General Science Plan for Monitoring and Research of a High-Flow Experiment Protocol at Glen Canyon Dam

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Introduction

This general science plan describes a program of monitoring and research activities that support ongoing information needs associated with implementation of the proposed action described in the **Environmental Assessment for Development and Implementation of a Protocol for High-Flow Experimental Releases from Glen Canyon Dam, 2011 through 2020** (hereafter referred to as the HFE EA). These high flows are proposed to repeatedly occur during a ten-year period.

This document represents an initial plan for science activities that will be implemented in FY2012. In response to the Grand Canyon Monitoring and Research Center's (GCMRC) initial 2011 proposal for studying flows under the HFE EA, these tasks were recommended by the Glen Canyon Dam Adaptive Management Program (GCDAMP) as part of the **Glen Canyon Dam Adaptive Management Program Biennial Budget and Work Plan—Fiscal Years 2011-12** (hereafter referred to as the FY 2011-12 BWP.

The proposed action of the HFE EA is based on the best available knowledge of sediment transport and geomorphic processes of the Colorado River downstream from Glen Canyon Dam. Previous research demonstrates that high-magnitude dam releases have beneficial geomorphic effects on the Colorado River ecosystem only if there is a large amount of antecedent fine sediment stored on the channel bed or being delivered to the Colorado River at the time of large dam releases (Melis, 2011). Measurement of antecedent fine sediment storage requires continuation of GCMRC's sediment-transport monitoring programs. This science plan recognizes a need to inform future decisions about implementation of high flows and the appropriateness of trigger criteria. Thus, this science plan will be adaptively revised so as to inform the adaptive management of the Colorado River.

The proposed action of the HFE EA has as its goal the retention of fine sediment within the Colorado River ecosystem. Retention of fine sediment – those sizes of sediment < 2 mm and classified as sand and mud – as eddy sandbars and channel-margin

deposits fulfills many ecological objectives for the management of the Colorado River in Grand Canyon National Park. Retention of fine sediment is hereafter referred to as "fine-sediment conservation." Most of the FY2012 tasks described in this plan focus on flow and suspended-sediment transport monitoring, conducted in combination with measurements of sand-bar topography. The resulting data are intended to document changes in the amount of sand and mud temporarily stored in and near the channel, as well as documenting the characteristics of riparian and aquatic habitats associated with fine-sediment deposits.

Although the HFE EA is focused on issues of sediment transport and geomorphology, the HFE EA also notes that high flow releases have the potential to directly affect biological and cultural resources. Thus, other tasks scheduled for the initial year (FY2012) of this science plan are intended to document biotic, economic, and recreational responses associated with the timing and frequency of repeated high flow experiments (HFEs).

The tasks identified in this general science plan have only been approved for FY2012, and other science planning activities associated with the GCDAMP are ongoing and not yet completed for 2013 and thereafter. As such, this plan is not comprehensive or inclusive of all science activities that may eventually be needed to evaluate the proposed ten-year period of high-flow experiments under the recommended action of the HFE EA (hereafter referred to as the HFE Protocol).

Need for Experimental Project

Previous HFEs released from Glen Canyon Dam were conducted in 1996, 1997, 2000, 2004, and 2008. These previous releases varied from 2.5 to 7 days in length and had peak flows ranging from power-plant capacity of about 31,500 to 45,000 cubic feet per second (ft^3/s). From these experiments, sediment scientists generally concluded that the only presently available tool for rebuilding sand bars is to release short duration, high flows after tributary floods have deposited new sand and mud into the main channel of the Colorado River. The HFE EA takes advantage of the knowledge gained in the previous experiments (Melis, 2011) and proposes to implement HFEs on a more regular basis following tributary fine sediment inputs. A brief summary of some elements the HFE Protocol, as described in the HFE EA follows:

> "The timing of high-flow releases would be March/April or October/November; the magnitude would be from 31,500 [ft^3/s] to 45,000 [ft^3/s]. The duration would be from less than one hour to 96 hours.
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> This protocol is intended to be experimental in nature in order to learn how to incorporate high releases into future dam operations in a manner that effectively conserves sediment in the long-term. A number of hypotheses may be tested through this experimental protocol, including the timing of a high release to the delivery and availability of sediment in the river channel. Two approaches are: (1) the "store and release" approach that allows sediment to become stored in the channel over time before a high release, and (2) a "rapid response" approach in which a high release is timed to

coordinate with a flood event in the Paria River. The store and release approach was used for the three prior HFEs and has been shown to be effective at redepositing sediment. The second approach has not been tried but is considered to have scientific merit. This rapid response alternative requires a short notice for dam operators, researchers, and downstream recreational users.

Developing this protocol is important in order to implement a strategy for high-flow releases over a period of time longer than one year or one event. In the past, Reclamation has done three single-event HFEs and the benefits to sediment have been temporary. One purpose for this protocol is to assess whether multiple, sequential, predictable HFEs conducted under consistent criteria can better conserve sediment resources while not negatively impacting other resources.

The purpose of this general science plan is to outline how ongoing monitoring and research projects will initially evaluate the effectiveness of high-flow releases under the HFE Protocol starting in 2012. These tasks are described in more detail in the FY 2011-12 BWP. Revisions to this science plan in years beyond 2012 will very likely be needed based on availability of funds. Additionally, knowledge gained from the initial scientific studies will inform future HFEs within an adaptive management framework. Revisions may also be required to address additional experimental activities identified in the **Long Term Experimental and Management Plan** (LTEMP) environmental impact statement (EIS) for Glen Canyon Dam operations that was initiated by the U. S. Department of the Interior in 2011.

The approach described in this science plan relies on existing quality-of-water, sediment, aquatic biology, and other resource monitoring projects funded in the FY 2011-12 BWP. No new studies are proposed, however, some existing 2012 monitoring and research efforts are expanded or adjusted to provide information that is directly relevant to the evaluation of a high flow experiment in 2012 should one occur.

This initial science plan is focused on assessing only the effects of the "store and release approach" described in the HFE EA. A separate science plan will be developed to assess the effects of the "rapid response approach" that is also described in the HFE EA. The details of this alternative approach have not yet been extensively described.

It is expected that many of the studies described below will inform both approaches to releasing high flows under the HFE Protocol, but more specific short-term investigations may be needed to evaluate the efficacy of the rapid response approach. This alternative release strategy may need to be adapted during periods when upper Colorado River basin hydrology is average or wetter and dam releases need to be increased to meet downstream water transfers or for dam safety purposes. In response to above-average runoff from the upper basin in 2011, Glen Canyon Dam releases during Water Year 2012 are predicted to be above-average to achieve equalization requirements for water storage between Lake Powell and Lake Mead. Owing to these required releases, ongoing science planning associated with a rapid response strategy is expected to occur during 2012. Science tasks that may be needed beyond the scope of this initial plan will

be developed in coordination with the GCDAMP as part of the FY2013-14 biennial work plan as well as the next 5-year monitoring and research plan (FY2013-17).

Experimental Project Goals

The primary goal of HFE EA is to test the hypothesis that a series of tributary sand-enriched high flows will be an effective strategy for rebuilding and maintaining sand bars using dam operations. A secondary scientific goal will be to evaluate the effects of implementation of the HFE Protocol on other priority GCDAMP resources including the aquatic food base, riparian vegetation and spring habitats, camping beaches, archaeological sites, and hydropower economics.

Strategic Science Questions

A major task of the GCMRC in 2010 was the synthesis of the results of the 1996, 2004 and 2008 high flow experiments (Melis, 2011). In this report Wright and Kennedy (2011) provided direction that is relevant to the primary focus of HFE Protocol science activities:

> "HFEs are an important tool for rebuilding sandbars. The three previous HFEs have demonstrated the effectiveness of individual HFEs for rebuilding sandbars, particularly when they occur after sand has been stored on the channel bed downstream from the dam. A logical next step in the adaptive-management process of the GCDAMP is to evaluate the cumulative effects of multiple HFEs over longer periods of time. This would be helpful because it is still uncertain whether sandbar building during HFEs can offset or exceed the sandbar erosion that occurs during periods of typical dam operations between HFEs. Thus, it is important to consider the frequency of HFEs and the erosion of sandbars between HFEs for future HFE planning. The fundamental sandbar-related science question therefore is:
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> - Can sandbar building during HFEs exceed sandbar erosion during periods between HFEs, such that sandbar size can be increased and maintained over several years?
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> Based on studies that have been conducted to date, HFEs do not appear to be a tool that can be used to benefit humpback chub. Rainbow trout pose a threat to juvenile humpback chub rearing in the mainstem near the confluence with the Little Colorado River due to increased competition and predation. Beneficial effects of the March 2008 HFE on rainbow trout populations appear to be largely responsible for the 38-fold increase in rainbow trout observed near the confluence between 2006 and 2009. A large increase in rainbow trout near the confluence with the Little Colorado River also occurred in the year following the 1996 HFE. The November 2004 HFE did not benefit rainbow trout populations, but a preexisting downward trend in rainbow trout populations and the absence of data make this finding highly uncertain. Thus, natural-resource managers might consider proceeding with caution when implementing any HFE strategies, particularly those involving frequent spring-time events, because currently (2010) the biological response to HFEs appears to be inconsistent with management goals for humpback chub. A logical next step in the HFE process is evaluating whether the seasonal timing of HFEs affects the rainbow trout recruitment response. If fall-timed HFEs do not lead to increases in rainbow trout populations near the confluence with the Little Colorado River (or it is later demonstrated that rainbow trout do not exert strong

influence on humpback chub rearing), then managers might be able to balance goals for sandbars and native fish without the need for substantial rainbow trout mitigation or removal. The fundamental fish-related science question therefore is:

- Does the seasonal timing of HFEs influence the rainbow trout response?

An adaptive-management process for HFE decision-making would be flexible and incorporate relevant scientific information, such as near real-time information about sediment conditions downstream from the dam and information on adult population trends for rainbow trout and humpback chub, as well as other resources. Indeed, as more HFEs are conducted, strong links connecting other resources to dam operations may be identified and incorporated into subsequent HFE strategies. An integrated science-based strategy would allow for effective management of the available post-dam sand supply while considering the impacts of the strategy on other resources within an adaptive-management framework."

Thus, in addition to the fundamental strategic science questions related to sediment resources, other science tasks will need to focus on assessing the effects of HFEs on other priority GCDAMP resources including aquatic food base, riparian vegetation and springs habitat, recreational camping beaches, archaeological sites, and hydropower economics. Science questions and tasks pertaining to HFEs and effects on native fish (especially humpback chub) and Lees Ferry rainbow trout (including recreational angling satisfaction) will also be addressed by the GCMRC and its cooperators, and are described within a separate general science plan associated with the U.S. Department of Interior, Bureau of Reclamation's **Environmental Assessment of Non-Native Fish Control Downstream from Glen Canyon Dam** (NNFC EA).

Scientists emphasize that there is substantial uncertainty about some of the resource outcomes that may result from implementation of the HFE Protocol. For example, the biological responses to fall HFEs are difficult to predict. Thus, modification of the HFE Protocol may be required based on knowledge gained from biological responses to future HFEs. Modification of the HFE Protocol in response to sandbar monitoring may also be required, and a different HFE strategy may be justified during average-to-wet versus dry runoff periods in the upper Colorado River basin. Because of these uncertainties, the annual "status check" outlined in the HFE EA will be a critical component of an adaptive strategy for future high flows from the dam. This status check would involve reviewing recent monitoring data for sand budgets, sandbar size and other resource responses. Based on the findings of these reviews, the HFE Protocol may also need to be adapted to address undesirable resource responses. Likewise, HFE science tasks may need to be adapted annually based on new knowledge and learning and to address new or evolving science questions.

Methods and Tasks

Initial HFE Protocol monitoring and research tasks are summarized below. Reference should be made to the individual project descriptions in the FY 2011-12 BWP for more detailed descriptions. Implementation of these projects assumes that (a) the respective annual work plan projects are funded at the level indicated in the approved FY 2011-12 BWP, and (b) additional funding is not available to provide expanded research

and monitoring of the effects of the HFE Protocol in 2012, should a high flow be released.

Additional funding or reprogramming of existing FY 2011-12 BWP funds would be required to expand the scope of the initial work described here for year-1 of HFE Protocol implementation. While the tasks are listed separately below, in reality many of the studies are linked. Studies will be coordinated and integrated as needed to provide a comprehensive assessment of the effect of the HFE Protocol on priority GCDAMP resources (also, see general science plan associated with the NNFC EA).

The priority focus of this general science plan in 2012 will be to address and answer, to the extent possible, the following HFE Protocol science questions:

Sandbars, Camping Beaches, and Archaeological Sites

1. Will multiple high flows conducted over a period of 10 years result in net increases in sandbar area and volume?
2. With the available sand supply that comes from tributary inputs, is the approach of using repeated floods to build sandbars sustainable?
3. Will multiple high flows conducted over a period of 10 years result in net increases in campable area along the Colorado River?
4. Will multiple high flows conducted over a period of 10 years improve archaeological site condition as reflected in increased sand deposition, increased site stability, and reduction in rates of erosion?

Aquatic Food Base

5. What is the effect of a fall HFE on the aquatic food base of the Lees Ferry reach, defined as the Glen Canyon Dam tailwater reach extending approximately 15 miles downstream from the dam?

Riparian Vegetation and Spring Habitats

6. How does HFE timing and frequency affect woody riparian and marsh vegetation composition?
7. How does riparian vegetation influence sandbar building, campable area, and wind-blown transport of sand?
8. How do Kanab ambersnail populations and habitat vary over a 10-year period of repeated high flows?

Water Quality

9. How do high flow experiments affect water quality (especially dissolved oxygen and temperature) in the forebay of Lake Powell and in the Colorado River between Glen Canyon Dam and Lees Ferry?

Hydropower

10. What are the effects of repeated HFEs on hydropower production and marketable capacity at Glen Canyon Dam?

Additional studies aimed at addressing the effects of dam operations on native and nonnative fisheries in Glen, Marble, and Grand Canyons, either under the HFE Protocol or other proposed flow experiments, are described within the general science plan accompanying the NNFC EA.

Task 1. Monitoring Within-Channel and High-Elevation Sediment Storage

This task involves monitoring the topography of fine sediment deposits. The ultimate measure of whether or not fine sediment is conserved along the Colorado River is whether or not fine sediment deposits increase or decrease in volume and area. For purposes of informing dam management, it is also important to distinguish between changes in the volume and area of fine sediment that occur below the water surface and changes that occur at higher elevations. Measurement of such changes in the mass of fine sediment requires a mix of direct field measurement and extrapolation throughout the 255 miles of the Colorado River ecosystem between Glen Canyon Dam and River Mile 240, which is the upstream end of Lake Mead. To meet this objective of measuring changes in fine sediment in response to the HFE protocol, the results of four currently funded programs will be integrated.

Project a (infrequent measurement of entire segments of the river corridor):

This project involves measuring changes in the area and volume of sandbars. The ***SedTrend*** channel-mapping project is designed to monitor the cumulative effects of multiple high flows. The results from previous high flow monitoring demonstrate that high flows build sandbars and that the magnitude of bar building is greatest when sand concentrations are highest. The question that is unresolved is whether repeated high flows and intervening dam operations can result in maintenance or increase in sandbars over longer periods of time. This objective of the project is described in detail in the Goal 8 project description of the FY 2011-12 BWP. Because the approach of this project is to monitor average sandbar size in a "typical" condition, the channel mapping associated with ***SedTrend*** will occur six months or more following each HFE. Thus, in some years that have high flows, channel mapping may be postponed or deferred depending on HFE timing.

Project b (frequent measurement of sandbar monitoring sites):

Additionally, changes in sandbar area and volume above the 8,000 ft^3/s water surface will be measured at long-term sandbar monitoring sites. While the focus of measurements described in *Project a* is comprehensive monitoring of total changes in sand storage - including sandbars - at infrequent measurement intervals, measurements at long-term measurement sites will be used to describe changes at a subset of sandbars at more frequent intervals. Reference should be made to the project descriptions of Goal 8 of the FY 2011-12 BWP for a summary of the methods. To enable comparison with historical conditions, it is essential that this task monitor the same set of 50 study sites that have been monitored in the past. The data collected here and in *Project c* will be used to address the issues related to the use of this small set of monitoring sites relative to the large number of sandbars that are in Grand Canyon. Sediment scientists believe that only by collecting and analyzing the more spatially robust data outlined in this project and in

Project d, will it be possible to improve the understanding of the behavior of these study sites relative to system wide behavior.

In the absence of high flows, the repeat surveys of these sites have documented that sandbars gradually erode. For this reason, this monitoring is scheduled to occur every two years unless a high flow occurs. Similarly, the surveys done immediately before and after high flows have repeatedly documented deposition. While continued quantification of the precise magnitude of deposition associated with each high flow would be beneficial, it is not critical to this monitoring effort. Instead, the GCMRC proposes to perform a survey approximately six months following each flood and use that as the benchmark monitoring record. This monitoring would be accomplished by the regular biennial sandbar survey unless the high flow occurs in an alternate year. In that case, an additional monitoring trip would be required. This sandbar monitoring was conducted in FY 2011, so FY 2012 is the first year that this activity would occur.

Monitoring of the immediate response of future high flows would be limited to information gained by daily photographs taken by remote cameras. The photographic data would allow comparison of the degree of sandbar building between past and future high flows. Currently, 18 sandbar-monitoring sites are instrumented with digital remote cameras. The GCMRC plans to install cameras at up to 20 additional sites before the next high flow, should one occur in fall 2012. Reference should be made to the FY 11-12 BWP for more details on this project.

Project c (campsite monitoring):

Measurement of the high elevation parts of sandbars is critical to estimating the impact of the HFE Protocol on the availability of campsites. Monitoring is currently scheduled to occur every two years unless a high flow occurs. Reference should be made to the Goal 9 project description for a summary of the planned campsite-monitoring component in the FY 2011-12 BWP. In the absence of high flows, repeat surveys of the campable area at these sites have documented that the lower elevation portions of the sandbars erode while campsites on the higher elevation open sand areas that form the major component of campable area along the Colorado River ecosystem also decrease, although much of the change appears due to vegetation encroachment and aeolian reworking of open sand areas. While continued quantification of the precise magnitude of deposition and erosion associated with each high flow would be beneficial, it is not critical. Instead, the GCMRC proposes to perform a campable area survey approximately six months following each high flow in conjunction with the proposed sandbar-monitoring program following each HFE and will use that as the benchmark monitoring record. This monitoring would be accomplished by the regular biennial sandbar survey unless the high flow occurs in an off year. In that case, an additional monitoring trip would be required. Sandbar monitoring occurred in FY 2011, so FY 2013 is the first year that this need for supplementary funding would occur should an HFE be released in fall 2012.

Project d (remote sensing):

This project is needed to supplement other measurements to fully track changes in sandbar area above the stage of 8,000 ft^3/s. Remote sensing can provide a system-wide quantitative measure of the area of sand exposed above the water surface at the time of

imagery collection (usually about 8,000 ft^3/s). Collection and processing of these data will provide long-term monitoring of the area of exposed sand to evaluate the cumulative result of multiple high flows and intervening operations over the experimental period. These data will also be used to evaluate the degree to which the more precise measurements made of sandbar volume in Project b are representative of sandbar trends throughout the Colorado River ecosystem. These data will also be used to quantify changes in vegetation distribution that may result in increases or decreases in the area of exposed sand along shorelines used by fish. Reference should be made to Goal 8 and Goal 12 for more detailed project descriptions within the FY 2011-12 BWP. This activity is part of the regular monitoring program for terrestrial resources along shorelines of the Colorado River below Glen Canyon Dam to address high-flow responses and does not require additional funding when high flows occur. Remote sensing data collection is scheduled to occur every 4 years, with the last imagery data set collected in May 2009 and the next over flight scheduled for May 2013.

Task 2. Monitoring Suspended-Sediment Flux

This project addresses the fundamental premises of the HFE Protocol by tracking tributary sand inputs and main channel export. Monitoring of sand and mud flux during future high flows will be conducted as part of the regular Goal 7 monitoring activities. The methods, monitoring sites, and planned products are described in the Goal 7 project description found in the FY 2011-12 BWP should an HFE occur in 2012. This task requires added work during a high flow to maintain the monitoring record because the instrumentation is vulnerable to high dam releases and additional samples are required to maintain instrument calibration.

Task 3. Monitor Archaeological Site Condition and Stability in Response to Repeated HFEs

Monitoring protocols are under development by the GCMRC that are specifically intended to be applicable for evaluating physical changes at archaeological sites tied to changes in sediment supply under a variety of dam operations. The initial 2012 HFE monitoring program for archaeological sites will continue with a limited phase of research and development while also evaluating use of 2009 remote imagery data intended to support ongoing National Park Service monitoring efforts in Grand Canyon National Park. In 2012, this task will consist of combining use of remotely sensed imagery with ongoing site monitoring methods conducted by National Park Service. At the same time, other site monitoring techniques will continue to be piloted in Glen Canyon National Recreation Area and evaluated for possible ongoing use to meet management information needs as HFEs are repeated between 2013 and 2020 under the HFE Protocol. Existing remote imagery data from 2002, 2005, and 2009 are also being evaluated by GCMRC and the National Park Service in 2012 to determine how aerial imagery might be used throughout the Colorado River ecosystem to track changes in sandbar area resulting from repeated high flows and other dam operations.

Task 4. Monitoring the Aquatic Food Base

The presently funded aquatic food base (AFB) project has been focused since 2006 on establishing a monitoring protocol that accurately captures key metrics relevant

to other resources in the Colorado River, including rainbow trout and humpback chub. Based on their work to date, the aquatic food base research scientists have determined that monthly monitoring of benthic organisms at Lees Ferry and at Diamond Creek, and monthly monitoring of drifting organisms is important information that supports assessment of all Glen Canyon Dam release regimes, whether modified low fluctuating flows, an experimental high flow, or other flows. Quarterly AFB sampling in Lees Ferry and Diamond Creek (located 240 miles downstream of Glen Canyon Dam) is included in the final FY 2011-12 BWP. Monthly sampling is planned during FY 2012. The GCMRC suggests that monthly sampling of AFB beyond FY 2012 is also needed to support evaluation of the future HFEs between 2013 and 2020. The monthly sampling protocol was effective at detecting significant changes in AFB at Lees Ferry in response to the March 2008 HFE. These data helped explain the strong positive rainbow trout response in Lees Ferry. Monthly AFB sampling is recommended to provide the statistical power needed to detect potential changes in the AFB due to future HFEs. Collecting these data in years without a high flow provides important baseline information, including assessment of seasonal variability. Collecting these data in years when an HFE occurs allows assessment of the amount of change, if any, which occurs as a result of the high flow. Reference should be made to the FY2011-12 BWP for a more detailed description of this project.

Task 5. Riparian Vegetation Monitoring

Together with its cooperators, the GCMRC has been monitoring the riparian vegetation community since 2000. Because of the distribution and extent of the vegetation community, the GCMRC has been developing methods that use remotely sensed overflight imagery to assess vegetation changes. Part of this development has included identification of the limitations of the overflight data. An important limitation is that understory plants and herbaceous species are difficult if not impossible to detect from aerial data. Therefore, the proposed ongoing GCMRC monitoring program includes a field component that monitors vegetation at established vegetation transects on a biennial schedule. Repeated sampling at established vegetation transects allows for the establishment of natural variability versus changes associated with a large-scale disturbance, like an HFE. Vegetation monitoring using transects is scheduled to take place in 2012 and over a biennial schedule thereafter. Supplemental monitoring of vegetation in 2013 would be needed if a controlled flood occurred in fall of 2012 or spring 2013 and subsequently every other year thereafter. Monitoring vegetation in years with a high flow release allows for assessment of both short and long-term impacts of HFEs to riparian vegetation. The FY 2011-12 BWP approved budget covers the cost of field transect monitoring in 2012, and details of this monitoring are described in the biennial work plan.

Task 6. Kanab Ambersnail Monitoring

As described in the US Fish and Wildlife Service's 2011 Final Biological Opinion related to the NNFC EA, information related to changes in Kanab ambersnail habitat at Vaseys Paradise, located 47 miles downstream from Glen Canyon Dam, will be provided through annual monitoring, as described in the FY 2011-12 BWP (p. 107). No additional work will be programmed during FY 2012 in association with an HFE unless further

information needs are identified through the GCDAMP planning process as part of the FY 2013-14 biennial work plan.

Task 7. Lake Powell and Lees Ferry Water Quality Monitoring

Monitoring of the water quality in Lake Powell provides an important perspective in the assessment of any high-flow release impacts to the reservoir itself or to downstream resources that respond to the quality of water released from the dam. Existing monitoring of Lake Powell water quality provides an important baseline. Leading up to a high flow release this standard monitoring is particularly important for establishing antecedent conditions, which vary from year to year. Immediately following a high flow release, additional water quality monitoring is needed to assess changes in water quality that may occur. Changes to the released water quality, especially dissolved oxygen, were observed in previous high flow releases.

Data from the Lake Powell monitoring program provides a basis from which the effects of a high-flow release can be evaluated. As part of the FY 2011-12 BWP, regular water-quality monitoring of the Lake Powell forebay is conducted on a monthly basis. The entire reservoir is sampled at multiple locations on a quarterly basis. This monitoring will be conducted in years without a high flow release to support continued characterization of the reservoir and effects to its water quality.

In years with a high flow release, some additional monitoring will be conducted so that high flow impacts to the water-quality of the reservoir and dam releases can be assessed. The primary focus will be the establishment of additional monitoring sites in the Glen Canyon Dam tailwater during the high-flow release to assess changes in combined releases between the dam and Lees Ferry.

Task 8. Evaluate Effects to Hydropower from Repeated HFEs

As part of the FY 2011-12 BWP, the GCMRC convened an expert workshop in 2011 to evaluate Western Area Power Administration's GTMax model and explore the utility of this model and potentially other existing models for assessing economic costs associated with alternative operating scenarios at Glen Canyon Dam. As economic studies continue to be developed as part of the GCDAMP during 2012, the GTMax model, as well as other models, may start to be used by GCMRC and its cooperators to assess potential costs and benefits to hydropower from implementing repeated HFEs, as well as for evaluating other alternative experimental operational scenarios in the future. During early 2012, the GCMRC is also adding an economist to its staff who will continue to work with the GCDAMP to develop studies intended to evaluate HFEs, as well as other related dam operation and resource topics.

Science Products/Reports on HFE Protocol

Primary reporting of results of the above tasks will be performed in the context of annual reporting and publications as described in the work plans associated with each individual monitoring project (see individual project descriptions in the FY 2011-12 BWP) with updated information also posted at the GCMRC's web site (http://www.gcmrc.gov/). In addition, a summary of relevant results and findings specific to an individual HFE should one occur in 2012 will be provided by the GCMRC in fiscal year 2013 and beyond as HFEs continue to be released under the protocol.

Budget

The GCMRC anticipates that the HFE Protocol science tasks described above will be funded as part of ongoing monitoring and research projects included in the approved FY 2011-12 BWP, including use of experimental funds as described in that work plan. Continuation of the tasks described here, or the addition of any other tasks that may be needed to provide information about repeated high flows released beyond 2012, will be developed through ongoing planning efforts between the GCMRC and the GCDAMP, starting with development of the draft FY 2013-14 Biennial Work Plan during 2012.

References Cited

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