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April 6, 2012

Memorandum

To: Technical Work Group (TWG)

From: John (Jack) C. Schmidt, Chief

Subject: Preliminary Draft Budget and Summary of Work Plan for Fiscal Years 2013 and 2014

Attached are the preliminary budgets for FY 2013 and 2014 for your consideration. Attachment 1 is a spreadsheet listing the project titles, primary investigators and primary collaborators, total budget amount, as well as the estimated costs for some of the primary budget categories. For each project, we state the status of the project (either on-going or new), whether the project has been significantly expanded in scope, and the purpose of the project. The primary scientific projects also have been assigned a letter, and this letter refers to Attachment 2, where summaries of each major scientific project are provided. Attachment 3 is a simple chart depicting the relative amounts assigned to each project. The budget and the project summaries do not include activities in cultural resource monitoring, nor do they include staffing of an economist.

This budget and the project summaries have been reviewed in a preliminary sense by our sister agencies of the Department of the Interior. Based on this preliminary review, we are confident that the proposed work in the natural sciences (projects A–I) is consistent with the missions and management responsibilities of the various DoI agencies, including Grand Canyon National Park. In the case of cultural resources monitoring, the GCMRC and Grand Canyon National Park have agreed to review each other's proposed monitoring and research activities for FY13/14, to revise those programs so as to develop a complementary program that meets the needs of the Park Service and of the Glen Canyon Dam Adaptive Management Program (GCDAMP), and to subsequently propose an integrated, joint program. It is anticipated that development of this integrated program revision in cultural resources will be completed soon after the April TWG meeting and will be available for review prior to the May Adaptive Management Work Group (AMWG) meeting.

Excluding the program in cultural resources monitoring and excluding the funding of a staff economist, the preliminary budget for FY13 is $9.4 million. At this point, GCMRC expects that our available funds in FY13 will be approximately $8.5 million from GCDAMP funds and approximately $0.4 million from Reclamation funds that directly fund the Lake Powell

monitoring program and support GCMRC work in monitoring the efficacy of brown trout removal in Upper Granite Gorge. Thus, the preliminary budget of GCMRC is approximately $0.5 million greater than is needed to support the entire proposed work plan, and this shortfall does not include any funding for the pending program in cultural resources monitoring, nor support for a staff economist.

Nevertheless, I am optimistic of the potential to find funds to support the work described here. Reclamation has indicated that supplemental funds might be made available to support the new research efforts described in Project E as well as the laboratory studies proposed in Project G.

Approximately 31%, 42%, and 5% of the preliminary FY13 budget addresses monitoring and research needs in the physical sciences (Projects A, B, and C), aquatic and fisheries sciences (Projects D, E, F, G, and H), and riparian ecology (Project I), respectively. These proportions are approximately the same as in the FY11/12 budget period. Approximately 19% of the preliminary budget concerns administration of the GCMRC. The budget for independent reviews, including the budget for the Science Advisors, has been decreased to $170,000 (2% of the total budget).

Most of the projects are collaborative efforts of GCMRC staff and staff in sister agencies of federal and state government, universities, and private consulting firms. We also identify collaborations with other units of the U.S. Geological Survey. In terms of major budget categories, 39% of the total budget is allocated to salaries of GCMRC staff, 19% is allocated to the work of non-USGS cooperators, and 8% allocated to the work of other USGS offices. The budget for the logistical effort of supporting river trips is approximately $1 million (11% of the preliminary budget). In contrast to past years, there is no distinct budget for remote sensing and GIS activities. Instead, these costs are absorbed into the work of each scientific project; we estimate that the total work in remote sensing and GIS services is approximately $487,000 (5% of the budget).

The budget and program of work described here were developed based on guidance provided in the Strategic Science Plan published in March 2007 and amended in April 2009, the Monitoring and Research Plan published in August 2007 and amended in 2009, the draft General Core Monitoring Plan of February 2011, and the various Knowledge Assessment Workshops conducted in 2011 and 2012. This program of work was also developed in response to the Desired Future Conditions Ad Hoc Group report that was presented to the AMWG in February 2012. Lastly, this program of work is responsive to the science plans for the Environmental Assessment for the Development and Implementation of a Protocol for High-Flow Experimental Releases, the Environmental Assessment for Non-native Fish Control, the U.S. Fish and Wildlife Service's December 2011 Biological Opinions related to those EAs, and the recent Memoranda of Agreement developed by Reclamation and the Tribes.

My charge to the GCMRC staff was to develop integrative projects that are responsive to the major issues in natural and socio-economic science that are confronted by the GCDAMP. As such, this preliminary program of study is organized into 10 major projects (including the pending program in cultural resources monitoring). Additionally, there are three other programs: independent review, USGS and GCMRC administration, and an annual allocation to fund the quadrennial acquisition of aerial photos and other remotely sensed data. The 10 major projects are focused on the primary areas of concern to the GCDAMP:

- geomorphology of fine-grained sediment (Project A);
- measurement of stream flow quantity and quality and sediment transport (Project B);
- measurement of Lake Powell water quality (Project C)
- monitoring and research concerning mainstem and tributary humpback chub (Projects D, E, F);
- monitoring and research concerning tailwater recreational rainbow trout (Project H);
- monitoring and research concerning the interactions between trout and humpback chub (Project H);
- monitoring and research concerning riparian vegetation and its interactions with geomorphic processes; and,
- cultural resources monitoring.

Approximately 50% of the preliminary budget is related to fulfilling data collection and data analysis needs associated with environmental compliance issues of the two EAs and the Biological Opinion. Approximately 13% of the preliminary FY13 budget is associated with research activities needed to resolve critical management uncertainties, especially in the biological sciences. Approximately 18% of the preliminary budget constitutes new projects not previously undertaken.

The GCMRC staff especially appreciated the thoughts and perspectives of the Budget Ad Hoc Group (BAHG) and the compiled comments received in February 2012. GCMRC chose not to initiate some of the research projects suggested by the BAHG, largely due to budget considerations. Thus, we did not initiate a new study to evaluate opportunities to reintroduce humpback chub near the Paria River, nor do we propose to study the potential to reintroduce extirpated species. Our effort to expand the riparian vegetation studies in this budget is explicitly responsive to BAHG suggestions. At this time, we are not proposing to initiate a new ecosystem modeling study, although we recognize the potential utility of such an effort. We are uncertain how to fund the GCMRC staff economist at this time, and we are exploring various options.

We look forward to the April 12th discussion with the BAHG in which the relation of this budget to other BAHG suggestions can be discussed.

Attachment 2

Summaries of GCMRC's FY 13-14 Proposals

A. Project Title: Sandbars and sediment storage dynamics: Long-term monitoring and research at the site, reach, and ecosystem scales

Collaborators: Paul Grams and Keith Kohl (Grand Canyon Monitoring and Research Center); David Rubin (U.S. Geological Survey); Joseph E. Hazel, Jr. and Matt Kaplinski (Northern Arizona University); Rod Parnell (Northern Arizona University)

This ongoing project includes a set of integrated studies conducted at multiple spatial and temporal scales that are designed to track the results of individual high flow experiments (HFEs), monitor the cumulative effect of multiple high flows and intervening operations, and advance our understanding of sediment and eddy sandbar dynamics to improve capacity for predicting the effects of future dam operations. The key uncertainty about management of sandbars below glen canyon dam articulated in the recently completed Environmental Assessment for Development and Implementation of a Protocol for High-Flow Experimental Releases from Glen Canyon Dam, 2011 through 2020 is the question, "Can sandbar building during HFEs exceed sandbar erosion during periods between HFEs, such that sandbar size can be increased and maintained over several years?" This question will only be answered through continued monitoring of sand resources over a multi-year timeframe of repeated controlled flood experimentation.

Monitoring will include daily and annual observations of long-term sandbar monitoring sites by remote camera and conventional topographic survey, respectively. These observations contribute to the existing long-term dataset and will be available following each high flow as a preliminary partial assessment of resource condition that could be used to adjust the high-flow implementation strategy, if necessary. Because these monitoring sites represent only a small proportion of the total number of sandbars in Grand Canyon, the project also includes the use of systemwide airborne remote sensing to monitor a much larger set of sandbars every four years to assess sandbar size and abundance. While the sandbar monitoring studies provide needed information on resource condition, they do not provide any measure of how much sand is in storage, and the continued success of high flows to rebuild sandbars depends on maintaining an adequate supply of sand storage. If there is a decline in sand storage, future high flows are likely to be less effective at building sandbars. To provide this information and evaluate whether dam operations, including high flows, are likely to result in sandbar maintenance or eventual decline, sediment storage will be monitored by repeat channel-wide surveys of selected river segments approximately every three to ten years. Additional components of this project are designed to integrate findings across the spatial

and temporal scales, investigate how specific changes in sandbar morphology affects campsite quality, link sandbar deposition dynamics with the distribution of riparian vegetation along shorelines, provide habitat and riverbed substrate information to biological studies, and improve our understanding of the variability of sandbar response to dam operations thereby contributing to improved capacity to predict the effects of future high flows in the context of intervening daily operations.

B. Project Title: Streamflow, water quality, and sediment transport in the Colorado River Ecosystem

Collaborators: David Topping (Grand Canyon Monitoring and Research Center); Arizona Water Science Center; Utah Water Science Center; Scott Wright (U.S. Geological Survey); and the Center for Integrated Data Analytics.

This project funds the ongoing measurement of stage, discharge, water quality (water temperature, specific conductance, turbidity, dissolved oxygen), and suspended sediment at gaging stations. The data collected by this project provide the fundamental stream flow, sediment transport, temperature, and water quality data that are used by other physical, ecological, and socio-cultural resource studies. Thus, this project directly links dam operations to the physical, biological, and sociocultural resources of the Colorado River ecosystem (CRe). This project also funds interpretation of these basic data, specifically examining how stream flow and its related attributes affect resources of the CRe.

Much of the proposed work in this project consists of high-resolution (typically 15-minute) measurements of the following parameters: stage, discharge, water temperature, specific conductance, turbidity, dissolved oxygen, suspended-sediment concentration, and suspended-sediment grain-size distribution. In addition, episodic measurements of bed sediment are made. One of the major products of this project has been the mass-balance sand budgets used to trigger artificial floods and to evaluate the effects of all dam operations on the CRe. To make all of the data collected by this project, and especially these sediment budgets, more available to both GCDAMP stakeholders and the general public, a major emphasis is being placed on the development of user-interactive web tools for downloading and visualizing these data (through collaboration with the USGS Center for Integrated Data Analytics). The tools developed in collaboration with CIDA will allow anyone to plot the data, construct mass-balance sediment budgets, and plot changes in reach-averaged bed-sediment grain size for any time period in any reach of the CRE on demand. In addition, these tools will allow different user-chosen methods for error propagation through these sediment budgets. Because sandbar response during artificial floods depends on both the amount and grain-size distribution of the sand stored in each reach these tools should be extremely useful in the planning of artificial floods under the HFE protocol EA in the upcoming LTEMP EIS. Much of the proposed

increase in the budget for this project above previous funding levels is for this effort to make the data collected by this project more available, more usable, and therefore more relevant to the decision makers in the GCDAMP.

C. Project Title: Water-quality monitoring of Lake Powell and Glen Canyon Dam releases

Collaborators: William Vernieu (Grand Canyon Monitoring and Research Center); Reclamation; National Park Service; LP Cooperators Group; and Dale Robertson (U.S. Geological Survey)

This project conducts water-quality monitoring on Lake Powell and the Glen Canyon Dam tailwaters. The water-quality monitoring program consists of monthly surveys of the reservoir forebay and tailwater, as well as quarterly surveys of the entire reservoir, including the Colorado, San Juan, and Escalante arms of the reservoir to the inflow areas. It also includes continuous monitoring of dam releases. The data collected by this project describe the current quality of Glen Canyon Dam releases to the downstream ecosystem, as well as describe the current water-quality conditions and hydrologic processes in Lake Powell, which can be used to predict the quality of future releases from the dam. The current long-term monitoring program will continue at the current level, with possible minor revisions to the number of sites monitored or parameters collected. In an effort to improve the predictive capabilities of the CE-QUAL-W2 simulation model, it is proposed that one or more inflow monitoring stations be reestablished to provide input data on inflow temperature and salinity. It is also proposed to establish one or more weather stations at remote pumpout stations in the upper part of the reservoir to improve inputs to the model. In addition to the ongoing monitoring program, efforts are currently being made to analyze sonar chart paper data to develop longitudinal profiles of the sediment deltas of the three major tributaries to evaluate rates and patterns of deposition under varying hydrologic regimes and reservoir levels. These profiles have been collected in conjunction with most quarterly reservoir surveys since 2001.

D. Project Title: Mainstem Humpback Chub Aggregation Studies and Metapopulation Dynamics

Collaborators: William Persons, Theodore Kennedy, and David Ward (Grand Canyon Monitoring and Research Center); D.R. Van Haverbeke **(**U.S. Fish and Wildlife Service); Brian Healy and Emily Omana (National Park Service); Karen Limburg and Todd Hayden (State University of New York); Scott Bonar (University of Arizona); and Scott Wright (U.S. Geological Survey)

Standardized monitoring of mainstem humpback chub aggregations has been conducted during the fall in 2002 through 2004, 2006, 2010, and 2011. Fish were sampled by hoop and trammel nets at aggregations first described by Valdez and Ryel (1995). These monitoring efforts provide catch per unit effort indices, but not abundance estimates, so inferences that can be drawn from these data regarding chub response to ongoing management actions are extremely limited; continued monitoring of aggregations is required as part of the non-native control Environmental Assessment and associated Biological Opinion. This project, conducted in collaboration with the U.S. Fish and Wildlife Service, Grand Canyon National Park , and the University of Arizona, will increase aggregation sampling during FY13-14, including the addition of a second aggregation sampling trip in late spring/early summer, to improve monitoring techniques and provide estimates of humpback chub abundance at all mainstem aggregations. This additional sampling will also improve our understanding of the role ongoing juvenile humpback chub translocations play in the metapopulation dynamics of this species.

Although recent catch rate information indicates aggregations might be growing, absolute numbers of humpback chub at aggregations remains low. Therefore, we propose a suite of research activities to better understand the factors limiting the abundance of aggregations. We propose research on otolith microchemistry of juvenile humpback chub at aggregations to assess whether these aggregations are supported by emigration of juvenile fish from the Little Colorado River or local spawning and recruitment. Recent foodbase research efforts indicate fish production throughout Glen, Marble, and Grand Canyon is limited by the availability of high quality prey, particularly midges and black flies; although food availability was quantified across 5 sites in Grand Canyon including at least one aggregation (Middle Granite Gorge, river mile ~127), the feeding habits and energy intake by humpback chub were only quantified at the Little Colorado River confluence area. We therefore propose estimating the growth potential of humpback chub at aggregations by quantifying food resource availability (i.e., invertebrate drift), , measurement of chub feeding habits, and integration of these data using models of net energy intake potential that account for prey detection and the energetic costs of swimming by fish, among other things. These data will be compared with similar data collected near the Little Colorado River, which are described in a different project. Reproductive potential of humpback chub will be determined using condition indices (i.e., lipids) and manipulative experiments. Collectively, the proposed research will yield a more rigorous aggregation monitoring program and will increase our understanding of the ecology of aggregations, including whether downstream reaches in Grand Canyon are capable of supporting self-sustaining populations of humpback chub.

E. Project Title: Humpback chub (*Gila cypha*) early life history in and around the Little Colorado River

Collaborators: Charles Yackulic, Theodore Kennedy, and David Ward (Grand Canyon Monitoring and Research Center); Colden Baxter (Idaho State University); Bill Pine (University of Florida); D.R. Van Haverbeke (U.S. Fish and Wildlife Service); and Scott Wright (U.S. Geological Survey)

The Nearshore Ecology Project (NSE) validated Visual Implant Elastomer (VIE) tags and otolith microchemistry as useful tools for understanding juvenile humpback chub movements, growth, and survival. Prior to NSE, our ability to quantify variation in cohort strength was limited to back-calculations from two-year old fish (Coggins and Walters 2009). These tools provide information that is critical for evaluating ongoing adaptive management experimentation because population dynamics of many fish species are driven by changes in survival at early life stages (i.e., <1 year; Walters and Martell 2004). A better understanding of juvenile humpback chub early life history was identified as a critical information need at recent Knowledge Assessment Workshops (GCMRC and Cooperator presentations, 2011-2012). Recent foodbase research efforts indicate fish production throughout Glen, Marble, and Grand Canyon is limited by the availability of high quality prey, particularly midges and black flies; however, food web structure and the potential for food limitation of humpback chub in the Little Colorado River itself have not been studied. Because foodbase and NSE sampling was/is limited to the mainstem and current LCR monitoring is limited to the spring and fall, these projects do not allow us to understand the relative importance of LCR hydrology, food availability and food web structure in the LCR itself, and inter- and intraspecific interactions in determining young-of-year survival and outmigration. A better understanding of the drivers of among year variation in juvenile humpback chub survival and outmigration from the LCR, combined with ongoing NSE survival estimates from the mainstem, would allow us to evaluate the relative importance of the LCR versus the mainstem in humpback chub population dynamics.

Our proposal calls for: a) estimating growth, survival and dispersal of juvenile humpback chub in the Little Colorado River by marking young-of-year humpback chub in the Little Colorado River in July of each year, b) determining food availability and food web structure in the Little Colorado River confluence including describing the feeding habits of juvenile chub in both the LCR and mainstem, c) systematic collection of otoliths from young-of-year in both the LCR and mainstem across seasons to better resolve movement and dispersal, d) laboratory studies on chemical imprinting to determine whether the timing of juvenile outmigration ultimately affects spawning site fidelity for chub, and e) data analysis and modeling to determine both the relative roles of hydrology and

intraspecific interactions in LCR juvenile dynamics and the relative importance of the LCR versus the mainstem in humpback chub population dynamics.

F. Project Title: Long-term monitoring of native and nonnative fishes in the mainstem Colorado River and the Little Colorado River

Collaborators: William Persons, Luke Avery, Charles Yackulic, and Mike Yard (Grand Canyon Monitoring and Research Center); Aaron Bunch and Brian Clark (Arizona Game and Fish Department); D.R. Van Haverbeke, Dennis Stone, and Mike Pillow (U.S. Fish and Wildlife Service); Brian Healy and Emily Omana (Grand Canyon National Park); Josh Korman (Ecometric Research); and Dana Winkelman and Kristen Pearson (Colorado State University)

Native and nonnative fish populations in Grand Canyon are key resources of concern influencing decisions on both the operation of Glen Canyon Dam and non-flow actions. To inform these decisions, it is imperative that accurate and timely information on the status of fish populations, particularly the endangered humpback chub, 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 and nonnative fishes 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 and nonnative 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 humpback chub in Grand Canyon.

G. Project Title: Interactions between native fish and nonnative trout

Collaborators: David Ward (Grand Canyon Monitoring and Research Center); Aaron Bunch and Mike Anderson (Arizona Game and Fish Department); D.R. Van Haverbeke (U.S. Fish and Wildlife Service); Brian Healy and Emily Omana (Grand Canyon National Park)

We propose to evaluate impacts of rainbow and brown trout on humpback chub in both laboratory and field settings. Laboratory studies will be used to isolate confounding variables and quantify relative competition and predation impacts of rainbow and brown trout on humpback chub under varying environmental conditions. Results of laboratory

tests will then be used in conjunction with data from long-term monitoring to model population level impacts of trout on humpback chub. A field study conducted in collaboration with Grand Canyon National Park will remove brown trout using electrofishing in and around Bright Angel Creek and subsequently evaluate impacts of brown trout removal on native fish populations. Combining laboratory studies, field studies, monitoring efforts, and modeling will allow researchers to understand and quantify how predation and competition by trout are impacting humpback chub at a population level, and will allow managers to better plan and implement management actions designed to conserve Colorado River native fishes.

H. Project Title: Identifying the main driver(s) of rainbow trout growth, population size, demographics and distribution in Glen and Marble Canyon

Collaborators: Mike Yard, David Ward, Theodore Kennedy, and Charles Yackulic (Grand Canyon Monitoring and Research Center); Aaron Bunch and Mike Anderson (Arizona Game and Fish Department); Robert Hall (University of Wyoming); Scott Wright (U.S. Geological Survey); and Josh Korman (Ecometric Research)

Over the last few decades the rainbow trout (Oncorhynchus mykiss; hereafter RBT) fishery in Lees Ferry has been characterized by three undesirable properties: 1) an absence of the large RBT that are highly valued by the angling community (Schmidt and others 1998), 2) increasing potential for negative interactions between RBT and native fishes as RBT populations expanded downstream (Yard and others 2011), and 3) decadal scale cycles in RBT population abundance (Makinster and others 2011). The causes of the long term population cycles (3) are fairly well understood (Korman et al., in press), and the Natal Origins project was specifically designed to address uncertainties surrounding the downstream migration of RBT (2). Here, we propose a suite of activities, many of which build on the Natal Origins platform, to better understand the factors limiting the growth of large RBT (1). Research efforts have repeatedly identified the limited prey base in Glen Canyon as a likely cause of some of these undesirable properties (Stevens and others 1997, McKinney and Speas 2001, Cross and others 2011) so our proposal emphasizes continued research on fish-food linkages.

Our proposal calls for: a) a simple laboratory experiment to determine if the strain of rainbow trout in Lees Ferry is actually capable of growing to large size, b) measurement of algae primary production, invertebrate drift, and rainbow trout diets to quantify prey abundance, and c) modeling that combines hydrodynamics, invertebrate drift, and fish bioenergetics to estimate net energy intake and growth potential for rainbow trout, and d) a synthesis of data from tailwaters throughout the nation to better understand the link between salmonid population dynamics and flow and temperature regimes, which will

help identify alternative flow regimes that could be considered for implementation on Glen Canyon Dam. In addition, we present a contingency plan for a potential fall High Flow Experiment (HFE). Although we have a good understanding of food web response to the spring HFEs conducted in 1996 and 2008, our understanding of food web response to the fall HFE in 2004 is more limited. Thus, we are also poised to take advantage of the learning opportunity presented by any HFEs that occur during FY13-14.

I. Project Title: Integrated riparian vegetation studies

Collaborators: Barbara Ralston, Phil Davis, and Paul Grams (Grand Canyon Monitoring and Research Center); Dustin Perkins (Northern Plateau I&M Program); Grand Canyon National Park; Northern Arizona University

Riparian vegetation affects physical process as well as ecological and cultural interactions along the river corridor. Reduced local precipitation, altered basin hydrology, and the introduction of the tamarisk leaf-beetle into the river corridor in 2008 are conditions that collectively may significantly alter the composition of the riparian community and indirectly affect efforts to manage and conserve sediment along the corridor. The presence and expansion of vegetation promotes bank stability which is the antithesis of the historic Colorado River sediment dynamics. The effect of riparian vegetation's presence and the uncertain direction that compositional changes may take has garnered the attention of stakeholders within the Adaptive Management Program for Glen Canyon Dam (GCDAMP), and resource managers along other stretch of the Colorado Rivers. The stakeholders for the GCDAMP requested a greater emphasis be put on quantifying and understanding riparian vegetation dynamics. Better understanding of the response of riparian vegetation to Glen Canyon Dam and the effect of riparian vegetation on other resources can be gained by improving the monitoring efforts within the river corridor downstream of Glen Canyon Dam, and by expanding opportunities to compare and integrate riparian monitoring data and research across the Colorado River Basin. This proposal includes three study elements that are intended to initiate a monitoring approach that is collaborative with the National Park Service's Northern Colorado Plateau's Inventory and Monitoring Program and Grand Canyon National Park, and research efforts intended to be integrative with the physical sciences and trophic interactions.

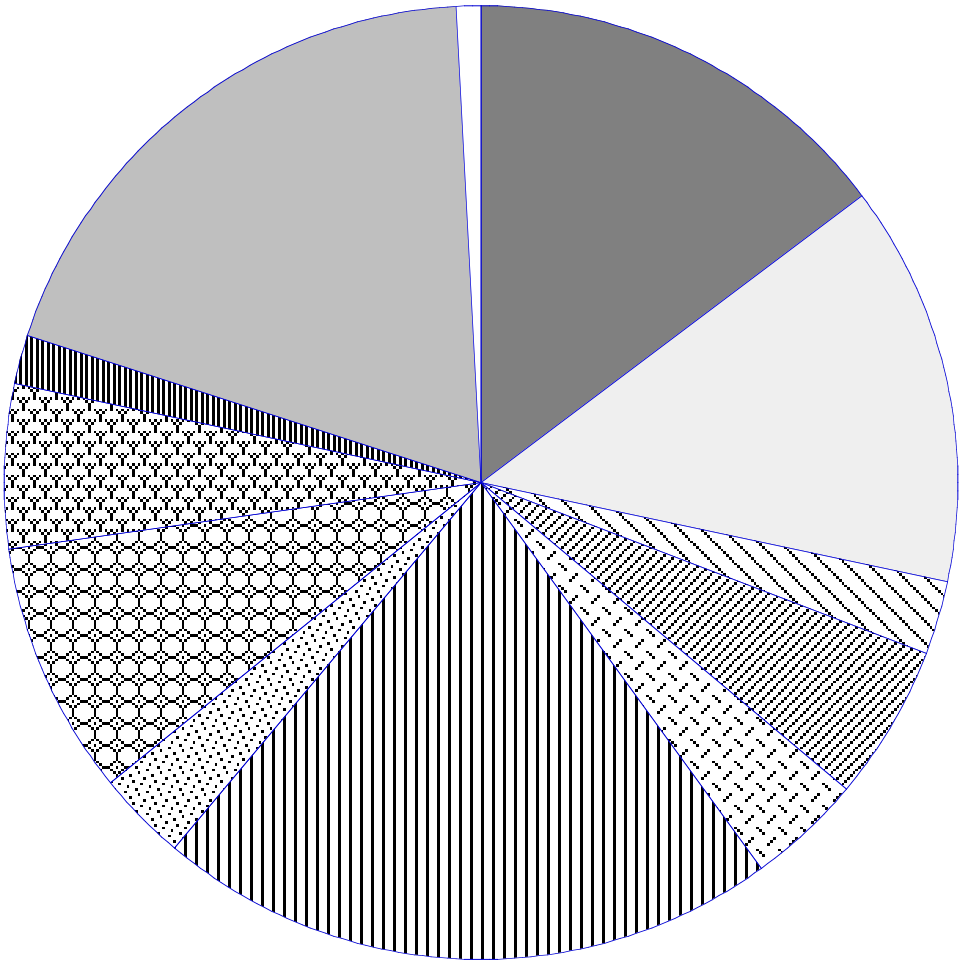
This proposed work includes three complimentary elements: 1) Remote and ground-based riparian vegetation monitoring; 2) Investigating Eddy Sandbar Variability: Interactions among Flow, Vegetation, and Geomorphology; 3) Riparian vegetation dynamics and trophic level linkages. Vegetation monitoring data should inform resource managers about the status of vegetation as it relates to biotic, physical and cultural resources within a geomorphic framework that allows comparison of vegetation response

across the river corridor (Element 1 goal). Monitoring the response of vegetation may provide feedback information to geomorphology research concerned about responsive or unresponsive bars either within or between river reaches (Element 2 goal). Data collected for vegetation monitoring can also compliment research focused on understanding trophic linkages between aquatic and terrestrial systems and how dam operations and other agents of change (e.g., tamarisk beetle) may affect these linkages (Element 3 goal). The Adaptive Management Program has identified specific monitoring information needs associated with Goal 6 that identify species composition distribution and area cover as basic data the program needs to understand plant response to dam operations. Consistent data collection of species presence and cover that is nested within a geomorphic framework can assist resource managers in answering the following questions which are drawn from the stated information needs:

1. Which species (native and nonnative species) and what is the percent cover of species that occupy and form habitat within the depositional environments of debris-fan eddy complexes and the channel margins associated with the hydrologic features of pools, eddys, and runs? (Element 1 goal)
2. How do patterns of species composition and cover vary by stage and by river reach?
3. Do species common to all reaches of river within Grand Canyon respond similarly to changes in operations of Glen Canyon Dam? (Element 1 goal).
4. How does woody riparian vegetation expansion below power plant capacity limit sediment conservation associated with experimental high flows? (Element 2 goal).
5. How does woody riparian vegetation expansion below power plant capacity affect shoreline complexity for juvenile fish? (Element 2 goal).
6. How will the decline in tamarisk cover affect riparian breeding bird habitat, reptile abundance along the river corridor and (or) available terrestrial food resources (e.g., ground-dwelling arthropods)? (Element 3 goal).

Answering these questions requires data collection and analysis at multiple spatial scales using ground-based sampling, periodic collection of remotely sensed imagery and modeling that is integrated with physical resources. By answering these questions through monitoring and research, opportunities to experiment with release volumes and patterns of release from Glen Canyon Dam may allow resource managers to move toward reaching their resource goal of supporting native vegetation in some portions of the river if not the majority of the Colorado River downstream from Glen Canyon Dam.

Preliminary FY13 GCMRC budget
(does not include cultural resources)



- Sandbars and sediment storage dynamics
- Stream flow, water quality, and sediment transport
- Lake Powell water quality monitoring
- Mainstem humpback chub aggregation studies
- Humpback chub early life history near LCR
- Long-term monitoring native and nonnative mainstem
- Native fish and nonnative trout interactions
- Identifying main drivers rainbow trout growth, etc
- Integrated riparian vegetation studies
- Independent Review
- USGS Administration
- Other Allocations

Attachment 1

						FY 13						FY14	
					investigators	GCMRC salaries	logistics	GIS / RS / electronics support (includes burden)	cooperators (non-USGS)	USGS cooperators	total	total	collaborators / cooperators
				Total (does not include Cultural Resources monitoring)		$3,669,000	$1,047,000	$487,000	$1,808,000	$757,000	$9,370,000	$9,739,000	
			A	***Sandbars and sediment storage dynamics ($1,391,000)***									
on-going		GCDAMP monitoring, including environmental compliance		1. Sandbar and camping beach monitoring …	Grams et al	$106,000	$27,000	77,000	$98,000		$344,000	$354,000	Northern Arizona U
on-going		GCDAMP monitoring, including environmental compliance / research		2. Sediment storage monitoring and research	Grams et al	$259,000	$74,000	$81,000	$164,000	$14,000	$691,000	$712,000	Northern Arizona U, USGS/Coastal Marine Geology
new		research		3. Bed sediment influences on suspended sediment	Rubin et al	$43,000	$37,000	$22,000	$65,000	$83,000	$267,000	$275,000	USGS/Coastal Marine Geology
new		research		4. Geochemical signatures of mined pre-dam sediment	Takesue et al	$6,000				$46,000	$53,000	$55,000	USGS/Coastal Marine Geology
on-going				5. General survey support	Kohl et al	$22,000	$6,000				$36,000	$37,000	
on-going		GCDAMP monitoring, including environmental compliance	B	***Stream flow, water quality, and sediment transport ($1,258,000)***	Topping	$524,000	$60,000	$55,000		$480,000	$1,258,000	$1,336,000	USGS/AZ Water Science Center, USGS/UT Water Science Center, USGS/Center Integrated Data Analytics
on-going		GCDAMP monitoring	C	***Lake Powell water quality monitoring ($236,000)***	Vernieu	$166,000	$22,000				$236,000	$243,000	Reclamation, National Park Service
			D	***Mainstem humpback chub aggregation studies (504,000)***									
on-going	expanded	GCDAMP monitoring, including environmental compliance		1. Aggregation sampling	Ward et al	$22,000	$100,000	$15,000	$80,000		$250,000	$257,000	US Fish Wildlife Service
on-going	expanded	GCDAMP monitoring, including environmental compliance		2. Aggregation ecology	Kennedy et al.	$51,000	$15,000	$15,000	$27,000		$124,000	$127,000	US Fish Wildlife Service
new		research		3a. Adult condition and reproductive potential (ovaprim studies)	Ward et al.	$7,000			$15,000		$27,000	$28,000	USGS/AZ Co-op Unit, US Fish Wildlife Service
new		research		3b. Adult condition and reproductive potential (ultrasonic imaging)	Ward et al.	$7,000			$15,000		$36,000	$28,000	USGS/AZ Co-op Unit, US Fish Wildlife Service
new		research		3c. Adult condition and reproductive potential (diet nutritional studies)	Ward et al.	$7,000			$15,000		$29,000	$31,000	USGS/AZ Co-op Unit, US Fish Wildlife Service
new		research		4. Humpback chub natal origins	Persons et al.	$10,000			$20,000		$38,000	$38,000	US Fish Wildlife Service, SUNY
			E	***Humpback chub early life history near LCR ($358,000)***									
new		research		1. July LCR marking	Yackulic et al.	$65,000	$10,000				$93,000	$97,000	
new		research		2. Describing trophic ecology humpback chub in LCR	Kennedy et al	$69,000			$20,000		$119,000	$110,000	Univ Wyoming
new		research		3. Otolith sampling NSE reach in fall		$11,000					$32,000	$32,000	SUNY
new		research		4. Laboaratory study imprinting of humpback chub (FY 14 project)	Ward et al.							$39,000	
new		research		5. Linkages / modeling	Yackulic et al.	$84,000			$10,000		$114,000	$118,000	Univ Florida
			F	***Long-term monitoring native nonnative fishes mainstem Colorado River and LCR ($1,988,000)***									
on-going		GCDAMP monitoring, including environmental compliance		1. Mainstem spring native/nonnative fish monitoring	Persons et al.	$23,000	$55,000		$103,000		$206,000	$212,000	AZ Game Fish Dept
on-going		GCDAMP monitoring, including environmental compliance		1c.1. Rainbow trout monitoring	Persons et al.	$23,000	$42,000		$132,000		$216,000	$222,000	AZ Game Fish Dept
on-going		GCDAMP monitoring, including environmental compliance		1c.2. Rainbow trout early life studies	Avery et al.	$46,000	$42,000				$109,000	$113,000	
on-going		GCDAMP monitoring, including environmental compliance		1d. Mainstem monitoring native/nonnative fish near LCR confluences	Yard et al.	$13,000	$206,000		$177,000		$432,000	$445,000	Ecometric Inc.
on-going		GCDAMP monitoring, including environmental compliance		2a. Annual spring/fall HBC abundance estimates lower 13.6km ofLCR	Persons et al.	$18,000	$86,000		$364,000		$511,000	$526,000	US Fish Wildlife Service
on-going		GCDAMP monitoring, including environmental compliance		2b. Monitoring native/nonative in lower 1,200m LCR	Persons et al.	$17,000	$12,000		$50,000		$88,000	$90,000	AZ Game Fish Dept

						FY 13						FY14	
					investigators	GCMRC salaries	logistics	GIS / RS / electronics support (includes burden)	cooperators (non-USGS)	USGS cooperators	total	total	collaborators / cooperators
on-going		GCDAMP monitoring, including environmental compliance		2c. Translocation and monitoring above Chute Falls	Persons et al.	$17,000	$37,000		$67,000		$132,000	$135,000	US Fish Wildlife Service
on-going		GCDAMP monitoring / research		2d. PIT tag antenna monitoring	Persons et al.	$23,000	$6,000		$40,000		$80,000	$41,000	Colorado State U
on-going		GCDAMP monitoring, including environmental compliance		3. Stock assessment and structured mark recapture model humpback chub abundance estimates	Yackulic et al.	$19,000					$22,000	$23,000	
on-going		GCDAMP monitoring, including environmental compliance		4. Detection of rainbow trout movement from upper Colorado River below GCD	Korman	$35,000	$28,000		$67,000		$192,000	$198,000	Ecometric Inc.
			G	***Interactions between native fish and nonnative trout ($277,000)***									
new		research		1. Laboratory studies…	Ward	$52,000					$83,000	$84,000	AZ Game Fish Dept, US Fish Wildlife Service, US Forest Service
new		GCDAMP monitoring / research		2. Efficacy ecological impacts brown trout	Ward et al.	$71,000	$89,000				$194,000	$196,000	AZ Game Fish Dept, National Park Service
			H	***Identifying main drivers rainbow trout growth, population size, demographics, distribution ($814,000)***									
on-going	expanded	GCDAMP monitoring / research		1. Establishing current conditions	Yard et al	$59,000					$113,000	$116,000	Ecometrics, Inc.
new		research		2. Laboratory feeding studies	Ward	$15,000					$36,000	$5,000	
on-going	expanded	GCDAMP monitoring / research		3. Monitoring modeling food base	Kennedy et al.	$254,000			$20,000		$327,000	$337,000	Idaho State U
new		GCDAMP monitoring / research		4. Integration modeling factors limiting large rainbow trout growth	Yackulic et al.	$98,000					$111,000	$114,000	
new		research		5. Tailwater synthesis	Yackulic et al.	$93,000					$118,000	$128,000	
new		GCDAMP monitoring, including environmental compliance / research		6. Rainbow trout population management	Yard et al	$45,000	$23,000				$109,000	$113,000	
			I	***Integrated riparian vegetation studies ($509,000)***									
on-going	expanded	GCDAMP monitoring		1. Integrated vegetation monitoring	Ralston	$69,000	$30,000	$137,000	$25,000		$276,000	$281,000	National Park Service
new		research		2. Vegetation-sediment modeling	Ralston	$113,000	$35,000				$189,000	$193,000	
new		research		3. Riparian vegetation dynamics - trophic linkages	Ralston	$26,000	$5,000				$44,000	$45,000	
				Cultural Resources monitoring									
on-going	expanded	GCDAMP monitoring, including environmental compliance		Glen Canyon NRA and Grand Canyon NP Cultural Resource Pilot Monitoring Project; Grand Canyon NP remote sensing analysis ***(GCMRC and NPS project proposals are under review)***	Fairley et al.								USGS/Geology, Minerals, Energy, and Geophysics Science Center
				Independent Review ($170,000)									
on-going	reduced			Independent Reviewers					$21,000		$24,000	$25,000	
on-going	reduced			Science Advisors					$142,000		$146,000	$150,000	
				USGS Administration ($1,780,000)									
				Budget analyst, communications support, library, discretionary awards		$253,000			$71,000		$426,000	$439,000	
				vehicles							$134,000	$138,000	
				leadership personnel		$584,000					$699,960	$717,000	
				AMWG/TWG travel							$32,000	$33,000	
				SBSC IT overhead						$134,000	$153,000	$158,000	
				Logistics base costs		$244,000					$335,000	$345,000	
				Other Allocations ($85,000)									
				Annual contribution of Overflight Fund				$85,000			$85,000	$200,000	