	74,000
Project Subtotal	**$ 207,454**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	32,532
Project Total (Gross)	**$ 239,986**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	35.7%

FY2011

PLAN 12.P1.11	
Support and Enhancement of Ecosystem Modeling Efforts (FY2008–12)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	79,256
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	50,000
Project Subtotal	**$ 129,256**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	19,689
Project Total (Gross)	**$ 148,945**
Percent Outsourced (Outside of GCMRC; includes 50% of	38.7%

Logistics)	

PLAN 12.P3.10—Low Steady Summer Flows Data and Research Compilation, Synopsis, and Synthesis

Start Date

2008

End Date

July 2010

Principal Investigator

Barbara E. Ralston, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Colorado River ecosystem corridor from forebay of Glen Canyon Dam to upper Lake Mead

Project Goals

The overall goal of this project is to develop a synthesis of the effects of the FY2000 low steady summer flow (LSSF) experiment on the CRE in Grand Canyon. The four phases we will employ to achieve the goal are:

- Phase I. Status of reports/data and synopsis. Identify data and products associated with the FY2000 LSSF experiment; synopsize the results of the individual projects. This synopsis was completed in the summer of 2008 and was provided to workshop participants.
- Phase II. Data evaluation and identification of secondary analyses. Evaluate individual data sets and provide recommendations for further analysis and/or integration of resource responses to operations. Two workshops were conducted in FY2008 to gather input from original investigators and external reviewers.
- Phase III. Synthesis. Use integrated analysis results to develop a synthesis of the effects of the FY2000 LSSF Experiment on the CRE. A draft of this document will be completed in FY2009.
- Phase IV. Publication. Publication of secondary analysis in a special volume of a journal or USGS circular or other publishing source. This phase will be completed in FY2010.

The project outcome is intended to provide managers, and others interested in resource management, with information about how multiple resources respond to a series of flows that varied in duration from several days to several months and in magnitude from 8,000 cubic feet per second (cfs) to 31,000 cfs.

Need for Project

In August 2007, the GCDAMP AMWG identified the need to produce a summary document of the effects of the LSSF experiment (implemented in spring and summer 2000) on resources. The managers requested this summary project so that the results could be used to implement long-term experiments associated with the GCDAMP for GCD.

The data collected in association with the FY2000 experiment were in the areas of sediment transport and storage, mainstem and shoreline water temperature, small-bodied fish sampling, long-term monitoring methods development for fish, vegetation change, and recreational aspects of the varied flows. To date, several of the data collection efforts have resulted in data reports or journal publications, while other projects remain incomplete, lacking a final report. A unifying document regarding the flow experiment investigations has been lacking to date due to other funding and administrative priorities (for example, fish removal experiments, long-term planning documents). The lack of such a document may be perceived as an impediment to learning and applying this knowledge in an adaptive management setting. It is for this reason that a summary document is being proposed that synopsizes individual resource response and considers collective resource responses within an ecosystem framework to create a subsequent synthesis.

Strategic Science Questions

The LSSF experiment was expected to affect, and possibly show benefit to, multiple resources in the CRE. Similarly, there are multiple SSQs, developed as guidance for GCMRC after the LSSF, that pertain to the flow experiment. The summary project will investigate whether, and to what degree, these SSQs were addressed by the FY2000 LSSF experiment. Those SSQs most pertinent to the LSSF experiment are listed below.

SSQ 4-1. Is there a "Flow-Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

SSQ 4-2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possibly mortality of young humpback chub) associated with high flows?

SSQ 1-7. Which tributary and mainstem habitats are most important to native fish and how can these habitats best be made useable and maintained?

SSQ 2-1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?

SSQ 3-9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?

Information Needs Addressed

Information needs that pertain to work done during the LSSF are focused on experimental information needs for each resource. Specific information needs that focus on adaptive management and that are pertinent to the proposed project are the following:

IN 12.1. Develop information that can be used by the TWG, in collaboration with the GCMRC, to establish current and target levels for all resources within the GCDAMP as called for in the GCDAMP strategic plan.

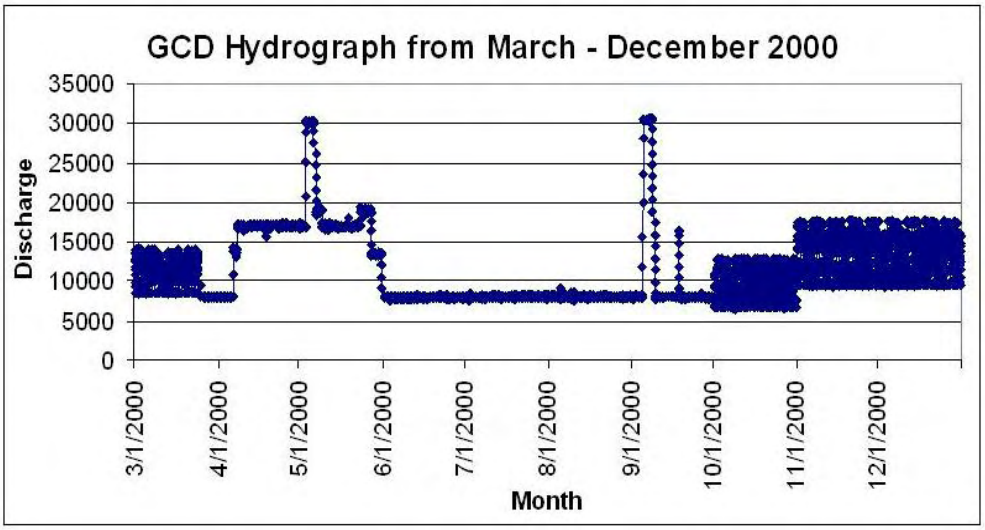
RIN 12.3.1. As necessary, investigate the most effective methods to integrate and synthesize resource data.

Methods and Tasks

As a part of the 1995 Biological Opinion on the Operations of the Glen Canyon Dam (USFWS, 1995), the USFWS described reasonable and prudent alternatives (RPAs). One element of the RPAs directed Reclamation to develop and test a program of steady flows under minimum hydrologic conditions. The intention of these experimental releases was to move toward the removal of the jeopardy opinion for HBC in the CRE.

A plan of flows developed by SWCA Environmental Consultants, Inc. (SWCA, 2000) intended to address 1995 USFWS reasonable and prudent alternatives to the biological opinion (USFWS, 1995). The plan incorporated high steady spring flows and low summer steady flows and divided the flows into three time periods: March–May (high flows of 21,000 cfs with a 31,000-cfs spike), June–September (steady flows of 8,000 cfs, ending with a 31,000-cfs spike), and October–February (8,000-cfs flows). The flows that were implemented in spring 2000 were slightly different in that the high flows in the spring were a slightly lower discharge of 17,500 cfs rather than 21,000 cfs, and the duration of the flows was shorter by approximately a month in the beginning and by 5 months in the end, ending in September rather than February (figure 5).

Figure 5. Hydrograph from March–December 2000 including discharge pattern associated with the LSSF experiment.



Data collected around these flows focused on physical resources (sediment, water temperature), biological resources (aquatic productivity, fisheries, vegetation), and cultural resources (recreation, economics). SWCA (2000) provided some hypotheses regarding the benefits and risks to abiotic and biotic resources relative to each flow period (table 8). These hypotheses form the basis for data consolidation, synopsis, and subsequent synthesis.

Table 8. Hypothesized effects of flows on physical and biological resources.

Benefits/risks to resources	Period I: March–May	Period II: June–September	Period III: October–February
Benefit to physical resources/ habitat	• Scouring backwaters • May spike flow to mobilize and store sands and sediment	• Storing of sand and sediment in river channel • Expansion of campable beach area • September spike flow • Resuspension, storing of sand from summer tributary inputs	
Risks to physical resources/ habitat	Export of sediment, reduction of campsite areas	September spike flow, export of sand and sediment instead of storing it	No significant risks
Benefits to biotic resources	• Ponded tributary inflows as thermal refuges for drifting larvae and young fish • Ponded tributary inflows ease access for spawning native fish • Destabilizing of habitats to disadvantage nonnatives • Redistribution of nutrients • Resetting of community production • Spike flows to flush nonnative fish from nearshore habitats	• Increased growth and survival of young native fish • Increased autotrophic algal and macroinvertebrate production • Possible mainstem hatching success • Spike flows to flush nonnatives fish from nearshore habitats	• Increased survival of young native fish • Maintenance of stable winter conditions to minimize energy expenditure • Maintenance of overwinter autotrophic production in mainstem, shorelines, backwaters
Risk to biotic resources	Attraction of nonnative fish predators/competitors to ponded tributaries	• Mainstem reproduction by nonnative fish • Increased growth and survival of nonnative fish • Increased infestation of parasites and diseases • Decreased drift of food for fish • Minimized thermal plume at 30-mile may reduce survival of young HBC • Increased water clarity leading to increased predation of	• Possible overwinter survival and expansion of nonnative fish • Possible greater spawning success of downstream populations of trout • Increased predation by sight feeders • Decreased drift of food for fish

		native fish by sight predators	

Status of Project

Phase I. Status of reports/data and synopsis (FY2008)

- Identification of studies in LSSF plan—Completed studies and metadata regarding overflights conducted throughout the period of March through September provided in a summary document. The document described the scope of each completed study and includes the authors' recommendations for subsequent analysis. Draft provided in June 2008. Synopsis to be included in final synthesis report.
- Determination of location of data and other deliverables—call principal investigators (PIs) to determine status of project, location of data, and identification of any work that was not done and/or cannot be done and consolidating data. Completed in conjunction with summary document.

Phase II. Data evaluation and identification of secondary analyses (FY2008–09)

- Convened two workshops (August 2008 and October 2008) to evaluate possibility of subsequent analysis among studies. Workshop composed of LSSF PIs, GCMRC staff, ecosystem scientist, science advisors, and other resource specific experts. Natural resource managers attended to offer their perspectives on relating science information to management needs. The August 2008 workshop focused on biological and physical resources and the October 2008 workshop focused on social sciences.
- Identification of potential secondary analyses of data including incorporating more recent monitoring and research data to provide longer term analyses of effects.
- Presented findings/recommendations to AMWG in September 2008 for FY2009 work plan.
- Limited funding and a need to expedite the process resulted in GCMRC taking the lead in synthesis.

Phase III. Synthesis (FY2009–10, 15 months)

- The 2008 workshops resulted in only limited recommendations for additional analyses. The investigators agreed to provide the reports and data originally collected, and GCMRC determined to synthesize as much of the existing data as possible, anticipating that the collected results from the finalized projects could comprise a single peer reviewed volume or USGS circular publication. These results would also be incorporated in the 5-year SCORE report scheduled in FY2011.

Phase IV. Publication (FY2010, 3 months)

- In coordination with editing staff at the GCMRC/SBSC, complete publication of manuscripts in target journal or circular.

Links/Relationships to Other Projects

Because much of the biological data collected in FY2000, in association with the LSSF, represent a single growing season or single cohort, data from subsequent years could be used to understand the effects of conditions in a single year on recruitment signals or species compositions in subsequent surveys. These LSSF data would be linked to monitoring data from fisheries and vegetation collected since FY2000. Following single cohorts of endangered fish can be problematic, however, given the

already low numbers of individuals within the population and observing a recruitment signal from a single summer treatment may be an unrealistic expectation.

The sediment response throughout the duration of the project can be incorporated into the current shoreline study project to understand the relationship of reworking eddy sand supply and available shoreline habitats through remote-sensing analysis. In the same vein, water temperature data collected in FY2000 is applicable to current water temperature modeling efforts for shoreline habitats. Lastly, recreational aspects associated with downstream travel and visitation could be interpreted under the current Colorado River Management Plan to determine how similar flows, if they occur in the future, might affect recreational experiences.

Products/Reports

- Phase I. Synopses of individual project, metadata, background information about LSSF was completed in July 2008 and provided to participants in the workshops of August and October 2008
- Phase II. Workshops to discuss data from and results of original investigations were conducted in August and October 2008.
- Phase III. Initiation of synthesis (FY2009). Draft for internal review submitted by September 2009. Finalized manuscript submitted by March 2010 (FY2010)
- Phase IV. Complete publication of manuscript. Completed by July 2010

Budget

FY2010

PLAN 12.P3.10	
Low Steady Summer Flows Data and Research Compilation, Synopsis, and Synthesis (FY2008–10)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	8,561
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	5,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 13,561**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	2,848
Project Total (Gross)	**$ 16,409**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

PLAN: 12.P4.11—Update of Knowledge Assessment and SCORE Report

Start Date

October 2010

End Date

December 2011

Principal Investigators

U.S. Geological Survey, Grand Canyon Monitoring and Research Center staff and various cooperators, including Carl Walters, Fisheries Centre, University of British Columbia

Geographic Scope

Entire Grand Canyon Monitoring and Research Center study area, from the forebay of Lake Powell to upper Lake Mead.

Project Goals

Five years after the first knowledge assessment (Melis and others, 2006a) and SCORE report published by the GCMRC (Gloss and others, 2005), the GCMRC proposes to conduct a second knowledge assessment to inform the FY2012–16 Monitoring and Research Plan. The second SCORE report, following the FY2011 knowledge assessment is intended to:

- update the status and trends of GCDAMP resource goals and
- report results of all experimental treatments implemented under the GCDAMP since completion of the 1995 EIS.

In contrast to the approach taken in the first SCORE report, which focused mainly on reporting status and trends of each of the resources of importance to the GCDAMP, the FY2011 SCORE report shall identify critical information that ties resource responses (monitoring and research data) to experimental flow and non-flow treatments associated with the 1996 Record of Decision operations and other treatments implemented by the Department of the Interior since 1996 at the recommendation of the GCDAMP. Experimental research topics will include record of decision MLFF, experimental winter fluctuations of FY2003–05, the FY2000 LSSF testing, various fall steady flow tests, three HMF tests, three HFEs, mechanical removal of nonnative fish, and translocation of HBC and Kanab ambersnail. These experimental treatments will be evaluated relative to the resource goals of the GCDAMP strategic plan as part of a knowledge assessment conducted in advance of the SCORE reporting, similar to the approach taken in FY2005 (see table 9).

Need for Project

A key element of the collaborative science planning process outlined in the FY 2007-11 Strategic Science Plan (SSP) (USGS 2006) and Monitoring and Research Plan (MRP) (USGS 2007) is a synthesis at 5 year intervals of new science information in an updated SCORE report and knowledge assessment. The SCORE report and KA are a critical part of the adaptive management process that are needed to inform the review and revision of the GCDAMP Strategic Plan and the FY 2012-17 SSP and MRP. The KA and SCORE report will incorporate summarize and evaluate new information regarding statues and trend s of AMP resources and responses of those resources to various experimental treatments in a format useful by managers, stakeholders and scientist as they consider new direction in the GCDAMP science and management activities.

A priority need in the FY2011 knowledge assessment will be to identify resource responses that were not predicted in the 1995 EIS or identified in the last knowledge assessment. One example that provides an excellent opportunity for learning is the arrested decline of the HBC adult population (Melis and others, 2006b) and the recent increasing trend in this endangered fish (Coggins, 2009). The turnaround in HBC population has occurred despite a high level of uncertainty about limiting its early life history below GCD. Fine sediment, another example of resource response that was not well anticipated in the 1995 EIS, will also be a major focus of the FY2011 knowledge assessment and SCORE following recent modeling research advances in FY2009–10 (Wright and others, 2008).

Strategic Science Questions

The FY2011 knowledge assessment and resulting SCORE report will be aimed at addressing priority AMWG questions identified by the GCDAMP in 2004, the Strategic Science Questions derived from the 2005 knowledge assessment and additional questions identified since then by the Science Advisors:

SSQ 4-1. Is there a "Flow Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will rebuild and maintain sandbar habitats over decadal timescales?

SSQ 1-4. Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.

SSQ 1-8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling?

SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

SSQ 3-5. How is invertebrate flux affected by water quality (for example, temperature, nutrient concentrations, turbidity) and dam operations?

SSQ 1-2. Does a decrease in the abundance of rainbow trout and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile HBC to the adult population?

SSQ 5-1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE?

SA 1. What are the most limiting factors to successful humpback chub adult recruitment in the mainstem: spawning success, predation on young of year and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

SA 2. What are the most probably positive and negative impacts of warming the Colorado River on humpback chub adults and juveniles?

Methods and Tasks

FY2011

The GCMRC will work with the Science Advisors to develop the FY20011 knowledge assessment process. It is anticipated that the KA process will involve one or more workshops with scientists and stakeholders. Alternative approaches will be reviewed to determine the most appropriate method for summarizing knowledge, characterizing the level of certainty associated resource responses to treatments or management actions and engaging scientists, managers and stakeholders in the process. New information that will be addressed in the KA and SCORE reports includes:

- 2008 HFE results
- Synthesis of the 1996, 2004 and 2008 HFE's
- Campsite and sandbar monitoring results
- Results of the Aquatic Food Based Research and Develop Project
- Ecosystem modeling and workshop results
- Integrated sediment, flow, and temp modeling results
- Vegetation mapping and transects synthesis results
- Low Summer Steady Flows synthesis results

Assessment of the effects of experimental flow and non-flow treatments would encompass the topics shown in the matrix below. The **X**s shown in table 9 denote the resource response topics that would be addressed in the knowledge assessment and reported by goal in the SCORE report.

Table 9. Matrix of various flow and nonflow experimental treatments implemented within the Colorado River ecosystem and the response of resources identified within the Glen Canyon Dam Adaptive Management Program's strategic plan to be addressed by knowledge assessment and *State of the Colorado River Ecosystem in Grand Canyon* report. N/A = not applicable.

Resources	MLFF	EXP winter-fluctuations	BHBF	HMF	Steady Flows	Nonnative fish control	Translocating HBC and KAS
Food Availability	X	X	X	X	X	X	N/A
Native Fish	X	X	X	X	X	X	X
Extirpated Species	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lees Ferry Rainbow Trout	X	X	X	X	X	N/A	N/A
Springs and Related Species (KAS)	X	X	X	X	X	N/A	X
Riparian Community	X	X	X	X	X	N/A	N/A
Downstream Quality of Water	X	X	X	X	X	N/A	N/A
Sediment	X	X	X	X	X	N/A	N/A
Recreational Experiences	X	X	X	X	X	N/A	N/A
Hydropower	X	X	X	X	X	N/A	N/A
Cultural Resources - TCPs	X	X	X	X	X	N/A	N/A

Links/Relationships to Other Projects

The SCORE report would be linked with a second knowledge assessment conducted in the first quarter of 2011. The new KA and Score reports will provided updated status and trends information, including the effects of experimental treatments, for all GCDAMP resource goals.

Logistics

None

Products/Reports

FY2011

- Multi-chapter USGS Circular with numerous authors that documents the outcome of the 2011 knowledge assessment, including updated status and trends information for all GCDAMP resources and the results of experimental treatments evaluated below Glen Canyon Dam since 1995.

Budget

FY2011

PLAN 12.P4.11	
Update of Knowledge Assessment and SCORE Report (FY2011)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	25,000
GCMRC Project Related Travel / Training (21% Burden)	3,870
GCMRC Operations / Supplies / Publishing (21% Burden)	50,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	75,000
Project Subtotal	**$ 153,870**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	21,130
Project Total (Gross)	**$ 175,000**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	48.8%

NOTE: Total project amount for FY2011 is $175,000, all of which is funded from BOR Experimental Fund from power revenues under cap.

SUP 12.S1.10–11—Logistics Base Costs

Start Date

Ongoing

End Date

Ongoing

Principal Investigator

Carol Fritzinger, Logistics and Survey Program Manager, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Colorado River ecosystem corridor between Glen Canyon Dam and Lake Mead, and the greater Colorado River Basin

Project Goals

Provide cost effective, efficient, and complete logistical support for all GCMRC funded projects

Need for Project

The GCMRC provides complete logistical support for 25–40 research, monitoring, administrative, and tribal river trips through the Grand Canyon annually. These trips range in length from 7–21 days and from 4–24 people in size. Trips utilize a variety of motor- and oar-powered boats operated by contracted boat operators. Projects operating in the Glen Canyon reach of the Colorado River (GCD to Lees Ferry) are supported by a variety of motor-powered boats operated by GCMRC researchers and contracted boat operators. Additionally, research activities on the Little Colorado River and at other locations outside of the Grand Canyon National Park boundaries are supported by helicopter services contracted with Reclamation. Ground based support for other research activities outside of the river corridor is also coordinated with the GCMRC Logistics Program.

Strategic Science Questions

Not applicable

Information Needs Addressed

Not applicable

Methods and Tasks

FY2010

The GCMRC utilizes Government-owned boats and river logistical equipment in conjunction with a contracted vendor who supplies technical and logistical boat operators. Put-in and takeout transportation is provided with the use of General Service Administration (GSA) leased vehicles and contracted shuttle drivers.

Effective communication with principal investigators and sensitivity to and awareness of the challenges they face in implementing their studies enable the GCMRC to offer more customized (and

therefore more cost effective and productive) logistical support than other support strategies utilized previously. Retaining control over the process of supporting trips also facilitates compliance with NPS regulations and allows greater control over issues sensitive to the general public and the "recreational river community."

FY2011

Same as FY2010

Links/Relationships to Other Projects

The GCMRC logistics program supports all GCMRC projects that have field data collection components.

Logistics

There are no logistical needs for this project.

Products/Reports

Not applicable

Budget

FY2010

SUP 12.S1.10	
Logistics Base Costs (Other costs dispersed throughout projects; Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	138,762
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	35,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 173,762**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	36,490
Project Total (Gross)	**$ 210,252**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

SUP 12.S1.11	
Logistics Base Costs (Other costs dispersed throughout projects; Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	147,930
GCMRC Project Related Travel / Training (21% Burden)	1,885
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	35,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 184,815**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	38,811
Project Total (Gross)	**$ 223,626**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

SUP 12.S2.10–11—Survey Operations

Start Date

Ongoing

End Date

Ongoing

Principal Investigator

Keith Kohl, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Survey operations occur throughout the CRE in support of scientific activities.

Project Goals

We must supply GCMRC principal investigators with all necessary information, equipment, and survey knowledge to address their scientific needs. In some cases, that means performing all collection, processing, and documentation of all spatial data required by their research. The principal investigators and researchers must be educated regarding the limits of various mapping techniques. Data sets used for change detection analysis must be conscientiously evaluated for precision so as provide accurate scientific analysis and resulting decision making.

Need for Project

Spatial measurements are required for any long-term monitoring program. The measurements are made using a variety of survey methods and stored in a variety of formats. All measurements reference a position of greater confidence whether the measurement is made using the GPS, LiDAR, digital or analog imagery, conventional survey angles and distances to reflective prisms, or sub aqueous bathymetry. With consistent reference, and explicit protocols, the survey operations program ensures the integrity of spatial data sets, which increases confidence in scientific analysis.

Strategic Science Questions

Many strategic science questions require stage discharge relationships to determine inundation extents under various flows. These relationships must be collected in the field using consistent survey methods and be referenced to validated control. Answers to questions relating to habitat (for example, sandbar, sand terraces, old and new high water zones, reach morphology, etc) will all require survey measurements. All SSQ’s addressed in projects supported by Survey Operations are applicable.

Information Needs Addressed

Accurate and consistent spatial positioning of scientific data is necessary for facilitating change detection. Change detection methods are applied to spatial data collected within the cultural, biological, and physical programs to determine impacts on habitat, validate models, and to determine fine and course sediment storage. Survey protocols also provide spatial data as the foundation of the GIS database. All information needs addressed in projects supported by Survey Operations are applicable.

Methods and Tasks

FY2010

Survey marks are typically stable positions (referred to as survey marks, survey monuments, control points, stations, etc.) on bedrock or large boulders with positions preserved by chiseling or scribing marks, or by physical attachment of foreign substances (nails, caps, screws, bolts, rebar, etc.). These stations were placed in a manner that allows for tripods and conventional or GPS survey equipment to set up over the control point. The points that are occupied regularly are located above the stage reached by the flow of 30,000 cubic feet per second (ft3/s) and have fair but diminishing line of sight due to expanding vegetation. Some stations may be lower in elevation and are occasionally inundated by water during normal dam operations. The survey marks are reference for measurements of:

- sandbar sites located throughout the CRE, many of which have a spatial data set of topographic and bathymetric data collected at least once per year since 1990
- long-term monitoring reaches where topography, bathymetry, and LiDAR, digital imagery were collected between FY2000 and FY2008
- line-of-site stations between GCD and Bright Angel Creek plus 15 miles of traverse points from Blue Springs to the LCR/ Colorado River confluence. The traverses used acceptable distances for conventional optical equipment (typically 600 meters and consistently less than 1,000 meters)
- photo-identifiable fixed points
- cultural sites including locations of features, artifacts, and erosion controls
- USGS stage gages 09380000 : “Colorado River at Lee’s Ferry” and 09402500 “Colorado River near Grand Canyon”
- instrumentation sites (weather, LISST, Acoustic Doppler, water quality, pump samplers)

FY2011

Same as FY2010

Links/Relationships to Other Projects

Any and all spatial data collection required by GCDAMP is supported through this program.

Logistics

FY2010

Survey support is provided for GCMRC projects as required by specific project needs, no stand-alone logistics are required.

FY2011

Same as FY2010

Products/Reports

Control monuments are established at consistent intervals throughout the CRE and at locations required for accurate positions and elevations of past, current, and future data sets. Stable control monuments and accurate coordinates should be completed prior to spatial data acquisition to reduce post-processing efforts, conserving considerable manpower. Documentation of station information,

coordinate history and network accuracy are provided. Current and historical data sets are accurately prepared for integration into the GIS database.

Budget

FY2010

SUP 12.S2.10	
Survey Operations (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	47,927
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	25,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 72,927**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	15,315
Project Total (Gross)	**$ 88,242**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

SUP 12.S2.11	
Survey Operations (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	49,481
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	25,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 74,481**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	15,641
Project Total (Gross)	**$ 90,132**
Percent Outsourced (Outside of GCMRC; includes 50% of	0%

Logistics)	

SUP 12.S3.10–11—Control Network

Start Date

Ongoing

End Date

Ongoing

Principal Investigator

Keith Kohl, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

High accuracy geodetic control now encompasses the entire Colorado River ecosystem (CRE) corridor between Glen Canyon Dam and Lake Mead, and the greater Colorado River Basin.

Project Goals

The objective of this effort is to:

- document methods and results of the geodetic control network developed within Grand Canyon's CRE,
- maintain the integrity of the network and all future spatial data referenced to the network by proposing data collection, processing, adjustment and documentation standards,
- provide reference and methods for consistent and accurate error determination for several spatial data measurement types, and
- provide valid reference for emphasis on spatial data collection and evaluation of remote sensing surveying techniques for river monitoring. Data sets used for change detection analysis must be conscientiously evaluated for accuracy and blunders so as not to skew scientific analysis and resulting decision making.

Need for Project

According to Executive Order 12906 (OMB< 2002), federal agencies must:

- prepare, maintain, publish, and implement a strategy for advancing geographic information and related spatial data activities appropriate to their mission,
- allocate agency resources to fulfill the responsibilities of effective spatial data collection, production, and stewardship,
- coordinate and work in partnership with federal, state, tribal and local government agencies, academia and the private sector to efficiently and cost-effectively collect, integrate, maintain, disseminate, and preserve spatial data, building upon local data wherever possible, and
- use Federal Geographic Data Committee (FGDC) data standards, such as the Geospatial Positioning Accuracy Standards and the Content Standard for Digital Geospatial Metadata, and other appropriate standards to ensure all relevant data and metadata are appropriately documented before finally making the metadata available to the public online.

These standards include publications on reporting methodology, standards for geodetic networks, and the National Standard for Spatial Data Accuracy (NSSDA). It is the purpose of this effort to document

adherence to these standards and add recommendations that will ensure policy decisions based on long-term monitoring data and analysis are based on accurate and quality assured data sets.

Strategic Science Questions

Accurate and consistent spatial positioning of scientific data is necessary for facilitating change detection. Change-detection methods are applied to spatial data collected within the cultural, biological, and physical programs to determine impacts on habitat, validate models, and determine fine and course sediment storage. Many strategic science questions require stage discharge relationships to determine inundation extents under various flows. These relationships must be collected in the field using consistent survey methods and be referenced to validated control. Answers to questions relating to habitat (for example, sandbar, sand terraces, old and new high-water zones, reach morphology, etc) will all require survey measurements. All SSQ's addressed in projects supported by Control Network Operations are applicable.

Information Needs Addressed

Accurate and consistent spatial positioning of scientific data is necessary for facilitating change detection. Change-detection methods are applied to spatial data collected within the cultural, biological, and physical programs to determine impacts on habitat, validate models, and determine fine and course sediment storage. Survey protocols also provide spatial data as the foundation of the GIS database. All information needs addressed in projects supported by Control Network Operations are applicable.

Methods and Tasks

FY2010

The geodetic control network establishes the foundation for all spatial measurements within the CRE. The survey stations are all referenced to the most accurate and up-to-date coordinates available designated as NSRS2007. This is the most recent realization of the North American Datum of 1983 as determined in a multiyear nationwide readjustment performed by the National Geodetic Survey (NGS) and completed in 2007. These stations provide the primary reference for both kinematic GPS positioning of aircraft during remote sensing flights and static GPS surveys to hundreds of monuments along the river corridor. This consistent framework allows for accurate and reliable accuracy assessment of all spatial data collected within the CRE, and assures the integrity of spatial analysis and resulting management decisions.

FY2011

Same as FY2010

Links/Relationships to Other Projects

Any and all spatial data collection required by GCDAMG is supported through this program.

Logistics

FY2010

The control network project will require one motor trip annually to support field data collection.

Month	Boats	Length	Personnel	Budget
April	2-33', 2-sport	15 days	12	$38,000

FY2011

The control network project will require one motor trip annually to support field data collection.

Month	Boats	Length	Personnel	Budget
April	2-33', 2-sport	15 days	12	$40,000

Products/Reports

We will work with GCMRC staff to identify realistic and achievable accuracies using existing technologies and theory. This will also include meeting with GCMRC scientists to establish accuracy requirements that are appropriate for supporting CRE scientific investigations.

We will generate a comprehensive report on the survey control network. The report will include collection and processing methodologies, analysis and discussion of results, accuracy validation per FGDC requirements, and recommendations for ensuring the network meets the positioning needs of GCMRC for current and future scientific endeavors.

Budget

FY2010

SUP 12.S3.10	
Control Network (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	88,848
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	38,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	25,000
Project Subtotal	**$ 151,848**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	28,161
Project Total (Gross)	**$ 180,009**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	29.0%

FY2011

SUP 12.S3.11	
Control Network (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	91,555
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	40,000
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	25,000
Project Subtotal	**$ 156,555**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	29,149
Project Total (Gross)	**$ 185,704**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	28.8%

ADM 12.A1.10-11 (A)—Administrative Operations

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

The goals of the project are to:

- provide budgetary oversight and support to the chief, program managers, and all employees of the GCMRC so that they may conduct their responsibilities in the most efficient, ethical, and professional manner possible;
- unburden the scientists, to the largest extent possible, of mundane administrative matters; and
- support the USGS and GCMRC missions of conducting scientific research in support of the GCDAMP.

Need for Project

It is necessary to have smooth running, transparent administrative operations that ensure that the GCMRC scientists can focus on their research rather than on the administrative details involved with the payment of rent and utilities, timekeeping concerns, filing, and various other administrative topics. Administrative operations activities provide the oversight and management of facilities, burden, and overhead; personnel issues; expenditure tracking; processing and financial management of cooperative and interagency agreements; processing of contracts; timekeeping; bank card tracking and reconciliation; travel plans and voucher processing; and liaison activities between the USGS administrative groups (Flagstaff Science Center Administration, Western Region Budget and Fiscal Services and Contracting Offices, Biological Headquarters in Reston, VA). In addition, this project is innately involved with the USGS nationwide budget tracking and reporting system known as BASIS+, which is used by the USGS Headquarters and Regional offices to make their annual reports to Congress, as well as to respond to Congressional inquiries with short turnaround times. (As part of the GCDAMP, GCMRC administrators have been called upon to provide information of this type from the system on many occasions.)

Many standard overhead charges, including facilities, space, general office supplies, costs for the USGS local network, and support for the Flagstaff Science Center and USGS regional services (including contracting and personnel, as well as salaries and general travel for the GCMRC secretary and budget analyst) are paid for out of the Southwest Biological Science Center's (SBSC) overhead account. Only charges directly tied and traceable to the GCMRC continue to be directly charged to the administrative operations account. These charges include General Services Administration vehicle lease and maintenance; Department of the Interior vehicle gas, maintenance, and replacement costs; safety and/or other non-project-specific mandated training; GCMRC non-project-specific personnel support; telecommunications and shipping charges; and others.

Strategic Science Questions

Not applicable

Information Needs Addressed

Not applicable

Methods and Tasks

General methods will include standard accounting procedures and regulatory and legal standards as required by the USGS and other Federal agencies with legal oversight. Monthly updates to program managers will be provided as well as budgetary and other information provided upon request. The GCMRC will follow USGS guidelines as assigned for personnel, travel, and other processes. Administrative personnel will focus on how to accomplish requests most efficiently within Federal laws and regulations. The SBSC Administrative Officer and the GCMRC Budget Analyst will report biannually to the AMWG/TWG on mid-year and year-end projections and on the actual expenditures for the previous fiscal year.

Links/Relationships to Other Projects

This project is innately linked to all other projects. All project budgets are impacted by burden charges that are tracked and managed through administrative operations, all employees are required to track their time through a USGS personnel system, and many program managers use cooperative or interagency agreements that are processed and tracked financially via administrative operations. Every project is given an account number and must be entered into and tracked, via its budget and its narrative, through the BASIS+ system. Administrative operations activities are tied to each project at the project's earliest development.

Logistics

There are no logistical needs for this project.

Products/Reports

The SBSC Administrative Officer and the GCMRC Budget Analyst will produce a projection report (usually at the August AMWG meeting) for year end. In addition, they will present a report in actual expenditures for the previous fiscal year that will normally be presented at the March AMWG meeting.

Budget

FY2010

ADM 12.A1.10 (A)	
Administrative Operations (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	44,100
GCMRC Project Related Travel / Training (21% Burden)	5,300
GCMRC Operations / Supplies / Publishing (21% Burden)	30,200
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	13,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	47,000
Project Subtotal	**$ 139,600**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	22,308
Project Total (Gross)	**$ 161,908**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	33.7%

FY2011

ADM 12.A1.11 (A)	
Administrative Operations (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	45,000
GCMRC Project Related Travel / Training (21% Burden)	5,500
GCMRC Operations / Supplies / Publishing (21% Burden)	31,100
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	13,400
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	50,000
Project Subtotal	**$ 145,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	22,995
Project Total (Gross)	**$ 167,995**
Percent Outsourced (Outside of GCMRC; includes 50% of	34.5%

Logistics)	

ADM 12.A1.10-11 (B)—Administrative Operations—GSA Vehicle Costs

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

The goals of the project are to provide reliable transportation for GCMRC.

Need for Project

It is necessary to have reliable transportation for GCMRC

Strategic Science Questions

Not applicable

Information Needs Addressed

Not applicable

Methods and Tasks

General methods will include standard accounting procedures and regulatory and legal standards as required by the USGS and other Federal agencies with legal oversight.

Links/Relationships to Other Projects

This project is innately linked to all other projects.

Logistics

There are no logistical needs for this project.

Products/Reports

Not applicable

Budget

FY2010

ADM 12.A1.10 (B)	
Administrative Operations—GSA Vehicle Costs (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	52,500
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 52,500**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	11,025
Project Total (Gross)	**$ 63,525**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

ADM 12.A1.11 (B)	
Administrative Operations - GSA Vehicle Costs (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	55,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 55,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	11,550
Project Total (Gross)	**$ 66,550**
Percent Outsourced (Outside of GCMRC; includes 50% of	0%

Logistics)	

ADM 12.A1.10-11 (C)—Administrative Operations—Interior Vehicle Costs

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

The goals of the project are to provide reliable transportation for GCMRC.

Need for Project

It is necessary to have reliable transportation for GCMRC

Strategic Science Questions

Not applicable

Information Needs Addressed

Not applicable

Methods and Tasks

General methods will include standard accounting procedures and regulatory and legal standards as required by the USGS and other Federal agencies with legal oversight.

Links/Relationships to Other Projects

This project is innately linked to all other projects.

Logistics

There are no logistical needs for this project.

Products/Reports

Not applicable

Budget

FY2010

ADM 12.A1.10 (C)	
Administrative Operations—Interior Vehicle Costs (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	26,500
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 26,500**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	5,565
Project Total (Gross)	**$ 32,065**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

ADM 12.A1.11 (C)	
Administrative Operations—Interior Vehicle Costs (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	28,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 28,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	5,880
Project Total (Gross)	**$ 33,880**
Percent Outsourced (Outside of GCMRC; includes 50% of	0%

Logistics)	

ADM 12.A2.10-11—Program Planning and Management

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

The GCMRC's goal is to deliver a comprehensive ecosystem science program over the next 5 years that is effective in responding to management needs articulated through the GCDAMP and by the Department of Interior. Productive, well-qualified personnel are critical to achieving this goal.

Need for Project

Successful scientific research and reporting can be enhanced by strong and effective leadership that provides close working relationships between managers and employees and between GCMRC and the GCDAMP stakeholders. Good managers can apply knowledge as management actions that can enhance scientific research and imagination. In addition to their program management responsibilities, the GCMRC program managers are also subject area experts in their respective fields. It is important that GCMRC program managers and scientific staff maintain this expertise so they can provide high-quality technical assistance in the form of expert analysis, opinion, and advice to the Chief, TWG, and AMWG, as requested. The Sociocultural Program Manager also functions as the Native American coordinator. The program managers supervise additional technical and support staff, and act as project leads with their cooperators.

Beginning in FY2006, in an effort to simplify distribution of program planning and management salaries and travel, the Program Manager salaries were assigned to this category exclusively. Salaries and travel costs, separate from TWG and AMWG meeting travel for the Chief, Deputy Chief, and five program managers, are included in the program planning and management budget. Position descriptions are provided below.

Strategic Science Questions

Not applicable

Information Needs Addressed

Not applicable

General Methods/Tasks

In order to provide strong leadership of a quality science program that is responsive to the needs of the GCDAMP, the GCMRC will be administered by a core program management staff that includes the following key positions:

Center Chief

Establishes GCMRC science policies and strategic direction and provides accountability for the GCMRC budget. Interfaces with USGS management, the Secretary of the Interior's GCDAMP Designee, and GCDAMP managers to ensure that quality science is provided in a timely manner on priority issues identified by the GCDAMP leadership.

Deputy Chief

The Deputy Chief shall be responsible for oversight of the Physical Science and Modeling and Data Acquisition, Storage, and Analysis (DASA) Programs and shall ensure that integrated ecosystem science methods and procedures are utilized in science design and analysis.

Program Managers

Responsible for the timely execution of the science program within their program area; interaction with other program areas to ensure integrated ecosystem approaches, quality control of products and contractors/cooperators; contract/agreement management; management of budget within their program area, and production of reports to GCDAMP work groups as needed. The GCMRC activities now encompass five major program areas:

1. The Physical Science and Modeling Program conducts research and monitoring activities on physical elements of the CRE, including studies of sediment storage and transport in the regulated river, and integrated downstream water-quality monitoring and research. The program has been responsible for monitoring several experimental high-flow releases from GCD to conserve sediment resources for building beaches and improving habitat for native aquatic species in the Colorado River. More recent tasks have included development of a downstream temperature model for the ecosystem.
2. The Data Acquisition, Storage, and Analysis Program provides GIS, data quality control, data management, and library services support to all program areas. In addition, DASA also participates in collaborative science analyses with GCMRC program staff and cooperators to help achieve better integrated science outcomes. The DASA program manager also oversees the GCMRC peer-review process under guidelines of the USGS Fundamental Science Practice protocols.
3. The Biological Program provides scientific information that supports the conservation of native species in the Grand Canyon and the Lees Ferry trout fishery. Elements of the program include assessing the effects of GCD on fishery resources; characterizing the aquatic food base; evaluating terrestrial contributions to the aquatic food base; improving fish community monitoring, developing, and testing of techniques to control nonnative fish; evaluate the nearshore ecology of native fish and the effects of fall steady flows on native fish recruitment; evaluating terrestrial vegetation changes as a result of dam operations; and water-quality monitoring and modeling in Lake Powell and the Colorado River below GCD.
4. The Cultural and Socioeconomic Program develops research and monitoring projects to determine the effects of Glen Canyon Dam on culturally significant sites and recreation activities. The current focus is on development of comprehensive monitoring programs to assess the condition of the culturally significant sites and recreation campsites affected by the operation of GCD. In addition, the program oversees research and monitoring related to assessing the economic effects of Glen Canyon Dam operations on recreation, hydropower,

and other program elements and coordinates Native American consultation activities on behalf of GCMRC.

5. The Logistics and Survey Support Program supports up to 40 river trips per year and coordinates research permit management for the GCMRC. The Logistics Program also provides survey support to various program and activities, as well as maintains integrity of the network and spatial data of the geodetic control network.

Links/Relationships to Other Projects

This project is linked by nature to all other projects, since each project must be managed by a program manager or the Chief.

Logistics

There are no logistical needs for this project

Products/Reports

All products and reports produced by the GCMRC are a result of this project.

Budget

FY2010

ADM 12.A2.10	
Program Planning and Management (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	936,000
GCMRC Project Related Travel / Training (21% Burden)	41,000
GCMRC Operations / Supplies / Publishing (21% Burden)	11,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 988,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	207,480
Project Total (Gross)	**$ 1,195,480**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

ADM 12.A2.11	
Program Planning and Management (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	970,000
GCMRC Project Related Travel / Training (21% Burden)	42,000
GCMRC Operations / Supplies / Publishing (21% Burden)	11,500
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 1,023,500**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	214,935
Project Total (Gross)	**$ 1,238,435**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

ADM 12.A3.10-11—AMWG/TWG Meeting Travel Funds

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

To provide travel funds for employees who participate in AMWG and TWG meetings.

Need for Project

This project is an account to hold funds for travel expenses for GCMRC employees who participate in AMWG and TWG meetings. Project-related travel expenses are accounted for by projects, and administrative travel (for example, general safety and security training) is planned under the Administrative Operations budget.

Strategic Science Questions

Not applicable

Information Needs Addressed

Not applicable

General Methods/Tasks

Methods used are standard USGS travel authorizations and vouchers.

Links/Relationships to Other Projects

Not applicable

Logistics

There are no logistical needs for this project

Products/Reports

Not applicable

Budget

FY2010

ADM 12.A3.10	
AMWG/TWG Meeting Travel Funds (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	16,100
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 16,100**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	3,381
Project Total (Gross)	**$ 19,481**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

FY2011

ADM 12.A3.11	
AMWG/TWG Meeting Travel Funds (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	16,500
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 16,500**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	3,465
Project Total (Gross)	**$ 19,965**
Percent Outsourced (Outside of GCMRC; includes 50% of	0%

Logistics)	

ADM 12.A4.10-11(A)—Independent Reviews

Start Date

1996

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

To increase the efficiency and quality of the science being developed by the GCMRC and used by the AMWG and the Secretary of the Interior, the GCMRC will establish a peer review process to ensure that all unsolicited, solicited, or in-house proposals and all draft reports received by the GCMRC undergo independent, external peer review.

Need for Project

Independent external review is at the heart of the GCMRC's approach to program management and implementation. Together with the competitive process, independent external peer review ensures the quality and objectivity of the GCMRC's programs. Independent review panels are used to evaluate the GCMRC's plans and activities. All proposals, reports, and programs are subject to independent peer review according to the GCMRC's peer review protocols. The SBSC secretary under the supervision of the SBSC Deputy Center Director manages GCMRC's peer-review process.

To ensure program integrity, Science Advisors (SAs) provide independent scientific oversight and technical advice to ensure that all GCMRC science plans and programs are efficient, unbiased, objective, and scientifically sound. The SAs are expected upon request to review and comment on the following:

- Results of ongoing and completed monitoring and research program activities, as well as any synthesis and assessment activities initiated by the GCMRC
- The appropriateness of the GCMRC's Requests for Proposals (RFPs), especially their responsiveness to management objectives
- Protocols used in GCMRC-sponsored scientific activities, including a 5-year review of GCMRC monitoring and research protocols
- GCMRC's long-term monitoring plan
- GCMRC's biennial monitoring and research plans
- GCMRC's biennial budget proposals, to ensure that the science program is efficiently and effectively responding to AMWG goals (that is, management objectives)

The SAs and Executive Director also provide other program-specific scientific and technical advice when asked by the AMWG, the GCMRC, or the Secretary of the Interior.

Strategic Science Questions

Not applicable

Information Needs Addressed

Not applicable

Methods and Tasks

Peer Review

All of GCMRC's scientific activities undergo an independent, external peer review, including all unsolicited, solicited, or in-house proposals. Similarly, all draft reports received by the GCMRC undergo independent external peer review. The peer review protocols developed by the GCMRC meet or exceed the standards articulated by the Secretary of the Interior for DOI agencies.

Peer review for proposals received by the GCMRC in response to an RFP is conducted through a panel process, while peer reviews for unsolicited and in-house proposals, as well as project reports, are conducted through correspondence. In all cases, the reviewers are offered anonymity, and the individual and panel reviews, where applicable, are provided to the principal investigators along with comments from the GCMRC. In addition, the GCMRC conducts PEPs to review and assess GCMRC's projects and methodologies. To date, PEPs have been held for remote sensing, physical, survey control, terrestrial and aquatic, cultural resource, biological, and water-quality programs. No PEPs are planned for FY2010. FY2011 includes PEP reviews for:

- Aquatic food base in conjunction with Lake Powell downstream IQW
- Camping beaches monitoring

The GCMRC review process is handled by a Southwest Biological Science Center Review Coordinator to ensure that the peer-review process is not under the immediate supervision of individual GCMRC program managers to guard against any conflicts of interest—real or perceived. Strict conflict-of-interest guidelines are adhered to. The GCMRC annually recruits new peer reviewers and maintains a database of almost 500 potential reviewers, organized by area of expertise. GCMRC peer reviewers come from academia; Federal, State, and Tribal governmental and nongovernmental organizations; and the private sector. Reviewers are selected on the basis of their record of scientific accomplishment and expertise.

Links/Relationships to Other Projects

Not applicable

Products/Reports

Not applicable

Budget

FY2010

ADM 12.A4.10 (A)	
Independent Reviews (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	10,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	10,300
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 20,300**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	2,100
Project Total (Gross)	**$ 22,400**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	50.7%

FY2011

ADM 12.A4.11 (A)	
Independent Reviews (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	50,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	10,500
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 60,500**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	12,705
Project Total (Gross)	**$ 73,205**

Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	17.4%

ADM 12.A4.10-11(B)—Coordination and Review of Services Provided by Science Advisors

Start Date

FY2009

End Date

Ongoing

Principal Investigator

Lawrence D. Garrett, Principal M3 Research and Executive Coordinator of the Science Advisors

Project Overview

The Science Advisors (SAs) provide two types of science support: (1) review of scientific and planning documents and (2) advise on a range of scientific issues and questions related to the Glen Canyon Dam Adaptive Management Program (GCDAMP). The SAs review a wide range of scientific research and planning documents, including multiyear and annual strategic and operational plans, budgets, and special project science plans for activities such as the 2008 high-flow experiment (HFE). The SAs also provide advisory services to the Grand Canyon Monitoring and Research Center (GCMRC0, Adaptive Management Work Group (AMWG), and Technical Work Group (TWG) on topics ranging from adaptive management and long-term experimental approaches to the development of new ecosystem science approaches and technical projects such as a temperature control device (TCD).

In FY2010–11, the SAs will include six interdisciplinary senior scientists, primarily from universities supporting natural resource research programs.

Need for Project

The SAs contribute to the overall science support needs of the GCDAMP as one of the Independent Review Panels (IRPs), serving special functions not provided by other IRPs. SAs service is enlisted to increase the efficiency and quality of the science being developed by the GCMRC and used by the AMWG and the Secretary of the Interior. SAs provide independent scientific oversight and technical advice to ensure that GCMRC science programs are efficient, unbiased, objective, and scientifically sound.

General Methods/Tasks

Administrative Services

In FY2009, the GCMRC and GCDAMP requested a significant revision of the composition of the SAs, which will result in the replacement of all but three disciplines and recruiting three to five new SA members in full- or part-time positions. Several administrative activities to support new positions will occur in 2010. First, the SA Executive Coordinator will work with GCMRC staff to screen specialists to fill three to five SA positions, award positions, develop briefing materials, issue contracts, revise procedures, and other activities, as needed. The new SAs will also be provided an orientation and opportunity to meet GCMRC staff and stakeholders.

Independent Reviews

Based on activities presented in this work plan, it is anticipated that the SAs will review the following planning and science documents and activities in FY2010–11:

- General core-monitoring proposal (proposed resources and time commitments, general approaches)
- Proposed 2011–12 science program and related activities, including the integration of these activities into the existing Strategic Science Plan and Monitoring and Research Plan
- Proposed 2011 science program budget
- Fall steady flow science plan
- 2000 low summer steady flows synthesis report
- Core-monitoring plans for (1) Aquatic Food Base/Lake Powell and Downstream Water-quality Monitoring, (2) Native and Nonnative Fish Monitoring, (3) Vegetation Monitoring; and (4) Camping Beaches Monitoring
- Overall fisheries science and modeling direction
- Overall sediment science and modeling direction
- Proposed socioeconomic science request for proposals and science plan
- Humpback chub translocation and trout abatement science plan
- 2008 HFE project reports (projects 1–5)
- Review of HFE synthesis report

Advisory Services

The SAs provide reviews and advisory service to the GCMRC, the TWG, the AMWG, and the Secretary's Designee. SAs communicate in a variety of ways (emails, phone conversations, reports, and workshops) with GCMRC and GCDAMP members, facilitators, outside scientists and managers to clarify review positions, provide information, develop prospectus for collaborative efforts, and assist with the evaluation and development of program direction.

FY2010–11, the SAs anticipate providing the following advisory services:

- Assist with development and participate in workshop on GCDAMP effectiveness
- Assist with prospectus development, facilitation, and reports for workshop on management actions
- Assist with prospectus development, facilitation, and reports for workshop on socioeconomics program plan
- Participate in GCMRC science workshop on aquatics/fisheries ecosystem modeling led by Senior Ecologist in FY2010
- Assist GCMRC in designing and implementing ecosystem science approaches in research and monitoring programs, experimental options, modeling, sampling designs, etc.
- Work with GCMRC Chief, leadership team, and Senior Ecologist to assess opportunities for greater integration and improved overall system assessments of biology programs
- Participate in January 2010 annual reporting workshop/TWG meeting on 2008 HFE results

- Participate in April 2010 science/stakeholder workshop on aquatic ecosystem modeling outcomes
- Participate in combined final quality-of-water (including Lake Powell) and aquatics protocol evaluation panel in FY2011
- Participate in final recreational protocol evaluation panel in FY2011
- Assist GCMRC in development of advanced knowledge assessment procedures to support workshop(s) and participation in the workshop(s) in FY2011
- Participate in development of *State of the Colorado River Ecosystem in Grand Canyon* II report as outcome of knowledge assessment in FY2011

Budget

The M3 Research 5-year award included a base year and 4 option years for reviews and services.

FY2010

ADM 12.A4.10 (B)	
Coordination and Review of Services Provided by Science Advisors; includes Science Advisors' expenses (Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
AMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	180,000
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 180,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	37,800
Project Total (Gross)	**$ 217,800**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	100%

FY2011

ADM 12.A4.11 (B)	
Coordination and Review of Services Provided by Science Advisors; includes Science Advisors' expenses (Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
AMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	185,000
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 185,000**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	38,850
Project Total (Gross)	**$ 223,850**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	100%

ADM 12.A5.10-11—GCMRC Component of SBSC Computer Systems Support

Start Date

FY2005

End Date

Ongoing

Principal Investigator

John Hamill, Chief, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Grand Canyon Monitoring and Research Center

Project Goals

It is the Information Technology (IT) Department's goal to ensure that GCMRC and all stations within SBSC are able to conduct scientific and administrative functions smoothly and with the least amount of disruption in service as possible. It is the IT Department's task to make IT functions as transparent as possible, to ensure each program has adequate current and future storage, and to provide excellent customer service at all times. IT maintains the security of GCMRC and SBSC networks up to current Federal standards and ensures that all those who access the systems meet Federal security standards in order to protect personal information and scientific research that has not yet been released to the public. At the same time, the IT Department ensures that the public has full and easy access to publicly released data via GCMRC Web sites and works closely with the DASA program to make this possible.

Need for Project

The IT Department of the SBSC supports a variety of technology needs of the GCMRC's various program areas: computer security, systems administration and procurement of new servers and computers, as well as Web site development and Web page maintenance. These support, development, and maintenance services costs are shared between the GCMRC, the SBSC, and the IT Department, and coordinated by the Center's Deputy Director to meet the IT needs of all four research stations.

Strategic Science Questions

Not applicable

Information Needs Addressed

Not applicable

Methods and Tasks

The IT Department follows all Federal, DOI, and USGS regulations regarding purchase of, access to, and distribution and release of electronic information. Methods also include the following:

- Network environment: Computer interconnectivity is provided using transmission control protocol/Internet protocol (TCP/IP) network communication protocol running on 1000baseT

and 100baseT network media. Network traffic is arbitrated by 6 3COM switches and hubs operating at 1 gigabyte per second (Gbps).

- Internet connectivity: The GCMRC computer network is linked to the Internet through the Flagstaff Science Center GEOnet-3 router that provides a DS-3 (45 Megabytes [Mbps]) virtual circuit to Menlo Park, where it joins the USGS GEOnet network. Also located in Menlo Park is a network portal to the Internet operated by the USGS and NASA through a peering partnership. GEOnet provides a secure Surveywide networking environment that interconnects headquarter region, district, and field offices located throughout the United States.
- Intranet Web site: GCMRC's intranet offers a secure centralized medium for information exchange among GCMRC employees. Among things to be internally shared via the intranet are standard operating procedures, personnel availability and contact info, vehicle and equipment checkout, and an IT support system. The GCMRC intranet is served from a Windows 2003 Server utilizing Active Server Pages (ASP).
- GCMRC.GOV: The GCMRC Web site will continue to be redesigned in FY2010-11 to improve functionality and provide direct user/stakeholder access to all GCMRC products.
- Computer security: Network security is provided by firewalls, routers, a patch management server, a systems management server (SMS), and antivirus software. Firewalls and routers are configured and maintained to restrict outside access to authorized systems. Operating systems are updated monthly to minimize vulnerabilities using Software Update Services (SUS), which automates a central delivery system for patch management. Antivirus updates are downloaded from the Web as released and pushed to all systems the same night.
- Desktop and servers: CMRC's computing environment is based upon the PC platform, Microsoft Windows operating system, and Microsoft Office automation software. Systems maintenance is performed using a combination of warranty service, service contracts, and in-house service as needed to facilitate quick turnaround, minimize downtime, and reduce costs.
- System backup and disaster recovery: System backup and disaster recovery is accomplished using dual linear tape open (LTO) tape drives in a 30-slot carriage with a capacity of 12 Terabytes (Tbytes) native up to 24 Tbytes compressed before swapping tapes. Tapes are stored locally in a fire vault and archival tapes are stored offsite. Server disks are configured to run either a raid-5 array or mirrored for redundancy.
- Troubleshooting and maintenance: Helpdesk support is provided as requested/required. Requests are received via the Web, email, and telephone.
- Assistance with GCMRC's data storage: Over 30 Tbytes of online disk storage is provided by multiple servers with small computer system interface (SCSI) disk arrays. Server disk arrays are hot swappable to minimize downtime. GCMRC also utilizes networked attached storage (NAS) devices. Integrated Drive Electronics (IDE) and Serial Advanced Technology Attachment (STA) drives connected to a SCSI backplane. NAS units are used to provide bulk storage capacity at less expense. Servers are connected via a Fiber 1Gbps backbone to multiple NAS units.

Links/Relationships to Other Projects

All projects are integrated with IT support. Refer to the DASA section for more information on integration with these projects.

Products/Reports

The primary products and services of the SBSC Information Technology Department with respect to ongoing support of the GCMRC's needs are as follows:

- Comprehensive and fully functional Web site development and maintenance, with access to all nonsensitive digital data and information relating to the effects of dam operations on the CRE. GCMRC Web sites to make the mission and findings of the GCMRC accessible to the public (Sites offer our updated work plan, descriptions of our program areas, and various interactive stores of data including an Internet Map Server and an online library)
- Coordination with GCMRC's DASA to ensure and support a comprehensive and fully functional library containing all hard copy and digital media (cataloged and accessible) with data and information relating to the effects of dam operations on the CRE (Sensitive and nonreleasable data and information will be archived and secured separately from releasable data and information)
- Fully functional and integrated computing environment

Budget

FY2010

ADM 12.A5.10	
GCMRC Component of SBSC Computer Systems Support (FY2005–Ongoing)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	38,658
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	69,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	106,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	5,000
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 218,658**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	44,868
Project Total (Gross)	**$ 263,526**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	2.3%

FY2011

ADM 12.A5.11	
GCMRC Component of SBSC Computer Systems Support (FY2005–Ongoing)	
	Fiscal Year 2011
GCMRC Personnel Costs (21% Burden)	0
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	71,000
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	110,000
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	5,100
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 186,100**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	39,081
Project Total (Gross)	**$ 225,181**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	2.7%

EXP 7 FY2010—Synthesis of High-Flow Experimental Results (1996, 2004, and 2008)

Start Date

2009

End Date

September 2010

Principal Investigators

John Schmidt, Utah State University, and Richard Valdez, working in cooperation with a variety of other cooperating scientists

Geographic Scope

Entire Grand Canyon Monitoring and Research Center study area, from the forebay of Lake Powell to upper Lake Mead

Project Goals

The project will produce a comprehensive synthesis of experimental findings associated with past high-flow experiments (HFEs) at Glen Canyon Dam (GCD). Quality-of-water (flow, temperature and sediment), biological, cultural, recreational, and economic data reported for tests conducted in FY1996, FY2004, and FY2008 will be included in the report. The synthesis seeks to identify the ecological learning that has occurred with respect to the objectives originally identified for high-flow releases in the 1995 *Operation of Glen Canyon Dam Final Environmental Impact Statement*, as well as the objectives associated with the 12 Glen Canyon Dam Adaptive Management Program goals. Where possible, data and reports relating to earlier high-flow releases from GCD (FY1965 and FY1983–86) will also be evaluated and included in the synthesis. The synthesis of HFEs at GCD should also be placed in context with other reported findings about such flow releases that have been previously published in other settings.

Need for Project

Resource managers have requested that the previous results of three HFEs be synthesized to provide a more comprehensive understanding about the possible effectiveness of high flows for achieving resource objectives within the Colorado River ecosystem. The primary, but not exclusive, focus of HFEs has been the conservation of fine sediment and creation and maintenance of associated sandbar habitats, including backwaters and higher elevation sandbars that support riparian vegetation and recreational camping areas. A complete synthesis of the HFE findings is required for managers to determine future plans for additional experiments and to support current flow-, sediment-, and temperature-modeling research. The project will also support the proposed knowledge assessment effort scheduled for FY2011.

Strategic Science Questions

The synthesis of high-flow experimental results will address the following SSQ on sediment and other associated resource issues:

SSQ 1.3. Do RBT immigrate from Glen to Marble and eastern Grand Canyons, and, if so, during what life stages? To what extent do Glen Canyon immigrants support the population in Marble and eastern Grand Canyons? [FY2007–11]

SSQ 2. 2. How do flows impact old high-water zone terraces in the Colorado River ecosystem (CRE) (where the majority of archaeological sites occur), and what kinds of important information about the historical ecology and human history of the CRE are being lost due to ongoing erosion of the Holocene sedimentary deposits? [FY2004–11]

SSQ 3.1. Is there a "Flow-Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales? [FY2008–11]

SSQ 3.2. To what extent could predation impacts by nonnative fish be mitigated by higher turbidities or dam-controlled high-flow releases? [FY2007–08]

SSQ 4-1. Is there a "Flow Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will rebuild and maintain sandbar habitats over decadal timescales?]

Information Needs Addressed

Not applicable

Methods and Tasks

FY2010

Meetings will be convened with Grand Canyon Monitoring and Research Center and cooperating scientists who have be active on HFE research to review and evaluate previous findings of the FY1996, FY2004, and FY2008 experiments. At least one or two workshops will be convened as part of the synthesis, similar to those undertaken during the FY2008 low summer steady flow (LSSF) synthesis effort. In addition, the three habitat maintenance flow experiments (HMF) of FY1997 and FY2000 will also be reviewed and evaluated to determine the degree to which those experimental results should also be included in the HFE synthesis.

Links/Relationships to Other Projects

This experimental synthesis project will use data from previously published HFE studies in FY1996 and FY2004, as well as reports published in FY2009 on the March 2008 HFE.

Logistics

There are no logistical needs for this project.

Products/Reports

FY2010

This project will result in a USGS series publication synthesizing the natural and cultural resource findings associated with the FY1996, FY2004, and FY2008 HFEs, including recommendations for future high-flow experimentation. Additionally, the principal investigators will update GCDAMP stakeholders on preliminary HFE synthesis progress and findings at Technical Work Group and Adaptive Management Work Group meetings in fall 2010.

Budget

The budget for this project is proposed to be funded from FY2010 Experimental Fund.

FY2010

EXP 7 FY2010	
Synthesis of High-Flow Experimental Results (1996, 2004, and 2008)	
	Fiscal Year 2010
GCMRC Personnel Costs (21% Burden)	144,628
GCMRC Project Related Travel / Training (21% Burden)	0
GCMRC Operations / Supplies / Publishing (21% Burden)	0
GCMRC Equipment Purchase / Replacement / Maintenance (21% Burden)	0
GCDAMP Logistical Support (21% Burden)	0
Outside GCMRC & Contract Science Labor (21% and/or Other Burden Rate)	0
Cooperative / Interagency Agreements (6.09% GCMRC Burden plus Cooperator's Burden)	0
Project Subtotal	**$ 144,628**
DOI Customer Burden (Combined 6.09%, 21% and/or Other Rates)	30,372
Project Total (Gross)	**$ 175,000**
Percent Outsourced (Outside of GCMRC; includes 50% of Logistics)	0%

NOTE: Total project amount for FY2010 is $175,000 of which $66,326 is BOR reimbursable agreement # 06-AA-40-2439 and $108,674 is from BOR Experimental Fund, all from power revenues under cap.

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Appendix A. Key Strategic Science Questions Addressed in the FY2007–11 Science Program

AMWG Priority 1: Why are the humpback chub not thriving, and what can we do about it? How many humpback chub are there and how are they doing? (GCDAMP goal 2)

Key Strategic Science Questions

1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year (YoY) and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions? [FY2006–11]

2. Does a decrease in the abundance of rainbow trout (RBT) and other cold- and warmwater nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile humpback chub to the adult population? [FY2006–11]

3. Do RBT immigrate from Glen to Marble and eastern Grand Canyons, and, if so, during what life stages? To what extent do Glen Canyon immigrants support the population in Marble and eastern Grand Canyons? [FY2007–11]

4. Can long-term decreases in abundance of RBT in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species. [FY2007–11]

5. What are the important pathways, and the rate of flux among them, that link lower trophic levels with fish and how will they link to dam operations? [FY2006–09]

6. Are trends in the abundance of fish populations, or indicators from fish such as growth, condition, and body composition (for example, lipids), correlated with patterns in invertebrate flux? [FY2006–09].

7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained? [FY2008–09].

8. How can native and nonnative fishes best be monitored while minimizing impacts from capture and handling or sampling? [FY2007–11].

AMWG Priority 2: Which cultural resources, including traditional cultural properties, are within the Area of Potential Effect, which should we treat, and how do we best protect them? What is the status and trends of cultural resources and what are the agents of deterioration? (GCDAMP goal 11).

Key Strategic Science Questions

1. Do dam-controlled flows affect (increase or decrease) rates of erosion and vegetation growth at archaeological sites and traditional cultural properties (TCP) sites, and if so, how? [FY2007–11]

2. How do flows impact old high-water zone terraces in the Colorado River ecosystem (CRE) (where the majority of archaeological sites occur), and what kinds of important information about the historical ecology and human history of the CRE are being lost due to ongoing erosion of the Holocene sedimentary deposits? [FY2004–11]

3. If dam-controlled flows are contributing to (influencing rates of) archaeological site/TCP erosion, what are the optimal flows for minimizing future impacts to historic properties? [FY2009–11]

4. How effective are various treatments (for example, check dams, vegetation management, etc.) in slowing rates of erosion at archaeological sites over the long term? [FY2006–11]

5. What are the TCPs in the CRE, and where are they located? [FY2006–11]

6. How can Tribal values/data/analyses be appropriately incorporated into a science-driven adaptive management process in order to evaluate the effects of flow operations and management actions on TCPs? [FY2006–08]

7. Are dam-controlled flows affecting TCPs and other tribally valued resources in the CRE, and, if so, in what respects are they being affected, and are those effects considered positive or negative by the tribes who value these resources? [FY2006–11]

AMWG Priority 3: What is the best flow regime? (GCDAMP goals 1–11)

Key Strategic Science Questions

1. Is there a "Flow-Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales? [FY2008–11]

2. To what extent could predation impacts by nonnative fish be mitigated by higher turbidities or dam-controlled high-flow releases? [FY2007–08]

3. What are the hydropower replacements costs of the modified low fluctuating flow (MLFF) (annually, since 1996)? [FY2007–08]

4. What are the projected hydropower costs associated with the various alternative flow regimes being discussed for future experimental science (as defined in the next phase experimental design)? [FY2006–07]

5. How is invertebrate flux affected by water quality (for example, temperature, nutrient concentrations, turbidity) and dam operations? [FY2006–08]
6. What Glen Canyon Dam operations (ramping rates, daily flow range, etc.) maximize trout fishing opportunities and catchability? [FY2007–08]

7. How do dam-controlled flows affect visitors' recreational experiences, and what is/are the optimal flows for maintaining a high-quality recreational experience in the CRE? [FY2007–08]

8. What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes? [FY2007–09]

9. How do varying flows positively or negatively affect campsite attributes that are important to visitor experience? [FY2009–11]

10. How can safety and navigability be reliably measured relative to flows? [FY2007–08]

11. How do varying flows positively or negatively affect visitor safety, health, and navigability of the rapids? [FY2007–09]

12. How do varying flows regimes positively or negatively affect group encounter rates, campsite competition, and other social parameters that are known to be important variables of visitor experience? [FY2007–09]

AMWG Priority 4: What is the impact of sediment loss and what should we do about it? (GCDAMP goal 8)

Key Strategic Science Questions

1. Is there a "Flow-Only" operation (that is, a strategy for dam releases, including managing tributary inputs with BHBFs, without sediment augmentation) that will restore and maintain sandbar habitats over decadal timescales? (FY2008–11)

2. How important are backwaters and vegetated shoreline habitats to the overall growth and survival of YoY and juvenile native fish? Does the long-term benefit of increasing these habitats outweigh short-term potential costs (displacement and possibly mortality of young humpback chub) associated with high flows? [FY2007–11]

AMWG Priority 5: What will happen when we test or implement the temperature control device (TCD)? How should it be operated? Are safeguards needed for management? (GCDAMP goals 1–4 and 7–10)

Strategic Science Questions

1. How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRE? [FY2006–08]

2. How is invertebrate flux affected by water quality (for example, temperature, nutrient concentrations, turbidity) and dam operations? [FY2006–08]

3. To what extent do temperature and fluctuations in flow limit spawning and incubation success for native fish? [FY2003–08]

4. What is the relative importance of increased water temperature, shoreline stability, and food availability on the survival and growth of YoY and juvenile native fish? [FY2003–08]

5. Will increased water temperatures increase the incidence of Asian tapeworm in humpback chub or the magnitude of infestation, and if so, what is the impact on survival and growth rates? [FY2003–08]

6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance? [FY2007–11]

7. How do warmer releases affect viability and productivity of native/nonnative vegetation? [FY2007–11]

Appendix B—Deferred Projects

BIO 6.R4.10—Terrestrial Habitat Monitoring

Start Date

September 2010

End Date

2012 (and possibly ongoing as a part of core monitoring)

Principal Investigators

Barbara E. Ralston, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, and other cooperators, to be determined

Geographic Scope

The riparian zone, including the old high-water zone (OHWZ; >97,000 cfs), in the Colorado River corridor from Glen Canyon Dam to Lake Mead

Project Goals

The goal of this project is to evaluate the efficacy of arthropod sampling for monitoring change in the NHWZ and OHWZ of the riparian system. Arthropods perform essential ecosystem functions such as decomposition, nutrient recycling and pollination, and are an important food resource for higher organisms. Their small size and rapid population growth rates permit them to be responsive to both fine scale spatial variation and short temporal scales. Consequently, arthropods are typically useful indicators of environmental change. Arthropods are likely to respond rapidly to management practices, potentially informing these decisions faster than if longer lived organisms are used.

The goal of monitoring ground dwelling arthropods (for example, beetles, ants, spiders) is to provide status and trends data on key species and community composition as one of several indicators of ecosystem condition. Questions to be addressed are relative to the NHWZ and OHWZ and include:

- What are the seasonal and annual trends in arthropod composition and abundance?
- What are the relationships among arthropod composition and abundance, vegetation structure and composition, soil stability, and soil moisture?
- Information of the status and trends in ground-dwelling arthropod assemblages can be integrated with monitoring data relating to:
    - vegetation composition and structure,
    - soil stability and upland hydrologic function, and
    - bird community dynamics, to report on the overall condition of these ecosystems.

Need for Project

Ground arthropod species composition (for example, beetles, ants, spiders, crickets, grasshoppers) and abundance are greatly determined by soil texture (that is,, grain size and sandbar coarseness) and moisture conditions, which in shoreline and new high water zones are directly affected by discharges

from Glen Canyon Dam. They are also related to overall habitat structure resulting from variation in topography and vegetation structure and cover (Antvogel and Bonn, 2004) which, themselves, are indirectly linked to dam operations. As the vegetated cover changes, these changes should be correlated with arthropod densities and composition. Their links to other resources biotic resources include the periodic contribution to fish diets (Valdez and Ryel, 1995; Yard and Coggins, in review), and their primary contribution to the diets of riparian breeding birds (Yard and others, 2004).

There are interests in arthropods beyond their ecological roles. Some arthropod taxa are of special interest to both Native American Tribes and to recreational visitors in Grand Canyon. The Hopi are interested in spiders, dragonflies, and butterflies (Huisinga & Yeatts, 2003). Spiders comprised a significant part of the arthropods sampled during the terrestrial ecosystem-monitoring (TEM) project (Kearsley and others, 2006). Dragonflies and butterflies live and breed in the smaller side canyon streams of Grand Canyon, but not in the mainstem. Spiders are common riparian arthropods in Grand Canyon, and in that respect, they are an important group of arthropods of Hopi concern for future monitoring studies. Recreation visitors in Grand Canyon are particularly concerned about arthropods that pose health concerns, especially scorpions, spiders, ants, and biting flies.

Strategic Science Questions

This project does not directly address a strategic science question.

Information Needs Addressed

The primary information needs addressed by these projects are CMINs 6.1.1., 6.2.1, 6.5.1, and 6.6.1 as applied to a broader sense of community, which area summarized as the following:

- Determine how the abundance, composition, and distribution of the OHWZ, NHWZ, and sand beach community.

These information needs will be addressed through the following actions:

- Pitfall traps will be located in OHWZ and NHWZ sites along the river corridor. The traps will be deployed over the spring and summer months and emptied on a monthly basis to determine arthropod composition, distribution and abundance within zones and along the river corridor.

Methods and Tasks

Site Set-up

At each site there will be placed 8–10 pitfall traps 5 meters apart in a line parallel with the river for both a NHWZ and a OHWZ area. The exact study sites and trap locations are to be determined. A pitfall tap is 4.5 cm diameter and 22 cm deep. A 5 cm wide soil auger creates a hole with minimum soil disturbance. A rebar is inserted into the ground prior to soil auger use to make sure there is enough soil depth to hold a pitfall trap. Within each pitfall tube we place a borosilicate test tube filled half-way with propylene glycol for preserving arthropods. A 6 cm X 7.5 cm PVC tube segment is placed over the trap and secured with medium gage wire to prevent rain from entering the trap and animals from disturbing the trap. Trapping periods can vary, but once a time period has been set it is important to maintain that time schedule. Other project sites typically trap for 3-week periods throughout the trapping season.

Analysis

Apply three types of statistical analyses to test for effects of water zone on ground dwelling arthropods.

- Repeated-measures ANOVA tests to test for differences in arthropod abundances and species richness.

- Multi-response permutation procedure (MRPP) will be used to determine arthropod community difference among water zones.
- Non-metric multi dimensional scaling (NMS) scatter plot (Clarke, 1993) will be used to examine similarities of arthropod assemblages among water zones based on Bray-Curtis distances (Beals, 1984; McCune and Beals, 1993).
- Finally, a species indicator analysis to determine if specific arthropod taxa are responding to water zone using a Monte Carlo Test of significance.
- Compare our results with those presented in Kearsley and others (2006).

The following tasks in FY2010 are designed to reach the goal for vegetation mapping:

- Consult with GRCA regarding efficacy of long-term trap deployment.
- Release an RFP for arthropod sampling.
- Determine sampling sites with cooperator and in consultation with GRCA.
- Deploy traps and empty samples on monthly schedule.
- Analyze data in fall 2010.

Links/Relationships to Other Projects

Riparian areas are a critical interface between aquatic and terrestrial environments around the world. In the CRE, the vegetation itself serves as a host for invertebrates, which provide forage for birds and fish. Changes in the composition or structure of riparian vegetation like expansion of an exotic species may alter higher trophic level interactions. Ground arthropod species composition (for example, beetles, ants, spiders, crickets, grasshoppers) and abundance are greatly determined by soil texture (that is,, grain size and sandbar coarseness associated with Goal 8) and moisture conditions, which in shoreline and new high water zones are directly affected by discharges from GCD (Goal 7). They are also related to overall habitat structure resulting from variation in topography and vegetation structure and cover (Antvogel and Bonn, 2004) which, themselves, are indirectly linked to dam operations (sediment transport and conservation Goal 8). Their links to other resources biotic resources include the periodic contribution to fish diets (Valdez and Ryel, 1995; Yard and Coggins, in review), and their primary contribution to the diets of riparian breeding birds (Yard and others, 2004). Some arthropods also affect recreational experience (Goal 9) in a negative manner (for example, biting flies, stinging ants in popular camp areas) and may be an indication of campsite quality.

Logistics

A single snout trip in April and September FY2010 for deployment of traps and follow-up trips coordinated with other resource trips or Grand Canyon Youth trips to empty traps on a regular basis through September.

Products/Reports

These projects will produce a USGS draft report on arthropod composition along the CRE for FY2010, including a species list for those taxa identifiable to species. It will also evaluate the utility of the approach for long-term implementation.

Budget

FY2010

BIO 6.R4.10: $95,395

BIO 6.M1.10—Vegetation Mapping

Start Date

September 2009

End Date

Ongoing. FY2010 is the initiation of long-term monitoring for riparian vegetation.

Principal Investigators

Barbara E. Ralston, U.S. Geological Survey, Grand Canyon Monitoring and Research Center; and other cooperators, to be determined

Geographic Scope

The riparian zone, including the old high-water zone (OHWZ; >97,000 cfs), in the Colorado River corridor from Glen Canyon Dam to Lake Mead

Project Goals

Logistics for groundtruthing hyperspectral overflight deferred due to budget constraints in FY2010.

Need for Project

Strategic Science Questions

Information Needs Addressed

Methods and Tasks

Links/Relationships to Other Projects

Logistics

Logistics for groundtruthing hyperspectral overflight will be deferred.

Products/Reports

Budget

FY2010

BIO 6.M1.10: $48,400

REC 9.R2.10—Evaluate Remotely Sensed Data for Monitoring Campable Area Change in the CRE

See Project DASA 12.D9.10

Start Date

October 1, 2009

End Date

September 30, 2011

Principal Investigators

Helen Fairley, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, with Michael Breedlove, Utah State University, and Hoda Sondossi, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Entire Colorado River ecosystem from base of Glen Canyon Dam (GCD) to Lake Mead (Mile 277)

Project Goals

The goals of this project are to systematically evaluate whether and to what degree remotely sensed imagery combined with photogrammetric data can be used to quantify the total amount of campable area in the CRE. These goals will be accomplished by:

- evaluating campable area derived from imagery and photogrametry to campable area measurements obtained just prior to the May 2009 overflight at a sample of sites, and
- if step 1 shows a strong agreement between the two data sets, by expanding the analysis to include an assessment of total campable area at a random sample of campsites and at all heavily used (NPS priority 1) campsites in the CRE.

See description of Project DASA 12.D9.10–11 for more details about this analysis project.

Need for Project

Current campsite monitoring for the GCDAMP focuses on measuring changes in campable area at a relatively small, non-random but presumably fairly representative sample of sites. However, there are concerns that the sites being monitored at the long-term sandbar sites are not an adequate representation of all campsites, nor do they provide adequate data concerning distribution of campsite areas throughout the CRE. If remotely sensed data can be used to assess changes in campsite area and distribution throughout the CRE, this would reduce or perhaps eliminate the need for frequent repeat surveys using total stations and would provide a more systemwide perspective on the effects of flows on campsite area and distribution. This analysis will be completed in advance of the FY2011 campsite PEP to provide additional options for consideration as future core-monitoring approaches.

Strategic Science Questions

This project directly addresses the following strategic science question:

> **SSQ 3-9.** How do varying flows positively or negatively affect campsite attributes that are important to visitor experience?

Indirectly, this project will also provide information that is relevant for addressing a second strategic science question about the effects of flows on the quality of recreational experience in the CRE:

> **SSQ 3-8.** What are the drivers for recreational experiences in the CRE, and how important are flows relative to other drivers in shaping recreational experience outcomes?

Information Needs Addressed

This project is designed to address management objective 9.3 and specifically, the AMP's top priority CMIN for Goal 9:

> **CMIN 9.3.1.** Determine and track the size, quality, and distribution of camping beaches by reach and stage level in Glen and Grand Canyons.

CMIN 9.3.1 is very closely related to a second CMIN under Management Objective. 9.3

> **CMIN 9.3.2.** Determine and track the effects of ROD operations on the size, quality, and distribution of camping beaches in the CRE.

The current recreation monitoring program focuses primarily on one aspect of CMIN 9.3.1: campsite size. This project will contribute information relative to assessing changes in camp size on a systemwide basis, and will explore alternative options for meeting the information objectives of CMIN 9.3.1 and will also contribute potentially valuable information relative to interpreting the effects of experimental flows on camping sites, as defined by EIN 9.3.1.

> **EIN 9.3.1.** How do the size, quality, and distribution of camping beaches change in response to an experiment performed under the ROD, unanticipated event, or other management action?

Methods and Tasks

The work proposed in FY2010–11 will involve two primary components;

- evaluate remotely sensed imagery and photogrammetric data in relation to survey data of campable area collected just prior to the May 2009 overflight; and
- use the photogrammetric data collected in 2009, as appropriate and feasible, to assess the overall amount of campable area at a random sample of sites and at the most heavily used sites in the CRE.

Links/Relationships to Other Projects

This project is part of the remotely sensed image analysis project described under Goal 12. This project will provide additional data about potential alternative or supplementary approaches for monitoring campsites that can be considered by the FY2011 campsite monitoring PEP.

Logistics

The work planned for FY2010–11 does not anticipate a need for project specific logistical support. Field work required to verify or update the remotely sensed data will be accomplished through coordination with other projects with planned river trips (for example, campsite atlas or other trips to ground truth or update survey data for the imagery analysis project).

Products/Reports

An assessment of the quality and accuracy of remotely sensed data for determining campsite area systemwide will be published as an OFR or Scientific Investigation Report in FY2011.

Budget

FY2010

REC 9.R2.10: See Project DASA 12.D9.10

REC 9.R5.xx—Evaluate Relation Between Flows and Recreation Experience

Start Date

End Date

Principal Investigator(s)

Geographic Scope

Project Goals

Need for Project

Strategic Science Questions

Information Needs Addressed

Methods and Tasks

Links/Relationships to Other Projects

Logistics

Products/Reports

Budget

FY2010

REC 9.R5.xx: $225,000

FY2011

REC 9.R5.xx: $225,000

REC 9.R6.xx—1973 Weeden Survey Revisited

Start Date

End Date

Principal Investigator(s)

Geographic Scope

Project Goals

Need for Project

Strategic Science Questions

Information Needs Addressed

Methods and Tasks

Links/Relationships to Other Projects

Logistics

Products/Reports

Budget

FY2010

REC 9.R6.xx: $75,000

FY2011

REC 9.R6.xx: $75,000

REC 9.R7.xx—Update Regional Recreation Economic Study

Start Date

End Date

Principal Investigator(s)

Geographic Scope

Project Goals

Need for Project

Strategic Science Questions

Information Needs Addressed

Methods and Tasks

Links/Relationships to Other Projects

Logistics

Products/Reports

Budget

FY2010

REC 9.R7.xx: $250,000

FY2011

REC 9.R7.xx: $250,000

CUL 11.R3.xx—Geomorphic Model of Archaeological Site Vulnerability

Start Date

End Date

Principal Investigator(s)

Geographic Scope

Project Goals

Need for Project

Strategic Science Questions

Information Needs Addressed

Methods and Tasks

Links/Relationships to Other Projects

Logistics

Products/Reports

Budget

FY2010

CUL 11.R3.xx: $250,000

FY2011

CUL 11.R3.xx: $250,000

DASA 12.D1.11—Quadrennial Remote Sensing Overflight

Start Date

October 1, 2009

End Date

Ongoing

Principal Investigator(s)

Philip A. Davis, U.S. Geological Survey, Western Mineral Resources Science Center

Geographic Scope

Project Goals

Hyperspectral airborne imagery that provides 357 bands between 0.4 and 2.5 micrometers of wavelength flown at 2,500 feet above the riparian zone between river miles 42 to 73. The purpose of this flight is to evaluate the use of hyperspectral image data for core monitoring of marsh vegetation, better identification of species of woody vegetation, as well as all vegetation species, and to collect baseline information for monitoring potential tamarisk defoliation due to the tamarisk beetle. Current 4-band sensors provide limited discrimination and identification of riparian and xeric species; recent research has shown hyperspectral data to provide significantly increased discrimination, including senescent vegetation and crytogamic soil (Aspinall, 2002; Kalkhan, 2003; Hauer and Lorang, 2004). Funds for this overflight are already available; the flight would occur during early September 2010 during the scheduled steady flow. If this system can accurately map most or all major vegetation species within the river corridor, then the vegetation inventory will be dramatically more accurate and more useful for monitoring vegetation change due to dam release, climate, and infestation. In addition, these data may be able to map cryptogamic soil within the corridor, to map nearshore aquatic vegetation, and to determine certain water properties.

- Specific to FY2010, we intend to collect hyperspectral image data over a 30-mile segment of the CRE during early September 2010. This will involve a fixed wing aircraft flying at 2,500 feet above the channel and providing calibrated, reflectance data for 357 spectral bands at a spatial resolution near 1 meter. This will require rim support by GCMRC personnel to occupy three nearby base stations. Ground truth surveys near the time of overflight will be conducted under the guidance and permit of the biological program (B. Ralston), with participation of a remote sensing specialist (P. Davis). Analysis of the data will commence in early FY2011 and is discussed under the task “Integrated Analysis of Remotely Sensed Data,”

Need for Project

Strategic Science Questions

Information Needs Addressed

Methods and Tasks

Links/Relationships to Other Projects

Logistics

Products/Reports

Budget

FY2010

DASA 12.D1.10: $46,776

FY2011

DASA 12.D1.11: $200,000

DASA 12.D9.10–11—Integrated Image Analysis and Change Detection

Start Date

October 2009

End Date

Ongoing

Principal Investigators

Philip A. Davis, U.S. Geological Survey, Western Mineral Resources Science Center; Glenn Bennett, Paul Grams, Barbara Ralston, and Helen Fairley, U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Colorado River ecosystem corridor between the forebay of Glen Canyon Dam and upper Lake Mead

Project Goals

- photogrammetric analyses of historical aerial photography for selected river reaches to derive sandbar topography and extend sandbar volumetric change analyses back in time to 1984;
- detailed analyses of hyperspectral imagery to determine level of species discrimination and accuracy of mapping vegetation composition at the alliance level, as well as to determine the ability of the data for mapping cryptogamic soil;

Methods and Tasks

Analysis of Historical Aerial Photographs to Determine 1984 Sandbar Topography (Lead Scientist – P. Grams)

Aerial photographs from the mid-1930s, 1951-52, 1965, 1973, 1984, 1990, and 1996 have been used to map the area of exposed sand in broad elevation categories for select monitoring reaches (Schmidt and others, 1999). A pilot study completed in FY2000 (O'Brien and others, 2000) investigated the feasibility of applying digital photogrammetric methods to the 1984 photographs to derive sandbar topography for comparison with modern surveys. Although this study found that the photogrammetric surfaces did not agree perfectly with ground-based surveys, the elevations for sand areas were generally within 30 cm of surveyed elevations, which is sufficient for detecting significant change in sandbar elevation. This task will apply similar methods using more sophisticated techniques for selected sandbar study sites in order to extend the NAU sandbar time series back in time. This project will produce digital elevation models using digitally scanned 1984 stereo photographs. In FY2010, representative sites will be selected and various techniques and approaches will be tested to determine the method that produces the best, acceptable results. The results will be reported in an annual report and included in a peer reviewed report or journal article produced in cooperation with project PHY 8.M2.10–11.

Methods and Tasks

Analysis of historical aerial photographs to determine 1984 sandbar topography (Lead Scientist – P. Grams)

In FY2011, the method developed in FY2010 will be applied to other selected, but larger areas. The results from this analysis and all previous ground based and airborne data collections will be analyzed to examine changes within the available time series. The results will be reported in an annual report and included in a peer reviewed report or journal article produced in cooperation with project PHY 8.M2.10-11.

Analysis of Hyperspectral Imagery for Improved Vegetation Mapping and Monitoring (Lead Scientist – B. Ralston)

If we collect hyperspectral image data in FY2010, we will analyze the data to determine its ability to accurately map the major vegetation species within the CRE, including vegetation that is mostly woody or in senescence. This analysis will require ground-truth data for selected, large vegetation patches that collectively possess the range of species within the CRE. We may also need to collect ground reflectance data for some vegetation patches near the time of the data collection. All of these ground data will be used to determine the full capability of the hyperspectral data for mapping and monitoring vegetation at the community level or better. An important result would be the ability to not only map communities but also determine their vegetation compositions, which ultimately will allow close, detailed mapping and monitoring change in native and nonnative species, dam release and climatic effects, potential tamarisk beetle effects, habitat quality, and cryptogamic soil. The results of this analysis will be presented to the AMWG and TWG and will be published in a formal USGS or journal publication.

Products/Reports

- The results of the hyperspectral data analysis for improved vegetation mapping and monitoring will be presented to the AMWG and TWG and published as a formal USGS or journal publication

Budget

FY2010

DASA 12.D9.10: $89,568

FY2011

DASA 12.D9.11: $0

PLAN 12.P1.10–11: Identify Critical Ecosystem Interactions and Data Gaps

Start Date

August 2008

End Date

December 2011

Principal Investigators

Carl Walters, University of British Columbia
CO-I(s): Scott Wright, U.S. Geological Survey, California Water Science Center, William Pine, University of Florida, Karen Limburg, University of New York, Syracuse (SUNY), Robert Hall, University of Wyoming, Emma Rossi-Marshall, Loyola University, Colden Baxter, Idaho State University, Josh Korman, Ecometric Research, Inc.; Lew Coggins, Ted Kennedy, Kara Hilwig and Mike Yard, U.S. Geological Survey Grand Canyon Monitoring and Research Center, Dale Robertson, U.S. Geological Survey, Wisconsin Water Science Center

Geographic Scope

Continued research and decision support for review, revision, upgrade and use of various Ecosystem Models in collaboration with Senior Ecologist and other cooperators; Includes additional support from GCMRC staff, Senior Ecologist, and select cooperators

Entire Grand Canyon Monitoring and Research Center study area, from the forebay of Lake Powell to upper Lake Mead. During FY2010–11, the work will focus mainly in the Lees Ferry and LCR confluence reaches of the Colorado River, where current aquatic ecosystem values and monitoring (rainbow trout, native fish) are concentrated. Some monitoring evaluations and data analysis will extend from GCD to Lake Mead, especially to evaluate longitudinal changes in aquatic system productivity and carrying capacity for native fish.

Project Goals

Need for Project

Strategic Science Questions

Methods and Tasks

FY2011

- Multi-attribute tradeoff analysis (MATA) workshop deferred in FY2011

Links/Relationships to Other Projects

This project will utilize data from all studies that collect information on the aquatic biota of Glen, Marble, and Grand Canyons, including the aquatic food web, HBC monitoring, Lees Ferry trout monitoring, mechanical removal, nonnative fish monitoring, and the NSE project. The main benefits to the projects listed will be to provide novel analyses of data and methods for linking project results into overall conceptual and quantitative models for response of the CR aquatic ecosystem to management changes. The flow and sediment modeling elements of this project are linked most closely to the Integrated Flow, Sediment, and Temperature Modeling project.

Logistics

There are no logistical needs for this project

Products/Reports

FY2011

- Multi-attribute tradeoff analysis (MATA) workshop deferred in FY2011

Budgets

FY2011

PLAN 12.P1.11: $33,169

Appendix C. Conservation Measures from 2008 Biological Opinion

Pursuant to Section 7 of the Endangered Species Act of 1973, as amended, the U.S. Fish and Wildlife Service (USFWS) consulted with the Bureau of Reclamation (Reclamation) on the operation of Glen Canyon Dam and developed Conservation Measures. The following conservation measures are extracted directly from the USFWS February 27, 2008, Final Biological Opinion for the Operation of Glen Canyon Dam.

Conservation Measures

Reclamation has included the following conservation measures for listed species in the action area as part of its proposed action. As described above, the AMP provides a process for assessing the effects of current operations of Glen Canyon Dam on downstream resources and using the results to develop recommendations for modifying dam operations and other resource management and conservation actions. The AMP also provides for long-term monitoring and research activities to evaluate the effectiveness of the operational modifications to Glen Canyon Dam and other management actions. Many of the conservation measures listed below have already been occurring through the AMP at various levels. We believe conservation measures carried out through the AMP have resulted in significant conservation benefits to humpback chub and Kanab ambersnail. The existence of the AMP and the history of conservation of these species through the AMP serve to substantiate that the following conservation measures will be implemented as proposed by Reclamation. Implementation of some of these conservation measures may require additional compliance. USFWS is currently investigating the feasibility of developing a recovery program for humpback chub in Grand Canyon. All of the conservation measures listed here could fall under such a program. Agreements would need to be developed to facilitate cost sharing with other agencies and organizations, both within and outside of the AMP, to fully implement a recovery program.

Humpback Chub

Humpback Chub Consultation Trigger

Pursuant to 50 CFR § 402.16 (c), reinitiation of formal consultation is required and shall be requested by the Federal agency or by the USFWS, where discretionary Federal involvement or control over the action has been retained or is authorized by law and if new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered. Reclamation and USFWS agree to specifically define this reinitiation trigger relative to humpback chub, in part, as being exceeded if the population of adult humpback chub (≥200 mm [7.87 in] TL) in Grand Canyon declines significantly, or, if in any single year, based on the age-structured mark recapture model (ASMR; Coggins 2007), the population drops below 3,500 adult fish within the 95 percent confidence interval. USFWS and Reclamation have agreed on this trigger based on the current estimated population size and past population trend, genetic considerations, and the capabilities of the ASMR model to estimate population size. This number was derived as a conservative approach to preventing the population from declining to the minimum viable population size for humpback chub, estimated to be 2,100 adult fish (U.S. Fish and Wildlife Service 2002a), with consideration for a buffer and acknowledging the variance inherent in the ASMR resulting from age estimation based on recent results from this model (Coggins 2007). This trigger provides additional protection against possible adverse affects to humpback chub from the proposed action. If the population of humpback chub declines to this level, Reclamation and USFWS will consider appropriate actions through reinitiated section 7 consultation, for example, extending the period of steady releases to include July and August.

Conversely, if the population of humpback chub expands significantly, USFWS and Reclamation will consider the potential for reinitiation of consultation to determine if steady flows continue to be necessary.

Comprehensive Plan for the Management and Conservation of Humpback Chub in Grand Canyon

Reclamation has been a primary contributor to the development of the AMP's Comprehensive Plan for the Management and Conservation of Humpback Chub in Grand Canyon. Reclamation will continue to work with AMP cooperators to develop a comprehensive approach to management of humpback chub. Reclamation has committed to specific conservation measures in this biological opinion, but will also consider funding and implementing other actions not identified here to implement the plan.

Humpback Chub Translocation

In coordination with other Department of the Interior (DOI) AMP participants and through the AMP, Reclamation will assist NPS and the AMP in funding and implementation of translocation of humpback chub into tributaries of the Colorado River in Marble and Grand canyons. Nonnative control in these tributaries will be an essential precursor to translocation, so Reclamation will help fund control of both cold and warm-water nonnative fish in tributaries, as well as efforts to translocate humpback chub into these tributaries. Havasu, Shinumo and Bright Angel creeks will initially be targeted for translocation, although other tributaries may be considered. Reclamation will work with USFWS, NPS and other cooperators to develop translocation plans for each of these streams, utilizing existing information available such as SWCA and Grand Canyon Wildlands (2007) and Valdez and others. (2000a). These plans will consider and utilize genetic assessments (Douglas and Douglas 2007, Keeler-Foster in prep.), identify legal requirements and jurisdictional issues, methods, and assess needs for nonnative control, monitoring and other logistics, as well as an implementation schedule, funding sources, and permitting. Reclamation and the AMP will also fund and implement translocation of up to 500 young humpback chub from the lower Little Colorado River to above Chute Falls in 2008 if USFWS determines that a translocation is warranted. Reclamation and the AMP will continue to monitor humpback chub in the reach of the Little Colorado River above Chute Falls for the 5-year period of the proposed action, and will undertake additional translocations above Chute Falls as deemed necessary by USFWS.

Nonnative Fish Control

As first presented in the biological opinion on the Shortage Guidelines, Reclamation will, in coordination with other DOI AMP participants and through the AMP, continue efforts to assist NPS and the AMP in control of both cold- and warm-water nonnative fish species in both the mainstem of Marble and Grand canyons and in their tributaries, including determining and implementing levels of nonnative fish control as necessary. Because Reclamation predicts that dam releases will be cool to cold during the period of the proposed action, control of nonnative trout may be particularly important. Control of these species will utilize mechanical removal, similar to recent efforts by the AMP, and may utilize other methods, to help to reduce this threat. GCMRC is preparing a nonnative fish control plan through the AMP process that addresses both cold and warm-water species that will further guide implementation of this conservation measure.

Humpback Chub Nearshore Ecology Study

In coordination with other DOI AMP participants and through the AMP, Reclamation will implement a nearshore ecology study that will relate river flow variables to ecological attributes of nearshore habitats (velocity, depth, temperature, productivity, etc.) and the relative importance of such habitat conditions to important life stages of native and nonnative fish. This study will incorporate planned science activities for evaluating the high-flow test on nearshore habitats as well as the 5-year period of steady flow releases in September and October. A research plan will be developed with US via the AMP for this study by August 1, 2008, and a 5-year review report will be completed by 2013. The plan will include monitoring of sufficient intensity to ensure significant relationships can be

established, as acceptable to the USFWS. This conservation measure is consistent with the Sediment Research conservation measure in the Shortage Guidelines biological opinion. This study will help clarify the relationship between flows and mainstem habitat characteristics and availability for young-of-year and juvenile humpback chub, other native fish, and competitive or predaceous nonnative fish, and support continued management to sustain mainstem aggregations. The feasibility and effectiveness of marking small humpback chub (<150 and <100 mm TL [5.91 and 3.93 in]) will also be evaluated as part of the study, and if effective, marking young fish will be utilized in the study. Marking young humpback chub, if feasible and effective, could greatly aid in developing information on the early life history, growth and survival of young humpback chub.

Monthly Flow Transition Study

Transitions between monthly flow volumes can often result in drastic changes to nearshore habitats. For example, past transitions from August to September in some years have consisted of a transition from a lower limit of 10,000 cfs in August to an upper limit of 10,000 cfs in September. Such a transition results in a river stage level that is below the varial zone of the previous month's flow, and may be detrimental to fish and food base for fish. Reclamation has committed to adjusting daily flows between months to attempt to attenuate these transitions such that they are more gradual, and to studying the biological effects of these transitions, in particular to humpback chub. If possible, Reclamation will work to adjust September and October monthly flow volumes to achieve improved conditions for young-of-year, juvenile, and adult humpback chub, as acceptable to the USFWS.

Humpback Chub Refuge

Once appropriate planning documents are in place, and refuge populations of humpback chub are created (as a conservation measure of the Shortage Guidelines biological opinion), Reclamation will assist USFWS in maintenance of a humpback chub refuge population at a Federal hatchery or other appropriate facility by providing funding to assist in annual maintenance. In case of a catastrophic loss of the Grand Canyon population of humpback chub, a humpback chub refuge will provide a permanent source of sufficient numbers of genetically representative stock for repatriating the species. This action would also be an important step toward attaining recovery.

Little Colorado River Watershed Planning

Reclamation will continue its efforts to help other stakeholders in the Little Colorado River watershed develop watershed planning efforts, with consideration for watershed level effects to the humpback chub in Grand Canyon.

Kanab Ambersnail

Habitat Protection

Reclamation will, through the AMP, temporarily remove and safe-guard all Kanab ambersnails found in the zone that would be inundated during the high-flow test, as well as approximately 15 percent (17 m2 [180 ft2]) of the Kanab ambersnail habitat that would be flooded by the experimental high-flow test. The ambersnails would be released above the inundation zone, and habitat would be held locally above the level of inundation until the high-flow test has ended (approximately 60 hours). Habitat will be replaced in a manner that will facilitate regrowth of vegetation. Subsequent monitoring of this conservation measure will be coordinated with GCMRC.

Appendix D. Fiscal Years 2010–11 Budget Explanatory Material

The draft budget for the Glen Canyon Dam Adaptive Management Program (GCDAMP) for fiscal years (FY) 2010 and 2011, which includes budgets for GCDAMP activities preformed by Reclamation and the U.S. Geological Survey (USGS) Grand Canyon Monitoring and Research Center (GCMRC), is attached separately. Table C.1 explains the information found in various columns of the budget document. Following the table is an explanation of USGS policy on cost-recovery accounting and cost share.

Table D.1. Explanation of information found in columns of draft fiscal year (FY) 2010-11 Glen Canyon Dam Adaptive Management Program (GCDAMP) budget.

Column	Title	Key
A	Grand Canyon Monitoring and Research Center (GCMRC) Project ID	Characters 1–3 Identify program area BIO: Biology PHY: Physical Science REC: Recreation HYD: Hydropower CUL: Cultural DASA: Data Acquisition, Storage and Analysis SUP: Support (Logistics and Survey) ADM: Administration and Management PLA: Planning Characters 4–5 Identify GCDAMP goal number Characters 6–7 Identify GCMRC project number Characters 8–9 Identify fiscal year
B	Status	O: Ongoing N: New C: Complete D: Deferred NA: Not applicable
C	Funding emphasis	APM: Administrative program management. Activities/projects that are administrative in nature or are conducted in support of the overall GCMRC science program, including base funding for program managers, logistics staff and permanent DASA staff. COR: Core-monitoring project. Monitoring projects that have been piloted, subjected to initial and secondary protocols evaluation panel (PEP) reviews, documented through a core-monitoring report and formally adopted as a core-monitoring project by the Technical Work Group (TWG). CRD: Core-monitoring research and development project. Monitoring projects that are currently undergoing research and development, including projects that have been piloted and peer reviewed but which have not yet been formally documented with a core-monitoring report or formally adopted as a core-monitoring project by the TWG. LTE: Long-term experiment. Projects specifically undertaken as part of or in direct support of the Long-Term Experimental Plan. ORD: Other research and development projects. Other research projects or research and development work that is NOT directly tied to the development of core-monitoring projects.
D	Project description	Project title (start date–end date)
E	Actual FY2009 budget	Actual GCDAMP FY2009 gross budget figures as of this revision date
F	Proposed FY2010 or FY2011 budget	Proposed FY2010 or FY2011 gross cost of project as of this revision date

Explanation of USGS Policy on Cost Share

In FY2003, the U.S. Geological Survey (USGS) began full-cost recovery accounting and instituted a Department of the Interior (DOI) customer rate of 15 percent against all DOI agency reimbursable funding. In FY2010–11, the customer rate is estimated at the 15-percent DOI customer rate with an additional 6 percent added to achieve the required additional facilities costs. The DOI customer rate was established by the USGS Headquarters and determined to be significantly lower than the "full" burden rate that varies annually and includes facilities and the Cost Center and the Bureau-level burdens. In addition to the above rates, a special "pass through" rate of 6 percent was also instated. As a transitional aid to the GCMRC, which had received under a previous administration the guarantee that USGS would not charge the power revenue funds any burden, the Bureau allowed the entire GCMRC power revenue budget to be charged only the 6-percent special rate (3 percent was retained by the Cost Center and 3 percent by Headquarters) for FY2003 only.

Beginning in FY2004, USGS Headquarters approved the special rate of 6 percent for a portion of GCMRC's power revenue funding. This rate is applied to approximately $3 million of funding that is directly "passed through" to GCMRC cooperators. The balance of power revenue funds are charged the full DOI customer rate of 15 percent plus facilities. As a part of the full-cost recovery policy, the USGS established a process, referred to as cost share, as a means of handling a limited electronic financial system.

Cost share is the funding that "covers" the balance of the full burden rate minus the DOI customer rate. In most cases, reimbursable funding from non-DOI agencies is charged the full burden rate. In FY2009, the full burden rate for the GCMRC was approximately 56 percent (including facilities). The difference between the full rate of 56 percent and the DOI customer rate of 21 percent (which includes approximately 4 percent for facilities), equals 35 percent (all percentages are approximate). In FY2009 the cost-share funding requirement for all DOI agency reimbursable dollars received by the GCMRC was approximately $1 million. USGS policy requires that cost-share funding be from appropriated dollars only, and those appropriated funds are also charged the Cost Center burden rate. In essence, the approximately $1 million appropriation provided by the USGS to the GCMRC in FY2009 had the effect of not adding funding, but merely filling the holes created by the cost-share policy.

In previous fiscal years, the USGS appropriation requested for GCMRC (approximately $1 million each fiscal year) has been used for cost-share funding. Per the full-cost accounting policy and the requirement that cost-share dollars be appropriated dollars only, the effect of these appropriations is entirely transparent and does not add funding to the GCDAMP. The issue relating to how these cost-share funds are derived in the future has and continues to be a major area of concern for the GCMRC science program.

Appendix E. GCDAMP Fiscal Year 2010–11 Budget

Oversized budget sheets follow this page.

APPENDIX E
FY2010

	ID	Project Descriptions	Approved FY09 Budget (incl 4.9% CPI Increase)	FY10 GROSS Proposed Budget (incl 0% CPI Increase)	Comments
2	**Reclamation Administration Power Revenue Under Cap Funded Projects**				
3	A	Adaptive Management Work Group			
4	1	Personnel Costs	176,747	176,747	
5	2	AMWG Member Travel Reimbursement	17,467	17,467	
6	3	Reclamation Travel	14,178	14,178	
7	4	Facilitation Contract	26,959	26,959	
8	5	POAHG Expenses	55,536	55,536	
9	6	Other	7,969	7,969	
10	Reclamation AMWG Subtotal		**298,856**	**298,856**	
11	B	Technical Work Group			
12	1	Personnel Costs	86,195	86,195	
13	2	TWG Member Travel Reimbursement	23,952	23,952	
14	3	Reclamation Travel	17,658	17,658	
15	4	TWG Chair Reimbursement	24,625	24,625	
16	5	Other	2,277	2,277	
17	Reclamation TWG Subtotal		**154,707**	**154,707**	
18	C	Other			
19	1	Compliance Documents	50,000	50,000	The intent is to carry over unused funds for future compliance needs.
20	2	Administrative Support for NPS Permitting	118,852	118,852	
21	3	Contract Administration	39,953	39,953	
22	4	Experimental Carryover Funds - to be held by BOR	500,000	500,000	GCMRC proposes to use $258,674 in FY10, if accepted balance would be $241,326. This is not a Reclamation proposal.
23	5	Integrated Tribal Resources Monitoring	142,884	142,884	+ 75k Appropriated Funds from Tribal Consultation Carryover from Prior Fiscal Years
24	6	Mainstem Non-native Mechanical Removal	-	-	
25	7	Non-native Fish Suppression Contingency Fund	48,483	48,483	GCMRC proposes to use $48,483 from FY09 carryover + $48,483 from FY10. If accepted, balance would be 0. This is not a Reclamation proposal.
26	Other Subtotal		**900,172**	**900,172**	
27	Reclamation Administrative Subtotal		**1,353,735**	**1,353,735**	
28	D	Programmatic Agreement Cultural Resources			
29	1	Reclamation Administration	60,164	60,164	
30	2	Canyon Treatment Plan and Implementation	500,000	500,000	
31	Programmatic Agreement Subtotal		**560,164**	**560,164**	
32	Reclamation Power Revenue Under Cap Program		**1,913,899**	**1,913,899**	
33					
34	Reclamation Appropriated Funded Projects				
35	HCA	Development of a LCR Management Plan	-	-	
36	Tribal Consultation				
37	A	Cooperative Agreements with Tribes			
38	1	Hopi Tribe	95,000	95,000	
39	2	Hualapai Tribe	95,000	95,000	
40	3	Navajo Nation	95,000	95,000	
41	4	Pueblo of Zuni	95,000	95,000	
42	5	Southern Paiute	95,000	95,000	
43	6	DOI Handling Fee	-	-	
44	Tribal Consultation Subtotal		**475,000**	**475,000**	
45	Reclamation Appropriated Projects Subtotal:		**475,000**	**475,000**	
46					
47		**BUREAU OF RECLAMATION TOTAL AMP**	**2,388,899**	**2,388,899**	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
48																		
49	GCMRC Project ID	FY10 Status	Funding Emphasis	Project Descriptions	Carry Over Funding from FY09 Available for Use in FY10	BOR Experimental Funds Used in FY10 (included in FY10 Gross Budget)	Approved FY09 Budget (incl 4.9% CPI Increase)	FY10 GROSS Proposed Budget (incl 0% CPI Increase)	FY10 DOI Customer Burden (Combined 6.09%, 21% and/or Other Rate)	FY10 NET Project Subtotal (w/o Burden)	FY10 GCMRC Personnel Costs (21% Burden)	FY10 GCMRC Project Related Travel / Training (21% Burden)	FY10 GCMRC Operations / Supplies / Publishing (21% Burden)	FY10 GCMRC Equipment Purchase / Replacement (21% Burden)	FY10 AMP Logistics Support (21% Burden)	FY10 Suballocation Outside GCMRC Contract & Science Labor (O% GCMRC Burden plus Suballocator's Burden Rate)	FY10 Coop & Inter Agency Agmts (6.09% GCMRC Burden plus Cooperator's Burden)	Comments
50	U.S. Geological Survey - Biological Resource Division - GCMRC - Power Revenues Under Cap Funded Projects																	
51																		
52	**GOAL 1 - FOOD BASE**																	
53	BIO 1.R1.10	O	CRD	Aquatic Food Base (FY05--FY10)	20,000	-	510,626	505,945	60,823	445,122	185,122	5,000	5,000	1,000	30,000	-	219,000	
54	BIO 1.M1.11	-	COR	Aquatic Food Base (FY11--Ongoing)	-	-	-	-	-	-	-	-	-	-	-	-	-	
55	BIO 1.R4.10	O	CRD	Impacts of Various Flow Regimes on the Aquatic Food Base (FY08--FY10)	-	-	85,472	62,111	5,851	56,260	11,260	-	-	-	5,000	-	40,000	Any future work will be Integrated with Aquatic Food Base (BIO 1.M1.10)
56				**SUB-TOTAL GOAL 1**	**20,000**	**-**	**596,098**	**568,055**	**66,673**	**501,382**	**196,382**	**5,000**	**5,000**	**1,000**	**35,000**	**-**	**259,000**	
57	**GOAL 2 - NATIVE FISHES**																	
58	BIO 2.R1.10	O	CRD	LCR HBC Monitoring Lower 13.6km (HBC Population Est) (Ongoing)	-	-	487,666	455,735	36,280	419,455	-	-	-	20,000	52,000	-	347,455	**BOCM**
59	BIO 2.R2.10	O	CRD	LCR HBC Monitoring Lower 1,200m (Ongoing)	-	-	61,635	57,421	4,421	53,000	-	-	-	-	8,000	-	45,000	**BOCM**
60	BIO 2.M1.11	-	COR	LCR Fish Monitoring (FY11--Ongoing)	-	-		-	-	-	-	-	-	-	-	-	-	
61	BIO 2.M3.10	O	CRD	HBC Monitoring Above Chute Falls (Ongoing)	-	-	136,490	143,194	15,950	127,244	-	-	-	-	55,000	-	72,244	**BOCM**
62	BIO 2.R4.09	C	ORD	Monitoring Mainstem Fishes (incl Diamond Down) (FY09)	-	-	474,723	-	-	-	-	-	-	-	-	-	-	**BOCM**
63	BIO 2.M4.10	N	COR	Monitoring Mainstem Fishes (FY10--Ongoing)	-	-	-	632,461	72,799	559,662	59,662	10,000	10,000	30,000	150,000	-	300,000	**BOCM** Implements 2009 PEP recommendations
64	BIO 2.R5.09	C	ORD	Nonnative Control Planning (FY06--FY09)	-	-	63,640	-	-	-	-	-	-	-	-	-	-	**BOCM**
65	BIO 2.R6.09	C	ORD	Nonnative Control Pilot Testing (FY06--FY09)	-	-	110,281	-	-	-	-	-	-	-	-	-	-	**BOCM**
66	BIO 2.R17.10	N	ORD	Nonnative Control Plan Science Support (FY10--Ongoing)	-	-	-	78,058	13,547	64,511	62,511	2,000	-	-	-	-	-	**BOCM** Provide science support for implementation for the Nonnative Fish Control Plan
67	BIO 2.R7.10	O	ORD	Stock Assessment of Native Fish in Grand Canyon (FY07--Ongoing)	-	-	54,619	110,877	19,243	91,634	86,634	3,000	2,000	-	-	-	-	**BOCM**
68	BIO 2.R9.09	C	CRD	Mainstem Fish Survival (FY07--FY09)	-	-	96,013	-	-	-	-	-	-	-	-	-	-	**BOCM** FY10 Integrated with Conceptual Ecosystem Model (PLAN 12.P1.10) & Near Shore Ecology (BIO 2.R15.10) projects
69	BIO 2.R13.10	O	CRD	Remote PIT Tag Reading (FY07--Ongoing)	-	-	107,319	217,268	21,689	195,579	5,579	-	-	45,000	15,000	-	130,000	**BOCM**
70	BIO 2.R15.10	O	CRD	Near Shore Ecology / Fall Steady Flows (FY08--FY12)	-	-	11,970	-	-	-	-	-	-	-	-	-	-	**BOCM** Funding provided by BOR appropriated funds (see below)
71	BIO 2.R16.10	O	ORD	Mainstem Nonnative Fish Control (Ongoing)	-	150,000	141,023	68,842	11,948	56,894	20,000	1,554	2,000	23,000	10,340	-	-	**BOCM** TOTAL FY10 Funding $315,308; $68,842 funded Power Revenues + $150,000 funded from BOR Experimental Fund <see below> + $96,466 funded from BOR Nonnative Contingency Fund <see below>
72	BIO 2.TBD	O	ORD	Nonnative Fish Contingency Fund	36,818	-	-	-	-	-	-	-	-	-	-	-	-	
73				**SUB-TOTAL GOAL 2**	**36,818**	**150,000**	**1,745,379**	**1,763,855**	**195,876**	**1,567,979**	**234,386**	**16,554**	**14,000**	**118,000**	**290,340**	**-**	**894,699**	
74	**GOAL 3 - EXTIRPATED SPECIES**																	
75	07.3.00	-	NA	None Identified	-	-	-	-	-	-	-	-	-	-	-	-	-	
76				**SUB-TOTAL GOAL 3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	
77	**GOAL 4 - RAINBOW TROUT**																	
78	BIO 4.M1.09	C	COR	Monitoring Lees Ferry Trout (FY96--FY09)	-	-	118,454	-	-	-	-	-	-	-	-	-	-	Moved to Core Monitoring (BIO 4.M2.10) beginning FY10; Subject to revision based on Cooperator analyses
79	BIO 4.E1.09	C	LTE	Monitoring Rainbow Trout Redds & Larvae (FY07--FY09)	-	-	-	-	-	-	-	-	-	-	-	-	-	Work conducted under HFE Science Plan in FY 08 and 09; Moved to Core Monitoring (BIO 4.M2.10) beginning FY10
80	BIO 4.M2.10	N	COR	Monitoring Lees Ferry Fishes (FY10--Ongoing)	-	-	-	175,737	12,879	162,858	4,858				15,000		143,000	Core Monitoring Project beginning in FY10; Subject to revision based on Cooperator analyses
81				**SUB-TOTAL GOAL 4**	**-**	**-**	**118,454**	**175,737**	**12,879**	**162,858**	**4,858**	**-**	**-**	**-**	**15,000**	**-**	**143,000**	
82	**GOAL 5 - KANAB AMBERSNAIL**																	
83	BIO 5.R1.10	O	CRD	Monitor Kanab Ambersnail (FY07--FY11)	-	-	22,883	24,764	2,124	22,640	-	-	-	-	5,000	-	17,640	**BOCM**
84				**SUB-TOTAL GOAL 5**	**-**	**-**	**22,883**	**24,764**	**2,124**	**22,640**	**-**	**-**	**-**	**-**	**5,000**	**-**	**17,640**	
85	**GOAL 6 - SPRINGS / RIPARIAN**																	
86	BIO 6.R1.09	C	CRD	Vegetation Mapping (FY07--FY09)	-	-	121,804	-	-	-	-	-	-	-	-	-	-	Final core monitoring report will be completed FY09
87	BIO 6.M1.10	N	COR	Vegetation Mapping (FY10--Ongoing)	-	-	-	95,828	16,631	79,197	73,197	2,000	3,000	1,000	-	-	-	Will be implemented as component of Integrated Image Analysis and Change Detection (DASA 12.9.10); Assumes approval as a Core Monitoring Project beginning in FY10
88	BIO 6.R2.09	C	COR	Vegetation Transects (FY07--FY09)	41,777	-	52,502	-	-	-	-	-	-	-	-	-	-	Final core monitoring report will be completed FY09
89	BIO 6.M2.11	-	COR	Vegetation Transects (FY11--Ongoing)	-	-	-	-	-	-	-	-	-	-	-	-	-	Will be implemented as core monitoring project in alternating years; Assumes approval as a Core Monitoring Project beginning in FY10; Transects monitoring will be implemented in alternating years
90	BIO 6.R3.10	O	CRD	Vegetation Synthesis (FY07--FY10)	5,000	-	60,364	38,526	6,686	31,840	31,840	-	-	-	-	-	-	Will be implemented as component of new initiative for Ecosyst Change Detection; See Goal 12; Final report will be completed in FY10
91				**SUB-TOTAL GOAL 6**	**46,777**	**-**	**234,670**	**134,355**	**23,318**	**111,037**	**105,037**	**2,000**	**3,000**	**1,000**	**-**	**-**	**-**	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
92	GCMRC Project ID	FY10 Status	Funding Emphasis	Project Descriptions	Carry Over Funding from FY09 Available for Use in FY10	BOR Experimental Funds Used in FY10 (included in FY10 Gross Budget)	Approved FY09 Budget (incl 4.9% CPI Increase)	FY10 GROSS Proposed Budget (incl 0% CPI Increase)	FY10 DOI Customer Burden (Combined 6.09%, 21% and/or Other Rate)	FY10 NET Project Subtotal (w/o Burden)	FY10 GCMRC Personnel Costs (21% Burden)	FY10 GCMRC Project Related Travel / Training (21% Burden)	FY10 GCMRC Operations / Supplies / Publishing (21% Burden)	FY10 GCMRC Equipment Purchase / Replacement (21% Burden)	FY10 AMP Logistics Support (21% Burden)	FY10 Suballocation Outside GCMRC Contract & Science Labor (0% GCMRC Burden plus Suballocator's Burden Rate)	FY10 Coop & Inter Agency Agmts (6.09% GCMRC Burden plus Cooperator's Burden)	Comments
93	**GOAL 7 - QUALITY-OF-WATER**																	
94	BIO 7.R1.10	O	CRD	Water Quality Monitoring Lake - Powell & Tailwaters (BUDGET PRESENTED BELOW) (Ongoing)	-	-	-	-	-	-	-	-	-	-	-	-	-	Funded under separate agreement, refer to table below
95	PHY 7.M1.10	O	COR	Integrated Quality-of-Water Monitoring (Downstream of GCD) (FY07--Ongoing)	-	-	931,513	979,691	106,569	873,122	397,262	9,270	30,900	9,270	60,770	365,650	-	This represents 1 of the 4 longterm core monitoring protocols for sediment; FY10: move 1/2 1 tech's salary to modeling; Data collection FY10 & FY11 will be same as FY09 (not everything recommended in core monitoring report due to budget constraints); assumes continued funding of DC gage by SNWA.; Water Qual Monitoring associated w/ Goal 1 will be addressed in FY11 food base PEP
96	PHY 7.R2.10	O	CRD	Integrated Flow, Sediment Transport and Temperature Modeling of the CRE (FY09--FY10)	-	-	127,134	295,398	21,086	274,312	70,158	6,000	8,000	9,000	-	156,154	25,000	Report containing results & recommendations for future model development will be completed in FY10
97	PHY 7.R3.11	-	CRD	Modeling Support & Temperature Models (FY11--Ongoing)	-	-	-	-	-	-	-	-	-	-	-	-	-	
98				**SUB-TOTAL GOAL 7**	**-**	**-**	**1,058,647**	**1,275,089**	**127,655**	**1,147,434**	**467,420**	**15,270**	**38,900**	**18,270**	**60,770**	**521,804**	**25,000**	
99	**GOAL 8 - SEDIMENT**																	
100	PHY 8.M2.10	O	COR	Integrated Longterm Monitoring of System Wide Changes in Sediment Storage (FY09--Ongoing)	-	-	309,224	219,668	21,372	198,296	50,725	4,120	7,500	-	-	-	135,951	Channel mapping and sandbar data collection suspended in FY10; Focus on data analysis & reporting; Resume data collection FY11; Analysis of Overflight imagery will be implemented as component of Integrated Image Analysis and Change Detection 1(DASA 2.D9.10)
101				**SUB-TOTAL GOAL 8**	**-**	**-**	**309,224**	**219,668**	**21,372**	**198,296**	**50,725**	**4,120**	**7,500**	**-**	**-**	**-**	**135,951**	
102	**GOAL 9 - RECREATIONAL EXPERIENCE**																	
103	REC 9.R1.10	O	CRD	Sand Bar and Campable Area Monitoring R & D (FY98--Ongoing)	-	-	55,075	78,118	5,918	72,200	7,200	-	3,000	-	-	-	62,000	Fieldwork suspended in FY10; Focus on analysis & reporting; Assumes PEP review in early FY11 and approval as a Core Monitoring Project in FY11
104	REC 9.R3.10	O	CRD	Compile Campsite Inventory and GIS Atlas (FY07--FY11)	-	-	-	75,020	13,020	62,000	40,000	3,000	4,000	-	15,000	-	-	Website maintenance & updating (ongoing) and analysis of campsite data
105	REC 9.R4.09	C	CRD	Compile and Analyze Existing Safety Data (FY09)	-	-	26,296	-	-	-	-	-	-	-	-	-	-	Project ongoing with FY09 obligations in FY10; Final report will be completed in FY11
106				**SUB-TOTAL GOAL 9**	**-**	**-**	**81,371**	**153,138**	**18,938**	**134,200**	**47,200**	**3,000**	**7,000**	**-**	**15,000**	**-**	**62,000**	
107	**GOAL 10 - HYDROPOWER**																	
108	HYD 10.M1.10	O	CRD	Monitor Power Generation and Market Values under Current and Future Dam Operations (FY07--Ongoing)	-	-	19,587	9,680	1,680	8,000	5,000	-	3,000	-	-	-	-	Annual report and website maintenance
109				**SUB-TOTAL GOAL 10**	**-**	**-**	**19,587**	**9,680**	**1,680**	**8,000**	**5,000**	**-**	**3,000**	**-**	**-**	**-**	**-**	
110	**GOAL 11 - CULTURAL**																	
111	CUL 11.R1.10	O	CRD	Cultural Research & Development toward Core Monitoring, Phase II (FY06--FY12)	287,904	-	448,088	373,577	38,577	335,000	95,000	3,500	10,000	8,000	58,500	130,000	30,000	Assumes closer integration with NPS CRMP monitoring efforts in FY10; PEP review in FY12 to determine long term monitoring program
112	CUL 11.R2.10	O	CRD	Implement Tribal Monitoring Projects (See funding in BOR section)		-	-	-	-	-	-	-	-	-	-	-	-	See funding in BOR section. Line 23.
113				**SUB-TOTAL GOAL 11**	**287,904**	**-**	**448,088**	**373,577**	**38,577**	**335,000**	**95,000**	**3,500**	**10,000**	**8,000**	**58,500**	**130,000**	**30,000**	
114	**GOAL 12 - HIGH QUALITY MONITORING, RESEARCH & ADAPTIVE MANAGEMENT PROGRAM**																	
115	DASA 12.D1.10	O	CRD	Quadrennial & Resource-Specific Remote Sensing Overflight <Previously Acquisition for Monitoring Data Acquisition - 4 Band Imagery (Remote Sensing)> (FY08--Ongoing)	160,928	-	202,340	200,000	11,481	188,519	-	-	-	-	-	-	188,519	Hyperspectral overflight deferred in FY10
116	DASA 12.D9.10	N	APM	Integrated Image Analysis and Change Detection (FY10--Ongoing)	-	-	-	234,674	25,731	208,943	87,231	-	-	-	-	-	121,712	New
117	DASA 12.D2.10	O	APM	Grand Canyon Integrated Oracle Database Management System (FY07--Ongoing)	-	-	184,485	166,858	28,959	137,899	137,899	-	-	-	-	-	-	
118	DASA 12.D8.10	N	APM	Biometrics & General Analysis (FY10--Ongoing)	-	-	-	165,841	28,782	137,059	126,784	3,000	7,275	-	-	-	-	Absorbs efforts of E Hamilton, provides scanning support to DASA 12.D9.10
119	DASA 12.D3.10	O	APM	Library Operations (FY08--Ongoing)		-	56,284	80,263	13,930	66,333	56,058	-	10,275	-	-	-	-	
120	DASA 12.D4.10	O	APM	Legacy Analog Data Conversion (Analog to Digital - Reports & Imagery) (FY08--Ongoing)	-	-	130,739	-	-	-	-	-	-	-	-	-	-	Moved project & related funding to Library Operations (DASA 12.D3.10)
121	DASA 12.D5.10	O	APM	GIS Support for Integrated Analyses and Projects, GIS Lead (FY07--Ongoing)	32,860	-	332,871	351,882	46,073	305,809	179,797	-	4,300	-	-	-	121,712	
122	DASA 12.D7.10	C	CRD	Integrated Analysis and Modeling - FY09 Overflight (FY09)	-	-	129,124	-	-	-	-	-	-	-	-	-	-	Project completed; future efforts of M Breedlove will be in DASA 12.D9.10
123				**Sub-total Goal 12 DASA Portion**	**193,788**	**-**	**1,035,843**	**1,199,517**	**154,955**	**1,044,562**	**587,769**	**3,000**	**21,850**	**-**	**-**	**-**	**431,943**	

APPENDIX E
FY2010

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
124	GCMRC Project ID	FY10 Status	Funding Emphasis	Project Descriptions	Carry Over Funding from FY09 Available for Use in FY10	BOR Experimental Funds Used in FY10 (included in FY10 Gross Budget)	Approved FY09 Budget (incl 4.9% CPI Increase)	FY10 GROSS Proposed Budget (incl 0% CPI Increase)	FY10 DOI Customer Burden (Combined 6.09%, 21% and/or Other Rate)	FY10 NET Project Subtotal (w/o Burden)	FY10 GCMRC Personnel Costs (21% Burden)	FY10 GCMRC Project Related Travel / Training (21% Burden)	FY10 GCMRC Operations / Supplies / Publishing (21% Burden)	FY10 GCMRC Equipment Purchase / Replacement (21% Burden)	FY10 AMP Logistics Support (21% Burden)	FY10 Suballocation Outside GCMRC Contract & Science Labor (O% GCMRC Burden plus Suballocator's Burden Rate)	FY10 Coop & Inter Agency Agmts (6.09% GCMRC Burden plus Cooperator's Burden)	Comments
125	SUP 12.S1.10	O	APM	Logistics Base Costs (See each project for project related logistics costs) (Ongoing)	-	-	180,531	210,252	36,490	173,762	138,762	-	-	35,000		-	-	
126	SUP 12.S2.10	O	APM	Survey Operations (Ongoing)	-	-	114,718	88,242	15,315	72,927	47,927	-	-	25,000	-	-	-	Includes annual deposit in a WCF for survey equipment to be replaced in FY11
127	SUP 12.S3.10	O	APM	Control Network (Ongoing)	-	-	91,104	180,009	28,161	151,848	88,848	-	-	-	38,000	-	25,000	
128				**Sub-total Goal 12 Support Portion**	**-**	**-**	**386,353**	**478,502**	**79,965**	**398,537**	**275,537**	**-**	**-**	**60,000**	**38,000**	**-**	**25,000**	
129	PLAN 12.P1.10	O	CRD	Enhancing the Conceptual Ecosystem Model to Identify Critical Ecosystem Interactions and Data Gap (FY08--FY12)	-	-	50,585	239,986	32,532	207,454	97,454	36,000	-	-	-	-	74,000	Continued support for Review, Revision and Upgrade of GCEM in Collaboration with Senior Ecologist.
130	PLAN 12.P3.10	O	LTE	Low Steady Summer Flows - Data and Research Compilation, Synopsis and Synthesis (FY08--FY10)	18,067	-	29,251	16,409	2,848	13,561	8,561	-	5,000	-	-	-	-	Report finalization and publication in FY10
131				**Sub-total Goal 12 Planning Portion**	**18,067**	**-**	**79,836**	**256,395**	**35,380**	**221,015**	**106,015**	**36,000**	**5,000**	**-**	**-**	**-**	**74,000**	
132	ADM 12.A1.10 (A)	O	APM	Administrative Operations (Ongoing)	23,930	-	173,812	161,908	22,308	139,600	44,100	5,300	30,200	13,000	-	-	47,000	Travel, telephones, supplies, furniture & staff awards not specific to projects
133	ADM 12.A1.10 (B)	O	APM	Administrative Operations - GSA Vehicle Costs (Ongoing)	-	-	50,950	63,525	11,025	52,500	-	-	52,500	-	-	-	-	GSA Vehicle Fleet
134	ADM 12.A1.10 (C)	O	APM	Administrative Operations - Interior Vehicle Costs (Ongoing)	-	-	25,475	32,065	5,565	26,500	-	-	26,500	-	-	-	-	Interior Vehicle Fleet
135	ADM 12.A2.10	O	APM	Program Planning & Management (Ongoing)	-	-	1,111,596	1,195,480	207,480	988,000	936,000	41,000	11,000	-	-	-	-	GCMRC Program Management staff, travel, & supplies
136	ADM 12.A3.10	O	APM	AMWG/TWG Meeting Travel Funds (Ongoing)	-	-	19,154	19,481	3,381	16,100	-	16,100	-	-	-	-	-	
137	ADM 12.A4.10 (A)	O	APM	Independent Reviews (Ongoing)	8,663	-	21,423	22,400	2,100	20,300	-	-	10,000	-	-	10,300	-	PEPs and other non-SA peer reviews
138	ADM 12.A4.10 (B)	O	APM	Executive Director of Science Advisors Review and Coordination; includes Science Advisors' Expenses (Ongoing)	-	-	214,227	217,800	37,800	180,000	-	-	180,000	-	-		-	
139	ADM 12.A6.10	O	APM	2010 Colorado River Basin Science and Management Symposium (Biennial--Ongoing)	-	-	-	-	-	-	-	-	-	-	-	-	-	Total estimated cost: $200,000. Assumes contributions from various Colorado River Recovery programs and other agencies.
140	ADM 12.A5.10	O	APM	GCMRC Component of SBSC Sys Admin Support (FY05--Ongoing)	5,150	-	214,350	263,526	44,868	218,658	38,658	-	69,000	106,000	-	5,000	-	20k for Website support
141				**Sub-total Goal 12 Administrative/Management Portion**	**37,743**	**-**	**1,830,987**	**1,976,185**	**334,527**	**1,641,658**	**1,018,758**	**62,400**	**379,200**	**119,000**	**-**	**15,300**	**47,000**	
142				**SUB-TOTAL GOAL 12**	**249,598**	**-**	**3,333,019**	**3,910,600**	**604,828**	**3,305,772**	**1,988,079**	**101,400**	**406,050**	**179,000**	**38,000**	**15,300**	**577,943**	
143				**GCMRC Power Revenues Under Cap Projects Sub-totals**	**641,097**	**150,000**	**7,967,420**	**8,608,517**	**1,113,919**	**7,494,598**	**3,194,087**	**150,844**	**494,450**	**325,270**	**517,610**	**667,104**	**2,145,233**	
144				Capped Funding based on FY09 Budget with 0% CPI Index			**7,967,420**	**7,967,420**										
145				**GROSS Spending <Deficit>**				**(641,097)**										
146																		
147																		
148	**GCMRC Power Revenue Funded Projects (NOT Capped) and Other Funded Projects FY2010**																	
149	BIO 7.R1.10	O	CRD	Water Quality Monitoring - Lake Powell & Tailwaters (FY07-Ongoing)	-	-	257,137	275,502	45,350	230,152	166,152	11,000	23,000	10,000	-	-	20,000	Refer to Goal 7 section above Quality-of-Water
150	***GCMRC Other Power Revenue Agreements Projects Subtotals***						**257,137**	**275,502**	**45,350**	**230,152**	**166,152**	**11,000**	**23,000**	**10,000**	**-**	**-**	**20,000**	
151																		
152	**GCMRC Other Agreement Funding FY2010**																	
153	BIO 2.R15.10	O	CRD	Near Shore Ecology / Fall Steady Flows (FY08--FY12)	536,641	-	500,000	552,825	55,281	497,544	67,544	-	-	-	100,000	-	330,000	BOCM $552,825 FY2010 not new FY2010 funding - Received FY10 funding in FY09, which is FY09 Carryover Amount
154	BIO 2.R16.10	O	CRD	Mainstem Nonnative Fish Control (Ongoing)		150,000	-	246,966	31,525	215,441	-	-	-	8,768	114,673	-	92,000	**BOCM** $315,308 TOTAL FY10 FUNDING: $150,000 funded from BOR Experimental Fund + $96,466 funded from BOR Nonnative Contingency Fund + $68,842 AMP Capped Power Revenues
155	Exp 7	O	EXP	Experimental Study - 7 - Synthesis of Knowledge	66,326	108,674	66,326	175,000	30,372	144,628	144,628	-	-	-	-	-	-	
156	PLAN 12.P4.11	-	APM	S.C.O.R.E. Report & Knowledge Assessment Updates (FY11)	-	-	-	-	-	-	-	-	-	-	-	-	-	
157				***GCMRC Other Agreement Funding Projects Subtotals***	**602,967**	**258,674**	**566,326**	**974,792**	**117,179**	**857,613**	**212,172**	**-**	**-**	**8,768**	**214,673**	**-**	**422,000**	
158				**GCMRC ALL Other Agreements Projects TOTALS**	**602,967**	**258,674**	**823,463**	**1,250,293**	**162,528**	**1,087,765**	**378,324**	**11,000**	**23,000**	**18,768**	**214,673**	**-**	**442,000**	
159																		
160																		
161				**GCMRC TOTAL AMP FY2010 PLANNED PROGRAM COSTS**	**1,244,064**	**258,674**	**8,790,883**	**9,858,811**	**1,276,448**	**8,582,363**	**3,572,411**	**161,844**	**517,450**	**344,038**	**732,283**	**667,104**	**2,587,233**	
162																		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
163	**GCMRC Carryover Funds from Prior Years Available for Use in FY10**				**Gross Carryover from FY09 by Project**	**Comments**												
164	BIO 1.R1.09	C	CRD	Aquatic Food Base (FY05--FY10)	20,000	Personnel costs due to lapse in position not used in FY09												
165	BIO TBD	O		Nonnative Fish Contingency Plan	36,818	Planned carry forward to FY10 in FY09 if indicated by BIO 2.R16.09												
166	BIO 6.R2.09	C	COR	Vegetation Transects (FY07--FY09)	41,777	Cooperative Agreement not used; planned carry forward to FY10 in FY09 for hyperspectral overflight												
167	BIO 6.R3.09	C	CRD	Vegetation Synthesis (FY07--FY10)	5,000	Cooperative Agreement not used; planned carry forward to FY10 in FY09 for hyperspectral overflight												
168	CUL 11.R1.09	O	CRD	Research & Development toward Core Monitoring (FY06--FY11)	287,904	27,166 Logistics, 81,533 Suballocati0on, 174,000 COOP not used in FY09 due to permitting restraints												
169	DASA 12.D1.09	O	CRD	Acquisition for Monitoring Data Acquisition - 4 Band Imagery (Remote Sensing) (FY08--Ongoing)	160,928	135,000 FY09 Contingency fund / shoals flight not used due to permitting restraints												
170	DASA 12.D5.09	O	APM	GIS Support for Integrated Analyses and Projects, GIS Lead (FY07--Ongoing)	32,860	32,860 FY09 COOP not used in FY09												
171	PLAN 12.P3.09	O	ORD	Low Steady Summer Flows - Data and Research Compilation, Synopsis and Synthesis	18,067	18,067 FY09 COOP not used in FY09												
172	ADM 12.A1.09 (A)	O	APM	Administrative Operations (Ongoing)	23,930	23,930 FY09 COOP not used in FY09												
173	ADM 12.A4.09	O	APM	Independent Reviews (Ongoing)	8,663	8,633 FY09 Suballocation not used in FY09												
174	ADM 12.A5.09	O	APM	GCMRC Component of SBSC Sys Admin Support (FY05--Ongoing)	5,150	5,150 FY09 Suballocation not used in FY09												
175	***GCMRC FY2009 Carryover Funds - Capped Revenues Subtotal***				**641,097**													
176	BIO 2.R15.09	O	CRD	Near Shore Ecology / Fall Steady Flows - New Initiative	536,641	Planned carry forward to FY10 - received FY10 funds in FY09												
177	HFE Experiment 7	O	EXP	Experimental Study - 7 - Synthesis of Knowledge	66,326	Planned carry forward to FY10												
178	***GCMRC FY2009 Carryover Funds - All Funding Sources Total***				**1,244,064**	**-**												
179																		
180	**BOR Experimental Fund Summary**				**Gross FY10 Proposed Funding from BOR Experimental Fund**	**BOR Experimental Fund Balance**	**Comments**											
181	BIO 2.R16.10	O	CRD	Mainstem Nonnative Fish Control (Ongoing)	150,000	350,000	BOR FY10 Contribution $500,000 less $150,000 = $350,000 Balance											
182	Exp 7	O	EXP	Experimental Study - 7 - Synthesis of Knowledge	108,674	241,326	$350,000 Balance less $108,674 = $241,326 Balance as of 09/30/2010											
183	**BOR Experimental Fund Summary**				**258,674**	**241,326**												
184																		
185	**DEFERRED / Unfunded Projects**				**Deferred / Unfunded GROSS FY10 Budget**	**DOI Customer Burden**	**NET Project Subtotal (w/o Burden)**	**GCMRC Personnel Costs**	**GCMRC Project Related Travel / Training**	**GCMRC Operations / Supplies / Publishing**	**GCMRC Equipment Purchase / Replacement**	**AMP Logistics Support**	**Suballocation Outside GCMRC Contract & Science Labor**	**Coop & Inter Agency Agmts**	**Comments**			
186	BIO 6.R4.10	N	ORD	Terrestrial Habitat Monitoring R & D (FY10--FY12)	95,395	10,395	85,000	-	2,000	2,000	1,000	30,000	-	50,000	Sampling for arthropods; Proposed to be implemented as a research project in alternating years (FY10 & FY12)			
187	BIO 6.M1.10	N	CRD	Vegetation Mapping (FY10--Ongoing)	48,400	8,400	40,000	-	-	-	-	40,000	-	-	Logistics for ground truthing Hyperspectral Overflight			
188	REC 9.R5.xx	D	CRD	Evaluate Relation between Flows and Recreation Experience	225,000	25,755	199,245	46,353	30,000	15,000	-	-	-	107,892	Deferred in FY09 and FY10			
189	REC 9.R6.xx	D	CRD	1973 Weeden Survey Revisited	75,000	4,305	70,695	-	-	-	-	-	-	70,695	Deferred in FY09 and FY10			
190	REC 9.R7.xx	D	ORD	Update Regional Recreation Economic Study	250,000	26,137	223,863	60,863	15,000	8,000	-	-	-	140,000	Deferred in FY09 and FY10			
191	CUL 11.R3.xx	D	CRD	Geomorphic Model of Archaeological Site Vulnerability	250,000	15,194	234,806	-	3,000	3,000	-	-	-	228,806	Deferred in FY09 and FY10			
192	DASA 12.D1.10	O	CRD	Quadrennial & Resource-Specific Remote Sensing Overflight <Previously Acquisition for Monitoring Data Acquisition - 4 Band Imagery (Remote Sensing> (FY08--Ongoing)	46,776	2,685	44,091	-	-	-	-	-	-	44,091	Hyperspectral Overflight for Vegetation Mapping BIO 6.M1.10			
193	DASA 12.D9.10	D	ORD	Integrated Image Analysis and Change Detection (FY10--Ongoing)	89,568	6,303	83,265	-	-	-	8,265	-	-	75,000	Photogrammetry Analysis of 1984 Imagery			
194	**FY10 Deferred / Unfunded Projects**				**1,080,140**	**99,175**	**980,965**	**107,216**	**50,000**	**28,000**	**9,265**	**70,000**	**-**	**716,484**				
195																		
196																		

	A	B	C	D	E	F	G	H	I
197	PROGRAM COSTS		BOR Power Revenues Under Cap Program COSTS			FISCAL YEAR 2009	FISCAL YEAR 2010		
198			BOR Power Revenues Under Cap Program COSTS			1,913,899	1,913,899		
199			GCMRC Power Revenues Under Cap Program COSTS			7,967,420	8,608,517	8,608,517	GCMRC FY2010 Expenses under Cap
200			Subtotal BOR & GCMRC Power Revenue Program COSTS Under Cap			**9,881,319**	**10,522,416**		
201									
202	PROGRAM FUNDING		BOR Power REVENUES Under Cap Program Funding			FISCAL YEAR 2009	FISCAL YEAR 2010		
203			BOR Power REVENUES Under Cap Funding			1,824,747	1,824,747		
204			GCMRC Power REVENUES Under Cap Funding			7,967,420	7,967,420		
205			GCMRC FY2009 Carryover Power REVENUES Under Cap Funding			-	641,097	8,608,517	GCMRC Total FY2010 Revenues under Cap Including FY2009 Carryover
206			Subtotal BOR & GCMRC Power REVENUE Under Cap Funding			**9,792,167**	**10,433,264**	(0)	GCMRC Difference between FY2010 Total Revenues and Expenses Under Cap
207			Subtotal Difference between FY2010 Estimated Costs and Estimated Revenues Under Cap			**(89,152)**	**(89,152)**		
208									
209	PROGRAM COSTS		BOR Appropriated and Other Program COSTS			FISCAL YEAR 2009	FISCAL YEAR 2010		
210			BOR Appropriated and Other Program COSTS			475,000	475,000		
211			GCMRC Appropriated and Other Program COSTS			823,463	1,250,293	1,250,293	GCMRC FY2010 Expenses - Appropriated and Other Fund Sources
212			Subtotal BOR & GCMRC Power Revenue (Non-Capped) and Other Funded Program COSTS			**1,298,463**	**1,725,293**		
213									
214	PROGRAM FUNDING		BOR Appropriated and Other Program Funding			FISCAL YEAR 2009	FISCAL YEAR 2010		
215			BOR Appropriated and Other Program FUNDING			475,000	475,000		
216			GCMRC Appropriated and Other Program FUNDING			823,463	647,326		
217			GCMRC FY2009 Carryover Appropriated and Other FUNDING			-	602,967	1,250,293	GCMRC Total FY2010 Appropriated & Other Revenues
218			Subtotal BOR & GCMRC Appropriated and Other (Non-Capped)			**1,298,463**	**1,725,293**	-	GCMRC Difference between FY2010 Total Other Funding and Other Expenses (Not-Capped)
219									
220			Difference between Projected COSTS and INCOME for FY2010 POWER REVENUES UNDER CAP			-	-		
221									
222	Explanation of information found in columns A and H, & R of the Draft Budget for the GCMRC GCDAMP FY2010-11								
223	Column								
224	GCMRC Project ID Program Areas	A	1-3	BIO: Biology PHY: Physical Science REC: Recreation HYD: Hydropower CUL: Cultural					
225				DASA: Data Acquisition, Storage and Analysis SUP: Support PLA: Planning ADM: Administration					
226									
227			4-5	GCDAMP Goal Number					
228			6-7	Project Number within GCMRC Annual Work Plan					
229			7-8	Fiscal Year of Proposed Budget / Annual Work Plan					
230	Column								
231	Status	B	O: Ongoing N: New C: Complete						
232	Column	C	APM: Admin & Program Mgmt COR: Core Monitoring					Anticipates completion of the Core Monitoring plan according to the process defined in the MRP (including AMP Committed review and approval by the Secretary)	
233	Category		CRD: Core Monitoring Research & Development ORD: Ongoing Research and Development						
234			LTE: Longterm Experiment NA: Not Applicable						
235	Column								
236	Project Description	D	Project Title (Start Date -- End Date)						
237	Column								
238	Gross Carryover	E	FY 2009 Gross Carryover to FY 2010						
239	Column								
240	Experimental Fund	F	FY 2010 Use of BOR Experimental Funds						
241	Column								
242	FY09 Approved Budget	G	FY 2009 GCDAMP Approved Budget						
243	Column								
244	FY10 Proposed Budget	H	FY 2010 GCDAMP Proposed Draft Budget						
245	Column								
246	Comments	R	Comments; BOCM represents Biological Opinion Core Monitoring items						

APPENDIX E
FY2011

Revised August 6, 2009

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1			**ID**	**Project Descriptions**	**FY10 Gross Proposed Budget**	**FY11 Gross Proposed Budget (incl 3% CPI Increase)**	**Comments**										
2			**Reclamation Administration Power Revenue Under Cap Funded Projects**														
3			A	Adaptive Management Work Group													
4			1	Personnel Costs	176,747	182,049											
5			2	AMWG Member Travel Reimbursement	17,467	17,991											
6			3	Reclamation Travel	14,178	14,873											
7			4	Facilitation Contract	26,959	27,768											
8			5	POAHG Expenses	55,536	57,202											
9			6	Other	7,969	8,208											
10			**Reclamation AMWG Subtotal**		**298,856**	**308,091**											
11			B	Technical Work Group													
12			1	Personnel Costs	86,195	88,780											
13			2	TWG Member Travel Reimbursement	23,952	24,670											
14			3	Reclamation Travel	17,658	18,188											
15			4	TWG Chair Reimbursement	24,625	25,363											
16			5	Other	2,277	2,345											
17			**Reclamation TWG Subtotal**		**154,707**	**159,346**											
18			C	Other													
19			1	Compliance Documents	50,000	51,500											
20			2	Administrative Support for NPS Permitting	118,852	122,417											
21			3	Contract Administration	39,953	41,152											
22			4	Experimental Carryover Funds - to be held by BOR	500,000	515,000	$241,326 FY10 Balance + $515,000 = $756,326 Available for use in FY11 less $484,251 used in FY11 by GCMRC = $272,075 Balance as of 09/30/2011										
23			5	Integrated Tribal Resources Monitoring	142,884	147,171	+ 75k Appropriated Funds from Tribal Consultation Carryover from Prior Fiscal Years										
24			6	Mainstem Non-native Mechanical Removal	-	-											
25			7	Non-native Fish Suppression Contingency Fund	48,483	49,937	$0 FY10 Balance + $49,937 FY11 Funding = $49,937 Balance Available as of 09/30/2011										
26			**Other Subtotal**		**900,172**	**927,177**											
27			**Reclamation Administrative Subtotal**		**1,353,735**	**1,394,614**											
28			D	Programmatic Agreement Cultural Resources													
29			1	Reclamation Administration	60,164	61,969											
30			2	Canyon Treatment Plan and Implementation	500,000	500,000											
31			Programmatic Agreement Subtotal		**560,164**	**561,969**											
32			**Reclamation Power Revenue Under Cap Program Subtotal**		**1,913,899**	**1,956,583**											
33																	
34			Reclamation Appropriated Funded Projects														
35			HCA	Development of a LCR Management Plan													
36			Tribal Consultation														
37			A	Cooperative Agreements with Tribes													
38			1	Hopi Tribe	95,000	95,000											
39			2	Hualapai Tribe	95,000	95,000											
40			3	Navajo Nation	95,000	95,000											
41			4	Pueblo of Zuni	95,000	95,000											
42			5	Southern Paiute	95,000	95,000											
43			6	DOI Handling Fee	-	-											
44			Tribal Consultation Subtotal		**475,000**	**475,000**											
45			Reclamation Appropriated Projects Subtotal		**475,000**	**475,000**											
46																	
47			**BUREAU OF RECLAMATION TOTAL AMP PROGRAM COSTS**		**2,388,899**	**2,431,583**											

APPENDIX E
FY2011

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
48																	
49	GCMRC Project ID	FY11 Status	Funding Emphasis	Project Descriptions	FY10 Gross Proposed Budget	BOR Experimental Funds Used in FY11 (included in FY11 Gross Budget)	FY11 Gross Proposed Budget (incl 3% CPI Increase)	FY11 DOI Customer Burden (Combined 6.09%, 21% and/or Other Rate)	FY11 NET Project Subtotal (w/o Burden)	FY11 GCMRC Personnel Costs (21% Burden)	FY11 GCMRC Project Related Travel / Training (21% Burden)	FY11 GCMRC Operations / Supplies / Publishing (21% Burden)	FY11 GCMRC Equipment Purchase / Replacement (21% Burden)	FY11 AMP Logistics Support (21% Burden)	FY11 Suballocation Outside GCMRC Contract & Science Labor (O% GCMRC Burden plus Suballocator's Burden Rate)	FY11 Coop & Inter Agency Agmts (6.09% GCMRC Burden plus Cooperator's Burden)	Comments
50	**U.S. Geological Survey - Biological Resource Division - GCMRC - Power Revenues Under Cap Funded Projects**																
51	**GOAL 1 - FOOD BASE**																
52	BIO 1.R1.10	C	CRD	Aquatic Food Base (FY05--FY10)	505,945	-	-	-	-	-	-	-	-	-	-	-	FY11 Move to Monitoring
53	BIO 1.M1.11	N	COR	Aquatic Food Base (FY11--Ongoing)	-	-	250,712	43,512	207,200	164,200	3,000	5,000	5,000	30,000	-	-	One trip for data collection planned in FY11; FY11 PEP Review and implementation as a Core Monitoring Project
54	BIO 1.R4.10	C	CRD	Impacts of Various Flow Regimes on the Aquatic Food Base (FY08--FY10)	62,111	-	-	-	-	-	-	-	-	-	-	-	FY11: Any future work will be Integrated with Aquatic Food Base (BIO 1.M1.10)
55				**SUB-TOTAL GOAL 1**	**568,056**	**-**	**250,712**	**43,512**	**207,200**	**164,200**	**3,000**	**5,000**	**5,000**	**30,000**	**-**	**-**	
56	**GOAL 2 - NATIVE FISHES**																
57	BIO 2.R1.10	C	CRD	LCR HBC Monitoring Lower 13.6km (HBC Population Est) (Ongoing)	455,735	-	-	-	-	-	-	-	-	-	-	-	**BOCM** FY11 Moved to Core Monitoring (BIO 2.M1.11); Subject to revision based on Cooperator analyses
58	BIO 2.R2.10	C	CRD	LCR HBC Monitoring Lower 1,200m (Ongoing)	57,421	-	-	-	-	-	-	-	-	-	-	-	**BOCM** FY11 Moved to Core Monitoring (BIO 2.M1.11); Subject to revision based on Cooperator analyses
59	BIO 2.M1.11	N	COR	LCR Fish Monitoring (FY11--Ongoing)	-	-	308,824	23,349	285,475	-	-	-	12,000	28,000	-	245,475	Core Monitoring Project beginning in FY11 subject to revision based on Cooperator analyses
60	BIO 2.M3.11	O	CRD	HBC Monitoring Above Chute Falls (Ongoing)	143,194	-	145,494	16,082	129,412	-	-	-	-	55,000	-	74,412	**BOCM**
61	BIO 2.M4.11	O	COR	Monitoring Mainstem Fishes (FY10--Ongoing)	632,461	-	798,930	80,126	718,804	43,804	10,000	10,000	30,000	150,000	-	475,000	**BOCM** Core Monitoring subject to revision based on Cooperator analyses
62	BIO 2.R17.11	O	ORD	Nonnative Control Plan Science Support (FY10--Ongoing)	78,058	-	138,599	24,054	114,545	111,545	3,000	-	-	-	-	-	**BOCM** Provide science support for implementation for the Nonnative Fish Control Plan
63	BIO 2.R7.11	O	ORD	Stock Assessment of Native Fish in Grand Canyon (FY07--Ongoing)	110,877	-	103,776	18,011	85,765	80,765	3,000	2,000	-	-	-	-	
64	BIO 2.R13.11	O	CRD	Remote PIT Tag Reading (FY07--Ongoing)	217,268	-	224,557	22,153	202,404	5,904	-	-	45,000	15,000	-	136,500	**BOCM**
65	BIO 2.R15.10	O	CRD	Near Shore Ecology / Fall Steady Flows (FY08--FY12)	-	-	-	-	-	-	-	-	-	-	-	-	**BOCM** Funding provided by BOR appropriated funds (see below)
66	BIO 2.R16.09	O	ORD	Mainstem Nonnative Fish Control (Ongoing)	68,842	-	-	-	-	-	-	-	-	-	-	-	**BOCM** Funded from BOR Experimental Funds <see below>
67				**SUB-TOTAL GOAL 2**	**1,763,856**	**-**	**1,720,180**	**183,775**	**1,536,405**	**242,018**	**16,000**	**12,000**	**87,000**	**248,000**	**-**	**931,387**	
68	**GOAL 3 - EXTIRPATED SPECIES**																
69	07.3.00	-	NA	None Identified	-	-	-	-	-	-	-	-	-	-	-	-	
70				**SUB-TOTAL GOAL 3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	
71	**GOAL 4 - RAINBOW TROUT**																
72	BIO 4.M2.11	O	COR	Monitoring Lees Ferry Fishes (FY10--Ongoing)	175,737	-	182,819	13,319	169,500	5,100	-	-	-	15,000		149,400	Core Monitoring Project beginning in FY10; Subject to revision based on Cooperator analyses
73				**SUB-TOTAL GOAL 4**	**175,737**	**-**	**182,819**	**13,319**	**169,500**	**5,100**	**-**	**-**	**-**	**15,000**	**-**	**149,400**	
74	**GOAL 5 - KANAB AMBERSNAIL**																
75	BIO 5.R1.11	O	CRD	Monitor Kanab Ambersnail (FY07--FY11)	24,764	-	25,700	2,178	23,522	-	-	-	-	5,000	-	18,522	**BOCM**
76				**SUB-TOTAL GOAL 5**	**24,764**	**-**	**25,700**	**2,178**	**23,522**	**-**	**-**	**-**	**-**	**5,000**	**-**	**18,522**	
77	**GOAL 6 - SPRINGS / RIPARIAN**																
78	BIO 6.M1.11	O	COR	Vegetation Mapping (FY10--Ongoing)	95,828	-	106,211	18,433	87,778	81,778	2,000	3,000	1,000	-	-	-	Will be implemented as component of Integrated Image Analysis and Change Detection (DASA 12.9.10); Assumes approval as a Core Monitoring Project beginning in FY10
79	BIO 6.M2.11	N	COR	Vegetation Transects (FY11--Ongoing)	-	-	142,917	18,643	124,274	35,274	3,000	5,000	1,000	30,000	-	50,000	Will be implemented as core monitoring project in alternating years; Assumes approval as a Core Monitoring Project beginning in FY10; Transects monitoring will be implemented in alternating years
80	BIO 6.R3.10	C	CRD	Vegetation Synthesis (FY07--FY10)	38,526	-	-	-	-	-	-	-	-	-	-	-	
81				**SUB-TOTAL GOAL 6**	**134,354**	**-**	**249,128**	**37,076**	**212,052**	**117,052**	**5,000**	**8,000**	**2,000**	**30,000**	**-**	**50,000**	
82	**GOAL 7 - QUALITY-OF-WATER**																
83	BIO 7.R1.11	O	CRD	Water Quality Monitoring Lake - Powell & Tailwaters (BUDGET PRESENTED BELOW) (Ongoing)	-	-	-	-	-	-	-	-	-	-	-	-	Funded under separate agreement, <see table below>
84	PHY 7.M1.11	O	COR	Integrated Quality-of-Water Monitoring (Downstream of GCD) (FY07--Ongoing)	979,691	-	1,025,906	112,686	913,220	423,084	9,548	31,827	9,548	62,593	376,620	-	This represents 1 of the 4 longterm core monitoring protocols for sediment; Data collection FY11 will be same as FY10 (not everything recommended in core monitoring report due to budget constraints); assumes continued funding of DC gage by SNWA.; Water Qual Monitoring associated w/ Goal 1 will be addressed in FY11 food base PEP.
85	PHY 7.R2.10	C	CRD	Integrated Flow, Sediment Transport and Temperature Modeling of the CRE (FY09--FY10)	295,398	-	-	-	-	-	-	-	-	-	-	-	
86	PHY 7.R3.11	N	CRD	Modeling Support & Temperature Models (FY11--Ongoing)	-	-	138,028	17,787	120,241	74,718	1,980	4,000	4,000	-	35,543	-	Models developed in FY09/10 model initiative maintained & supported in this project.
87				**SUB-TOTAL GOAL 7**	**1,275,089**	**-**	**1,163,934**	**130,473**	**1,033,461**	**497,802**	**11,528**	**35,827**	**13,548**	**62,593**	**412,163**	**-**	
88	**GOAL 8 - SEDIMENT**																
89	PHY 8.M2.11	O	COR	Integrated Longterm Monitoring of System Wide Changes in Sediment Storage (FY09--Ongoing)	219,668	-	381,990	46,406	335,584	66,747	2,122	11,157	31,523	62,622	-	161,413	Channel mapping and sandbar data collection will occur in FY11 and analysis & reporting included in FY10 will continue.
90				**SUB-TOTAL GOAL 8**	**219,668**	**-**	**381,990**	**46,406**	**335,584**	**66,747**	**2,122**	**11,157**	**31,523**	**62,622**	**-**	**161,413**	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
91	GCMRC Project ID	FY11 Status	Funding Emphasis	Project Descriptions	FY10 Gross Proposed Budget	BOR Experimental Funds Used in FY11 (included in FY11 Gross Budget)	FY11 Gross Proposed Budget (incl 3% CPI Increase)	FY11 DOI Customer Burden (Combined 6.09%, 21% and/or Other Rate)	FY11 NET Project Subtotal (w/o Burden)	FY11 GCMRC Personnel Costs (21% Burden)	FY11 GCMRC Project Related Travel / Training (21% Burden)	FY11 GCMRC Operations / Supplies / Publishing (21% Burden)	FY11 GCMRC Equipment Purchase / Replacement (21% Burden)	FY11 AMP Logistics Support (21% Burden)	FY11 Suballocation Outside GCMRC Contract & Science Labor (0% GCMRC Burden plus Suballocator's Burden Rate)	FY11 Coop & Inter Agency Agmts (6.09% GCMRC Burden plus Cooperator's Burden)	Comments
92	**GOAL 9 - RECREATIONAL EXPERIENCE**																
93	REC 9.R1.11	O	CRD	Sand Bar and Campable Area Monitoring (FY11--Ongoing)	78,118	-	78,082	7,082	71,000	7,500	-	3,000	-	8,000	-	52,500	Fieldwork suspended in FY10; Focus on analysis & reporting; Assumes PEP review in early FY11 and approval as a Core Monitoring Project in FY11
94	REC 9.R3.11	O	CRD	Compile Campsite Inventory and GIS Atlas (FY07--FY11)	75,020	-	60,500	10,500	50,000	43,000	3,000	4,000	-	-	-	-	Website maintenance & updating (ongoing) and analysis of campsite data
95				**SUB-TOTAL GOAL 9**	**153,138**	**-**	**138,582**	**17,582**	**121,000**	**50,500**	**3,000**	**7,000**	**-**	**8,000**	**-**	**52,500**	
96	**GOAL 10 - HYDROPOWER**																
97	HYD 10.M1.11	O	CRD	Monitor Power Generation and Market Values under Current and Future Dam Operations (FY07--Ongoing)	9,680	-	10,890	1,890	9,000	5,500	-	3,500	-	-	-	-	Annual report and website maintenance
98				**SUB-TOTAL GOAL 10**	**9,680**	**-**	**10,890**	**1,890**	**9,000**	**5,500**	**-**	**3,500**	**-**	**-**	**-**	**-**	
99	**GOAL 11 - CULTURAL**																
100	CUL 11.R1.11	O	CRD	Cultural Research & Development toward Core Monitoring (FY06--FY12)	373,577	-	361,989	37,989	324,000	96,000	4,000	10,000	8,000	60,000	136,000	10,000	Assumes closer integration with NPS CRMP monitoring efforts in FY10; PEP review in FY12 to determine long term monitoring program
101	CUL 11.R2.11	O	CRD	Implement Tribal Monitoring Projects (See funding in BOR section)	-	-	-	-	-	-	-	-	-	-	-	-	See funding in BOR section.
102				**SUB-TOTAL GOAL 11**	**373,577**	**-**	**361,989**	**37,989**	**324,000**	**96,000**	**4,000**	**10,000**	**8,000**	**60,000**	**136,000**	**10,000**	
103	**GOAL 12 - HIGH QUALITY MONITORING, RESEARCH & ADAPTIVE MANAGEMENT PROGRAM**																
104	DASA 12.D9.11	O	APM	Integrated Image Analysis and Change Detection (FY10--Ongoing)	234,674	-	245,482	26,707	218,775	89,761	-		-	-	-	129,014	
105	DASA 12.D2.12	O	APM	Grand Canyon Integrated Oracle Database Management System (FY07--Ongoing)	166,858	-	166,858	28,959	137,899	137,899	-	-	-	-	-	-	
106	DASA 12.D8.11	O	APM	Biometrics & General Analysis (FY10--Ongoing)	165,841	-	165,840	28,782	137,058	137,058	-	-	-	-	-	-	
107	DASA 12.D3.11	O	APM	Library Operations (FY08--Ongoing)	80,263	-	78,709	13,660	65,049	65,049	-	-	-	-	-	-	
108	DASA 12.D5.11	O	APM	GIS Support for Integrated Analyses and Projects, GIS Lead (FY07--Ongoing)	351,882	-	366,171	47,653	318,518	185,204	2,000	2,300	-	-	-	129,014	
109				**Sub-total Goal 12 DASA Portion**	**999,518**	**-**	**1,023,060**	**145,761**	**877,299**	**614,971**	**2,000**	**2,300**	**-**	**-**	**-**	**258,028**	
110	SUP 12.S1.11	O	APM	Logistics Base Costs (See each project for project related logistics costs) (Ongoing)	210,252	-	223,626	38,811	184,815	147,930	1,885	-	35,000		-	-	
111	SUP 12.S2.11	O	APM	Survey Operations (Ongoing)	88,242	-	90,122	15,641	74,481	49,481	-	-	25,000	-	-	-	
112	SUP 12.S3.11	O	APM	Control Network (Ongoing)	180,009	-	185,704	29,149	156,555	91,555	-	-	-	40,000	-	25,000	
113				**Sub-total Goal 12 Support Portion**	**478,503**	**-**	**499,452**	**83,601**	**415,851**	**288,966**	**1,885**	**-**	**60,000**	**40,000**	**-**	**25,000**	
114	PLAN 12.P1.11	O	CRD	Enhancing the Conceptual Ecosystem Model to Identify Critical Ecosystem Interactions and Data Gap (FY08--FY12)	239,986	-	148,945	19,689	129,256	79,256	-	-	-	-	-	50,000	
115	PLAN 12.P3.10	C	LTE	Low Steady Summer Flows - Data and Research Compilation, Synopsis and Synthesis (FY08--FY10)	16,409	-	-	-	-	-	-	-	-	-	-	-	
116				**Sub-total Goal 12 Planning Portion**	**256,395**	**-**	**148,945**	**19,689**	**129,256**	**79,256**	**-**	**-**	**-**	**-**	**-**	**50,000**	
117	ADM 12.A1.11 (A)	O	APM	Administrative Operations (Ongoing)	161,908	-	167,995	22,995	145,000	45,000	5,500	31,100	13,400	-	-	50,000	
118	ADM 12.A1.11 (B)	O	APM	Administrative Operations - GSA Vehicle Costs (Ongoing)	63,525	-	66,550	11,550	55,000	-	-	55,000	-	-	-	-	GSA Vehicle Fleet
119	ADM 12.A1.11 (C)	O	APM	Administrative Operations - Interior Vehicle Costs (Ongoing)	32,065	-	33,880	5,880	28,000	-	-	28,000	-	-	-	-	Interior Vehicle Fleet
120	ADM 12.A2.11	O	APM	Program Planning & Management (Ongoing)	1,195,480	-	1,238,435	214,935	1,023,500	970,000	42,000	11,500	-	-	-	-	GCMRC Program Management staff, travel, & supplies
121	ADM 12.A3.11	O	APM	AMWG/TWG Meeting Travel Funds (Ongoing)	19,481	-	19,965	3,465	16,500	-	16,500	-	-	-	-	-	
122	ADM 12.A4.11 (A)	O	APM	Independent Reviews (Ongoing)	22,400	-	73,205	12,705	60,500	-	-	50,000	-	-	10,500	-	
123	ADM 12.A4.11 (B)	O	APM	Executive Director of Science Advisors Review and Coordination; includes Science Advisors' Expenses (Ongoing)	217,800	-	223,850	38,850	185,000	-	-	185,000	-	-	-	-	
124	ADM 12.A6.11	O	APM	2011 Colorado River Basin Science and Management Symposium (Biennial--Ongoing)	-	-	-	-	-	-	-	-	-	-	-	-	
125	ADM 12.A5.11	O	APM	GCMRC Component of SBSC Sys Admin Support (FY05--Ongoing)	216,750	-	225,181	39,081	186,100	-	-	71,000	110,000	-	5,100	-	
126				**Sub-total Goal 12 Administrative/Management Portion**	**1,929,409**	**-**	**2,049,061**	**349,461**	**1,699,600**	**1,015,000**	**64,000**	**431,600**	**123,400**	**-**	**15,600**	**50,000**	
127				**SUB-TOTAL GOAL 12**	**3,663,825**	**-**	**3,720,518**	**598,512**	**3,122,006**	**1,998,193**	**67,885**	**433,900**	**183,400**	**40,000**	**15,600**	**383,028**	
128				**GCMRC Power Revenues Under Cap Projects Sub-totals**	**8,361,744**	**-**	**8,206,442**	**1,112,712**	**7,093,730**	**3,243,112**	**112,535**	**526,384**	**330,471**	**561,215**	**563,763**	**1,756,250**	
129																	
130	**GCMRC Power Revenue Funded Projects (NOT Capped) and Other Funded Projects**																
131	BIO 7.R1.11	O	CRD	Water Quality Monitoring - Lake Powell & Tailwaters (FY07-Ongoing)	275,502	-	286,342	47,108	239,234	172,234	12,000	24,000	10,000	-	-	21,000	Refer to Goal 7 section above Quality-of-Water
132				**GCMRC Other Power Revenue Agreements Projects Subtotals**	**275,502**	**-**	**286,342**	**47,108**	**239,234**	**172,234**	**12,000**	**24,000**	**10,000**	**-**	**-**	**21,000**	
133																	

APPENDIX E
FY2011

Revised August 6, 2009

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
134	GCMRC Project ID	FY11 Status	Funding Emphasis	Project Descriptions	FY10 Gross Proposed Budget	BOR Experimental Funds Used in FY11 (included in FY11 Gross Budget)	FY11 Gross Proposed Budget (incl 3% CPI Increase)	FY11 DOI Customer Burden (Combined 6.09%, 21% and/or Other Rate)	FY11 NET Project Subtotal (w/o Burden)	FY11 GCMRC Personnel Costs (21% Burden)	FY11 GCMRC Project Related Travel / Training (21% Burden)	FY11 GCMRC Operations / Supplies / Publishing (21% Burden)	FY11 GCMRC Equipment Purchase / Replacement (21% Burden)	FY11 AMP Logistics Support (21% Burden)	FY11 Suballocation Outside GCMRC Contract & Science Labor (0% GCMRC Burden plus Suballocator's Burden Rate)	FY11 Coop & Inter Agency Agmts (6.09% GCMRC Burden plus Cooperator's Burden)	Comments
135	GCMRC Other Agreement Funding FY2009																
136	BIO 2.R15.11	O	CRD	Near Shore Ecology / Fall Steady Flows (FY08--FY12)	552,825	-	556,911	55,990	500,921	70,921	-	-	-	100,000	-	330,000	BOCM
137	BIO 2.R16.09	O	ORD	Mainstem Nonnative Fish Control (Ongoing)	150,000	309,251	309,251	41,349	267,902	7,806	-	-	36,496	123,600	-	100,000	BOCM Funded from BOR Experimental Funds
138	PLAN 12.P4.11	N	APM	S.C.O.R.E. Report & Knowledge Assessment Updates (FY11)	175,000	175,000	175,000	21,130	153,870	25,000	3,870	50,000	-	-	-	75,000	Funded from BOR Experimental Funds
139	GCMRC Other Agreement Funding Projects Subtotals				877,825	484,251	1,041,163	118,470	922,693	103,727	3,870	50,000	36,496	223,600	-	505,000	
140	GCMRC ALL Other Agreements Projects TOTALS				1,153,327	484,251	1,327,505	165,578	1,161,927	275,961	15,870	74,000	46,496	223,600	-	526,000	
141																	
142	GCMRC TOTAL AMP FY2008 PLANNED PROGRAM COSTS				9,515,071	484,251	9,533,947	1,278,290	8,255,657	3,519,073	128,405	600,384	376,967	784,815	563,763	2,282,250	
143																	
144	BOR Experimental Fund Summary				Gross FY11 Proposed Funding from BOR Experimental Fund	BOR Experimental Fund Balance	Comments										
145	BIO 2.R16.11	O	CRD	Mainstem Nonnative Fish Control (Ongoing)	309,251	447,075	BOR FY10 Balance $241,326 + $515,000 = $756,326 Available less $309,251 = $447,075 Balance										
146	PLAN 12.P4.11	N	APM	S.C.O.R.E. & Knowledge Assessment Updates	175,000	272,075	$447,075 Balance less $175,000 = $272,075 Balance as of 09/30/2011										
147	BOR Experimental Fund and OTHER Funding Sources Summary				484,251												
148																	
149	DEFERRED / Unfunded Projects				Deferred / Unfunded GROSS FY11 Budget	DOI Customer Burden	NET Project Subtotal (w/o Burden)	GCMRC Personnel Costs	GCMRC Project Related Travel / Training	GCMRC Operations / Supplies / Publishing	GCMRC Equipment Purchase / Replacement	AMP Logistics Support	Suballocation Outside GCMRC Contract & Science Labor	Coop & Inter Agency Agmts	Comments		
150	REC 9.R5.xx	D	CRD	Evaluate Relation between Flows and Recreation Experience	225,000	25,755	199,245	46,353	30,000	15,000	-	-	-	107,892	Deferred in FY09 and FY10		
151	REC 9.R6.xx	D	CRD	1973 Weeden Survey Revisited	75,000	4,305	70,695	-	-	-	-	-	-	70,695	Deferred in FY09 and FY10		
152	REC 9.R7.xx	D		Update Regional Recreation Economic Study	250,000	26,137	223,863	60,863	15,000	8,000	-	-	-	140,000	Deferred in FY09 and FY10		
153	CUL 11.R3.xx	D	CRD	Geomorphic Model of Archaeological Site Vulnerability	250,000	15,194	234,806	-	3,000	3,000	-	-	-	228,806	Deferred in FY09 and FY10		
154	DASA 12.D1.11	D	CRD	Quadrennial & Resource-Specific Remote Sensing Overflight Working Capital Fund <Previously Acquisition for Monitoring Data Acquisition - 4 Band Imagery (Remote Sensing> (FY08--Ongoing)	200,000	11,481	188,519	-	-	-	-	-	-	188,519	Deferred to FY12 due to budget constraints		
155	PLAN 12.P1.11	O	CRD	Enhancing the Conceptual Ecosystem Model to Identify Critical Ecosystem Interactions and Data Gap (Funded in FY08 w/Carryover - not included in FY08 Power Revenue Budget Total)	33,169	3,169	30,000	-	9,000	-	-	-	-	21,000	Deferred to FY12 due to budget constraints - MATA (Multi-Attribute Trade-off Analysis) Workshop		
156	GCMRC FY2011 Deferred Projects				947,128	107,216	57,000	26,000	-	-	-	756,912	-	-			
157																	

APPENDIX E
FY2011

Revised August 6, 2009

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
158	PROGRAM COSTS			BOR Power Revenues Under Cap Program COSTS	**FISCAL YEAR 2010**	**FISCAL YEAR 2011**											
159				BOR Power Revenues Under Cap Program COSTS	1,913,899	1,956,583											
160				GCMRC Power Revenues Under Cap Program COSTS	7,967,420	8,206,442	8,206,442	**GCMRC FY2011 Expenses under Cap**									
161				Subtotal BOR & GCMRC Power Revenue Under Cap Program COSTS	**9,881,319**	**10,163,025**											
162																	
163	PROGRAM FUNDING			BOR Power REVENUES Under Cap Program Funding	**FISCAL YEAR 2010**	**FISCAL YEAR 2011**											
164				BOR Power REVENUES Under Cap Program	1,824,747	1,879,489											
165				GCMRC Power REVENUES Under Cap Program	7,967,420	8,206,443	8,206,443	**GCMRC Total FY2011 Revenues under Cap**									
166				Subtotal BOR & GCMRC Power REVENUES Under Cap Program	**9,792,167**	**10,085,932**	0	**GCMRC Difference between FY2011 Total Revenues and Expenses Under Cap**									
167				Subtotal Difference between FY2011 Estimated Costs and Estimated Revenues Under Cap	**(89,152)**	**(77,093)**											
168																	
169	PROGRAM COSTS			BOR Appropriated and Other Program COSTS	**FISCAL YEAR 2010**	**FISCAL YEAR 2011**											
170				BOR Appropriated and Other Program COSTS	475,000	475,000											
171				GCMRC Appropriated and Other Program COSTS	1,153,327	1,327,505	1,327,505	**GCMRC FY2011 Expenses - Appropriated and Other Fund Sources**									
172				Subtotal BOR & GCMRC Power Revenue (Non-Capped) and Other Funded Program COSTS	**1,628,327**	**1,802,505**											
173																	
174	PROGRAM FUNDING			BOR Appropriated and Other Program Funding	**FISCAL YEAR 2010**	**FISCAL YEAR 2011**											
175				BOR Appropriated and Other Program FUNDING	475,000	475,000											
176				GCMRC Appropriated and Other Program FUNDING	1,153,327	1,327,505	1,327,505	**GCMRC Total FY2011 Appropriated & Other Revenues**									
177				Subtotal BOR & GCMRC Power REVENUE (Non-Capped) and Other Funded Program FUNDING	**1,628,327**	**1,802,505**	-	**GCMRC Difference between FY2011 Total Other Funding and Other Expenses (Not-Capped)**									
178																	
179				Difference between Projected COSTS and REVENUE for FY11 POWER REVENUES UNDER CAP	**-**	**-**											
180																	

181 Explanation of information found in columns A and H, & Q of the Draft Budget for the GCMRC GCDAMP FY2010-11

182	Column			
183–185	GCMRC Project ID Program Areas	A	1-3	BIO: Biology PHY: Physical Science REC: Recreation HYD: Hydropower CUL: Cultural DASA: Data Acquisition, Storage and Analysis SUP: Support PLA: Planning ADM: Administration
186			4-5	GCDAMP Goal Number
187			6-7	Project Number within GCMRC Annual Work Plan
188			7-8	Fiscal Year of Proposed Budget / Annual Work Plan
189	Column			
190	Status	B		O: Ongoing N: New C: Complete
191	Column	C		APM: Admin & Program Mgmt COR: Core Monitoring
192–193	Category			CRD: Core Monitoring Research & Development ORD: Ongoing Research and Development LTE: Longterm Experiment NA: Not Applicable
194	Column			
195	Project Description	D		Project Title (Start Date -- End Date)
196	Column			
197	Gross Carryover	E		FY 2010 GDAMP Proposed Draft Budget
198	Column			
199	Experimental Fund	F		FY 2011 Use of BOR Experimental Funds
200	Column			
201	FY11 Proposed Budget	H		FY 2011 GCDAMP Proposed Draft Budget
202	Column			
203	Comments	Q		Comments; BOCM represents Biological Opinion Core Monitoring items

Anticipates completion of the Core Monitoring plan according to the process defined in the MRP (including AMP Committed review and approval by the Secretary)

	A	B	C	D	E	F	G	H	I
1		**Project Descriptions**	**Approved FY09 Budget (incl 4.9% CPI Increase)**	**FY10 GROSS Proposed Budget (incl 0% CPI Increase)**	**FY11 GROSS Proposed Budget (incl 3% CPI Increase)**				
2									
3		Adaptive Management Work Group							
4		Personnel Costs	176,747	176,747	182,049				
5		AMWG Member Travel Reimbursement	17,467	17,467	17,991				
6		Reclamation Travel	14,178	14,178	14,873				
7		Facilitation Contract	26,959	26,959	27,768				
8		POAHG Expenses	55,536	55,536	57,202				
9		Other	7,969	7,969	8,208				
10			**298,856**	**298,856**	**308,091**				
11		Technical Work Group							
12		Personnel Costs	86,195	86,195	88,780				
13		TWG Member Travel Reimbursement	23,952	23,952	24,670				
14		Reclamation Travel	17,658	17,658	18,188				
15		TWG Chair Reimbursement	24,625	24,625	25,363				
16		Other	2,277	2,277	2,345				
17			**154,707**	**154,707**	**159,346**				
18		Other							
19		Compliance Documents	50,000	50,000	51,500				
20		Administrative Support for NPS Permitting	118,852	118,852	122,417				
21		Contract Administration	39,953	39,953	41,152				
22		Experimental Carryover Funds - to be held by BOR	500,000	500,000	515,000				
23		Integrated Tribal Resources Monitoring	142,884	142,884	147,171				
24		Mainstem Non-native Mechanical Removal	-	-	-				
25		Non-native Fish Suppression Contingency Fund	48,483	48,483	49,937				
26			**900,172**	**900,172**	**927,177**				
27			**1,353,735**	**1,353,735**	**1,394,614**				
28		Programmatic Agreement Cultural Resources							
29		Reclamation Administration	60,164	60,164	61,969				
30		Canyon Treatment Plan and Implementation	500,000	500,000	500,000				
31			**560,164**	**560,164**	**561,969**				
32			**1,913,899**	**1,913,899**	**1,956,583**				
33									
34									
35		Development of a LCR Management Plan	-	-	-				
36									
37		Cooperative Agreements with Tribes							
38		Hopi Tribe	95,000	95,000	95,000				
39		Hualapai Tribe	95,000	95,000	95,000				
40		Navajo Nation	95,000	95,000	95,000				
41		Pueblo of Zuni	95,000	95,000	95,000				
42		Southern Paiute	95,000	95,000	95,000				
43		DOI Handling Fee	-	-	-				
44			**475,000**	**475,000**	**475,000**				
45			**475,000**	**475,000**	**475,000**				
46									
47			**2,388,899**	**2,388,899**	**2,431,583**				

	A	B	C	D	E	F	G	H	I
48									
49	**GCMRC Project ID**	**Project Descriptions**	**Carry Over Funding from FY09 Available for Use in FY10**	**Approved FY09 Budget (incl 4.9% CPI Increase)**	**FY10 GROSS Proposed Budget (incl 0% CPI Increase)**	**FY11 GROSS Proposed Budget (incl 3% CPI Increase)**			
50	U.S. Geological Survey - Biological Resource Division - GCMRC - Power Revenues Under Cap Funded Projects								
51									
52	**GOAL 1 - FOOD BASE**								
53	BIO 1.R1.10	Aquatic Food Base (FY05--FY10)	20,000	510,626	505,945	-			
54	BIO 1.M1.11	Aquatic Food Base (FY11--Ongoing)	-	-	-	250,712			
55	BIO 1.R4.10	Impacts of Various Flow Regimes on the Aquatic Food Base (FY08--FY10)	-	85,472	62,111	-			
56		**SUB-TOTAL GOAL 1**	**20,000**	**596,098**	**568,056**	**250,712**			
57	**GOAL 2 - NATIVE FISHES**								
58	BIO 2.R1.10	LCR HBC Monitoring Lower 13.6km (HBC Population Est) (Ongoing)	-	487,666	455,735	-			
59	BIO 2.R2.10	LCR HBC Monitoring Lower 1,200m (Ongoing)	-	61,635	57,421	-			
60	BIO 2.M1.11	LCR Fish Monitoring (FY11--Ongoing)	-		-	308,824			
61	BIO 2.M3.10	HBC Monitoring Above Chute Falls (Ongoing)	-	136,490	143,194	145,494			
62	BIO 2.R4.09	Monitoring Mainstem Fishes (incl Diamond Down) (FY09)	-	474,723	-	-			
63	BIO 2.M4.10	Monitoring Mainstem Fishes (FY10--Ongoing)	-	-	632,461	798,930			
64	BIO 2.R5.09	Nonnative Control Planning (FY06--FY09)	-	63,640	-	-			
65	BIO 2.R6.09	Nonnative Control Pilot Testing (FY06--FY09)	-	110,281	-	-			
66	BIO 2.R17.10	Nonnative Control Plan Science Support (FY10--Ongoing)	-	-	78,057	138,599			
67	BIO 2.R7.10	Stock Assessment of Native Fish in Grand Canyon (FY07--Ongoing)	-	54,619	110,877	103,776			
68	BIO 2.R9.09	Mainstem Fish Survival (FY07--FY09)	-	96,013	-	-			
69	BIO 2.R13.10	Remote PIT Tag Reading (FY07--Ongoing)	-	107,319	217,268	224,557			
70	BIO 2.R15.10	Near Shore Ecology / Fall Steady Flows (FY08--FY12)	-	11,970	-	-			
71	BIO 2.R16.10	Mainstem Nonnative Fish Control (Ongoing)	-	141,023	68,842	-			
72	BIO 2.TBD	Nonnative Fish Contingency Fund	36,818	-	-	-			
73		**SUB-TOTAL GOAL 2**	**36,818**	**1,745,379**	**1,763,855**	**1,720,180**			
74	**GOAL 3 - EXTIRPATED SPECIES**								
75	07.3.00	None Identified	-	-	-	-			
76		**SUB-TOTAL GOAL 3**	**-**	**-**	**-**	**-**			
77	**GOAL 4 - RAINBOW TROUT**								
78	BIO 4.M1.09	Monitoring Lees Ferry Trout (FY96--FY09)	-	118,454	-	-			
79	BIO 4.E1.09	Monitoring Rainbow Trout Redds & Larvae (FY07--FY09)	-	-	-	-			
80	BIO 4.M2.10	Monitoring Lees Ferry Fishes (FY10--Ongoing)	-	-	175,737	182,819			
81		**SUB-TOTAL GOAL 4**	**-**	**118,454**	**175,737**	**182,819**			
82	**GOAL 5 - KANAB AMBERSNAIL**								
83	BIO 5.R1.10	Monitor Kanab Ambersnail (FY07--FY11)	-	22,883	24,764	25,700			
84		**SUB-TOTAL GOAL 5**	**-**	**22,883**	**24,764**	**25,700**			

	A	B	C	D	E	F	G	H	I
85	GCMRC Project ID	Project Descriptions	Carry Over Funding from FY09 Available for Use in FY10	Approved FY09 Budget (incl 4.9% CPI Increase)	FY10 GROSS Proposed Budget (incl 0% CPI Increase)	FY11 GROSS Proposed Budget (incl 3% CPI Increase)			
86	**GOAL 6 - SPRINGS / RIPARIAN**								
87	BIO 6.R1.09	Vegetation Mapping (FY07--FY09)	-	121,804	-	-			
88	BIO 6.M1.10	Vegetation Mapping (FY10--Ongoing)	-	-	95,828	106,211			
89	BIO 6.R2.09	Vegetation Transects (FY07--FY09)	41,777	52,502	-	-			
90	BIO 6.M2.11	Vegetation Transects (FY11--Ongoing)	-	-	-	142,917			
91	BIO 6.R3.10	Vegetation Synthesis (FY07--FY10)	5,000	60,364	38,526	-			
92		**SUB-TOTAL GOAL 6**	**46,777**	**234,670**	**134,354**	**249,128**			
93	**GOAL 7 - QUALITY-OF-WATER**								
94	BIO 7.R1.10	Water Quality Monitoring Lake - Powell & Tailwaters (BUDGET PRESENTED BELOW) (Ongoing)	-	-	-	-			
95	PHY 7.M1.10	Integrated Quality-of-Water Monitoring (Downstream of GCD) (FY07--Ongoing)	-	931,513	979,691	1,025,906			
96	PHY 7.R2.10	Integrated Flow, Sediment Transport and Temperature Modeling of the CRE (FY09--FY10)	-	127,134	295,398	-			
97	PHY 7.R3.11	Modeling Support & Temperature Models (FY11--Ongoing)	-	-	-	138,028			
98		**SUB-TOTAL GOAL 7**	**-**	**1,058,647**	**1,275,089**	**1,163,934**			
99	**GOAL 8 - SEDIMENT**								
100	PHY 8.M2.10	Integrated Longterm Monitoring of System Wide Changes in Sediment Storage (FY09--Ongoing)	-	309,224	219,668	381,990			
101		**SUB-TOTAL GOAL 8**	**-**	**309,224**	**219,668**	**381,990**			
102	**GOAL 9 - RECREATIONAL EXPERIENCE**								
103	REC 9.R1.10	Sand Bar and Campable Area Monitoring R & D (FY98--Ongoing)	-	55,075	78,118	78,082			
104	REC 9.R3.10	Compile Campsite Inventory and GIS Atlas (FY07--FY11)	-	-	75,020	60,500			
105	REC 9.R4.09	Compile and Analyze Existing Safety Data (FY09)	-	26,296	-	-			
106		**SUB-TOTAL GOAL 9**	**-**	**81,371**	**153,138**	**138,582**			
107	**GOAL 10 - HYDROPOWER**								
108	HYD 10.M1.10	Monitor Power Generation and Market Values under Current and Future Dam Operations (FY07--Ongoing)	-	19,587	9,680	10,890			
109		**SUB-TOTAL GOAL 10**	**-**	**19,587**	**9,680**	**10,890**			
110	**GOAL 11 - CULTURAL**								
111	CUL 11.R1.10	Cultural Research & Development toward Core Monitoring, Phase II (FY06--FY12)	287,904	448,088	373,577	361,989			
112	CUL 11.R2.10	Implement Tribal Monitoring Projects (See funding in BOR section)		-	-	-			
113		**SUB-TOTAL GOAL 11**	**287,904**	**448,088**	**373,577**	**361,989**			

	A	B	C	D	E	F	G	H	I
114	GCMRC Project ID	Project Descriptions	Carry Over Funding from FY09 Available for Use in FY10	Approved FY09 Budget (incl 4.9% CPI Increase)	FY10 GROSS Proposed Budget (incl 0% CPI Increase)	FY10 GROSS Proposed Budget (incl 0% CPI Increase)			
115	GOAL 12 - HIGH QUALITY MONITORING, RESEARCH & ADAPTIVE MANAGEMENT PROGRAM								
116	DASA 12.D1.10	Quadrennial & Resource-Specific Remote Sensing Overflight <Previously Acquisition for Monitoring Data Acquisition - 4 Band Imagery (Remote Sensing)> (FY08 -Ongoing)	160,928	202,340	200,000	-			
117	DASA 12.D9.10	Integrated Image Analysis and Change Detection (FY10--Ongoing)	-	-	234,674	245,482			
118	DASA 12.D2.10	Grand Canyon Integrated Oracle Database Management System (FY07--Ongoing)	-	184,485	166,858	166,858			
119	DASA 12.D8.10	Biometrics & General Analysis (FY10--Ongoing)	-	-	165,841	165,840			
120	DASA 12.D3.10	Library Operations (FY08--Ongoing)		56,284	80,263	78,709			
121	DASA 12.D4.10	Legacy Analog Data Conversion (Analog to Digital - Reports & Imagery) (FY08--Ongoing)	-	130,739	-	-			
122	DASA 12.D5.10	GIS Support for Integrated Analyses and Projects, GIS Lead (FY07--Ongoing)	32,860	332,871	351,882	366,171			
123	DASA 12.D7.10	Integrated Analysis and Modeling - FY09 Overflight (FY09)	-	129,124	-	-			
124		**Sub-total Goal 12 DASA Portion**	**193,788**	**1,035,843**	**1,199,518**	**1,023,060**			
125	SUP 12.S1.10	Logistics Base Costs (See each project for project related logistics costs) (Ongoing)	-	180,531	210,252	223,626			
126	SUP 12.S2.10	Survey Operations (Ongoing)	-	114,718	88,242	90,122			
127	SUP 12.S3.10	Control Network (Ongoing)	-	91,104	180,009	185,704			
128		**Sub-total Goal 12 Support Portion**	**-**	**386,353**	**478,503**	**499,452**			
129	PLAN 12.P1.10	Enhancing the Conceptual Ecosystem Model to Identify Critical Ecosystem Interactions and Data Gap (FY08--FY12)	-	50,585	239,986	148,945			
130	PLAN 12.P3.10	Low Steady Summer Flows - Data and Research Compilation, Synopsis and Synthesis (FY08--FY10)	18,067	29,251	16,409	-			
131		**Sub-total Goal 12 Planning Portion**	**18,067**	**79,836**	**256,395**	**148,945**			
132	ADM 12.A1.10 (A)	Administrative Operations (Ongoing)	23,930	173,812	161,908	167,995			
133	ADM 12.A1.10 (B)	Administrative Operations - GSA Vehicle Costs (Ongoing)	-	50,950	63,525	66,550			
134	ADM 12.A1.10 (C)	Administrative Operations - Interior Vehicle Costs (Ongoing)	-	25,475	32,065	33,880			
135	ADM 12.A2.10	Program Planning & Management (Ongoing)	-	1,111,596	1,195,480	1,238,435			
136	ADM 12.A3.10	AMWG/TWG Meeting Travel Funds (Ongoing)	-	19,154	19,481	19,965			
137	ADM 12.A4.10 (A)	Independent Reviews (Ongoing)	8,663	21,423	22,400	73,205			
138	ADM 12.A4.10 (B)	Executive Director of Science Advisors Review and Coordination; includes Science Advisors' Expenses (Ongoing)	-	214,227	217,800	223,850			
139	ADM 12.A6.10	2010 Colorado River Basin Science and Management Symposium (Biennial--Ongoing)	-	-	-	-			
140	ADM 12.A5.10	GCMRC Component of SBSC Sys Admin Support (FY05--Ongoing)	5,150	214,350	263,526	225,181			
141		**Sub-total Goal 12 Administrative/Management Portion**	**37,743**	**1,830,987**	**1,976,185**	**2,049,061**			
142		**SUB-TOTAL GOAL 12**	**249,598**	**3,333,019**	**3,910,601**	**3,720,518**			
143		**GCMRC Power Revenues Under Cap Projects Sub-totals**	**641,097**	**7,967,420**	**8,608,518**	**8,206,442**			
144		Capped Funding based on FY09 Budget with 0% CPI Index		**7,967,420**	**7,967,420**	**8,206,442**			
145		**GROSS Spending <Deficit>**		**-**	**(641,098)**	**-**			

	A	B	C	D	E	F	G	H	I
146									
147	**GCMRC Power Revenue Funded Projects (NOT Capped) and Other Funded Projects**								
148	BIO 7.R1.10	Water Quality Monitoring - Lake Powell & Tailwaters (FY07-Ongoing)	-	257,137	275,502	286,342			
149	**GCMRC Other Power Revenue Agreements Projects Subtotals**			**257,137**	**275,502**	**286,342**			
150									
151	**GCMRC Other Agreement Funding**								
152	BIO 2.R15.10	Near Shore Ecology / Fall Steady Flows (FY08--FY12)	536,641	500,000	552,825	556,911			
153	BIO 2.R16.10	Mainstem Nonnative Fish Control (Ongoing)		-	246,966	309,251			
154	Exp 7	Experimental Study - 7 - Synthesis of Knowledge	66,326	500,000	175,000	-			
155	PLAN 12.P4.11	S.C.O.R.E. Report & Knowledge Assessment Updates (FY11)	-	-	-	175,000			
156	**GCMRC Other Agreement Funding Projects Subtotals**		**602,967**	**1,000,000**	**974,791**	**1,041,162**			
157	**GCMRC ALL Other Agreements Projects TOTALS**		**602,967**	**1,257,137**	**1,250,293**	**1,327,504**			
158									
159									
160	**GCMRC TOTAL AMP PLANNED PROGRAM COSTS**		**1,244,064**	**9,224,557**	**9,858,811**	**9,533,946**			
161									
162	**GCMRC Carryover Funds from Prior Years Available for Use in FY10**		**Gross Carryover from FY09 by Project**						
163	BIO 1.R1.09	Aquatic Food Base (FY05--FY10)	20,000						
164	BIO TBD	Nonnative Fish Contingency Plan	36,818						
165	BIO 6.R2.09	Vegetation Transects (FY07--FY09)	41,777						
166	BIO 6.R3.09	Vegetation Synthesis (FY07--FY10)	5,000						
167	CUL 11.R1.09	Research & Development toward Core Monitoring (FY06--FY11)	287,904						
168	DASA 12.D1.09	Acquisition for Monitoring Data Acquisition - 4 Band Imagery (Remote Sensing) (FY08--Ongoing)	160,928						
169	DASA 12.D5.09	GIS Support for Integrated Analyses and Projects, GIS Lead (FY07--Ongoing)	32,860						
170	PLAN 12.P3.09	Low Steady Summer Flows - Data and Research Compilation, Synopsis and Synthesis	18,067						
171	ADM 12.A1.09 (A)	Administrative Operations (Ongoing)	23,930						
172	ADM 12.A4.09	Independent Reviews (Ongoing)	8,663						
173	ADM 12.A5.09	GCMRC Component of SBSC Sys Admin Support (FY05--Ongoing)	5,150						
174	***MRC FY2009 Carryover Funds - Capped Revenues Subtotal***		**641,097**						
175	BIO 2.R15.09	Near Shore Ecology / Fall Steady Flows - New Initiative	536,641						
176	HFE Experiment 7	Experimental Study - 7 - Synthesis of Knowledge	66,326						
177	***MRC FY2009 Carryover Funds - All Funding Sources Total***		**1,244,064**						

	A	B	C	D	E	F	G	H	I
178									
179	**BOR Experimental Fund Summary**		**Gross FY10/11 Proposed Funding from BOR Experimental Fund**	**BOR Experimental Fund Balance**	**Comments**				
180	BIO 2.R16.10	Mainstem Nonnative Fish Control (Ongoing)	459,251	555,749					
181	PLAN 12.P4.11	S.C.O.R.E. Report & Knowledge Assessment Updates	175,000	380,749					
182	Exp 7	Experimental Study - 7 - Synthesis of Knowledge	108,674	272,075					
183		**BOR Experimental Fund Summary**	**742,925**	**272,075**					
184									
185	**DEFERRED / Unfunded Projects**		**Deferred / Unfunded GROSS FY10/11 Budgets**	**Comments**					
186	BIO 6.R4.10	Terrestrial Habitat Monitoring R & D (FY10--FY12)	95,395	Sampling for arthropods; Proposed to be implemented as a research project in alternating years (FY10 & FY12); Deferred in FY10 and FY11					
187	BIO 6.M1.10	Vegetation Mapping (FY10--Ongoing)	48,400	Logistics for ground truthing Hyperspectral Overflight Deferred FY10 and FY11					
188	REC 9.R5.xx	Evaluate Relation between Flows and Recreation Experience	225,000	Deferred in FY09, FY10 and FY11					
189	REC 9.R6.xx	1973 Weeden Survey Revisited	75,000	Deferred in FY09, FY10 and FY11					
190	REC 9.R7.xx	Update Regional Recreation Economic Study	250,000	Deferred in FY09, FY10 and FY11					
191	CUL 11.R3.xx	Geomorphic Model of Archaeological Site Vulnerability	250,000	Deferred in FY09, FY10 and FY11					
192	DASA 12.D1.10	Quadrennial & Resource-Specific Remote Sensing Overflight <Previously Acquisition for Monitoring Data Acquisition - 4 Band Imagery (Remote Sensing> (FY08-Ongoing)	246,776	$46,776 Hyperspectral Overflight for Vegetation Mapping Deferred in FY10 and FY11, $200,000 Contribution to Quadrennial Overflight Deferred in FY11					
193	DASA 12.D9.10	Integrated Image Analysis and Change Detection (FY10--Ongoing)	89,568	Photogrammetry Deferred in FY10 and FY11					
194	PLAN 12.P1.11	Enhancing the Conceptual Ecosystem Model to Identify Critical Ecosystem Interactions and Data Gap	33,169	Deferred MATA Workshop FY11					
195		**FY10 Deferred / Unfunded Projects**	**1,313,308**						
196									
197									